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GLOBALISTICS AND GLOBALIZATION STUDIES

BIG HISTORY & GLOBAL HISTORY

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This yearbook is the fourth in the series with the title *Globalistics and Globalization Studies*. The subtitle of the present volume is *Global History & Big History*. The point is that today our global world really demands global knowledge. Thus, there are a few actively developing multidisciplinary approaches and integral disciplines among which one can name Global Studies, Global History and Big History. They all provide a connection between the past, present, and future. Big History with its vast and extremely heterogeneous field of research encompasses all the forms of existence and all timescales and brings together constantly updated information from the scientific disciplines and the humanities. Global History is transnational or world history which examines history from a global perspective, making a wide use of comparative history and of the history of multiple cultures and nations. Global Studies express the view of systemic and epistemological unity of global processes. Thus, one may argue that Global Studies and Globalistics can well be combined with Global History and Big History and such a multi-disciplinary approach can open wide horizons for the modern university education as it helps to form a global view of various processes.

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Introduction. Big History and Global History in the Field of Globalistics

One often maintains that our global world demands global knowledge. The need to see the processes of development holistically, in their origins and growing complexity, is fundamental not only for science but also for the human advance in general. In the nineteenth and twentieth centuries, there was an explosive growth of scientific knowledge accompanied by a deep differentiation of disciplines. But scientists working in different fields may run the risk of losing sight of how each other's tireless work connects and contributes to their own. Thus, it is not surprising that in the twenty-first century we observe a vigorous development of multidisciplinary and integral disciplines among which one can name Global Studies, Global History, and Big History, each providing a connection between the past, present, and future.

The present volume is the fourth in the series of yearbooks with the title *Globalistics and Globalization Studies*[1]. However, why Globalistics, not Global Studies? As we explained earlier, the notion of Globalistics first appeared in Russia, this is a translation of the Russian term *globalistika*; however, we believe it might be useful within the English Global Studies thesaurus. We are sure that the introduction of this term is justifiable, because it expresses the vision of systemic and epistemological unity of global processes, the presence of some relatively autonomous field with its own research subject. Morphologically this term is identical with such well-established designations of academic disciplines as Economics, Linguistics, Physics, and so on (for more details see Grinin, Ilyin, and Korotayev 2012b, 2013b, 2014b).

The subtitle of the present volume is *Big History & Global History*. What is Big History? Big History is a vast and extremely heterogeneous field of research which encompasses all the forms of existence and all timescales and brings together constantly updated information from the scientific disciplines and the humanities. The unique approach of Big History has opened up vast research agendas and suggests variety of forms. This discipline weaves together all the disciplines into a single narrative where interdisciplinary work is not only possible, but essential. As has been mentioned on a number of occasions, the rapidly globalizing world needs global knowledge that explains a unified global system (about Big History see Hughes-Warrington 2005; Nazaretyan 2005; Spier 2005; Christian 2005; Carneiro 2005; Markov, Korotayev, Grinin 2009; Grinin, Carneiro, Korotayev, and Spier 2011; Grinin and Korotayev 2009; Grinin, Korotayev, and Baker 2014). Thus, we may say that globalization itself becomes propulsion for Big History.

Finally, what is Global History? It is transnational or world history which examines history from a global perspective, making a wide use of comparative history and of the

[1] For the earlier issues see Grinin, Ilyin, and Korotayev 2012a, 2013a, 2014a.

history of multiple cultures and nations. Many students of Global History also explore the trends often denoted as 'historical dimension of globalization'. Moreover, according to Bruce Mazlish and Akira Iriye (Mazlish and Iriye 2005: 19), heart and novelty of Global History are constituted by history of globalization. So it is quite clear in what way Global Studies and Globalistics are connected with Global History (see also Little 2014; Grinin and Korotayev 2013).

Today, in the framework of individual disciplines one may observe a growing interest in interdisciplinary research which is believed to be one of the most effective ways to conceptualize and integrate our growing knowledge of the Universe, society, and human thought. In this respect, one may argue that Global Studies and Globalistics can be well combined with Global History and Big History. Such a multidisciplinary approach can give a more integrated vision of the systemic and epistemological unity of global processes. A deep symbiosis of 'mega-paradigms' like Big History, Global History, and Globalistics will open up research areas that are vital to the development of the twenty-first century thought and culture. We think this will also open wide horizons for the modern university education as it will help to form a global view of various processes and move further the limits of our studies. Such synthesis of knowledge can be achieved within Globalistics framework and can be useful for the students to understand the evolution of our planet within the context of the evolution of our Universe.

The volume is subdivided into three parts.

Part 1 (*Globalization and Global Processes*) comprises articles analyzing some peculiar aspects of contemporary global development such as Kondratieff waves (K-wave), the Cybernetic Revolution, and the causes of the crisis situation in Russia. Among other issued discussed in the articles of this section are democratization of countries within globalization context, the growth of world economy, migration processes at the global level, globalization of political processes in their dynamics and development and some other topical issues.

Part 2 (*Global History and Modernity*) touches upon such global problems as Universal Darwinism, human history, development of the trade relations in the ancient world, a new classification of early and modern polities, the ways of statehood and democracy formation, the international institutional system through the prism of evolutionary institutionalism, socio-political aspects and others. We believe that all the issues considered in this section are relevant and important within Global Studies.

Part 3 (*Big History Perspective)* contains articles that address some issues from the realm of Big History, such as the evolution of Big History, modeling of biological and social phases of Big History, the development of the Universe, some common evolutionary laws and principles, collective learning as a key concept in Big History and other important issues.

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Part I. GLOBALIZATION AND GLOBAL PROCESS

Kondratieff Waves, Evolution, and Globalization*

George Modelski

Contemporary Kondratieff wave (K-wave) studies show two tendencies: one, a macroeconomic analysis that maps long trends of prosperity and depression with GDP data, but second, a sectoral approach that traces the influence of K-waves of basic innovations, and the rise of a succession of leading industrial and/or commercial sectors on the emergence of a global economy. What is more, K-waves are a not stand-alone feature of the modern world system but one in a cascade of processes that have shaped its emergence. They stand in a close relationship with world politics, democratization, and globalization. An evolutionary explanation of K-waves is one that gives a reasoned account of the emergence of the modern global economy over the past millennium, and one that may project equally far into the future.

Keywords: *Kondratieff waves (K-waves), evolution, sectoral vs. macroeconomic approaches, world politics, democratization, globalization, the next K-wave.*

Economic crises, and more generally, fluctuations in the output of the world economy, have drawn the attention of scholars and practitioners for the best part of the twentieth century, and since. Some of them saw these movements as the product of internal changes and external shocks; others saw them as the harbingers of an imminent collapse of capitalism. Among the first to draw attention in a sustained manner to long-term regularities in the behavior of the leading capitalist economies was Nikolay Kondratieff (1984 [1925]), an economist writing in the 1920s. Statistical work on the behavior of prices and some output series for the United States, Britain and France since the 1790s led him to conclude that the existence of long waves as a regular feature of such economics was quite probable. He saw the capitalist world economy as evolving and self-correcting and, by implication, he denied the notion of an approaching collapse of capitalism then current among Marxist economists.

In the 1930s, Joseph Schumpeter endorsed this concept and named the pattern the Kondratieff wave, a name that has since been attached to this phenomenon, but that hardly settled the matter. Keynesianism explained much that needed to be known about economic depression, and in the years after 1945 the existence of the 'Kondratieffs' remained in contention, and to this day neo-classical economists remain wary of them. In fact, the 'Schumpeterians', the 'Austrian School', hold a minority position among economists. But

* This article is a posthumous publication of George Modelski (1926–2014).

since the 1970s, as the post-World War II expansion slowed down attention was drawn to it once again, and new research especially on innovation, combined with a wealth of new statistical data, moved the subject forward in an important manner.

1. The Sectoral and the Macroeconomic Approaches

This is not the occasion to review a century's worth of writing on the Kondratieffs. At this point, it might suffice to draw the distinction between two possible ways of looking at these processes. One of them relies for evidence on *macroeconomic* data, such as GNP, and also Gross World Product (GWP) fluctuations, and changes in the relative size of GDP as evidence of economic success or failure. This tendency, reinforced by the recent availability of such data, harks back to the earlier search for mapping the incidence of market crashes and other economic crises as evidence for the instability of the capitalist system. Its watchwords are prosperity and depression, and wealth creation. Long-term movements in such indices would then be seen as evidence for Kondratieff waves.

The contrast here is with a *sectoral* approach which concedes that the rise of new industrial and/or commercial sectors might indeed be a source of instability but which also argues that basic economic (and technological) innovation and structural and thus qualitative change in the world economy are the enduring sources of economic growth and adaptation to new conditions and therefore stabilizing over the longer run. Successive Kondratieff waves would then represent a narrative of global economic evolution, a key terms of which are innovation and its diffusion. Kondratieffs of the structural variety may simply be called K-waves.

Let us, therefore, define K-waves in particular as a pattern of regularity characteristic of structural change in the modern global economy. Some 50–60 years in length, it consists of an alternation of start-up periods of slow build-up of globally significant innovations, with others of high growth, chiefly in lead industries, but influencing the entire world system. The growth of the IT (information technology) computer-internet sector in the past several decades is an excellent example of a K-wave and the extensive influence of that process, reshaping the economy, and moreover, is beyond any doubt. The study of this pattern helps to trace the rise of the global economy and aids in long-range study of the modern world system.

2. Leading Sectors and Global Economic Innovation

The emerging view, now broadly characteristic of a significant body of scholarship, privileges globally-significant innovation, and leading sector expansion (see, *e.g.*, Rostow 1978; Van Duijn 1983; Freeman 1983 and the work of the Sussex Group; Berry 1991; Modelski and Thompson 1992, 1996; Modelski 2008b) and it might be summarized as follows.

K-waves have been so far the processes characteristic first of all of a lead national economy (such as that of the United States in the twentieth century, or Britain in the eighteenth-nineteenth centuries) that are then diffused world-wide by such mechanisms as sheer emulation, and by world trade in products and services of leading sectors. In the high-growth period of new sectors they become characteristic of the global economy as a whole. Then they alter the attributes of the world economy, more visible in global data series than in those of national economies.

K-waves concern output, rather than prices, and sectoral output surges and targeted infrastructural investment in the world economy rather than the general macroeconomic performance (GNP growth) of national economies. They should not be sought for in the ups and downs of such indicators as gross domestic product and must be distinguished from shorter-term business cycles and financial crises. However, high-growth periods for leading sectors tend to translate into a good deal of economic expansion and prosperity; they also constitute a substantive basis for globalization.

K-waves unfold as phased processes that imply, for each particular sector, S-shaped growth (or learning) curves (as distinct from expecting sine curves when graphing world GNP data). Over a period of some 50–60 years, we observe a period of slow start-up, followed by fast growth rates, and ultimately, a leveling-off. Each wave is different in kind from the last one, in contrast with cycles, seen as mechanical fluctuations in attainment of some uniform quantity. The start-up period of the next leading sector is also the period of flattening growth rates, declining profits, and severe competition for the previous lead industry; this transition between two leading sectors peak may be known as downswing.

K-waves arise from the bunching of basic innovations that launch technological revolutions that in turn create leading industrial or commercial sectors. In Joseph Schumpeter's classic formulation, such innovations concern new products, services, and methods of production, the opening of new markets and sources of raw materials, and the pioneering of new forms of business organization. In that sense, K-waves are caused by the demand for solutions to new problems, and the supply of such solutions by innovative enterprises and entrepreneurs. Each such wave therefore has its own individual innovative character, and can be named accordingly, as in Table 1. Viewed over the modern world system, they constitute the story, an outline of a narrative, of the emergence of the global economy.

Each K-wave has its own characteristic location in space and time. Britain's cotton wave was centered on Manchester. The Information (IT) K-wave (K19) is preferentially seen as originating in the United States, in California's Silicon Valley, and in Orange County, and in Washington State's Seattle.

K-waves also have a clear location in time, and can be dated. There is no standard listing, but following Kondratieff's practice, there is some agreement on the four or five most recent ones. Albeit hesitantly, some historians and world system theorists now extend such dating further into the past.

Table 1 offers one recent scheme reaching all the way back to Song China, and grounded in the argument (advanced *inter alia* by William McNeill) that the beginnings of the contemporary market economy might be traced to that source one millennium ago. The dates shown next to each K-wave are for the start of hypothesized start-ups, and the transition period that follows, with the high growth peak reached only some decades later. All such dates must, of course, be regarded as approximate. Such specificity is lacking in world GNP analysis.

Each K-wave has its own special character and specialization but each in its own way also changes the structure of the world economy. That is why a sequence of K-waves gives rise to structural transformations. Hall and Preston (1988) have shown that the three most recent K-waves (each based on electrical energy, those that launched *inter alia* the telegraph and electric power, radio and electronics, and computers and the information industries) might jointly be seen as the carriers of the information revolution that is still in progress. Our Table 1 also suggests that each cluster of four K-waves might have its own coloration, and the three most recent K-waves (K17–19) might be seen as constructing an ‘information age’ yet to be completed.

Table 1. Global economics and politics co-evolving in the modern world system

1. K-Waves	**2. Global leading sectors**	**3. Date**	**4. Long Cycles**	**5. System-builders**
1	2	3	4	5
Market economies	*	** *Transitions*		
K1	Printing and paper	930	LC1	Northern Song
K2	National market	990		
K3	Fiscal framework	1060	LC2	Southern Song
K4	Maritime trade	1120		
K5	Champagne Fairs	1190	LC3	Genoa
K6	Black Sea trade	1250		
K7	Galley fleets	1300	LC4	Venice
K8	Pepper	1350		
		** *Global nucleus*		
K9	Guinea gold	1420	LC5	Portugal
K10	Spices	1492		
K11	Baltic trade	1540	LC6	Dutch Republic
K12	Asian trade	1580		
K13	American plantations	1640	LC7	Britain I
K14	Amerasian trade	1680		
K15	Cotton, iron	1740	LC8	Britain II
K16	Railroads	1792		
	* *World market*		** *Global organization*	
K17	Electric power, steel	1850	LC9	USA
K18	Electronics, oil, autos	1914		
K19	Computers, internet (IT)	1973	LC10	
K20		2030		

Notes: Based on Modelski and Thompson 1996: 137, table 8.5.
* periods of the world economy process.
** phases of global political evolution.

Only in such an extended time-frame can truly long-term processes, such as globalization, be properly observed. No such a long-term perspective can be expected from world GNP studies if only for lack of data but also because of difficulty of using such a concept in that early context.

In sum, the sectoral approach to Kondratieff appears well positioned to capture the global innovative focus of the forces that shape the world economy. As we about to show below, it is also better suited for clarifying the complex web of interactions among economic, political and other structural processes of the modern world system. That way, it makes possible a fully analytical approach to the study of globalization.

3. K-Waves and the Modern World System

This 'sectoral' analysis of K-waves has so far been one of a 'stand-alone' process, treating it as the sole object of observation, with 'wars', at best, as only sources of external 'shock'. That has also been the tendency in much of the Kondratieff wave literature. An implicit ground for such treatment might have been the conviction that such grand movements of the world economy must be basic to the functioning of all of the world system, hence the ultimate determinants of the world's social trajectory.

That assumption might well be questioned. Economic processes are indeed foundational to the working of the world system, for they rank high as factors that condition growth, that are relatively high in energy and necessary for mobilizing resources, but they do not suffice to complete social organization. That is why they cannot be viewed in isolation from other, equally significant processes. Next in importance as conditioning factors (in a cybernetic hierarchy) are those agent-based processes that work to create and operate the world's political systems, long cycles of global politics, the drivers of global political evolution.

In contrast with conditioning factors there also are controlling factors, relatively high in information, that cannot be ignored, especially in the longer run, and also at the global level: they are both the forces of community formation rife with symbolic communication, the solidarity-builders that make increasingly extensive, long-term cooperation possible. There are also those that are opinion-shaping, higher in information and reliant on learning, science and the media, for helping to spot global problems, and aiding in coping with them, by controlling the necessary plans or programs.

3.1. Power Law

Overlaying all this is the finding that the relationship between these four basic, agent-level processes: the K-waves, and the political, social, and cultural ones, are governed by a power law that maintains that the periods of these movements of the global system are multiples of the period of the K-wave: and in particular that the two K-waves equal the length of one period of the global politics' long cycle, and are also synchronized with it, as in Table 1 (Devezas and Modelski 2011).

These are the considerations that lead students of K-waves to study the interdependence of K-waves and the other global processes. At one level, K-waves are seen as an endogenously generated response to problems facing the world economy: basic innovations as responses to system problems, such as railroads meeting the demands of a rising industrial economy, or data-processing as responsive to the needs of the military forces or the space program. In that sense, K-waves are not the response to random shocks, as some economists have called for instance wars, but to predictable influences that make them coordinate with global political change; they may be seen as supplying the resources, hence the necessary conditions, for financing enterprises of system-building and global leadership. While it is clear that major warfare has so far marked the path of system-building it is also obvious that the evolutionary character of the enterprise means that major warfare is not an inherent feature of the emerging world system.

3.2. K-Waves and World Politics

Some students of International Political Economy (such as Joshua Goldstein 1988) have recognized but a loose connection between long economic waves and the fortunes of major powers in the modern world. A much stronger tie has been urged by Modelski and Thompson (1996) who have argued for an essential structural relationship between K-waves and global political leadership in system-building. A survey of economic history shows, as in Table 1, columns 1–3, a series of K-waves as the rise of successive globally significant lead industries; columns 4 and 5 of the same table also display tightly linked to a parallel (and structurally similar) process, the rise of system-building world powers, hence, a significant change in world political arrangements. That latter process is sometimes referred to as the hegemonic or leadership cycle, or more precisely in this context, as the long cycle of global politics (without implying that the process animates an unchanging system). Notice that this is a 'rise' (via S-type learning), but not 'rise and decline' of lead industries, and lead powers; those who have participated in this process endure and largely continue to play key roles.

While the exact conditions of that process remain a matter of some debate, the existence of a succession of world powers in modern world politics is now taken for granted, and the similarities in the several approaches are now greater than the differences. Participants in that debate, including Robert Gilpin, Immanuel Wallerstein, and Paul Kennedy have all recognized the role of economic growth in that process. It can further be shown that system-building world powers that served as foci of modern world politics, also accounted for the major proportion of economic innovations.

The right-hand columns 3–5 in Table 1 list the powers that in the past five hundred years, since about 1500, animated the global system via great enterprises of system-building (and contended with successive challenges from *inter alia* Spain, France, and Germany). It also shows, for the early modern era, that starts with Song China, two Italian republics, Genoa and Venice, that might be regarded as prototypical of later oceanic powers, whose trading networks organized a good part of the maritime routes while the Mongols, and then Timur, held sway over continental Eurasia.

The rise of each such power is seen to be coordinate with K-waves in two ways: in space, in as much as each K-wave is initially largely located in the world power of that period, and also in time, in as much as the timing of these two processes of change is synchronized. What is more, an economy that launches lead industrial sectors (but not necessarily with the biggest GWP) builds the foundation for a claim to leadership in global system-building. In turn, attainment of leadership position in the global system establishes the political framework for a global economic order.

In that way, illustrating the working of the power law discussed in the previous section, each long cycle of global politics (numbered in Table 1 as LC1–LC10) has been matched, in the experience of the modern world, by two K-waves (numbered as K1–K20). A rigorous, data-based test of that hypothesis of synchronization is a study of early globalization in the case of Portugal (Devezas and Modelski 2008, amplifying Modelski and Thompson 1996). The first of the K-waves that were analysed in those studies, and labeled K9, Guinea gold, created a new system of trade along Africa's west coast, based principally on the demand for gold; the experience and the resources thus gained helped to create the necessary conditions for the second K-wave, K10 Spices, that went out to capture the pepper trade (a commodity profitably handled by Venice in the West, but also traded to the Far East) by extending the reach of the Portuguese sea power into the Indian Ocean, and even to the South China Sea. The political aspect of system-building is marked by a complex of generation-long hostilities spreading from the Mediterranean via the Atlantic, to the eastern oceans, and illustrated by the record of building of Portuguese bases/fortresses serving as nodal points of a global political network. That record maps as a century-long learning curve (Devezas and Modelski 2008: 44).

The same process might be observed three centuries later, albeit on a larger scale, as when the later nineteenth century industrial expansion in electric power, steel, and chemistry (K17), laid the foundation for the United States' role in the 20th century, in its world wars in particular, to be followed by K18, as when the peace settlements of 1945 laid the groundwork for the economic expansion of the post-war years, led by autos, oil, and electronics, complementing the parallel formation the groundwork of an inter-governmental 'international community'. The location of the (odd-numbered) K-wave has served as a leading indicator of the identity of the next system-building global leadership.

The relationship between the Kondratieff processes and war has long been of interest to students of these matters. Indeed, Kondratieff himself strongly hinted at the hypothesized link between these two phenomena. In particular he observed that wars and revolutions were more likely to occur during what might be called the long start-up, or the transition period. A striking reminder of that relationship was the Great Depression of the 1930s, sandwiched between the two World Wars, in the start-up phases of K18.

In an empirical study of that relationship in a long time frame Joshua Goldstein (1988) saw economic upswings associated with K-waves as increasing the probability of severe war. Brian Berry (1991) doubts such a connection and is troubled by the notion of an inherent tendency to war in the global political system. The record of modern K-waves so far has shown a close connection between the long cycle and the incidence of global wars, but that is not a sound prescription for the future (see discussion in Modelski and Thompson 1996: 56–62; Modelski 2006).

3.3. K-Waves and Democratization

The relationship between K-waves and democratization may be less obvious but is also noteworthy, and has been reciprocal, in that democratic practices have been innovation-friendly and favorable to entrepreneurship, and the rise of new industries; while K-waves have been central to rising global connectivity and the creation of the elements not just of a world market but also of a global community. Most generally, the significant lowering of the cost of information that has been the most recent result of this trend has had a positive impact on the world-wide spread of democracy.

As another glance at Table 1 will confirm, the home bases of K-waves have been societies that can be classified as freer and more open, relatively to their competitors and their environment – in fact, a democratic lineage. An early case was Song China, that clearly cannot be called democratic, but was for its time notably open, educated 'learning society', under 'civilian control'. Forms of representative government were prominent in the Italian and Dutch Republics, as well as in Portugal and Britain. It is since the mid-nineteenth century that the K-wave-democracy connection has been demonstrably clear in particular relation to the United States. Innovation-engendering leading industrial sectors flourished first in environments favoring free flow of information, competitive markets, the rule of law, and openness to global problems, for innovation alone is not enough, it needs institutional support to create leading sectors.

The other strand of influences can be traced from K-wave system-building to an increasingly tightly connected world. As is also apparent from Table 1, in several instances, as, for example, in the Portuguese cases, the results of the K-wave process have been enhancements of the instruments and expansion of the products that animate world trade. The internet of the early twenty-first century is only the latest instance of higher connectivity, and it is that higher connectivity that has in turn favored the spread of democratic practices, often using U.S. or European examples as models to follow but retaining options of other ways too. In building a world market, the K-waves have put in place elements of a global community. But it is also clear that an increasingly interconnected world is also subject to new forms of instability.

4. K-Waves and Globalization: In a Cascade of Evolutionary Processes

For Nikolay Kondratieff (1984: 25–26, 35, 90) the long movements described by him were features of the capitalist world economy that was evidently evolving meaning that the processes he observed were evolutionary. Even his critics admitted that his concept of 'phases of capitalist evolution' deserved attention. But he was also acutely aware that the investigation of these processes was difficult because it called for a long period of observation for which lack of data was a severe problem, not forgetting the question of homogeneity. That is why his inquiries did not reach much further back than the nineteenth century. It is unfortunate that some students of this subject still regard long economic waves only as phenomena of the last century or two.

That makes Table 1 a foray into the past in the spirit of Kondratieff. It covers the modern era in its entirety (the ancient and classical worlds lacked global processes), and it makes it possible to explore, on its basis, the value of an evolutionary explanation. The weakness of such an explanation was one of the serious criticisms of Kondratieff's original thesis (Garvy 1943).

An evolutionary explanation of K-waves is one that gives a reasoned account of the emergence of the modern global economy over the past millennium, and one that may project equally far into the future. That is the essence of the 'mechanism-and-process' approach applied in the world system setting (Devezas and Modelski 2011). Its first requirement is a set of initial conditions favorable to innovation: competitive markets, rule of law, open society, and responsiveness to global problems. Maritime access, possibly with an insular position, also helps. In such propitious circumstances, an evolutionary mechanism of learning sets in motion a phased process that generates variety, mobilizes resources, selects, and then consolidates innovations bearing on global problems, translates them into fast-growing industrial or commercial sectors, and gradually diffuses them to other parts of the global economy.

Over a span of two generations (a generation being a basic unit of evolutionary time), the process reaches a peak, and its growth rate gradually flattens out, and tends to overlap with its successor, producing a succession of overlapping sociotechnical paradigms depicted in Table 1. The drivers of that evolution are large and small firms, often fresh start-ups launching innovative products that are, or are not, selected by consumers/buyers in the marketplace, and when selected, are diffused until they reach saturation in their global market place. The selective pressure is that of markets, but these markets might include large buyers, such as governments whose demands, and research, may stimulate innovation.

In a cascade of evolutionary processes, the K-(economic) wave coevolves not only with the political process of system leaders' rise that powers global political evolution, but also with that of global community-building, and also that of global opinion formation (via the rise of media, learning, and science) that shapes and legitimizes globalization. As noted earlier, much empirical evidence supports the conjecture that a power law is operating here: two K-waves synchronize with one long cycle of global politics (as in Table 1); four K-waves seem to be producing the current phase of democratization, and eight K-waves correspond to long swings of (emergent) world-wide consensus enabling globalization. That suggests systematic interaction and substantial interdependence, and makes K-waves a necessary ingredient of globalization (Modelski 2008a).

5. Questions

The two major propositions defended on this occasion are the following:

1. A K-wave, sectoral approach to the study of the global economy's long movements fuelled by innovation and system-building needs to be distinguished from a macroeconomic approach that maps the long-term trends of prosperity and depression of that economy. Both approaches have their own data bases, their preferred models, and their own merits.

2. K-waves are not a stand-alone feature of the modern world system but one in the cascade of processes that have shaped the emergence of that system. They stand in a close, co-evolutionary relationship with global politics, democratization, and globalization.

Important questions remain. At this time, consider just one set of these that concerns the timing, nature and future location of the next K-wave (K20).

What is the likely timing of K20? When might its start-up be expected? Table 1 suggests 2030, and while that is obviously arbitrary, the onset of a new wave seems to be approaching later in the next decade, of the 2020s, some five decades since the dawn of the computer age, and to continue well past the mid-twenty-first century.

What might we anticipate will be the nature of the next K-wave and what lead industries might it generate? Analysis presented here suggests that K20 will consolidate the achievements of the current four-K-waves (K17–20) period by producing a 'wired world'. Such a world will need to select a new authority structure, more specifically, considering that this Information Age began with the industrialization of electric power, and led the world towards a vast increase in energy use, that in turn created problems that are changing the world's climate, it would be only fitting if the next step in shaping of a viable economy were to be a recasting of the world's energy industries into a clean mode that minimizes the consumption of fossil fuels.

What is likely to be the location of K20? The United States seems the favored entrant in this race, *inter alia* on account of its contribution so far to the Information Age. But China that recently became the world's greatest emitter of greenhouse gases is also the biggest participant in the internet, and is staking out an important lead in the search for clean energy sources. The race will be played out in the face of rising competition for global leadership in the face of urgent global problems, the pace of democratization, and continued pressures of globalization.

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The Cybernetic Revolution and Historical Process[*]

Anton L. Grinin and Leonid E. Grinin

The article analyzes the technological shifts which took place in the second half of the twentieth and early twenty-first centuries and predict the main shifts in the next half a century. On the basis of the analysis of the latest achievements in medicine, bio- and nanotechnologies, robotics, ICT and other technological directions and also on the basis of the opportunities provided by the theory of production revolutions the authors present a detailed analysis of the latest production revolution which is denoted as 'Cybernetic'. There are given some forecasts about its development in the nearest five decades and up to the end of twenty-first century. It is shown that the development of various self-regulating systems will be the main trend of this revolution. The article gives a detailed analysis of the future breakthroughs in medicine, and also in bio- and nanotechnologies in terms of the development of self-regulating systems with their growing ability to select optimal modes of functioning as well as of other characteristics of the Cybernetic Revolution (resources and energy saving, miniaturization, and individualization).

Keywords: *production principle, production revolution, Cybernetic revolution, nanotechnologies, medicine.*

Introduction

The present article presents the analysis of contemporary technological shifts and forecasts the future technological transformations on the basis of the *theory of production principles and production revolution* which was introduced elsewhere (*e.g.*, Grinin 2006a, 2007b, 2006b, 2012b; Grinin and Grinin 2013, 2015). These new explanatory concepts are relevant for the analysis of causes and trends of major technological breakthroughs in the historical process and for the forecasting of new technological shifts. The article presents a general outline of this theory and analyzes its predictive capacities. We hope that the reader will be convinced, from the evidence presented, that this theory is invaluable in interpreting the complex array of facts and trends of current technological development. We also posit that the proposed theory provides a solid basis for making forecasts of future technological developments. The main part of the article is devoted to the analysis of the last production revolution – the Cybernetic Revolution – and the changes which took place in its course starting from the 1950s. The focus is on the changes which will most probably occur due to the Cybernetic Revolution in the next 30–60 years (with a focus on medicine); for some aspects we have made forecasts up to the end of the twenty-first century.

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Section 1. THEORY OF PRODUCTION REVOLUTION AND ITS PREDICTIVE CAPACITIES

1.1. The main ideas and implications of the theory of production revolutions

According to the theory we have developed (Grinin 2006a, 2006b, 2007a, 2007b, 2012; Grinin and Grinin 2013, 2015), the most fundamental causes of transition from one stage of historical development to a subsequent one are global technological transformations which create an essentially new level of productivity and initiate a new technological epoch. We propose that these basic technological levels and epochs can be defined in terms of *production principles.*

We single out four **production principles**:

1. Hunter-Gatherer.

2. Craft-Agrarian.

3. Trade-Industrial.

4. Scientific-Cybernetic.

Among large technological breakthroughs in history the most important are the three production revolutions: 1) the Agrarian or Neolithic Revolution; 2) the Industrial Revolution and 3) the newest Cybernetic one.

Each production revolution launches a new production principle; so the three production revolutions represent the borders between four production principles (see Fig. 1).

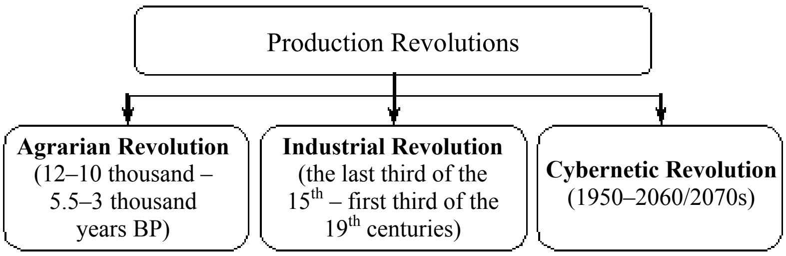

Fig. 1. Production revolutions in history

Each production revolution has its own cycle consisting of three phases: two innovative phases and between them – a modernization phase (see Fig. 2).

At *the initial innovative phase* a new revolutionizing productive sector emerges. The primary system for a new production principle emerges and for a long time it coexists alongside old technologies. *The modernization phase* is a long period of distribution and development of innovations. It is a period of progressive innovations when the conditions gradually emerge for the final innovative breakthrough. At *the final innovative phase* a new wave of innovations dramatically expands and improves opportunities for the new production principle, which, at this time, attain full strength. As the final phase of the production revolution unfolds, the 'essence' of the production principle, its opportunities and limitations are revealed, as well as the geographical borders of its expansion via merging with new states.

The production revolutions also bring about:

1. The development of fundamentally new resources.
2. A vigorous growth of production output and population.
3. Substantial complications to society.

(For more details see Grinin 2006b, 2007b, 2012b; Grinin and Grinin 2013; about Industrial revolution see Grinin, Korotayev 2015).

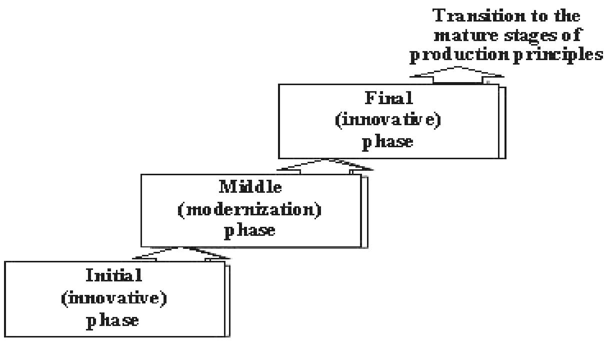

Fig. 2. The structure of production revolutions (phases and their types)

The Agrarian Revolution was a great breakthrough from hunter-gatherer production principle to farming. Its **initial innovative phase** was a transition from hunting and gathering to primitive hoe agriculture and animal husbandry (that took place around 12,000–9,000 BP).[1] The **final phase** was a transition to intensive agriculture (with large-scale irrigation and plowing) which started around 5,500 years ago. These changes are also presented in Table 1.

Table 1. The phases of the Agrarian Revolution

Phases	Type	Name	Dates	Changes
Initial	Innovative	Manual agriculture	12,000–9,000 BP	Transition to primitive manual (hoe) agriculture and cattle-breeding
Middle	Modernization	No designation*	9,000–5,500 BP	Emergence of new domesticated plants and animals, development of complex agriculture, emergence of a complete set of agricultural instruments
Final	Innovative	Irrigated and plow agriculture	5,500–3,500 BP	Transition to irrigative or plow agriculture without irrigation

Note: * In this and Table 2 below the titles are given only to the innovation phases; the modernization phases do not need special designation.

[1] Following V. Gordon Childe, the Agrarian Revolution is often called the Neolithic one. However, this notion is not quite satisfactory. First, it actually started during the Mesolithic era; second, it completed already in the Iron Age. One should not confuse the Agrarian Revolution as a global phenomenon with the British Agrarian Revolution of the seventeenth- eighteenth centuries (on the latter see, *e.g.*, Overton 1996).

The Industrial Revolution was a great breakthrough from craft-agrarian production principle to machine industry, marked by intentional search for and use of scientific and technological innovations in the production process.

Its **initial phase** started in the fifteenth and sixteenth centuries with the development of shipping, technology and mechanization based on the watermill as well as with a 'more organic' (Durkheim 1997 [1893]) division of labor. The **final phase** was the well-known breakthrough of the eighteenth and nineteenth centuries with the introduction of various machines and steam energy. These changes are presented in Table 2.

Table 2. The phases of the Industrial Revolution

Phases	Type	Name of the phase	Dates	Changes
Initial	Innovative	Manufacturing	15^{th}–16^{th} centuries	Development of shipping, technology and mechanization on the basis of water engine, development of manufacture based on the division of labor and mechanization
Middle	Modernization	No designation	17^{th} – early 18^{th} centuries	Formation of complex industrial sector and capitalist economy, increase in mechanization and division of labor
Final	Innovative	Machinery	1730–1830s	Formation of sectors with the machine cycle of production using steam energy

The Cybernetic Revolution is a great breakthrough from industrial production to the production and services based on the operation of self-regulating systems.

Its **initial** phase dates back to the 1950–1990s. The breakthroughs occurred in the spheres of automation, energy production, synthetic materials production, space technologies, exploration of space and sea, agriculture, and especially in the development of electronic control facilities, communication and information. The **final** phase is to begin in the 2030s and will last until the 2070s.

We denote the initial phase of the Cybernetic Revolution as **a scientific-information** one, and the final – as **a phase of self-regulating systems.** So now we are in its modernization phase which will probably last until the 2030s. This intermediate phase is a period of rapid distribution and improvement of the innovations made at the previous phase (*e.g.*, computers, internet, cell phone etc.). The technological and social conditions are also prepared for the future breakthrough. We assume that the final phase will begin in the nearest decades, that is in the 2030–2040s. We suppose that the final phase of the Cybernetic Revolution will lead to the emergence of many various self-regulating systems.

In our opinion, it will start in the field of medicine, which in the conjuncture with other fields will create the revolutionizing system of **MBNRIC (medico-bio-nano-roboto-info-cognitive) technologies**, which will also bring about a fundamental correction or even modification of human biological nature. The scheme of the Cybernetic Revolution is presented in Fig. 3.

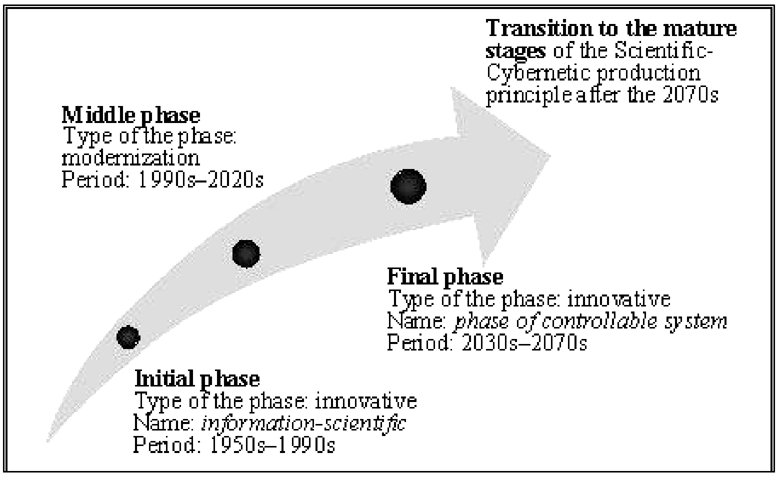

Fig. 3. The phases of the Cybernetic Revolution

1.2. Characteristics of the Cybernetic Revolution

What are self-regulating systems and why are they so important? Self-regulating systems are systems that can regulate themselves, responding in a pre-programmed and intelligent way to the feedback from the environment. They are systems that operate with minimal to zero human intervention. Today there are many self-regulating systems around us, for example, the artificial Earth satellites, pilotless planes, navigators laying the route for a driver. Another good example is life-supporting systems (such as medical ventilation apparatus or artificial heart). They can regulate a number of parameters, choose the most suitable mode and detect critical situations. There are also special programs that determine the value of stocks and other securities, react to the change of their prices, buy and sell them, carry out thousands of operations in a day and fix a profit. A great number of self-regulating systems have been created. But they are mostly technical and informational systems (as robots or computer programs). During the final phase of the Cybernetic Revolution there will emerge a lot of self-regulating systems connected with biology and bionics, physiology and medicine, agriculture and environment. The number of such systems as well as their complexity and autonomous character will dramatically increase. Besides, they will essentially reduce energy and consumption of resources. Human life will become organized to a greater extent by such self-regulating systems (*e.g.*, by monitoring of health, regulation of or recommendations concerning physical exertion, diet, and other controls over the patients' condition and behaviors; prevention of illegal actions, *etc.*).

Thus, we designate the modern revolution as 'Cybernetic', because its main sense is the wide creation and distribution of self-regulating autonomous systems. Cybernetics, as is well-known, is a science of regulatory systems. Its main principles are quite suitable for the description of self-regulating systems (see, *e.g.,* Wiener 1948; Ashby 1956; Foerster and Zopf 1962; Umpleby 1999; Tesler 2004; Beer 1959).

As a result, the opportunity to control various natural, social and industrial production processes without direct human intervention (which is impossible or extremely limited at present) will increase. The fourth phase (*of maturity and expansion*) (the 2070s and 2080s) will come after the completion of the final phase of the Cybernetic Revolution. In this final phase, the achievements of the revolution will become quite systemic and wide-scale (for more details see Grinin 2006b).

Below we enumerate the most important characteristics and trends of the Cybernetic Revolution. One can observe them today, but they will be realized in mature and mass forms only in the future. These features are closely interconnected and corroborate each other.

✓ Using transformation and analysis of information as an essential part of technologies and increasing connection of the latter with environment.

✓Implementation of smart technologies; as well as developing of trends a) towards humanization of their functions; and b) towards autonomation and automation of control.

✓Qualitatively growing controllability a) of systems and processes of various nature (including living material); and b) of new levels of organization of matter (up to sub-atomic and using tiny particles as building blocks);

✓ The transition to a wide distribution of self-regulating systems, which will become the major part of technological process.

✓ The capabilities of materials and technologies to adjust to different objectives and tasks (smart materials and technologies).

✓ The integration of machinery, equipment and hardware with technology (know-how and knowledge of the process) into a unified technical and technological system.[2]

✓ Control over human behaviour and activity to eliminate the negative influence of the so-called human factor.[3]

✓ Individualization as one of the most important technological trends.

✓ Resource and energy saving in many spheres.

✓ Increasing opportunities in the synthesis of materials with previously lacking properties in chemical, biological and bionic (techno-biological) systems.

✓ Miniaturization and micro-miniaturization as a trend of the constantly decreasing size of particles, mechanisms, electronic devices, implants, *etc.*

Various directions of development should generate a system cluster of innovations.[4]

1.3. The logic of the production revolution: The analysis of utility and correlations between the phases

The significance of the theory of principles of production and production revolutions is in the fact that they allow making more profound and more productive description of the

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[2] During the Industrial Epoch these elements existed separately: technologies were preserved on paper or in engineers' minds. At present, thanks to informational and other technologies the technological constituent fulfils the managing function. And this facilitates the path to the epoch of self-regulating systems.

[3] For example, the control of human insufficient attention in order to prevent dangerous situations (*e.g.*, in transport) as well as to prevent human beings from using means of high-risk in unlawful or disease state (*e.g.*, not allow driving a motor vehicle while under the influence of alcohol or drugs).

[4] Thus, for example, the resource and energy saving can be carried out via choosing optimal modes by the autonomous systems that fulfil concrete goals and tasks and *vice versa*, the choice of an optimal mode will depend on the level of energy and materials consumption, and a consumer's budget. Or, the opportunities of self-regulation will allow choosing a particular decision for the variety of individual tasks, orders and requests (*e.g.*, with 3D printers and choosing of an individual program as the optimal one).

evolution of production and technological development as well as provide the means to forecast the unfolding of the Cybernetic Revolution and of the scientific-cybernetic principle of production. The availability of such instruments proves the scientific nature of this theory. Our forecast is based on the identified regularities in the phases of production revolutions. This section will define these regularities and the way they can be used in forecasting.

Let us remind that the fundamental idea of the proposed conception of production revolutions is that *for every production revolution each of its three phases plays functionally the same role and the ratio between the duration of phases within the framework of each cycle remains approximately the same*. Thus, on the basis of the regularities identified within the Agrarian and Industrial Revolutions, one can make assumptions about the following factors: first, about the duration of the middle (modernization) phase of the Cybernetic Revolution; second, about the beginning and approximate duration of the final phase of the revolution; third, about the sectors and directions that will be affected by the new technological breakthrough.

Therefore, the theory of production revolutions provides with methodological approach to ground our forecasts about the future technological shifts within the Cybernetic Revolution. Let us remind the reader that the initial phase of the Cybernetic Revolution has already been completed (lasting from 1950 to the early 1990s) and the modernization one is approximately half way through its development (it started in the 1990s and presumably will last till the end of the 2020–2030s). So we can compare the forecasts of the theory concerning each phase of the production revolution with present-day reality, and we can also infer the role that technologies will play in the final phase of the Cybernetic Revolution.

To give a better explanation to such a methodology, we formulate a number of functional and processual relations between the initial and final phases of the production revolution, between the initial and middle phases, and between the middle and final phases of the production revolutions. Knowing the algorithm of how processes manifested in the initial phase of the production revolution can be transformed in the middle and final phases, we provide forecasts of the Cybernetic Revolution development for the upcoming decades proceeding from the study of its initial and uncompleted middle phase.

1.3.1. The peculiarities of the initial phase: Amalgamation of non-system tendencies into a system and the development of new ones

The initial phase of the production revolution is marked by the following peculiarities:

1. *A number of tendencies and innovations that used to be non-systemic within the previous production principle get a systemic character.* The non-systemic character means that within the previous production principle these phenomena did not play a crucial role and did not result from its main characteristics, whereas within a new production principle the role of these characteristics significantly increases. This can be shown by the example of automatization which to a certain extent was developed within industrial production long before the Cybernetic Revolution. One of the main characteristics of the industrial production principle is that the production process is carried out by means of machines which are

operated by humans using their sense organs, power and qualification. At the same time, some operations were performed without human involvement, in other words automatically. But the automatization of processes was not essential, in other words it was not a necessary characteristic of the industrial production principle but an extra bonus. In the early twentieth century, automatization started to develop vigorously (*e.g.*, in electrical engineering for the prevention of accidents, in engines for convenient control, *etc.*). But still it had no decisive importance as it was not generally used for the automatization of technological processes.

Therefore, in that period automatization can be regarded as a hyper-development of such essential characteristic as mechanization. Besides, in the first half of the twentieth century, automatization was not the leading direction of the industrial production principle. On the contrary, the leading position was taken by the processes of the latest division of labor including the wide distribution of assembly-flow production (a constant intensifying division of labor is an essential and transparent characteristic of the industrial production principle, strikingly manifested already in manufactures). The development of automatization in the second half of the twentieth century is quite a different matter. It has become the most important characteristic of the scientific-cybernetic production principle (in its initial stages), finding new forms of application and expression in releasing human costs in process control (especially in Information and communications technology [ICT]).

Thus, *the initial phase of the production revolution develops the non-system elements of the previous period to the highest degree.* In this regard, automatization was the continuation of mechanization (see *e.g.*, Lilley 1966; Philipson 1962; Bernal 1965); as the chemistry of synthetic materials was the continuation of organic chemistry (Zvorykin *et al.* 1962); and as the Green Revolution in agriculture was the continuation of agronomy (Thirtle *et al*. 2003). The development of radio and television technologies was the continuation of the trend of new methods of information transfer which had emerged earlier. Such continuity can hide the intensity of the transition from one epoch to another. So it is not surprising that in the 1950–1970s the scientific and technological development was considered as the continuation of the Industrial Revolution, and at best it was defined as a new industrial revolution (scientific and technical revolution [Bernal 1965]). However, this super-development possessed some qualitative characteristics which will be described below.

2. *The former non-system characteristics together with newly emerging ones now merge into a unified system representing a new production principle.* Automatization, the chemical production of synthetic materials, the powerful development of non-computer electronics and means of communication, the emergence of various engines, the general transition to a new type of energy and fuel, the breakthrough in selection and plant protection, the discharge of a million workers previously employed in agriculture and industry and their transition to the service sector; together with a number of new directions in technology, informatics and science – all this creates a principally new situation in economy and also evidences the start of a new production revolution, namely, the Cybernetic one.

3. *An important factor with a powerful synergistic effect is the temporal density (the cluster pattern) of the formation and development of a number of directions which, to a greater or lesser extent, is typical of a new production principle.* Such directions in the 1950–1960s were the nuclear power industry, space exploration and usage of space frequencies for

communication and other purposes, deep-sea exploration, information and computer technologies, multiplying equipment, laser technologies, and other areas (*e.g.*, in genetics, medicine and biotechnologies).

4. *However, the future of these innovative spheres can be different*: some of them get particular and important development in the second half of the initial phase and in the middle phase; and other areas will not develop so intensively. Some can turn (at least, temporally) into dead-ends. Thus, at present the atomic energy industry faces severe constraints due to environmental problems, the hopes to master thermonuclear energy fell short of expectations and deep-sea exploration (except for shelf sea) still remains exotic. At the same time, the development of ICT has become the leading trend.

5. *The change of the leading sector in the course of the production revolution.* The leading role of the peculiar characteristics and sectors of a new production principle becomes especially obvious by the end of its initial phase or during its modernization phase (as in the case with ICT). These sectors need some time to reach maturity and acquire a systemic character. *Thus, during these two first phases of the production revolution there is a constant alteration of the leading branches and sectors as well as the formation of new sectors.* One of the branches of a new production principle starts to dominate over the other branches for quite a long period of time (from the end of the initial phase until the middle phase). This branch becomes a key symbol of the production revolution and its driving force. *But later its role as a driving force decreases.* Thus, the wool industry (the most important branch of the initial phase of the Industrial Revolution) appeared to be unimportant in the final phase when it was replaced by the cotton industry. So one can make an assumption that ICT will not remain the most important sphere of the final phase of the Cybernetic Revolution. Besides, advancements in this field will become only one constituent (albeit an important one) of the breakthrough which will be made in other fields.

Later, in the course of the final phase of the Cybernetic Revolution (approximately in the 2050s) one can expect a new qualitative breakthrough in ICT. For example, one can assume that sooner or later serious changes will inevitably occur in programming itself. At present this process is labor-intensive and slow. It will most likely develop in the direction of simplification and robotization of some part of programming and especially in implementation of programs. In other words, machine programming will mainly substitute human programmers and 'the self-programming' trend will be developed.

6. *Already in the initial phase there emerges a prototype of the sectors which will become the leading ones in the final phase. But in the initial phase they do not play the leading role* (see below).

1.3.2. The characteristics of the middle (modernization) phase: Accumulation of innovations and the search for a breakthrough point

1. *The large scale of already existing tendencies and the formation of new ones.* On the one hand, in this phase many processes develop (to a varying degree) that were formed in the initial phase of the production revolution. On the other hand, in the modernization phase we can trace the roots of those forms which will emerge as leaders in the final phase of production revolution. Therefore, it is important to distinguish between the tendencies which have already appeared to be mature and the tendencies which are only formed. It is important to

understand which of them will increase and which of them will be unimportant, become stable or later will decrease.

2. *The expanded development. Need for profound social and political changes.* The expansion of new technologies is especially noticeable in the first half of the modernization phase. In its second half this expansion faces certain saturation and slows down and this increases activity in the field of innovations. There appears an anticipation of something important. But the decisive component for the formation of a new system is still lacking. Besides, this gap can be manifested not only in the absence of basic technological innovations but also of the social conditions for its implementation. One of the most important characteristics of the modernization phase is that *during this period some profound changes or even breakthroughs in social and political relations should take place*. As regards the Industrial Revolution, the period between the seventeenth and eighteenth centuries is the time of social revolutions in England, the Netherlands, the USA, and France which changed the world. It was also the time of changes in the world policy: The Thirty Years' War (1618–1648) and the subsequent Piece of Westphalia laid the foundations of international relations for a long time. Globalization and the period which we denoted as the epoch of new coalitions (Grinin 2009, 2013; Grinin and Korotayev 2010) will also significantly change the world and this process is already under way.

3. *The idea of a decisive component.* During the modernization phase opportunities and improvements accumulate that will play a role in making the final phase of the revolution possible. All components should be ready before it starts. However, we emphasize that the innovations will form a new system only as soon as the key component emerges. At the same time the reconstruction of the relationships within the framework of a whole production system (fields, branches and innovations according to their value) will be considerable.

4. *The emergence of the decisive innovation in the new field.* Basing on our analysis of production revolutions one can conclude that the decisive innovation will appear not within the most important sector of the economy. Thus, irrigated agriculture failed to become the most important sector of agriculture in pre-state barbarian societies; while the cotton industry was not the most important industrial sector in the first half of eighteenth century. Moreover, in this field there should appear certain conditions which should include high commercial profitability and attraction, thus producing a steady demand for a long period of time. Nevertheless, the emergence of the decisive innovation can remain underestimated for some time.

The decisive innovation for the final phase of the Cybernetic Revolution to begin can appear in different fields of bio- or nanomedicine. There can be a series of innovations which will turn the growing number of innovations into a qualitatively new system. It is quite possible that such a breakthrough will be connected with the invention of successful methods to fight cancer as this disease differs significantly from other diseases and requires solutions at the genetic level as well as the application of fundamentally new technologies.

1.3.3. The peculiarities of the final phase

1. *The main characteristics of the production revolution come to maturity.* One can find all the basic characteristics of the final phase of the revolution already in its initial phase though in undifferentiated, incomplete or undeveloped state. These characteristics of the

future system are revealed in the middle phase when the production principle takes a relatively complete although undeveloped form.

The first conclusion. *One may infer about the main characteristics of the Cybernetic Revolution on the basis of an analysis of the initial and middle phases, through a focus on their features and the dynamics of development.* This analysis allows for a singling out of the most important characteristics of the Cybernetic Revolution including resource savings, miniaturization, individualization, wider use of new materials, *etc.* These characteristics already show up in our epoch but they will absolutely dominate in the next epoch.

2. Given the *numerous directions that will appear during the initial phase, there will be some that will necessarily become leading directions in the final phase.* At the same time in the initial phase they play a less significant role. Thus, while in the final phase of the Industrial Revolution the main point is mechanisms, machines, replacement of manual labor by machinery, in its initial phase machinery was only a part of this new direction. In the beginning of the Industrial Revolution, the technical innovations (replacement of manual labor by machines) were not so important and the main point was the process that intensified the division of labor. If you consider the Agrarian Revolution, the leading direction of manual (hoe) agriculture was the use of fertile areas with the help of manual labor (*e.g.*, with the help of a sharp stick). The soil fertility was natural or was achieved by burning of plants. As to irrigation technologies, in the initial phase of the Agrarian Revolution they were not so widespread and were linked to the local environment. But in the final phase they became the leading factors and remained such during the whole period during which the craft-agrarian principle dominated production.

The second conclusion. Therefore, the leading sector of the final phase of the Cybernetic Revolution has already formed, but it is one of those sectors which does not, as yet, play a decisive role in the economy. In our opinion, medicine will play the leading role in the unfolding final phase of the Cybernetic Revolution (see below).

3. *The mutual integration of innovative sectors starts after the formation of the decisive innovations or their group.* This process especially intensifies in the final phase of the production revolution. Innovations are mutually integrated and form a fundamentally new system. That was the case with the invention of the power spinning loom (which was later improved). Before that time, for two decades separate important directions (steam engines, steam energy, new types of machines, principles of management at large enterprises, established institution of inventions and different technological innovations) allowed formation of the fundamentally new sector of cotton mills. This caused the cumulative effect of rapid invention of missing innovations in the field of cotton carding (*i.e.*, the separation of cotton fibers), painting, printing, *etc.*

The third conclusion. The breakthroughs in medicine and allied technologies will cause the 'catching up' and an amalgamation of different innovations into a system which might bring about the completion of the Cybernetic Revolution (see below).

4. One should *distinguish between the field of breakthrough and the essence of a new system of production.* The field of breakthrough just initiates profound transformations. The production revolution will fully gain its logic and 'sense' or 'essence' only later when the transformations become profound and expanded. However, one can try to guess this

'meaning', 'sense' and 'essence' on the basis of the processes occurring during the initial and middle phases of the production revolution.

The fourth conclusion. The general idea of the Cybernetic Revolution can be connected with a constant and comprehensive saving of energy, resources and materials which will start due to mass development of self-regulating systems at a fundamentally new level. In fact, without the breakthrough in saving there will be no growth of living standards of the world's population whose number will increase at least until the 2070s (according to most forecasts, see, *e.g.*, Population Division 2012).

1.3.4. The determination of the future sector of the breakthrough. Why medicine?

Thus, an assumption from the theory of production revolutions entails that one of the number of directions defined in the initial and middle phases of any production revolution becomes a breakthrough area by the beginning of its final phase. But this factor does not play a leading role in the economy until the beginning of the breakthrough. The analysis of the actual development of production revolutions also suggests the following characteristics of the future sector:

- the commodity produced in this sector should be of prime necessity. Thus, cereal in the period of the Agrarian Revolution and cotton in the period of the Industrial Revolution were basic necessities;
- the direction of development of the sector should conform to the leading tendencies and problems in the society (irrigation agriculture could support and increase the sudden exponential population growth; the cotton industry met the needs of increasing urbanization and made use of the surplus labor force which had emerged in the agrarian sector);
- the sector can influence a significant number of spheres and integrate them (*e.g.,* in the period of the Agrarian Revolution the irrigation facilities required joint actions in society; and in the period of the Industrial revolution the transition to machines and steam-engine in the cotton industry caused a rapid growth of economy, the reconstruction of transportation routes and trade);
- technological conservatism in this sector is relatively weak;
- the breaking through sector should provide high profits and rely on steady demand, otherwise it will fail to attract major investments. Besides, borrowing from this sector new technologies which arose in the advanced society will face no obstacles (*e.g.*, government's ban, *etc.*) in other societies;
- the sector must have a great potential for the growth of its productivity and the need for the growth of productivity must remain high for a long time to stimulate the innovations and investments.

Let us consider these conclusions in the context of the Cybernetic Revolution. It is evident that the future breaking through sector of the final phase of this revolution should have already developed. But which of the existing ones meets the mentioned characteristics? We argue that there will be no breakthrough, for example, in the field of green (low-carbon) energy sector (despite the fact that at present wind power demonstrates high growth rates) because green power will be unable to completely replace traditional energy resources but it will coexist with it similar to hydro- and nuclear power coexist with carbon energy. We think that robotics could become the break through direction if there were created robots that could perform different functions in the services sector. Not without reason the future scientific and technological progress was thought to be connected with developments in the sphere of robotics. At present robotics finds wide application and is rapidly developing (see, *e.g.,* Makarov and Topcheev 2003; Gates 2007). But still one can hardly say that robotics will become the breaking through direction judging by the current investment volumes in the sphere, by the level of resolution of problems (including the projects of the neural-network technologies), and the interest in this field. However, it will play a very important part in the final phase of the Cybernetic Revolution and should achieve outstanding results though somewhat later, perhaps after the Cybernetic Revolution is completed (see Conclusion).

On the basis of the analysis of the current situation one can conclude that the only field which meets all the requirements is medicine. That is why medicine will be the first sphere to start the final phase of the Cybernetic Revolution, but, later on, the development of self-regulating systems will cover the most diverse areas of production, services and life. We treat medicine in a broad sense, because it will include (and already actively includes) for its purposes a great number of other scientific-technological branches (*e.g.*, the use of robots in surgery and taking care of patients, information technologies in remote medicine, neural interfaces for treatment of mental illness and brain research; gene therapy and engineering, nanotechnologies for creation of artificial immunity and biochips which monitor an organism; new materials for growing artificial organs and many other things to become a powerful sector of economy).

Let us consider in detail why medicine is to become the breaking through sphere.

a) Medicine is unique because it inspires constant activity in the field of new high technologies.

b) There are far fewer social, cultural or structural obstructions to the application of these technologies in medicine than in other fields (as well as the obstacles to adoption of innovations).

c) The commercial prospects of new technologies in this sphere are huge since people are always ready to pay for them.

d) In the nearest decades not only the developed but also developing countries will face problems of population ageing, shortage of labor resources and the necessity to support a growing number of elderly people. The progress in medicine can contribute to the extension of working age (as well as to the general increase of the average life expectancy) of elderly people and to more actively involve disabled people into labor activities. *Thus, elderly people and people with disabilities could more and more subsist for themselves.*

e) A rapid growth of the world middle class and of population education level, especially in the developing countries (NIC 2012) is anticipated in the nearest decades and these two factors mean that there will be a sharp growth in the demand for health services.

f) The medical sphere has unique opportunities to combine the abovementioned technologies into a single complex. Many spheres (including but not limiting to biotechnologies, nanotechnologies, robotics, use of the latest ICTs and various devices, cognitive technologies, synthesis of new material) will be integrated in this field.[5]

Medicine as a sphere of the initial technological breakthrough and the emergence of MBNRIC-technology complex. It is worth remembering that the Industrial Revolution began in a rather narrow area of cotton textile manufactory and was connected with the solution of quite concrete problems – at first, liquidation of the gap between spinning and weaving, and then, after increasing weavers' productivity, searching for ways to mechanize spinning. However, the solutions for these narrow tasks caused an explosion of innovations mediated by many of the major elements of machine production (including abundant mechanisms, primitive steam-engines, the high volume of coal production, *etc.*) which gave an impulse to the development of the Industrial Revolution. In a similar way, we assume that the Cybernetic Revolution will start first in a certain area. Given the general vector of scientific achievements and technological development and taking into account that a future breakthrough area is to be highly commercially attractive and have a wide market, we predict that the final phase (the one of self-regulating systems) of this revolution will begin in one of the new branches of medicine. Perhaps, it has already formed (as biomedicine or nanomedicine) or it can form as a result of involving other innovative technologies into medicine.

Certainly, it is almost impossible to predict the concrete course of innovations. However, the general breakthrough vector can be defined as a rapid growth of *opportunities for correction or even modification of our biological nature*. In other words, it will be possible to extend opportunities to alter a human body, perhaps, to some extent, its genome; to widen sharply opportunities for minimally invasive operations instead of the modern surgical ones; to use extensively cultivated biological materials, bodies or their parts and elements for regeneration and rehabilitation of an organism, and also to make and use artificial analogues of this biological material (bodies, receptors), *etc.*

This will make it possible to *radically expand the opportunities to prolong life and improve its biological quality.* It will be the technologies intended for common use in the form of mass market services. Certainly, it will take a rather long period (about two or three decades) from the first steps in that direction (in the 2030–2040s) to their common use.

The drivers of the final phase of the Cybernetic Revolution will be medicine, bio- and nanotechnologies, robotics, ICT, cognitive sciences, which will together form a sophisticated system of self-regulating production. We can denote this complex as *MBNRIC-technologies.* As is known, there is a widely used abbreviation of NBIC-technology (or convergence), that is nano-bio-information and cognitive (see Lynch 2004; Dator 2006; Akayev 2012). However, we believe that this complex will be larger.

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[5] It should be noted that Leo Nefiodow has been writing about medicine as the leading technology of the Sixth Kondratieff Wave (according to his approach, until the 2050s) (Nefiodow 1996; Nefiodow and Nefiodow 2014a, 2014b). We generally support his ideas (including the ideas about a new type of medicine), but it is important to point out that Nefiodow believes that it is biotechnologies that will become an integrated core of a new mode. However, we suppose that the leading role of biotechnologies will consist, first of all, in their ability to solve the major medical problems. That is why, it makes sense to speak about medicine as the core of new technological paradigm.

Section 2. MEDICINE, BIO- AND NANOTECHNOLOGIES IN THE CYBERNETIC REVOLUTION

Having no opportunity to describe the whole range of MBNRIC-technologies (for more details see Grinin and Grinin 2015) in this paper we will concentrate on describing current and future transformations in medicine. Our focus will be on those transformations that are an integral part of this complex during the starting period of the final phase of the Cybernetic Revolution. Where possible we will point out the interconnections of medicine with robotics, cognitive and information technologies.

2.1. Medicine in the initial and middle phases of the Cybernetic Revolution (the 1950–2020s)

In the initial phase of the Cybernetic Revolution (between 1950 and the1990s) there was a rapid growth of medicine as an increasingly important service sector. *At the same time the growth of health services constituted the general process of a rapid increase in service sector. In the economies of developed countries the service sector is the leading sector in terms of GDP.*

During this initial phase of the Cybernetic Revolution new directions of medicine emerged while those directions that had emerged earlier (*e.g.*, electroencephalography, electric shock therapy, transplantology, active use of electronics, laser and new methods of diagnostics such as ultrasound) reached a certain level of maturity. Substantial progress has been achieved in the sphere of child mortality reduction, infertility treatment, gerontology, psychiatry, development of contraceptive methods, and transplantation of organs and the creation of artificial organs, gender reassignment surgery *etc.* Sport medicine, space medicine and other directions in medicine appeared during this time. On the whole, due to medicine people learned about controlling their bodies and maximizing their health.

The period from the 1990s till the present represents the modernization phase of the Cybernetic Revolution. At present medicine is highly computerized especially in the field of diagnostics, various automatic control systems have been developed; for example, for the control of breathing, nutrient supply to specific organs, blood pressure, control over the functioning of some internal organs, *etc.* A large range of drugs have been developed which over time decrease in price and become more available to the general public. Surgery connected with the transplanting of organs and the replacement of certain human organs by artificial organs, endoscopic surgery providing operations without incisions, and rehabilitation medicine are all developing rapidly. Surgical methods have become less invasive and require less time for rehabilitation. In medicine there appear new directions such as shockwave therapy and control of cholesterol levels. The directions which emerged earlier have been actively developing, for example those which are related to artificial fertilization, maintenance of pregnancy and obstetrics, *etc.*

The current stage is represented by the prevalence of innovations accumulated over the last decades since most of the latest technologies are based on improvements to previous discoveries and inventions. Starting with the 1980–1990s we observe considerable progress in the struggle against the most common causes of mortality – heart attacks, strokes, orphan diseases and other diseases including hereditary. Significant progress has been made in technologies for diagnosing internal organs and tissues using such methods as X-ray computed tomography, nuclear magnetic resonance introscopy, X-ray photography and others (Mirsky 2010: 19).

On the whole, medicine (supported by both government and private funding) has been a major influence on GDP. The distribution of medical technologies is a very expensive process. Despite that cost, there still has been a steady increase in funds allocated to medicine by the state. Generally, its growth is comparable to the GDP growth rate. But in the developed countries spending on health care per capita is 10–20 times larger than in the developing countries. Taking into consideration the anticipated faster growth rates of GDP in the developing countries and a rapid formation of the middle class there, one can suppose that in general, spending on health care will increase significantly. Ageing of the population together with growing prosperity will lead to a situation where health care spending will outpace the general GDP growth. And this tendency is likely to increase. The level of medical development has significant impact on such popular development indicators as the human development index (HDI).

At the same time within the medical sphere some major innovations will reach maturity in two or three decades (some of them even earlier). At present the fastest developing fields of medicine (in its broad sense) are the fight against incurable diseases, implantations, reproductive medicine, gene therapy, pharmaceutics and aesthetic medicine which we will consider below. Medicine is closely related to biotechnologies (through pharmaceuticals, gene technologies, new materials, *etc.*). The distinctive feature of modern medical science is its 'bio-related trends' a wide use of approaches based on the methods of molecular and cell biology. A new perspective direction – biomedicine – has emerged (see Strategy… 2013) and nanomedicine (Wagner *et al*. 2006). Below we will consider some important trends within medicine. Note that the growing importance of medicine is shown in the phenomenon of medicalization. It is expressed in the fact that many aspects of human behavior (especially deviant) and psyche which have never been related to medicine start to be described in medical terms and require medical observation and intervention (see Yudin 2008).

Development of new pharmaceuticals. One of the criteria of medical development is a constantly increasing production of drugs. In the USA, from 1950 to 2000, the number of firms producing drugs increased more than seven times (Demire and Mazzucato 2008). By 2006, the production of drugs doubled, and the total global market volume of drugs was estimated at US$ 640 billion, about half of which was accounted for in the USA (Kondratieff 2011). This field remains one of the most profitable fields with a sales profitability of 17 per cent (*Ibid*.). Every year the volume of consumed drugs increases by several percent. Meanwhile, along with the expansion of pharmaceutical production, its efficiency is decreasing and they only suppress symptoms but do not have a curative effect (of only 30–50 per cent). The growth of pharmaceutical production is connected with unification which leads to decreasing efficiency as even well-investigated diseases often proceed individually. The solution to this situation can be individualization of medicine due to genetic engineering.

2.2. Forecasts regarding developments in medicine. In what way will the characteristics of the Cybernetic Revolution appear in the development of the medical sphere?

2.2.1. Two decades before the beginning of the final phase of the Cybernetic Revolution

The development of aesthetic medicine. At present aesthetic and cosmetic medicines are vigorously developing and their main task is to correct defects or alterations which concern the person and improve attractiveness (eliminate wrinkles, provide attractive rejuvenation, fat excision, implant teeth, transplant hair etc.). According to *Forbes*, the global cosmetic surgical and aesthetic medical market amounts to 180 billion dollars (Zhokhova 2011).

One of the highest achievements of plastic surgery is the face transplantation. The first full face transplant was performed in France in 2005 on a woman who was mauled by her dog. Recently, details of the most extensive face transplant performed in March 2012 were presented. Doctors from the University of Maryland Medical Center gave a new face including jaw, teeth and tongue, to thirty-seven year old Richard Norris.

During the next two decades some directions of medicine such as cosmetic and aesthetic medicine are supposed to rapidly develop (though it can cause rather serious psychological problems including those connected with individual's self-identification). Along with the new technologies there will be a wide spread of already proven technologies (*e.g.*, different types of face lift, liposuction, body shaping, *etc.*). The wealthier a society, the more money people spend on health and beauty. Taking into account the growth of the world middle class, this direction and all types of aesthetic medicine are expected to develop rapidly. Once the new technologies based on the achievements of medicine and genetic engineering have been established, aesthetic medicine will be able to become the correction medicine of the future, whose most important task will be to correct birth defects and acquired defects.

The struggle against incurable diseases is the most important direction of medicine. According to WHO, in 2008 the most frequent causes of death were lower respiratory diseases (11.3 per cent), diarrheal diseases (8.2 per cent), HIV/AIDS (7.8 per cent). Meanwhile, in developed countries the most frequent causes of death are coronary artery disease (12–15 per cent), stroke and other cerebrovascular diseases (8.7 per cent), trachea cancer, bronchus cancer, lung cancer (5.9 per cent). In general, mortality from cancer in developed countries reaches the same level of mortality as the coronary artery disease.

With the rapid ageing of population the potential danger of age-related diseases will increase. The present tendency is that with growing life expectancy cancer diseases take first place among diseases. Therefore, the most significant task of medicine will be the struggle against cancer and other age-related diseases. In the nineteenth and twentieth centuries many fatal diseases were defeated (cholera, yellow fever, typhoid, tetanus, polio, whooping cough, measles, malaria, diphtheria, *etc.*). It would seem that fatal highly infectious diseases except for AIDS (which is widespread in African countries) have been defeated. However, at present in many developing countries with tropical climate a multitude of people die from infectious diseases and fevers. Nowadays incurable diseases are the challenge for humanity. It is not surprising that big awards are provided for solutions to these problems.

In the context of the struggle against cancer there are some positive changes connected with the possibility of early diagnosis and increasing percentage of cured people (see below) but the situation has not changed dramatically. It is possible that cancer will not be defeated by the 2030s. Apparently, cancer treatment requires considerable changes. If we defeat this disease, there will appear a strong impetus for a breakthrough in medicine and its transition to a completely new level.

Movement towards self-regulating systems and minimization of interference. We observe the growing controllability of systems in different branches of medicine. Some of them have already reached the stage of real self-regulation, for example, life support systems and artificial organs. Other systems are moving towards self-regulation and they are intrinsically linked to the minimization of traumatization of a patient. For example, in surgery there developed the trend to perform surgeries with the help of special flexible instruments allowing the doctor to be able to perform surgery on the most inaccessible parts of human body with minimal incision. These operations are conducted with the help of endoscopes and video cameras transmitting an enlarged image on the monitor. In order to solve the problem of hand tremor special robots are used to substitute for human hands. Operating such a device, a surgeon controls the smallest movements of the instrument (including the laser, or ultrasound). One can anticipate that in the nearest future a lot of operations will be conducted without human surgeon's participation.

2.3.2. The premises for a breakthrough

As we have mentioned that the field of some innovative branches of medicine will be the sector where the final phase of the Cybernetic Revolution will start and develop. The unfolding situation will arise by the 2030s in the growth of the economy, demography, culture, living standard *etc.*, will contribute to this. And this will determine a tremendous need for a scientific and technological breakthrough.

Let us denote these premises:

– a large volume of medical services which amounts to about 10 per cent of the world GDP;

– leveling of peripheral and developed countries;

– formation of a huge middle class, reduction in poverty and illiteracy. As a result, the focus of efforts will shift from elimination of the most unbearable conditions to the problems of raising the standards of living, healthcare, *etc*. So, there is a great potential for the development of medicine;

– by that time we will face the problem of population ageing. Moreover, this problem will be typical not only of the developed countries where it will become crucial for democracy, but also for a number of developing countries, in particular, China and India. The problem of pensions will become more acute (as the number of retirees per worker will increase) and at the same time the lack of a qualified labor force will increase (which in a number of countries, including Russia, is very critical). *Thus, we will have to solve the problem of labor force shortages and pension contributions by increasing the retirement age by 10 or 15 years (of course, it is necessary to solve complex social problems at first).*

It also refers to the adaptation of people with disabilities for their full involvement in the working process due to new technologies and achievements of medicine;

– at the same time by that time, the birth rates in many developing countries will significantly decrease. Therefore, the government will start to be concerned with the health of the national population and not with limiting population growth.

On the whole, these successful conditions will entail major investments in medicine: increase in the number of well-off and educated people and middle-aged and elderly people (who particularly are willing to actively spend money on medicine), strengthening of the need for extra labor force and interest of the state in improving the working capacity of elderly people. In other words, the conditions for activization of business, science and state in order to provide a breakthrough in the field of medicine can be unique and *the formation of such unique conditions is necessary for the beginning of a new phase of the Revolution!*

2.3.3. The shifts during the final phase of the Cybernetic Revolution

Nowadays the boundary between medical diagnosis and treatment already becomes more and more imperceptible. Diagnostics is a constant necessary measure for disease controlling and drug dosage. During the final phase of the Cybernetic Revolution there will start a breakthrough in medicine. It will be connected with the formation of systems for monitoring health, supporting the organism and treatment will be performed mainly by the autonomous systems which will be able to function regularly and constantly. Besides, due to opportunities of remote medical care, there will also be a leveling of conditions for patients. It means that the quality of services will not be so highly dependent on the qualifications of medical personnel in a particular medical care unit.

A breakthrough in the field of struggle against incurable diseases will occur but the most important – in the field of improving the quality of life and extending the working age. Medicine will also develop in the direction of: a) prevention and propedeutics of diseases; b) controlling the processes of life and elimination of irregularities; and c) maximal account of individual characteristics.

Self-regulation and controllability of systems is manifested in many branches of medicine. Self-regulation will manifest in the fact that treatment, operations and further rehabilitation will be under a fuller control of semi-autonomous and autonomous systems. In the future it will be possible to provide certain treatments through special devices, systems, robots, *etc.* It is one of the most important directions which will be realized during the 2030–2050s.

Another manifestation of self-regulation will consist in the technological and automated control of processes of human organs (through necessary albuminous compounds, cells, antibodies, activization of immune system, *etc.*). In other words, treatment will become more targeted.

The third direction can be associated with the development of the health monitoring system that will allow early diagnosis and preventing diseases. All these measures will provide control over diseases.

Finally, a number of functions of a doctor can be performed by the patients themselves with the help of different devices and systems. At present the tests for important indices (such as blood pressure, on pregnancy, blood sugar level) can be made without doctors by means of special devices. On the basis of the test results one can define the norm and abnormalities. Perhaps, in the near future diagnostics will be transferred from specialized institutions to mobile devices on the basis of nanochips which do not require the specialists' participation. There has been notable progress in this sphere.

According to *Scientific American,* there will appear stamp-size medical devices which, if you apply them to a wound, will carry out the blood test and determine which medicines should be used and then will inject them (Rybalkina 2005: 46). It is unlikely that such devices will appear in the very near future and besides similar devices most likely will work only on a narrow spectrum of issues. Nevertheless, the emergence of such forecasts is quite remarkable as they show the movement towards the development of self-regulating systems. However, nowadays in order to remotely control patients, the company Applied Digital Solutions proposes the device 'Digital Angel'.

In this connection the profession of a doctor in its current form can lose a number of its present attributes, first of all due to the transfer of its functions to different smart systems, secondly, due to the expanding competency of users due to different intelligent systems and rapid obtaining of information. At present such a metamorphosis occurs in service sector (such as photo service, type setting and page makeup, design, selection of interior, purchase of tourist vouchers, selection of routes, *etc.*). Of course, the profession of a doctor will exist but the number of doctors probably will not grow and in the end of the final phase of the Cybernetic Revolution its number will be even reduced. If there is a necessity to increase the number of doctors, it will be difficult to make a technological breakthrough because of problems of training and the costs.

Improving the accuracy of treatment is a very important direction which can transform the treatment of diseases into a controllable process. One method that will become accurate is drug delivery to target cells. Here nanotubes, which we will consider in the section on nanotechnologies, will probably play the key role. Other methods include affecting the immune system, correction for genetic disorders, change of the technology of surgical procedures towards less harmful manipulations, *etc.*

Economy and optimization of resource consumption. Medicine will make a significant contribution to *the optimization of resource consumption*: first, it will increase life expectancy (time of life is the most valuable resource); and second it will increase human health and thus productivity. Optimization of resource consumption will be expressed, for example, in the drugs economy due to the targeted delivery and minimization of interference with the organism. Hospital treatment will be less used as the operations will be more targeted, and the rehabilitation period will be minimal. More people will be treated at home since the development of remote treatment is rather probable when doctors control the indices of a patient online and can make the necessary prescriptions remotely. It could sharply decrease a cost of medical treatment which now is exorbitant one for a great number of people. Saving money (as well as resources) is one of the most important directions for the economy.

Medicine develops in the direction of growing **miniaturization (as one of the economy).** We think that with respect to medicine we can use the term miniaturization in two senses. One is the common one – as a trend of constantly decreasing size of instruments to micro and nano size (Peercy 2000). The second one is a trend of constantly decreasing the zone of medical intervention on human organism. For instance, during surgery contact is focused only on the target epidermis layers. For example, some eye operations with the use of laser are aimed at removing tissues only a few microns thick. Such operations require no subsequent rehabilitation.

Artificial antibodies and the growth of opportunities to use the immune system. There will never be any universal drug against all diseases. But strengthening the immune system is one of the universal directions which can transform this situation and help the struggle against different diseases. There is a special instrument of the human immune system – antibodies.

Antibodies are the molecules synthesized to fight against certain cells of foreign origin – antigens. The damage done by antigen usually leads to the destruction of foreign organisms and to recovery. Specific antibodies are produced for each antigen. They are produced by special immune cells – lymphocytes, which accumulate and circulate in the blood over the period of a lifetime. Thus, everyone has his own protective system based on the 'history of diseases'. It is one of the most important directions of development of **individualization**.[6] Medicine is always connected with a patient's individuality. However, in the twentieth century there was a tendency towards mass medicine (connected with mass vaccination, preventive examinations, *etc.*). At present there are some signs of transition from mass medicine to individual medicine (in particular, in aesthetic medicine), which is related to the general tendency of the Cybernetic Revolution towards individualization. But individualization to an even greater extent will be manifested when based on the unique characteristics of the organism one of which is the immune system. Artificial antibodies can strengthen the tendency towards the individualization of medicine.

Scientists have repeatedly attempted to produce artificial antibodies. Various methods were used, the most widespread method was isolating antibodies from the blood of animals but the degree of purification remained low. In 1970, Cesar Milstein and Georges Köhler found the method of producing the antibodies of a certain type, that is of monoclonal antibodies. In 1984, they were awarded the Nobel Prize for this discovery. By injecting the antigens into a mouse and by isolating the antibodies from its spleen, the scientists managed to get separate antibodies which were cloned by forming multiple copies of themselves. However, such cells could exist for a short period, and only via their hybridization with the cancer cells there were produced long-lived self-cloning antibodies – hybridomas. Nowadays a focus of much medical research is into the production of antibodies by other means (Schirhagl *et al.* 2012) and also the creation of chemoreceptors (Dickert *et al.* 2001). Antibodies have already become widely used in pregnancy tests, in the diagnostics of many diseases, in laboratory experiments.

We suppose that during the final phase of the Cybernetic Revolution there will be considerable progress in the creation of artificial antibodies and their acceptance by the organism. There is no doubt that progress in this field will lead to a breakthrough in medicine. The formation of artificial antibodies will play an important role in the prevention and treatment of many serious diseases, they will prevent the rejection of transplanted organs, *etc.* This will help make controlling the course of a disease easier and will help in

[6] Here the notion of individualization refers not to every antibody but to the artificial antibodies specifically created by each individual organism.

suppressing the disease and defeating the disease if it is possible. Progress towards the creation and acceptance level of artificial antibodies will mean a significant growth of *opportunities to control processes previously inaccessible for controllable interference and appearing of self-regulating systems for regulation of such interference.*

Constant health monitoring as a self-regulating supersystem. Let us consider another promising direction of medicine – biosensors, which are a good example of self-regulating systems and development of individualization. These are electronic registering devices which use biological material such as enzymes, cells and antibodies. Biosensors are able to transform biological energy into electric one. At present they are actively used in medicine for different analyses: determination of metabolites and hormone levels, *etc*. Also biosensors are already used which allow controlling the changes in organism during surgery. An example of biosensors used at home is the glucometer, a device used to define the glucose concentration in blood. Biosensors are also used in measuring physical activity. They are applied in production to measure different parameters: the proportions of mixture, concentration of toxins, poisonous gases, *etc.* There is the development of biosensors and nanorobots which, for example, can monitor the spread of viruses in the blood online (Cavalcanti *et al.* 2008). One can easily imagine that in the future biosensors will be able to become an integral part of human life fulfilling the function of a constant scanner of the organism or of certain organs and even transmitting the information about it to medical centers in case of potential threats or serious deterioration in the state of health. Built-in sensors will allow for controlling and regulating all vital processes, as well as prompting the time of drug intake and their dosage, time of physical activities and required exercises with the account of different circumstances, and recommending the most appropriate diet, *etc.* For sportsmen biosensors are already the instruments of control of their physiological indicators for calculation of physical activities level and probably their capabilities will increase. During surgeries, the biosensors will control necessary parameters and will prompt the surgeon regarding further actions. These programs giving particular recommendations for individuals will become a reality. At the same time, smart computer systems will be able to monitor significant fluctuations of indicators and give recommendations about short- and long-term living habits.

What will these innovations bring: will the consequences be good or bad? Of course, people's free agency will be restricted as sometimes it is more difficult to resist machines than human wishes. At the same time, certain imperatives with respect to health will be formed. In fact, everybody will have his own electronic nurse (just like the children of ancient Greek prosperous citizens had teachers from among the slaves, and the children of nobility of landowners had the teacher from among the servants). By the way, it can be especially important for controlling children and nursing sick people who stay at home. If there emerge some relatively cheap multifunctional robots able to flexibly react to changes then the life of people will become much more comfortable (but in that case their independence will decrease).

Respectively, such mini-systems can be integrated into a large system which monitors a large number of people, for example in medical centers, therapeutic facilities, hotels, *etc.* We have already mentioned the decreasing number of hospitals, and such monitoring and remote online access can significantly relieve hospitals. One can imagine that such systems will be able to detect potentially dangerous situations and quickly respond to critical situations. That is a good example of prognostics and prevention of problems. We suppose that it will take much time to create such systems. Besides, there are complicated ethical and legal problems as regards to such monitoring as there always exists the danger that a watching 'Big Brother' will take advantage of this.

Breakthroughs in the field of control of human body. Transplantation: on the way to biotechnical systems of the highest level. Another important direction of medicine is connected with the regeneration and transplantation of organs and parts of the human body. At present such operations are already performed, for example, heart, lungs, liver, pancreas, and kidneys are now transplanted. However, human donor organs are scarce, and people who distribute donor organs without special agreement are brought to criminal responsibility all over the world. The solution to the problem of shortage of organs is carried out in different directions:

1. Use of a part of a donor organ and growing a new organ using stem cells.
2. The possibility of xenotransplantation.
3. The development of different organ substitution technologies (the most promising direction).

Besides, in medicine scientists already use or work to design different artificial organs: skin, retina, trachea, vessels, heart, ear, eye, limbs, liver, lungs, pancreas, bladder, ovaries. Even combination of the above-mentioned opportunities is rather possible. There is already an opportunity of tissue engineering. In laboratories they cultivate healthy skin or cartilage cells to replace injured bone or cartilage. Having grown a sufficient number of cells, these cells are implanted in the developed materials on the basis of polysaccharides and special substrates which control this growth. Cells grow in these structures as they would in their natural environment. The potential of this technology is the formation of cell therapy and methods to regenerate tissues.

We can forecast that the finding of the opportunity to 'deceive' the mechanism of immune suppression of foreign cells will be the breakthrough in the field of regenerating and transplanting organs and tissues (see above). Already some steps have been made in this direction. Here one can also point to the opportunity to control processes by affecting the key elements, in this case switching off the most vigilant systems of immune protection (just like anesthesia during a surgical procedure). The important event was when Japanese scientists discovered a way to reprogram the functions of cells. For example, the skin cells were reprogrammed and substituted for the damaged cells of an eye. Such kind of cells are not rejected, so this direction is exceptionally promising (Kostina 2013).

Will the development proceed in the direction of cyborgization? All that we have written about artificial organs and tissues will contribute to the breakthrough in the field of both production of absolutely new materials which will expand the implementation of non-biological elements in the human body. Thus, we will follow the path of development of self-regulating systems of a new type which will be constituted by the elements of different origin: biological and artificial.

However, we should be aware of the fact that this actually means not only the formation of a new direction in medicine, but also the moving towards the **cyborgization** of a human being and the creation of transcybernetic systems (that is the systems which combine the elements of different nature). Of course, this can cause a certain and quite reasonable anxiety. On the other hand, expanding the opportunities for not just a long but also an active life is hardly possible without significant support for the sensory organs and other parts of the body which weaken as a result of ageing and other reasons. Finally, glasses or contact lenses, artificial teeth, tooth fillings, bones, aerophones, artificial blood vessels, mitral valves, *etc.* allow hundreds of millions of people to live and work and these people still remain humans. The same is true with respect to more complex systems and functions. However, we suppose that the idea that someday the human body will be fully replaced by non-biological material and only the brain or the organs which support the senses will remain are just pure fantasy. This will never come true (see about such fantasies in Rybalkina 2005: 333). People who propose such solutions, for example, to replace supposedly less lasting and comfortable biological material by the technological inventions (such as replacement of haematocytes by billions of nanorobots, *etc.*) in their forecasts try to use the outdated logic that was widespread several decades ago in science fiction or scary stories: the replacement of biological organisms with technical ones. The modern logic of scientific and technological progress including the latest achievements in bioengineering shows the movement towards the synthesis of biological forms and technical solutions into a unified system. Technical achievements can hardly replace the biological mechanisms which have been selected for many millions of years. On the contrary, we should follow the path of 'repair', improvement, the development of self-regulation and support of biological mechanisms via some technical solutions.

The human brain is very tightly connected with the body and sensory organs, most of its functions are based on the control of the body that does not imply its full-fledged work outside its biological foundation. The opportunities of science and medicine to replace worn organs will increase but the biological foundations of a human will always exist and must prevail. If one can help the human body by different means including methods of activization of immune system, opportunities of genetics, the methods of blocking or decelerating the process of ageing, *etc.* it is much more reasonable to preserve the human biological foundation. In any case, in the nearest decades in the process of cyborgization quite radical breakthroughs are possible, but nevertheless the process of cyborgization will not go too far.

In this context one should mention the neural interfaces.

Neural interfaces are an interaction between brain and computer systems that can be realized via electrode contact with head skin or via electrodes implanted into brain. The implementation of neural interfaces is already wide-spread. They have developed neural interfaces that allow prosthetic devices to be moved via brain signals. Today, there have been developed scanning techniques to study brain signals. This gives an opportunity to reproduce any brain response.

At present there already exist devices which allow paralyzed people to speak, write and even work at the computer as, for example, the case of the famous scientist, Stephen Hawking. The neurosurgeons from the University of Pittsburgh School of Medicine performed a miracle when they implanted a chip in Tim Hemmes's brain. Being paralyzed, he can move a bionic prosthesis with his mind. The prosthesis has a special computer which conducts the neural impulses from the brain to the specified action (Pylyshyn 2003). Global media actively discussed the news about the attaching of the electrical prosthesis by Italian and Swedish surgeons to a 22-years old drummer Robin Ekestam who lost his arm as a result of cancer.

The technologies creating the interaction between an individual's nervous system and external devices are called neural interfaces (Brain-Computer Interface). Despite the fact that neural interfaces show impressive results, their implementation is connected with many difficulties. For instance, many nanostructures and nanotubes are quite toxic for cells (Kotov *et al.* 2009). Implanting external devices leads to the traumatizing an organism despite the availability of many methods of mitigating the traumatizing effect (Grill, Norman, and Bellamkonda 2009). Another problem is the different electrical conductivity of biological tissue and of the technical device. Probably, new nanostructures from which nanofibers for neural interfaces are made, can solve this problem (Abidian and Martin 2009).

Development follows not only the path of implementation of electronic systems in biological systems but also the pattern of improvement of mechanical prostheses and microprostheses.

For example, the development of artificial cornea by the scientists of Stanford University (USA) has become a breakthrough in medicine. Such a great achievement became possible due to joint researches in the field of chemistry, nanotechnologies, biology and medicine (which are typical of complex technologies of the Cybernetic Revolution).

Thus, people with disabilities can make the most of the development of medicine and cyborgization as they will be able to significantly compensate their drawbacks.

Improvement of individuals' natural abilities. It is important to note that at present all these technologies aim at restoring individual's lost functions. It does not exclude the future possibility that this direction will provide opportunity to move towards improvement of natural and intellectual abilities beyond the natural bounds. However, in fact this can hardly happen by the end of the twenty-first century. Probably, the process will be similar to the process in the field of plastic surgery which was first created for the repair of damaged tissues but then it became the beauty industry.

Gene therapy is an advanced means of correction of an organism. Gene therapy constitutes a separate direction in modern medicine. A significant contribution to its development has been made by the Human Genome Project, whose aim is to determine the sequence of human DNA (Brown 2000; Stein 2004). However, the path from defining the structure of the genome to understanding its functions is long and this scientific discipline is at the very beginning of its development. The leading countries spend billions of dollars on the researches in the field of gene therapy.

Gene therapy combines a whole range of characteristics of the Cybernetic Revolution including expanding opportunities for *choosing optimal regimes in the context of certain goals and tasks*. Historically gene therapy was aimed at treating hereditary genetic disorders. But at present gene therapy is already considered as a potentially universal approach to the treatment of a wide range of diseases from genetic to infectious ones.

There are two approaches to gene therapy: *fetal gene therapy* when foreign DNA is introduced into the zygote (fertilized egg) or a germ at the early stage of development; thus, it is expected that introduced material will be inherited. The second approach is *somatic gene therapy* when the genetic material is introduced only in somatic (that is non-germinal) cells and it is not transferred to sex cells.

There is another approach – activization of organism's own genes for the sake of full or partial overcoming the impact of the mutated gene. The striking example of such approach is the usage of hydroxyurea for the activation of the synthesis of fetal hemoglobin in patients with sickle-cell anemia and thalassemia.

Gene therapy can become the example of individualization of the technologies and targeted influence on the processes. On the basis of the genetic data the most appropriate treatment will be adapted for individual patients, and if it is necessary the defective genes will be corrected. In addition, the actuation of necessary genes and gene silencing (if necessary) are quite possible. Presumably, gene therapy will manifest itself first of all in sports medicine as, first, it can become a new tool in the attempts of the pharmaceutical companies to avoid the control of anti-doping committee and, second, inherent potentialities become insufficient for achieving the best results in big-time sports.

When choosing the appearance of a future child (color of eyes, skin, *etc.*) gene therapy can be used. In future it might be possible that babies will be born almost by order, these will be 'the perfect babies' (Fukuyama 2002 with cite McGee 1997).[7]

In other words, that means that parents will choose desirable features of a child before his birth. So, the geneticists will probably find 'the genes' of such qualities as nobility, aggression or self-assessment and even intelligence and due to this there will be created an 'improved' baby. Such genetic improvement will remind the improvement of face and body by plastic surgery methods. In other words, it will be impossible to make a genius or a champion of any child but it is not excluded that it will be possible to improve his potentialities. Just like at present it is possible to improve the sports and intellectual potentialities via pedagogical technologies and certain conditions. Such improvement to a certain extent will remind the situation of agricultural biotechnology.

Changing human reproductive capabilities is an especially important field of medicine. The number of incurable diseases causing infertility decreases. Nevertheless, the only opportunity for such patients is to use *in vitro* fertilization. Besides, due to the development of medicine there increases a number of women who want to have children after their reproductive age is over. One should mention the technologies of growing an embryo outside the woman's body. The transplantation of reproductive organs becomes possible. The scientists are developing the artificial womb which can be transplanted to a woman with the damaged womb or even to a man that will radically change the concept of sex (McKie 2002) and will cause new ethical problems. Artificial womb experiments have been successfully conducted in Italy where artificial womb was grown and transplanted to a woman.

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[7] How it will be 'perfect', of course, and which can be problems with these technology it is hard to say. For example, the possibility to know a sex of baby created a big disproportion between sexes of young people in China. As a result there are a disproporitionate number of boys relative to girls born. However note that Francis Fukuyama calls to receive the future achievements 'biotechnology revolution' with great prudence (Fukuyama 2002). We agree with such position.

Section 3. FORECASTS: BIOTECHNOLOGIES IN CYBERNETIC REVOLUTION

3.1. The development before the beginning of the final phase of the Cybernetic Revolution (the 2010–2020/30s)

The modernization phase of a production revolution is characterized by the two major tendencies: 1) the extensive distribution of new technologies with simultaneous improvements as a result; 2) the strengthening of social struggles for necessary changes in some spheres of social life due to the introduction of these technologies. In order for the final phase of a production revolution to begin, the development of technologies during the modernization phase has to achieve both a rather large variety and 'density'. Taking into account that biotechnologies are innovative branches, any country which wants to be the leader in this field, will have to develop them anyway. Let us point out that international documents accepted by the UN Conference on the environment and development (Rio de Janeiro, June 3–14, 1992) placed their highest hopes on biotechnologies.

Therefore, on the one hand, we will observe a wide diffusion of biotechnologies into our lives: in nutrition, various nutritional supplements, influence on our body (through various branches of medicine, in particular cosmetic and one's own treatment of the body as, for example, body-builders do) *etc*. There must quickly develop both the branches which have already become a reality (*e.g*., the cultivation of genetically modified plants, affecting the productivity of domestic animals, production of biofuel), as well as the technologies which are less spread today, in particular in the development of biomaterials.

On the other hand, such a wide implementation of biotechnologies, undoubtedly, will intensify public, diplomatic and economic struggle against the change of traditions, national features, real or imaginary harm. Such a movement against cloning, GMO, computer selection, *etc.* has been already taking place in different countries. Such a reaction is quite natural, legitimate and in many respects useful though it may happen that conservatism will suppress progress. Just within the framework of this struggle and collisions, there may originate decisions which become important in the long term and will not only promote achieving of some balance, but also give an impetus to the development (let us remember that the ban on the importing of cotton fabrics in England served as a trigger for the development of its own cotton industry which became a cradle of the Industrial Revolution [Mantoux 1929; Allen 2009; Grinin, Korotayev 2015]).

3.2. The beginning of the final phase of the Cybernetic Revolution and the development of the Scientific-Cybernetic production principle

Now, proceeding from current tendencies and a general sense of the development of the Cybernetic Revolution, it becomes possible to set out *the future developmental milestones in biotechnology* in the final phase of the Cybernetic Revolution (the 2030–2070s). As has already been mentioned, it can start in a rather narrow sphere, from which the innovations will start distributing and gradually penetrate the new areas.

Certainly, it is very difficult to anticipate the direction and moment of concrete discoveries. We suppose that at the very first stage biotechnology, as an independent direction, will play a less important role than medicine. It will be rather an important component of medical technologies, providing breakthroughs in the area of the treatment of diseases and the regulation or monitoring of organism functions. But, probably, in adopting biotechnological achievements, it will become possible to make an organism successfully attack certain diseases.

Achievement of self-regulation of system without intervention of a person. The level of controllability will increase considerably within a number of important systems connected with biotechnologies. Thus, probably, while transforming an organism, they will insert not a separate useful gene (Simon, Priefer, and Pühler 1983), but a whole set of necessary genes which will operate depending on environmental conditions. Such characteristics will be extremely important in the case of climate changes which are quite probable. It will become possible to choose the most optimal varieties of seeds and seedling for a unique combination of weather conditions and territory (the sort of imitation of evolutionary selection via automatic search in databases). Consequently, huge databases of such plant varieties and variations will be created. It is quite possible that in the future the whole process of getting a transgenic plant will take place without human participation, thus, it will become self-regulating.

It is possible to assume that by the end of the phase of self-regulating systems (and perhaps, even earlier, *e.g.*, by the 2050s) the agricultural biotechnologies will be already developed to a degree that the very adaptiveness of the modified products will allow for a response even to the smallest fluctuations of local conditions. In other words, it will be possible to order producers or collectors to create varieties of plants for individual greenhouses, hotbeds or plots. Farmers will be able to select individual fodder and drugs by means of programs and to order them via the Internet. Even an individual will be able to invent a houseplant hybrid suitable for the interior and to order its production and delivery. Thus, individualization will reach a new level.

The same refers to domestic animals: it will be possible to breed animals with peculiar characteristics within separate breeds of animals (or even by the individual order). It is probable that the selection of animals on the basis of genetic engineering will also develop in the direction of decreasing human participation.

The solution of urban and some environmental problems. Undoubtedly, there will occur important changes in using biotechnologies for the solution of environmental problems. Here it is possible to assume that biotechnologies will be intruded first of all in the urban ecology. It is necessary to consider that in the coming decades the urban population will increase by 40–50 per cent (see, *e.g.*, NIC 2012). With the pace of development quickening in poor countries the problems of unsanitary conditions, incidences of disease, *etc*. will become very acute. And since different diseases can quickly spread worldwide the problems of some countries will become problems for all countries. Among the problems which can be potentially solved by means of the development of biotechnologies, are those related to water cleaning, recycling of waste, liquidation of stray animals (it will be promoted by introducing genes for sterility or something of that nature). Already today the micro-organisms for water cleaning are applied; with their help we also get bio-gas from waste recovery. But in the future these and similar problems will be solved by the development of self-regulating systems that will make it possible to solve a number of technical and scientific problems.

Thus, just as in the late nineteenth and early twentieth centuries people coped with mass infections by means of biotechnologies, in the middle of the twenty-first century, the latest biotechnologies, perhaps, will help to solve the most vexing problems of cities where at least two thirds of the population will live. But the problem of ecological self-regulating systems, naturally, is not limited by the cities; it has to be extended to the cleaning of reservoirs and other ecosystems. The creation of ecological self-regulating systems will considerably reduce expenses and free huge territories occupied by waste deposits, as well as allow breeding fish in self-cleaning reservoirs.

One can assume that an important direction will be the creation of self-regulating ecological systems in resort and recreational territories which will provide the best conditions for rest and business.

The breakthrough in the sphere of resource saving. Biotechnology can help to solve many global issues, for example, to cheapen the production of medicines and foodstuffs including producing and making them in ecologically sound ways that can also keep or make the environment pristine, thereby considerably expanding their production. The solution to the food problem will come in the different ways, in particular due to the mass production of food protein whose shortage is sharply perceived in many societies (at present the feed protein for animals is generally produced in this way). Even now there are results based on the production of food proteins or, for example, imitation meat. But so far such a production is too expensive. Now a gram of laboratorial meat costs 1000 dollars (Zagorski 2012), but this is part of the usual process from the laboratory to mass cheap production.

The creation of new materials. The opportunities of creation of self-regulating and self-operating systems by means of biotechnologies, in particular genetic manipulations, opens an important direction in the field of new materials with desirable properties. It potentially allows for making substitutes for the natural process feedstock, for example, leather. The respective projects are already present now. For example, the Modern Meadow Company aims at making a revolution in the clothing industry by growing leather and other types of animal skin in the laboratories (Zagorski 2012).

The process of creation of biotechnological genuine leather will include several stages. At first scientists will select millions of cells from the donor animals. It can be both cattle and exotic animal species who are often killed only because of skin. Then these cells will be multiplied in bioreactors. At the following stage the cells will be mingled in one mass which will be formed in layers by means of the 3D-bio-printer. The skin cells will create collagen fibers, and the 'meat' cells will form a real soft tissue. This process will take some weeks after which soft and fat tissues can be used in food production. Despite the exoticism and queerness of the above-described situation, in principle, it is very similar to the process of production of artificial furs which made it possible to solve the problem of warm clothes.

Section 4. NANOTECHNOLOGIES

The modernization phase (the period of distribution of innovations) of the Cybernetic Revolution is the period of the formation of 'modern nanotechnology' (the 1990–2020/30s). Nanotechnologies became an area of industrial production, the nanotechnological race between countries has started, dozens of projects and whole institutes of nanotechnologies have been created. The number of goods produced with nanotechnologies is rapidly increasing. The investments into researches increase, and the nanomaterials penetrate into various spheres: engineering, medicine, transport, aerospace and electronics industry, *etc*. According to the data of analytics of BBC Research (2012), the sales volume of products of nanotechnologies in 2009 amounted 11.67 billion dollars. Very soon they will amount 20 billion dollars.

4.1. Forecasts

4.1.1. Nanotechnologies as a breakthrough component in the final phase of the Cybernetic Revolution (the 2030–2070s)

One can trace all the characteristics of the Cybernetic Revolution in the future development of nanotechnologies: bionanotechnology and nanomedicine will start a vigorous development, the invention of technologies of regulating systems (in which nanorobots independently or as a part of more complex technology will play an important role), the production of new materials, saving of materials and energy (*e.g.,* in house due to nanomaterial for window glass; by delivering a minimum portion of medicine directly to the damaged area or even to separate cells), miniaturization, targeted actions *etc*.

Connection with medicine: large opportunities. Despite serious progress of nanotechnologies in electronics and other branches, the real nanotechnological revolution will most likely happen at first in medicine that will give an additional impulse to the development in other areas. As a result the breakthrough in the final phase of the Cybernetic Revolution will be provided by deep integration of medicine with biotechnologies and nanotechnologies which will bring the emergence of various technologies of regulatory systems. We have already mentioned some directions of integration of these branches in the previous sections. In general the prospects of such an integration are already evident. So, according to some forecasts, chimerical nanobiostructures (capable of transposing medical nanosensors, medicines and even reconstructing cells of an organism) will be created in a decade or so and in 15 years they will become everyday practice. Of course, their active use in diagnostics and developing means to acquire immunity will become an important direction in nanotechnologies. We already have examples of this process now. At the Engelhardt Institute of Molecular Biology (part of the Russian Academy of Sciences) they applied nanotechnologies to create a biochip allowing quick diagnosing of a number of dangerous diseases, including tuberculosis. Quite promising will be the development of nanotechnologies to create materials imitating properties of, for example, bone tissue. Nanotechnologies are already implemented in such surgeries as nano neuro knitting for repair of severed optic tract, implantation of artificial limbs with high precision, cardiological surgery *etc*.

One of the directions where huge efforts of nanotechnology are concentrated is the struggle with cancer. For example, the Institute of Cancer in the USA voted 150 million dollars for such researches.

One can suppose that cancer treatment will become possible as soon as there is found a means to better target a certain layer of cells in a necessary part of the organism. However, it is possible that cancer will be defeated without destroying cancer cells, but by means of the method to fight metastases. The work is conducted in various directions here. Perhaps, the organism will give a clue. For example, it is known that metastases do not appear in heart tissues: obviously, there are some defense mechanisms which should be discovered (Marx 2013).

There are some examples of new directions of the cancer control based on nanotechnologies. For example, the system of carcinoma treatment is being developed based on heating of nanoparticles of iron oxide which are put into the infected tissue and influenced with a magnetic field as a result of which particles heat up and destroy cells. At present, this method is passing clinical testing phases; however, the lifetime of the patients who underwent a cure considerably exceeded the time forecasted by doctors. A problem with this method is the exact injection of the iron oxide particles into the tumor cell.

At the Laboratory of Nanophotonics at Rice University in Houston, Professors Naomi Halas and Peter Nordlander, invented a new class of nanoparticles with unique optical properties – nanoshells. With a diameter twenty times smaller than red blood cells (erythrocytes), they can freely move in the blood system. Special proteins, that is antibodies attacking cancer cells are specifically attached to the surface of cartridges. Some hours later after their injection the organism is beamed with infrared light which nanoshells transform into the thermal energy. This energy destroys cancer cells, and that the neighbouring healthy cells are almost not injured.

The important direction of research in the area of oncotherapy consists in automatic 'smart' hitting of the malignant cells by nanoparticles. The thing is that, only one-millionth part of the revolutionary new substance Herceptin, used to treat a considerable number of patients with breast cancer, would target the diseased cell. To make the transportation of Herceptin more effective, a group of American scientists invented a special model of a capsule from porous silicon into which the medicine is injected and is directly delivered just to the damaged cell. Now this technology is being clinically tested. The American scholar Mark Davis discovered a special capsule which has a structure similar to sugar and therefore, is not rejected and not excreted by the organism. A preparation is put into this capsule and can be stored in the organism for weeks. It is searching for a tumor moving within the blood-vascular system. Cancer cells are more acidic, than the usual, healthy cells, and, when finding such cells, the capsule opens and discharges the strong medicine. A patient with a pancreas terminal cancer, at the stage of metastasis was subjected to such cure and is still alive and even did not lose his hair after chemotherapy.

A future direction of medicine is the development of diagnostic methods that are also cost-cutting. We have already spoken about nanochips which can play an important role here. The nanorobots which will be able not only to perform medical functions, but also to control individual cellular nourishing and excrete waste products will be put into practice. Nanorobots can be used for the solution of a wide range of problems, including diagnostics and the treatment of diseases, fighting ageing, reconstruction of some parts of human body, production of various heavy-duty constructions (Mallouk and Sen 2009).

It is clear that some promising technologies which are forecasted today, will fail to become successful in the future. But there is no doubt that the use of nanomaterials, nanorobots suitable for research, and other nanotechnologies will create important backgrounds for the future era of regulatory systems in the area of medicine.

The connection with biotechnologies and agriculture. Other important directions of nanotechnology are research in the field of nanobiotechnologies. One can mention here the development of controlled protein synthesis technologies for receiving peptides with desirable immunogenic properties. Vector systems for the cloning of immunologically significant proteins of the causative agents of the diseases and vaccines of the new generation possessing a high activity and safety are created. Research is being conducted on creating nanoparticles for making genetically engineered proteins, the development of biochips and test systems for biological screening (Persidis 1998), immune monitoring and forecasting of dangerous and economically significant contagions of animals.

It is expected that by means of nanotechnologies and use of robots the development and application of biotechnologies will significantly advance in the direction of creating self-regulating systems of farming, where agricultural operations will be for the most part performed in an autonomous mode. Many technologies will appear to promote this process. Thus, the implementation of membrane systems for cleaning, and also special biocidal coverings and silver-based materials will facilitate and increase the level of managing the farm livestock and providing them with high quality water. It is assumed that the use of nanotechnologies will allow changing technology of cultivation of lands due to the use of nanosensors, nanopesticides and a system for decentralized water purification. Nanotechnologies will make it possible to treat plants at the genetic level and allow creating high-yielding plant varieties especially resistant to the unfavorable conditions (Balabanov 2010).

Various prospects of using nanotechnologies in the Cybernetic Revolution and at the mature stages of Scientific-Cybernetic production principle. Nanotechnologies have considerable prospects. The components of nanoelectronics, photonics, neuroelectronic interfaces and nanoelectromechanical systems will be developed. Then on the basis of the achieved results it is expected to advance to a regulated self-assembly of nanosystems, the creation of three-dimensional networks, nanorobots *etc*. One can also speak about the use of molecular devices, nuclear design *etc*. Especially alluring prospects are observed in the development of nanomechanics, nanomechanical engineering and nanorobotics.

Quite long ago there appeared an idea where data creation and storage is performed not by means of a special condition of the environment (*e.g.*, magnetic, electric, and optical), but through the use of nanotechnologies, for example, the replacement of silicon, the basic material in the production of semiconductor devices, by carbon nanotubes. In this case a bit of information can be stored in the form of numerous atoms, for example, of 100 atoms. It would reduce the sizes of processors by an order of magnitude or would essentially increase their operation speed. Now the number of transistors in the processor reached a billion and more. However, a few years ago the goal was set to create a processor with more than one trillion transistors by the 2010s (that would lead to radical increase of the ICT opportunities). Most likely, this is an unreal task to solve even by the 2020s, before the beginning of the final phase of the Cybernetic Revolution. It is supposed that this level will be achieved later, as we are already in the process of developing this phase (this would also open new horizons of full replacement of the information computer equipment due to a transition from using silicon to nanomaterials).

However, it is possible that the smallest computers will have an essentially new basis. According to Eric Drexler, nanomechanics and not nanoelectronics can become such a base. He has developed mechanical constructions for the main components of the nano-computer. Their main components can be pushed in and out cores interdependently locking the movements of each other (Balabanov 2010).

From special structures, such as fullerenes, nanotubes, nanocones and others, molecules can be gathered in the shape of various nanodetails – tooth wheels, rods, bearing details, rotors of molecular turbines, moving parts of manipulators etc. The assembly of the finished parts into a mechanical design can be realized by using the assemblers (self-assemblers) with the biological macromolecules attached to the details capable of selective connection with each other. This idea was realized by Professor James Tour and his colleagues from Texas Rice University who in 2005 created a molecular mechanical design – the all-molecular four-wheel nanocar about two nanometers wide consuming light energy. It consisted of about three hundred atoms and had a frame and axes. The development and creation of the nanocar took eight years. The scientists plan to create nanotransport devices, the nanotrucks, to transport molecules to conveyors in nanofactories (*Ibid.*).

Certainly, this is more like toys, than research for practical use. They remind us of the steam toys like the mechanisms created by the Greek mechanic Heronus Alexandrinus, who amazed the audience in the first century AD. They hardly had any similarity with a steam-engine. But unlike Heronus who even did not think of a practical use of steam, the current nanotechnologists are absorbed with practical application. Therefore, the creation of nano-mechanical engineering is quite real, though a long-term perspective. It will most likely happen close to the end of the current century. The same refers to nanorobotics. At the present, the expected designs of nanorobots and their use exist only in forecasts.

There is an opinion that in the 2030s some nanodevices will be implanted into human brain and will be able to perform the input and output of necessary signals from the brain cells and this can even make learning and getting education become unnecessary. But it causes great doubts. Even if such a cyborgization is realizable in principle, it will occur essentially later.

Anyway it is obvious that both nanomechanical engineering and nanorobotics will propel the development of self-regulating systems to a new level towards the formation of an industry that will design such systems (similar the use of cars promoted their industrial manufacturing – mechanical engineering).

Conclusion

The described processes must prove the idea that the final phase of the Cybernetic Revolution will be the era of a rapid development of self-regulating systems. Actually, already now we use a lot of systems of the kind, but do not take them as such. Others have not found a broad application yet like self-cleaning glasses, but soon enough they can become a part of our everyday practice. With the emergence of machines in the preceding centuries there appeared dozens of bright insights about their future application, and at the same time numerous ideas which failed to come true. And today it is difficult to define what will become a reality and what will not. But there is no doubt that the development proceeds towards the invention of self-regulating systems. We expect the development of such systems which will work almost independently and control important aspects of human life like today computer programs of spelling start checking your style or spelling. All this demands a deep understanding of the field of minimization as a solution to important present day and emerging problems. As already mentioned, the Cybernetic Revolution (like any production revolution) brings changes in all spheres of production and areas of life. However, these changes being part of a single large process will happen not simultaneously.

Now it makes sense to say a few words about changes in other spheres.

Power industry. During the previous production revolutions the energy source would also change. The Agrarian Revolution brought biological energy into use, that was strength of animals; the Industrial one used at first water power, then it was replaced by steam power and then electricity and fuels.

To start the Cybernetic Revolution there has already existed an adequate energy source, namely, electricity. The idea that a new leading energy source will become thermonuclear, hydrogen or some other new type of power, has not been realized yet. There is a question: whether an adequate energy source for the final phase of the Cybernetic Revolution has to appear? The experience from previous revolutions shows that it is not necessary at all. The transition to the irrigational intensive agriculture did not demand the obligatory use of animal draught power (for plowing) as well as the first sectors of the machine industry quite managed with the known water energy source. However later, in the end of the final phase of every production revolution and during the transition to mature stages of every production principle, new sources of energy were already appearing (so, the completion of the Agrarian Revolution in the rain fed zones was connected with agriculture with the use of bulls and oxen; and the completion of the Industrial Revolution – with the use of steam energy). It should be noted that in both cases it was not totally unknown energy. Steam energy was occasionally used since the seventeenth century.

Deduction. Essentially new power source will not be required to start the final phase of the Cybernetic Revolution therefore the development of alternative power engineering will not play a decisive role here. However, a new energy source has to appear either during the final stage of revolution, or a bit later. Also, most likely, it will not be absolutely new and not previously used. Most probably, thanks to technical innovations, it will become possible 'to tame' and to make sufficiently available this or that type of alternative energy (hydrogen, thermonuclear, solar; or it will be the invention of easily stored electric power which will also solve the problem with a power source for eco-friendly transport). At the mature stages of production principle changes in the energy area are also taking place which create the base for the new production revolution (so during the period of maturity of the craft-agrarian production principle the power of water acquired those properties, used for driving mechanisms, and during the period of maturity of the trade-industrial production principle – the electric power became such a source). But what energy will appear at the final stage of the scientific-cybernetic production principle is difficult to imagine so far.

Transport and communications. Eventually the production revolution surely changes the ways of transportation and communication. But it is difficult to mark out any distinct regularities here. At the beginning of the only one (industrial) revolution the development of transport became one of its driving forces: the long-distance sailing ships played a crucial role in the organization of the oceanic trade which became one of the impulsive forces of communication. We mean the invention of printing. The role of the new types of communication and connection was even more essential at the beginning of cybernetic revolution. Thus, the initial phases of the production revolution can be caused by the emergence of the new types of communication. However for the final phase of production revolution it is not necessary (though writing appeared on the eve of the final phase of the agrarian revolution, its role was not essential).

Deduction. In the next decades the emergence of essentially new types of communication is hardly possible. The development of communication has made great progress during the last decades and in general even surpassed the overall level of the development. Most likely, the revolutionary new types of mass communication can appear only closer to the end of the twenty-first century. However the powerful progress in existing ICT as we mentioned above, is quite possible within the next three-four decades.

As it was already discussed, there also took place different changes in the transport area. The Agrarian Revolution was not connected with them. The transition to the riding and development of sea communications happened already in the course of its final stage on the periphery and during the later period. The Industrial Revolution on its initial phase was connected with already tested oceanic water crafts capable of moving in any wind (not only the fair wind). Such crafts were widely developed during this revolution. Great Geographical discoveries without which the Industrial Revolution would have collapsed were also connected with this innovation. But the emergence of the steamship and further the engine happened already toward the end of the final phase of the Industrial Revolution. The emergence of a new means of transport gave it an unprecedented scope. New means of transport appeared much later (a car, a plane), and it was quite enough to start the Cybernetic Revolution. It, certainly, brought very fundamental changes to all means of transport, but created nothing essentially new so far (space transport is no object) though one may note the development of high-speed railways (but they play a secondary role).

Deduction. In the middle or the end of the final phase of the Cybernetic Revolution (approximately in the 2050–2060s) there can be expected the emergence of some new means of transport. An electric car with a large power capacity and speed could be a possible example. But taking into account 'the sense' of the Cybernetic Revolution (as the revolution of self-regulating systems) the breakthrough most likely will happen in the direction of self-governed vehicle traffic and its control. That is the means of transport and systems will become self-regulating. Even today there exist some ideas concerning the realization of this opportunity.

Specialist area. The production revolution radically changes the specialist area of people, their professional skills (competencies) and creates a need for new professionals. The farmer and the craftsman replaced the competences of the hunter and gatherer during the Agrarian Revolution. With the emergence of metals specialists, stone working disappeared. But nevertheless, during the era of the Agrarian Revolution, changes were happening rather slowly.

Almost the whole period of the industrial revolution, since the sixteenth century and, at least, till the last third of the nineteenth century, passed under the banner of battles pitting the skilled craftsmen against the Leviathan of technological progress. This period is full of episodes of prohibitions on inventions, the acceptance by the representatives of factories of various constraining laws, and a history of destroyers of machines, *etc*. Thus the grounds for such bans and constraints were the most serious: product degeneration, falling of earnings, competition between the people who do not have the necessary professional skills. However as a result, machinery replaced manual operation, waves of technological innovations wiped out the groups of experts. The initial phase (and even the middle one) of the Cybernetic Revolution, especially during the extensive use of computers, led, in a great number of cases, to the replacement of professional skills, including in the area of intellectual functioning: books proofreading, magazines and newspapers, translation from one language into another (though of poor quality but still helpful), collection of information, library and archiving, design, advertising, photography, cinematography *etc*. No wonder that the time when books in the standard form will be treated as a rarity is around the corner. The emergence of the opportunity 'to be your own' (the cameraman, the publisher, the artist, the photographer, bank and ticket cashier *etc*.) became the sign of the times.

Deduction. Not least, further development will undermine the grounds of very many professions – from a doctor (what we mentioned above) and a teacher to the nurse and taxman. As a whole the general course of development has to move towards the reduction of the number of people employed in the service sectors (both simple types and more difficult), but a lot of new professions will be required at the same time. Reduction of the people employed in the service sector happens at least in part as a result of development in the field of robotics.

Legal, ethical, pedagogical and ideological problems in the development of medicine. The faster the pace of scientific and technological progress, the more difficult it is for society to keep pace with those changes, the more flexible become morals, more sophisticated the right, different minorities are emerging, defending their, not always clear rights, the society becomes more tolerant. But at the same time traditions are subverted more easily and quicker and it becomes more difficult to distinguish good from bad (criteria for these concepts are disappearing), it is more difficult for parents to pass on their experience to children *etc*. We have already discussed these changes (Grinin 2006; Grinin, Korotayev 2009; Grinin and Grinin 2013, 2015). The well-known book by A. Toffler 'Future Shock' (Toffler 1970) did not lose its topicality at all (see also Fukuyama 2002). These problems surely demand much attention. In particular, it should be noted that very complicated ethical problems can appear and a potential risk of violation of the social and biological basis of human existence can emerge. It is difficult to imagine, what will be the outcome of all of these changes. Radical changes in the human body are able to affect seriously such basic things as understanding of the family, gender, attitude to life. Just for this reason forecasting of the development of the Cybernetic Revolution is useful. It can help us become aware of the creation of the optimal social, legal and other instruments in advance, so that such changes would not take us completely unaware and so that it would be possible to minimize negative consequences. Eventually, the Cybernetic Revolution (constituted largely of regulatory systems) also involves or includes social systems. Therefore, technologies based on social insight and elimination of social problems have to be developed; importantly these technologies must be tested before the mass distribution of innovations leads to serious misgivings.

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A Worldview Approach to the Developmental Problems of Russia and the World*

Valentina M. Bondarenko

The article argues that the causes of the crisis situation in Russia and the whole world can be only understood through the prism of the worldview approach. This has been confirmed by many years of search, resulting in the development of a new cognition methodology which makes it possible to identify objective regularities in the development of the human community and to find the way to its further evolution.

Keywords: *systemic crisis, worldview, new methodology of cognition, human individual, goal, time, sole efficiency criterion, coordination of interests, new model of life organization.*

Both for Russia and for the whole world, the year of 2014 turned put to be a difficult period of grand trials and multiple contradictions. The ailing economy of Russia accumulated too many problems – reunification with the Crimea, the subsequent Western sanctions and, as a matter of response, the adoption of a number of prohibitory laws; collapse in the foreign-exchange market, a downfall of global oil prices, and the slow-down of economic growth. As a result, the situation in the Russian socio-economic sphere and the living standards of its population deteriorated tangibly. Experts refer to different factors that caused this situation, and some of them even state that 'there are suspicions that the authorities dropped ruble intentionally' (Grinberg 2014). However, the main point, according to Alexey Ulyukaev, the Russian Minister for Economic Development, is that 'In order to counter the crisis, a strategic plan is necessary, but at present it is difficult to elaborate such a plan because one can hardly predict the volatility vector of the situation' (Pavlova 2014).

For a long time, scholars in different parts of the world have been contemplating on the ways to transform the world order so that it would become possible to improve natural environment, get rid of poverty, resolve the food problem, eliminate the very possibility of periodically bursting-out wars, resolve a vast number of other problems and forever eliminate the crises that shake the foundations of human existence. Many prominent scholars focus their research on this complicated agenda, but so far no country of the world has a strategic anti-crisis development plan.

In the view of many economists the events currently taking place in the world serve as ample evidence of the second wave of the crisis which already started. However, as be-

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fore, the monetary methods to resolve the problems through the currency emission and investments in all kinds of assets for the purpose of resale (shares, raw-resource assets, real estate, *etc.*) prevail over investments in fixed capital. This means a further slowing down growth. That is, the old methods to counter the crisis by monetary pumping of economy do not work any longer and therefore, such method is not an anti-crisis remedy that could eliminate the primary cause of the crisis.

Furthermore, on the one hand, it is recognized that at present no serious discourse is underway that could offer any realizable measures to eliminate the crisis. On the other hand, at numerous meetings, starting from World Economic Forums in Davos to the G20 summits, we hear the ever stronger statements that the 2008 crisis and the current second wave are nothing else but the crisis of the modern economic model. In this context, until the causes of the crisis of the model are identified, any system of institutions and mechanisms designed to reduce tensions arising in the course of realization of anti-crisis measures would be inefficient, to say the least.

Therefore, we must state that today the rhetoric of academic discourse has changed, and the focus of discussion shifted from particular issues (such as improvement, acceleration, modernization, and reform, *etc.*) to more comprehensive ones. As never before, it became necessary to develop a worldview approach to the currently prevailing crisis situation in the world as well to search for new economic evolutionary models and new concepts of economic development. However, in order to shift to a new model of economic development, one should have a theoretically verified and practically feasible idea of such a model.

On the other hand, we must also recognize that the global systemic crisis is growing and extending to all spheres of human life, while nobody is aware of its profound objective causes or knows the ways to overcome it.

Since the observers do not know the formula to overcome the crisis, they even more often feel the need to turn to history and look for answers therein. The findings, however, are not at all encouraging. For example, Dr. Jeffrey Sommers, Professor of Political Economy and Government Policy at the Wisconsin Milwaukee University and participant of the first Moscow Economic Forum (held in March 2013), while discussing the strict adjustment measures to be taken in the face of the looming recession of the Russian economy, warned that his biggest concern about such measures could be expressed best by quoting Mark Twain's 'History does not repeat itself, but it rhymes', and that the result might be quite unfavorable. The last case, continues Sommers, when a strict adjustment was applied – in Germany, Italy and Japan between the two world wars – resulted in fascism. This time the result will hardly be the same, on the contrary, Sommers supposes that it would be quite 'unpleasant', as strict adjustment cannot be permanently imposed on people, because in the end they will react, and nobody knows what kind of reaction that will be (Astashenkov 2013).

Exactly because of the methodological vacuum many scholars, experts and policymakers today neither understand the objective causes of the crisis nor do they see a way out of it. Therefore, they are unable to find a mechanism to overcome the crisis and to find a crisis-free path of evolution, or to shift from the antisocial model of economic development to adoption and realization of the concept and strategy of economic growth that would focus on prioritized development of the real sector as well as on the development of every human individual and his/her qualities.

Today many scholars ask especially one question: shall we treat the crisis of the global civilization development, wars, terrorism, man-made and natural catastrophes, *etc*. as temporary phenomena and some random events or rather as a chain of cause-and-effect relations resulting from the profound and objective laws which are common for nature and society as well as for the world system's co-evolutionary development?

Therefore, the main prerequisite for a transition to the crisis-free development is to get and master the knowledge on the objective causes of the global systemic crisis, to find the ways to overcome it and to understand the implications of any decision made. The time of development by the trial-and-error method is irreversibly a matter of the past.

2. New Methodology to Understand the Regularities of the Development of Human Community

For many years, I have been conducting research on objective causes of the crisis in the development of human-system and forecasting the future. Over thirty years ago, while trying to explain the contradictions of the Soviet economy, I found out that the then existing economic theories and scientific knowledge at large had been exhausted in their explanatory potentials in search for ways to overcome the negative phenomena. However, it also became clear that for resolving these problems, it was necessary – in Marxist terms – to find the only possible mode of production and relevant productive forces. Since then, I have conducted the search for a theoretical thinking at the political-economic level and for the methodological instruments that would help to visualize the objective picture of the development of the ways in which people live together, to identify objective causes of the emergence of crises and to propose a possible anti-crisis model of human relations for the present and future.

At that stage of my political-economic research, including, inter alia, the philosophical understanding of the problem, the dialectical-materialist method served as a methodological and theoretical basis, supplemented by the instruments of economic cybernetics. With the attained understanding of the fact that space and time are the major forms of existence, and that being without time is the same grand error as being without space, we selected time as the generalizing index (criterion) that would characterize the positive or negative dynamic in relation to the goal.

The offered criterion was novel in science because it helped to elaborate a periodization of possible forms of development of relations of production and relevant productive forces in terms of reduction or increase of time required to attain the development goal (Bondarenko 2012a: 16–24). The goal was formulated similar to most of the literature in political economy – to satisfy the continuously growing human needs and to create conditions for multi-faceted and harmonious development of personalities. As a result, we obtained a sort of Mendeleev's table for the human system. All political-economic laws were arranged through by the factor of time into a system with a reverse connection – that is, the laws, which from the very start imply saving of time and then become regulating and thus, by their reverse action, define the new spiral for acceleration or a slow-down of development. The given periodization revealed that it was impossible to achieve the above-set goal. It became clear that according to the law of growing needs we may exhaust all resources, but still will fail to attain the goal. Hence, we must look for another goal that would enable us to define the ultimate essence of the development of human beings and the entire human system.

The major political-economic conclusion at that stage of research, presented in my thesis in 1991, was as follows: (1) a new step forward was made in development of the Marxist methodology. The kernel of society was defined not as a community (as suggested by Marx) but as a particular human individual; (2) no country of the world had reached socialism yet; (3) socialism would only develop when property becomes private and at the same time public; this will mean that private production will become interconnected with the needs of a particular individual and commodities will be manufactured by demand (order) of a particular individual, and therefore, there will be no production of redundant and unnecessary commodities and the resources will be consumed more rationally and efficiently.

However, in the early 1990s, the form of relations of production started to correlate with the phase of primary capital accumulation, and the productive forces became correspondingly a limitation. Innovations were being rejected and development was limited and reversed.

Again, there was a question: was that conclusion a random one? So, it appeared necessary to achieve a deeper understanding of the problem, and the research was oriented to the global level. As a result, a new methodology for cognition was developed which enabled me to identify objective regularities in the development of the way people live.

In other words, the novelty of this methodology consists in the fact that it allows defining objective regularities of different aspects of the development of humankind – whether the civilizational dimension, or the complex dynamics of a long-term historical development, or at the local, regional and global levels, or with respect to socio-economic and political systems, or an integral system. The major innovative point is that all the afore-mentioned subjects are considered, studied and analyzed through the prism of attaining a single and objectively set ultimate goal of development – that is, through the prism of the systemic approach.

One should note that as early as in 1784 Immanuel Kant in his 'Idea for a Universal History with a Cosmopolitan Purpose' considered the world history as a purpose-oriented process. Looking for the way to bring history under a law, he believed that such law of history must be a law of development. Kant saw the solution of the task in re-establishing the purpose to which history originally gravitated, as this would attach to it a logical and regular nature. In his view, to bring history under a law would be the same as to subordinate it to movement toward a certain goal. In other words, his proposal to comprehend history in teleological terms and to search for the purpose of nature in the meaningless course of human deeds, as with this purpose the creatures acting without their own plan would have their history correspond to a certain plan of nature (Kant 1963–1966: 8). Thus, according to Kant, the reason and purpose of history is to bring reasonable natural properties of a human individual to the accomplished development. And, such purpose of history is exactly a purpose of nature. At the same time, the development of reasonable human properties is expressed in the growth and accumulation of knowledge and use thereof by human individuals for reasonable organization of their life. According to Kant, the ultimate goal of the existence of the world is the supreme good, and the notion of the supreme good combines the full realization of moral law together with physical well-being of humans as natural creatures.

Many authors of the Reports to the Club of Rome also sought to formulate the global community's development goal, and to develop new ideas for reorganizing the international order (RIO) as well as to find a new, perfect social organization. For instance, in the third report to the Club of Rome, the authors described the major goal of the global community in terms of universal human values as equal opportunities within and beyond countries, as a dignified life and moderate welfare for all citizens of the world (RIO… 1976). However, there are weak hopes that the voice of those authors would be heard.

Another paper, whose authors considered global problems through the prism of the system of goals and values, and thus realized a cardinal transition from the qualitative to quantitative analysis, was the report entitled as ‘Goals for Mankind’. The focus was on the concept of ‘new humanism’ and the idea of prior importance of individual human characteristics that would bring about the ‘human revolution’ as well as ‘revolution of consciousness’ and societal transformation. Another cornerstone of the report was the global solidarity concept suggesting that norms of human behavior and norms of government policy would determine the ‘new standard of humanism’. To this end, however, in view of the authors led by Erwin Laszlo, a world-known professor of philosophy systemic and political sciences, honorary doctor of several universities, program director at the UN Institute for learning and research, and President of the Vienna Academy of Futures Studies, it would be necessary to articulate the global development goals and to present the latter to the world public.

Consistent with this task, Dr. Laszlo and his team analyzed the ‘atlas of goals’ pursued by different regions, countries, confessions, multinational corporations, UN and other international organizations both at the national and transnational levels. Also, they interviewed the maximal possible number of representatives from different spheres and areas of human activities, and finally set forth the four global goals: (1) global security – that is, elimination of wars and conflicts, and renunciation of violence; (2) solution of the food problem at the global level, elimination of starvation, and building of a global system that would make it possible to satisfy nutrition needs of all people in the world; (3) global control over consumption of energy and primary resources that would allow a rational and ecologically safe use of energy, control of technologies and economically efficient nature management; and, (4) global development oriented at a qualitative growth, that is to improvement of life quality and social justice in distribution of material and spiritual goods (Laszlo 1977).

Proceeding from such objectives, the authors of the report offered several scenarios for the ‘world solidarity revolution’, where the main role was assigned to different combinations of religious communities, intellectual groups, political leaders, government circles, businesspeople, *etc.* The authors hoped that scholars, religious figures and representatives of the business community in one country would be able to render influence on their respective counterparts in other countries, and then, acting ‘all together’, they would be able to address critical issues and work out the shared methods for joint resolution. Regrettably, this has not happened so far.

I have chosen a somewhat different method for defining the global development goal. My task was to identify the objective and initially set final goal of development. In this case, the final or ultimate goal is the one that cannot serve as a means to reach the goal of a higher level and at the same time is a source (through in reverse order) of a qualitatively new spiral in development of a whole system and its any sub-system.

The logic is as follows. If any socio-economic and political system can be considered through the prism of the realization of the final goal, then such goal is a planetary one. This leads to the following conclusion. If the existing practice of socio-economic and political development in any country of the world is juxtaposed to the theoretically outlined – or, rather, objectively preset – ultimate goal, it is possible to reveal some redundant or missing links in the mechanism of the realization of the goal and to identify the least time-consuming and hence the most efficient and sustainable way to its attainment.

So, the essence and the scientific novelty of the new methodological tool-kit consider in the fact that its basis is formed by the objectively preset and purpose-related nature of the human-community development. To this end, as said above, it was required to define not just the purpose of the human system development, but rather the ultimate goal, which cannot become a sub-goal of any higher-level objective within the framework of human existence on Earth. That is, to define the objective reason of the human system development means to understand that each particular human individual does not live in order to contribute to GDP growth or to manufacture a maximal possible amount of weapons for his/her own annihilation. A human individual can and should live only to attain a maximal development and realization of his/her spiritual and intellectual potential with the concomitant growth of his/her level of consciousness and physical perfection.

In other words, the objectively set goal is as follows: in the course of his/her development, each human individual must and can reach his/her own perfection or the Supreme Reason. Otherwise, the development can be diametrically opposite – that is, the blind-alley scenario, retrograde development to the point of starting everything anew, or a catastrophic final in form of apocalypse.

The second component of the new methodological tool-kit is its integrity, systemic nature and cross-disciplinary approach which are based on the premise that the world is a single entity and the laws of nature and society are general; thus, the world can only be cognized, if and when all sciences and spiritual knowledge merge in a universal, systemic, integral and cross-disciplinary (or, rather, trans-disciplinary) knowledge. Therefore, these elements should be systemically united through an identification of the functional target of the system as a whole and of any aspect of it (civilizational, formational, national, confessional, territorial, scientific, socio-economic, socio-technical, socio-cultural, political, organizational, *etc.*), and independently of the prevailing development model (whether the neo-liberal, Keynesian, totalitarian, or their combination). Only this knowledge allows to understand that the financial, economic, social, managerial, organizational, science-tech and, more generally, the systemic crisis of the world as well as all currently existing negative phenomena are links of one and the same chain. Hence, the integral, systemic and uniform solution must be found for the whole world, but with proper consideration of the diverse interests of all residents of our planet.

For the sake of justice one should note that scientists learned for a long time to combine or borrow from different disciplines. But, the spiritual knowledge is another story with some positive shifts underway. For example, Frijof Capra in his book *The Tao of Physics: An Exploration of the Parallels between Modern Physics and Eastern Mysticism,* as well as in other works, states that both physics and metaphysics inevitably come to one and the same knowledge. All his works bear the same underlying message that implicit connections exist between everything. Seeking to find a scientific resolution for the puzzle of life, Frijof Capra, proceeding from the theory of systems, tries to synthesize the latest attainments and discoveries made in physics, mathematics, biology, sociology, and other disciplines with the spiritual knowledge of the Orient (Capra 1975).

Another novelty of the methodology (designed for identification and cognition of objective regularities in the development of social system) consists in the selection of the major criterion that would encompass the whole variety of processes, separate the essence from the phenomenon and the objective from the subjective, as well as draw a generalizing assessment to characterize positive or negative development of the human system with respect to the ultimate objective.

In this respect one should note that the indices of GDP, GNP, human-potential development, happiness, *etc.,* do not reveal regularity, objectivity and the direction of the variety of processes, because the economic development proceeds faster than the relevant research. Besides, as contemporary analysts note, the reliability of global statistical data is highly doubtful and a large share of statistical information used in the analysis of economic processes is nothing else but an interpolation of main parameters based on the models constructed during the 'boom' period of mathematical programming between the late 1950s and early 1970s. Therefore, such models cannot provide a relevant description of modern economy, at least, because the typical growth rates extend beyond the small-error field of such models. Even the authors of reports to the Club of Rome noted that computer simulation makes it clear that any model inevitably reflects the subjective views, ideas, and preferences of its developers, and this becomes already evident in the selection of data. Therefore, such models could not serve the means to cognize objective processes and cause-effect relationships. And, finally, to forecast future is an unrewarding and sometimes even dangerous job, because negative scenarios and their underlying 'thought forms' often come true by way of a self-fulfilling prophecy. For many times it has been scientifically proven that thoughts are material and can be an instrument for creating, curing, raising crops, correcting weather, *etc.*, – and, for killing or forcing a human individual to commit inhuman actions and even crimes.

In other words, today, as never before, the existing model of the human-community development (with all its transformations) comes into conflict with scientific and technological achievements. Today humankind stands at the verge of self-annihilation by its own intellectual attainments. However, human society is still presented as probabilistic, quite unpredictable and not strictly controllable, absolutely incompatible with the goals, proclaimed by the UN and other high-level organizations in the conceptualising sustainable development, the 'Millennium Declaration' as well as in the concept, strategy and principles of information and civil society. On the other hand, scientific knowledge based on the analysis and generalization of empirical data and a huge mass of information, indices and calculations made after the pattern 'from the past to the present and future' does not reveal a true picture of the world and does not reflect the reality. Therefore, we need another paradigm, index and information-uptake rate – that is, another methodology of cognition which could disclose objective regularities in the human-community development. Thus, we can make a conclusion that the need in a different approach to the laws of human existence, in a new methodology for cognition of the human system and in a new measure for all processes is somehow in the air and today it is needed as it had never before the case.

These examples show the scale of responsibility for the decisions made to create the global society and its institutions, especially, if such decisions ignore the effects of the profound general laws providing the basis of the human-system development. Therefore, the most important task is to create proper conditions for evolutionary development of the societal system towards achieving the goal, and to bring the whole humankind to one and the same time-bound space, because its resolution will make it possible to overcome the crisis in development of the global community as well as to streamline and unify the whole complex of knowledge and theories.

Here comes another conclusion: from the point of the systemic idea on the status of human-system development and on the selected means to reach the goal and mechanism for its realization, it is the time that can be such a universal criterion. Today the human knowledge, growing like an avalanche, becomes immediately outdated. The knowledge based on the empirical analysis of the past and present, always lags behind since with implementing the conclusion the picture will change completely so that a linear prediction is not possible.

Thus, the third provision of the new cognition approach is the definition of the only possible criterion – the time, which can measure and juxtapose all processes and phenomena. By applying this criterion, we can measure and juxtapose things immeasurable in other indices, and, what is the main point – to correlate the facets of human and societal life with the target ideal and to identify the achieved stage in relation to the goal.

The only chance for knowledge to remain relevant is to go move to the front of the actual socio-economic and political processes, giving it from there a new direction. This can only be achieved if knowledge is obtained on the basis of cybernetic, systemic, and cross-disciplinary approaches and if it does not proceed from the empirical analysis, subjective assessments and theories developed o this foundation, built along the pattern 'from the past to the present and future', but rather from the theoretical approach 'from the future to the present and past'. We must know a priori which socio-economic and political structures and what technological system are relevant to this goal, and the mechanisms for its realization. Meanwhile, the closer we approach the goal, the faster is the pace of processes. Hence the time period between the emergence of a material and spiritual need of each particular individual or the society as a whole and the satisfaction of the need would become the sole criterion of efficiency in attainment the ultimate goal.

So, the fourth provision of our methodological tool-kit is the defined criterion of the human-system development which is the time between the need to realize the single goal of development and the reality, in which the society and each particular individual find themselves in relation to such goal at any given moment of time. If the time between arising and satisfaction of a particular individual's need tends to decrease continuously and to reach the point of zero, then the human system develops sustainably and efficiently towards the overall goal. Thus, we gain an absolutely new understanding of the human system development. If we apply this criterion, it would become possible to control or manage the time between arising and satisfaction of a particular individual's need. And, to control (manage) time is the same as to control development. Only in this case, the human system would start sustainable and efficient development towards the goal in the interests of each particular individual.

3. Brief Fundamental Conclusions Drawn from Applying the New Methodology for Cognition

In the framework of the present article we cannot give a detailed presentation of the results of the application of the new methodology, which, however, have been described in detail in such books as *Forecasting the Future: A New Paradigm* (Fetisov and Bondarenko 2008a) and *Crisis-Free Development: A Myth or Reality* (Bondarenko 2014a). Besides, these, results have been presented in numerous articles and conference papers published in Russia and abroad (a smaller part of such publications is included in the References: Fetisov and Bondarenko 2008b: 220–270; Bondarenko 2014b; 2008: 109–104; 2009: 78–83; 2011a: 4–12; 2012b: 7–22; 2013a: 89–93; 2013b: 12–19).

In brief, the new methodological tool-kit made it possible:

- to proceed beyond the limits of the entire human system and to view it as a single whole of the 'past–present–future' in relation to the objectively set development goal: to satisfy the highest need of any human individual to become spiritually, intellectually and physically perfect and at the same time to attain a high level of consciousness;
- not to rely upon empirical data and subjective judgments on the past and present;
- to understand in terms of time and space the objective picture of the human system development depending on the positive (sustainable) or negative (unstable) orientation to realization of a single goal.

In turn, it helped us to understand that over whole multi-century path of the human community development there have been only the two paradigms of development (see Fig. 1).

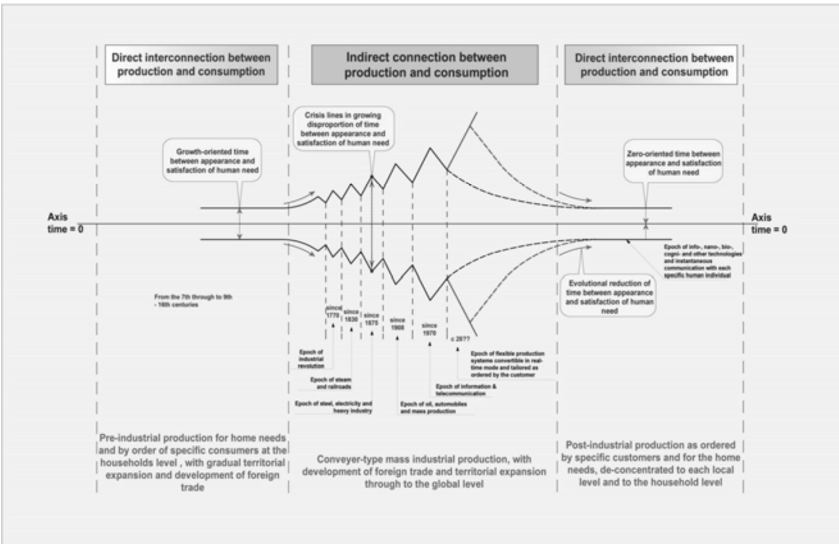

Fig. 1. The outlay of the human system development

✧ the **first paradigm**: the direct connection, short in time and space, exists between production and consumption. It started from the point, when everything was produced at the level of manual labor, and people consumed all products. Hence the time between the appearance and satisfaction of a particular individual's need was the shortest. That was the pre-industrial type of production for manufacturers' own needs and for specific consumers at the household level (craftsmen);

✧ the **second paradigm:** the connection between production and consumption is indirect or mediated. This paradigm of development dates back to the emergence of primitive technologies, labor division, market, brokers' class and the universal equivalent of exchange with results of such labor – money. With a gradual territorial expansion and development of foreign trade, the direct interconnection between production and consumption underwent a transformation into the indirect one. Its development in time and space accelerated in line with the transition to the industrial mode of development. The major landmarks of the process were the formation of the mass industrial production of the belt-line type, growing domestic and foreign trade as well as territorial expansion to the global level, plus mass consumption. Such type of production is oriented to satisfy demand of an abstract end-user through an elementary, archaic and market form of contact that would be mediated by the increasing time and space. In such circumstances, the uncertainty of consumption resulted in appearance and then the world-wide growth of disproportion in the time spent for production and time for circulation of commodities and money up to an absolute de-synchronization. The time for circulation is much longer that the time for production. Despite the massively grown volume of material and of production, the dynamics of their movement has strongly departed from the monetary form (both real and, in particular, virtual). Development in relation to the goal has become elemental, and involution substitutes evolution. Cycles, crises and all other negative phenomena in the human community development are the products of such paradigm of development. It is not without a reason that the beginning of the first Kondratieff's cycle (according to Sergey Glaziev) is dated to 1830, marked by the starting blossom of the industrial epoch, while the crises are results of the immensely long time between the emergence and actual satisfaction of a particular human individual.

The monetary methods of countering the financial crisis do nothing else but contribute to such breaking away of the link between real products and money, and contribute to the even stronger growth of disproportions between the time for production and circulation of commodities and money. As a matter of chain reaction, the financial crisis even faster transforms into economic, political and, finally, the systemic crises. This is the currently prevailing developmental model.

The essence of the second developmental paradigm consists in the belt-line mode of mass production, oriented to maximal profit rather than to satisfaction of a particular individual's needs as well as his/her comprehensive development and improvement. The basic relationship between human individuals is presented by the interconnection (desynchronized in time and space) of different technology for manufacturing of goods and intangible values as well as consumption thereof by an abstract consumer rather than by a particular individual. All crises of this paradigm of development took place at the peak of the growing time-bound and spatial disproportion between the arising and satisfaction of a particular individual's need.

The current systemic crisis is actually the peak, agony and inevitable decline of the modern development paradigm which is the model of human relations, based on the indirect connection between production and consumption and which has completely exhausted itself.

This time-bound and spatial flow of ideas, commodities, money, and information, alongside with the immensely long time between the emergence and satisfaction of a particular individual's need objectively serve the perfect conditions for absolutely all negative phenomena. To draw the examples, let us consider just a few phenomena. Poverty and inequality, the dollar-based Bretton-Woods system, slowing-down economic growth rates, recession, growing prices and inflation, de-industrialization, primitive production and trade, terrorism and corruption, natural abnormalities and disasters, terrorist actions, the recent events in Ukraine, the EU, the USA and Russia, *etc*., – all these are the links of one and the same chain, and a result of the indirect developmental model. Within this model of human relations, the factor of time plays a most negative role.

The existing development model, based on indirect human relations, does not comply with the current era of cosmic speeds and digital, info-, cognition, nano- and other technologies. The advanced technologies make the economic and other realities rapidly change and thus, they are no longer compatible either with the above-described production and consumption or with the indirect (mediated) type of connection with a particular individual.

Exactly at this point we find an objective cause of the currently observed gap between theory and reality. This happens because during the afore-mentioned long time of 'in-between', the interests of the state, business, and society run counter and fail to coincide with interests of a particular individual as well as with interests of those, who possess knowledge. Thus, science is put to oblivion and ostracism.

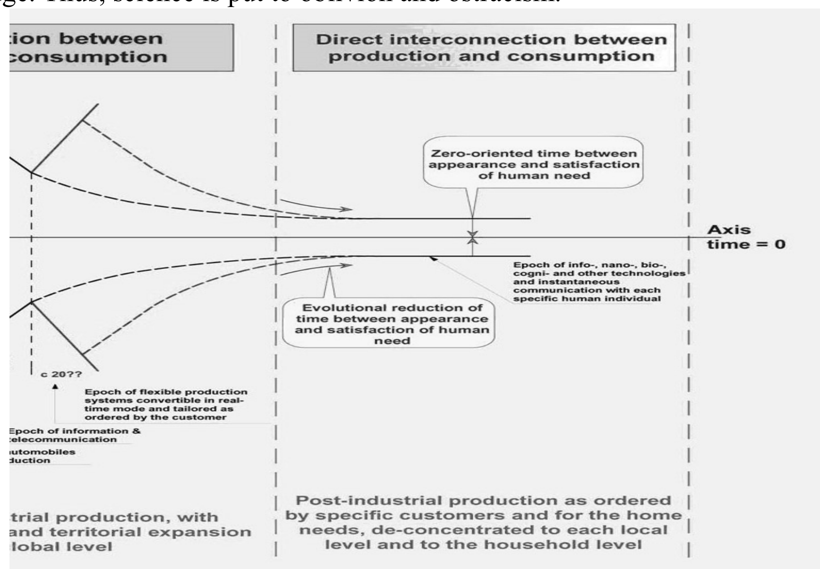

Fig. 2. Schematic Outlay transition to the new (first) development paradigm

We find ourselves currently in the period of transition from one development paradigm to another (Fig. 2). The periods of transition are frequently the most difficult times for mankind, especially, when the transition to the objectively set goal of development seems to be derived from a trial-and-error method.

The worldview approach allows understanding the objectively inevitable transition and 'reinventing' of the first direct paradigm of development, as well as of some other, different models of growth and relationships. This model becomes feasible only with the digital technologies of the twenty-first century, through which the production can again reorient to the satisfaction of individual needs avoiding the production of redundant goods. The transition to the indirect connection between production and consumption can reduce the 'in-between time', eliminate the primary cause of the systemic crisis and make it possible to proceed to the evolutionary mode of development.

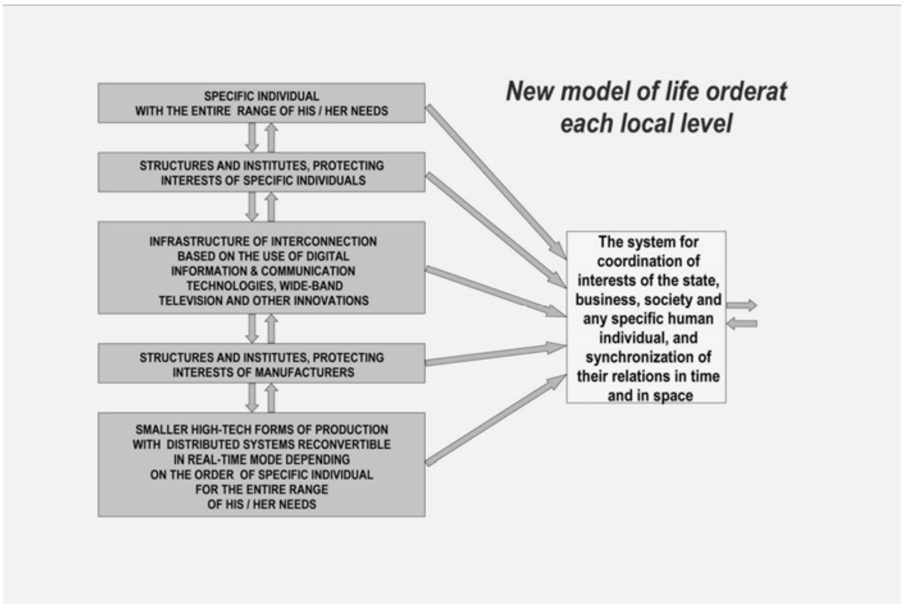

Fig. 3. New Model of Life Organization at Every Local Level

The general pattern of the new model (which has been discussed and described in many of my publications), is presented in Fig. 3. This is a new model of relations, or a new model of development of production forces at each local level relevant to such relations, and the mechanism for adjustment of interests between state, society, business, and particular individual.

The main point is that the worldview approach enables us to formulate and to substantiate the need in development and realization of the *megaproject* defined as 'Territory of the Faster Growth: Everything for People'. In 2014, this problem was in the focus of the Round-Table discussion held within the framework of the Moscow Economic Forum (MEF-2014). The participants of the round-table approved proposals on the Megaproject and the respective resolution was published on the MEF website (Bondarenko 2014d).

The main idea of the Megaproject with respect to strategic tasks suggests the necessity to form simultaneously all elements (*i.e.,* new production relations, relevant production forces, *etc*.) proceeding from the essential goal of the human system development on the basis of real-time coordination of the state, society and business interests with interests of particular individuals.

Elsewhere I have already pointed out that the most important points in terms of resolving the tactical tasks for the realization of the Megaproject are as follows:

1. The project can and should be developed by the scholars and scientists from all institutes of the Russian Academy of Sciences.
2. The development of the Megaproject and of the offered model demands building of an international cross-disciplinarian team of academic and practical experts, and also the involvement of the entire global intellectual community, linked and interacting via Internet.
3. To realize the pilot project in different Russian cities and then to provide transfer and proliferation of the new life-organization model throughout the whole territory of the country.
4. Partnership of the state, business, society, and particular individuals, all united by their shared interests, would generate the hope that the theory and reality will coincide in time and space.

The information below can fully confirm my theoretical conclusions.

Fig. 4. Cars manufactured using industrial techniques

Would you guess, what is there in Fig. 4? The unsold cars – just a tiny piece of the tip of the iceberg. So far, there are quite a few of such parking lots packed with new cars. Car producers have to purchase the ever bigger land plots in order to deploy the accumulating residuals. Every week plants produce dozens of thousands cars, but the sales are rather moderate. However surprising this might be, but there are more cars than human beings on our planet – almost ten billion cars! The stocks of unnecessary cars pile up throughout the world. Their number is growing continuously and, as it seems, endlessly.

However, this problem can be resolved through the digital production.

Fig. 5. The first car, manufactured by means of the 3D-printer

This was proved by Jim Kor, an inventor, who assembled a city car from 3D printed spare-parts. The car is rather small, light, and efficient and, what is the main point, environment-friendly. Jim Kor feels convinced that his project is a herald of the true revolution in the car production. From here it is evident that the future of the automobile industry will belong to smaller independent companies, developing original projects, and such companies can be located at any local level. Manufacturing of parts at 3D printers would enable them to start producing cars of diversified models.

Today, however, the excess production extends not only to cars and other commodities, but as well to money and information. For example, China, Mongolia and other countries have whole new towns built to please the investors hunting for high profits – however, the demand is very low because of high prices.

The case-study performed by the National Committee for Development and Reforms and the Academy of Macroeconomic Studies shows that between 2009 and 2013 about 6.8 trillion USD were invested in vain because the Chinese government sought to stimulate the economic growth while the agents in the construction sector were hyperactive to undertake the task. As noted by the authors of the case study, in the afore-mentioned period about 50 per cent of all investments in the Chinese economy were 'inefficient'. Today this is evidenced, in particular, by 'ghost towns' with unpopulated multistory apartment houses, dead motor roads and dormant steelmaking plants (Nevelsky 2014).

All these examples show that the model of human relations based on the belt-line mass production and its indirect connection with consumption has completely exhausted itself since it is cost-ineffective and has brought the negative consequences we face today.

I would like to make a special emphasis on the point that a broad access to digital technologies in production already poses a challenge to the traditional business models within the indirect development model, because the main factor at the basis of digital production is personalization – that is, manufacturing of products for the individualized 'market'! And this is not just the statement, I made in my works over thirty years ago. The same or similar statements are made by other scholars and can be found in global mass media. Thus, the regularities of the human-community development, identified at the theoretical level via the worldview approach find the confirmation in real life.

Fig. 6. Gun, manufactured by 3D-printer

However, the digital revolution in production has also a reverse side. In Fig. 6 we see a gun manufactured by means of a 3D-printer. One can easily imagine what will be going on in the world, if in future any individual can 'print' fire arms by means of 3D-printers. There have already been few such cases. But what will happen, if manufacturing of such items becomes a mass phenomenon?

It is quite clear, what threat the nano-, bio- and cognitive technologies can pose for mankind, if applied widely within the framework of the currently existing development paradigm (see already Bondarenko 2012c: 48–52).

Thus, we see that the revolution in production is already gaining momentum. But, it makes many people ask a question: How are we going to live, learn, work and play? How shall we abide by moral and ethical norms and resolve moral and ethical problems, and how shall we protect our lives if any person can do anything anywhere using such technologies?

Regrettably, there is almost no discussion on the necessity to transform the basic foundations of societal development, namely, to build a new model of human relations that would be relevant to the new forces of production. In Russia, we hear talks on the need to modernize industry on the basis of the sixth technological mode and the so-called NBIC (nano-bio-info-cogno) technologies. However, nobody even cares to think about the transformation of human relations in the context of such issues as to what and how people will produce by means of these innovations, will they be able to satisfy at least the daily-living needs, and, most important – what will be the purpose of production by means of innovations? (Akayev and Rudskoy 2014)

In other words, the results of the industrial revolution will only serve good to the humanity, if this revolution is accompanied with changes in the human-relations model and with the formation of a qualitatively new model of growth.

And, the new model of growth implies:

- mental realization and acceptance of objectivity of the human-community development goal;

- the acceptance of the inevitable necessity to create simultaneously all basic elements, including the new model of life (new production relations) and relevant productive forces, together with the mechanism to coordinate the state, society, business interests with a particular individual's interests in the real-time regime;
- the tasks, instruments and mechanisms that should provide minimization of all processes between the emergence and satisfaction of a particular individual's need and provide an efficient use of resources;
- orientation on particular individual's needs and production by order and without manufacturing anything redundant is the only possible condition that can also promote higher labor productivity;
- a balance should be established between technological and social changes in the real-time or proactively. Due to this solution of the problem, the primary cause of the crisis would be eliminated, and the system would operate proactively in relation to foreign and domestic threats;

In other words, the new growth model brings increasing opportunities to create conditions for each human individual to attain perfection!

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International Migration Management in the Era of Globalization*

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The present article considers the formation of regulatory frameworks of migration processes at the global level. It also analyzes the dual nature of migration policy at the regional, national, and global levels, which originates from the differing interests of the actors of the international relations. The author presents some recommendations how to improve the regulation of migration processes.

Keywords: *globalization, governance, international migration of population, forecast, migration policy, duality of the migration policy.*

In the second half of the twentieth century, globalization processes combined with sweeping changes in global political and economic systems led to a drastic intensification of interstate territorial movements of people and the formation of fundamentally new global patterns of migration. For example, for the last half century, the total number of 'classical' international migrants in the world increased by more than three times (from 75.46 million people in 1960 to 232 million in 2013). If we add here other categories of migrants (migrant workers together with their family members, undocumented migrants, pendulum migrants, seasonal and border workers, forced migrants and 'economic tourists', *i.e.* migrants who are involved in the business connected with crossing of a border using a tourist visa), then the total number of inhabitants of the globe participating in international migration exceeds 1.2 billion people. Thus, international migration became one of the global phenomena affecting all aspects of the community life and world politics.

Thus, a logical question has arisen about whether this phenomenon can be managed? To answer this question, it is necessary to identify the management of social phenomena. In our opinion, this term can be described by a simple formula: 'forecast plus policy'. And in reality to manage effectively a social phenomenon or process means both to understand clearly the current developmental trends of the process and also to conceive its prospects. The latter also allows forecasting migratory processes which are often connected with demographic forecasting, especially when we talk about the analysis of the world population, and its regional and national distribution.

According to forecasts by UN experts, the world population will amount about 9.6 billion people by the year 2050 – compared with 7.2 billion in 2014 (33 per cent growth). During the same period of time, the number of classical migrants in the world will double

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and exceed 450 million people. If we speak about all categories of migrants, the number, by our estimates, will approximately triple and amount 3 billion people.

The transformation of migratory flows into a global phenomenon generated a considerable interest of scholars, officials, politicians, international public organizations and the *public* in general. With this development of migration emerged especially the necessity to improve the management tools of migratory processes at the national and regional levels, as well as to develop a global migration policy by way of establishing *a system of international treaties, agreements and other bilateral and multilateral normative legal acts, regulating interstate territorial movements, pursuing social, economic, demographic, and geopolitical purposes, etc.*

Our analysis shows that the existing system of management of interstate territorial movements of population has a dual character which can be traced at three levels:

– *at the global level* it is the result of contradictions between interests of various actors of international relations system (developed and developing countries, international organizations and certain states);

– *at the regional level* the dual character is expressed in the counteracting trends towards liberalization of migration regimes within regional associations and simultaneous processes of tightening migration policy in relation to citizens of third countries;

– *at the national level* the dual character is manifested in the contradiction between social, demographic, and economic interests on the one hand, and national security on the other hand.

At the same time, the contradictions between immigrants and adopting states, businessmen and society in general gets a particular meaning. It is especially important to keep this fact in mind since in recent years the policy of immigrants integration in developed countries has been implemented both at the regional and national level.

Migration Policy: The Global (World) Level

The foundation of a regulatory management of migratory processes at the interstate level is expressed in the international treaties, agreements, recommendations and other regulating legal acts adopted at various meetings and conferences held under the auspices of leading international organizations. Here one can enumerate, first of all, the United Nations and its divisions (the United Nations Population Fund (UNFPA), the United Nations Conference on Trade and Development (UNCTAD), the United Nations High Commissioner for Refugees (UNHCR), the United Nations Development Program (UNDP), and the International Organization for Migration and International Labor Organization. However, one should note that today there is no universal migration practice at the global level (OSCE, IOM, ILO 2006).

Among global conferences, the UN World Conferences is of peculiar importance since it has an intergovernmental status. The issues of population were debated at three conferences (held in Bucharest in 1974, in Mexico City in 1984, and in Cairo in 1994) and two fundamental documents were adopted on the conceptual approaches to the management of international migration processes: the World Population Plan of Action (1974) and the Population and Development Program of Action (1994).

The World Population Plan of Action specifies, in particular, that 'for some countries international migration may, in certain circumstances, be an instrument of population policy … at least two types of international migration are of considerable concern to many countries in the world: the movement of migrant workers with limited skills, and the movement of skilled workers and professionals' (UN 1975).

In the World Population Plan of Action, among recommendations concerning the international migration management, one can single out the following ideas (UN 1975):

– governments and international organizations generally facilitate voluntary international movement;

– governments are urged to conduct bilateral or multilateral consultations, with the aim to harmonize their policies in the field of international migration management;

– countries accepting immigrants have to provide appropriate medical care and social security services for immigrants and members of their families, have to guarantee their physical safety;

– in the treatment of migrant workers, governments should work to prevent discrimination in the labor market and in society, to protect their human rights, to combat prejudice against them and to eliminate obstacles to the reunion of their families;

– governments should bear in mind humanitarian considerations in the treatment of foreigners who remain in a country with a non-legalized status;

– it is necessary to take measures to formulate national and international policy to avoid the 'brain drain' process.

At the International Conference on Population in 1984, intermediate ten-year results were analyzed. The conference suggested as well new recommendations about further implementation of the World Population Plan of Action in the field of international migration.

Among others, the following recommendations were offered (UN 1984):

– the accepting countries should take measures to protect fundamental human rights of all immigrants in their territory and ensure the respect for their cultural identity;

– measures should be taken to provide integration of immigrants and population of accepting countries;

– governments of accepting countries should take into account not only economic and social interests of their own countries, but also the issues of the wellbeing of immigrants and their families, and also demographic implications of migration;

– governments of accepting countries should consider measures to assist improvement of family life of registered immigrant workers through reunion of families;

– the measures set by the laws and regulations aimed at restricting illegal migration, should be applied both to undocumented migrants and to those who support and promote undocumented migration;

– governments and international organizations should try to find long-term solutions to the problems connected with refugees and movement of refugees, and to work in the direction of elimination of the causes of these problems.

In the twenty-year Population and Development Program of Action, adopted in 1994, a separate chapter (Chapter X) is devoted to international migration. In particular, it specifies that *an effective policy in the field of international migration should be established, taking into account the limited economic opportunities of a receiving country, the influence of migration on a receiving society, and its influence on countries of departure*.

Among recommendations in the sphere of migration policy, the Population and Development Program of Action of 1994 offers the following:

– it is recommended that governments of accepting countries consider possible use of certain forms of temporary migration … for professional development of citizens of countries of departure, especially of those from developing countries and countries with transitional economies;

– it is recommended that governments share the information about their policy in the field of international migration and rules regulating entrance and stay of immigrants in their territory;

– governments are advised to consider the possibility of ratification of the International Convention on the Protection of the Rights of All Immigrant Workers and Members of Their Families;[1]

– governments of receiving countries are recommended to consider a possibility for registered immigrants and members of their families to be given an identical treatment, in comparison with their own citizens, with respect of implementation of fundamental human rights, to take appropriate measures to avoid any forms of discrimination against immigrants;

– governments of countries accepting immigrants should provide protection of immigrants and their family members;

– governments of both receiving countries and countries of origin should apply effective sanctions against persons organizing unregistered migration, exploiting unregistered migrants or those who are engaged in trafficking in unregistered migrants;

– governments of countries of origins and of countries accepting immigrants should strive to find satisfactory and long-term resolutions of problems generated by unregistered migration, by conducting bilateral or multilateral negotiations, including concerning a conclusion of agreements on a re-admission;

– governments should respect rules of the international law in relation to refugees.

Thus, the recommendations offered at the World Conferences on Population reflect the fact that *international migration can contribute to the formation of a new international economic order, and it is recognized that an effective migration policy is a prerequisite for a positive contribution of migration to the development*.

Recommendations for improvement of international migration management are also present in the resolutions of other World Conferences and Summits, including the UN World Conferences on Environment and Development (Rio de Janeiro 1992; Johannesburg 2002); the International Conference on human rights (Vienna 1993); the World Summit on Social Development (Copenhagen 1995); the 4th International Conference on Women (Beijing 1995); the World Conference against Racism, Racial Discrimination, Xenophobia and Related Intolerance (Durban 2001); and the World Summit (New York 2005).

The Berne Initiative became another important intergovernmental event in 2001 and it aimed at enhancing cooperation between states to improve the migration management at the national, regional and global levels. The development of the International Agenda for Migration Management which contains a number of general recommendations for creation balanced and comprehensive approach to migratory processes management (OSCE, IOM, ILO 2006) became the most important result of the Berne Initiative.

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[1] The Convention adopted by the United Nations General Assembly in 1990 established, for the first time, an international definition of various categories of immigrant workers and represented an important step towards fixing of responsibility of receiving countries in recognition of the rights of immigrants and ensuring their protection. It came into force starting from 2003.

The 'Compendium of Recommendations on International Migration and Development' published by the Department of Economic and Social Affairs of United Nations Secretariat in 2006 demonstrates that the documents adopted at international conferences and summits can serve as a reference point for governments in terms of support of the joint initiatives in the sphere of international migration management.

In September 2006, in New York, the first High-Level Dialogue on International Migration and Development took place where multidimensional aspects of international migration and development were considered, including the exchange of experience and information about advanced practice and possible ways to increase the benefits from international migration as well as to reduce its negative consequences. Following the results of the Dialogue, a resolution was adopted to continue global discussions on international migration and to create a Global Forum on Migration and Development which will become a forum for systematic and comprehensive discussion of the issues of international migration and development. From 2007 to 2014, seven meetings took place within the framework of the Global Forum where representatives of more than 160 UN member-states and 45 international organizations took part.

The Global Forum allows experts and those responsible for decision-making discuss on an informal basis how to improve migration policy; to exchange the best practices in this sphere and reveal existing problems in regulation of migratory processes at the national, regional and international levels; to discuss opportunities for establishment of partnership and cooperation between countries, international organizations and diasporas on migration and development.

In October 2013, the second High-Level Dialogue on Migration and Development took place in New York. In particular, in the Declaration adopted following the results of the second Dialogue, it was pointed out that the representatives of states (UN 2013):

– make a decision to act in the direction of development of an effective and all-embracing agenda concerning international migration by improving the activity of existing institutions and structures, and also by increasing efficiency of partner ties at the regional and global levels;

– recognize the necessity of the international cooperation which would allow a complete and comprehensive solution of the problems of unorganized migration for ensuring a safe, orderly and organized migration in full compliance with human rights;

– recognize the efforts made by the international community to settle the related aspects of international migration and development basing of various initiatives both within the United Nations system and within the framework of other processes;

– confirm the necessity to effectively encourage observance and protection of human rights and fundamental freedoms for all migrants, especially women and children, irrespective of their migratory status, and to solve the problems of international migration on the basis of international, regional, and bilateral cooperation and dialogue;

– note in this regard the need to take appropriate measures for protection of female migrant workers in all sectors, including female migrants working as house maids;

– emphasize the necessity to observe and encourage relevant international labor standards and observe of the migrants' rights at work;

– recommend to member-states to cooperate in the development of mobility programs promoting a safe, orderly and organized migration, including the labor force mobility.

Thus, the conducted analysis showed that resulting documents of conferences and summits contain various recommendations for improvement of migration policy. At the same time, *a duality of approaches to migratory processes management at the global level* is also evident. The duality at the global level arises, first of all, from the often conflicting interests of various actors of international relations. For example, there are contradictions between the major countries of emigration and countries of immigration. As a result, many documents and agreements signed at international conferences do not become effective for many years or are applied in a limited number of countries as they were only ratified by an insignificant number of countries.

We can illustrate this by looking at international conventions dealing with migrant workers and affecting economic interests of receiving states. For example, by the present moment, the ILO Migration for Employment Convention, 1949 (No. 97) has been ratified only in 26 per cent of countries, and the ILO Convention, 1975 (No. 143) 'Convention concerning Migrations in Abusive Conditions and the Promotion of Equality of Opportunity and Treatment of Migrant Workers' has been ratified in 12 per cent of countries. In its turn, the International Convention on the Protection of the Rights of All Migrant Workers and Members of Their Families was adopted in 1990, came into force only in 2003, and has been ratified so far in only 24 per cent of countries (see Table 1).

Table 1. Situation with ratification of international legal documents dealing with international migration

Agreement	Year of coming into force	Participants of agreements as of 19.04.2006		Participants of agreements as of 01.12.2013	
		Number of countries	Percentage of countries	Number of countries	Percentage of countries
The 1949 Convention No. 97 of the ILO on migrant workers	1952	45	23	49	26
The 1975 Convention No. 143 of the ILO concerning Migrations in Abusive Conditions and the Promotion of Equality of Opportunity and Treatment of Migrant Workers	1978	19	10	23	12
The 1990 International Convention on the Protection of the Rights of All Migrant Workers and Members of Their Families	2003	34	17	47	24
The 2000 Protocol to Prevent, Suppress and Punish Trafficking in Persons Especially Women and Children	2003	97	50	157	81
The 2000 Protocol against the smuggling of migrants by land, sea and air	2004	89	46	137	71
The 1951 Convention on the status of refugees	1954	143	73	144	75

Source: data of the UN (UN 2006, 2013).

Concluding my analysis of migration policy at the global level, I would like to emphasize an important point in the relation of the world community towards this problem: international migration is considered as a function of changing political, economic and social conditions and an integral element of development.

At the same time, three key problems are obvious in all discussions concerning migration: 1) a lack of reliable and complete statistical data on migration; 2) a complex nature of international migration and absence of a comprehensive theory of migration; and 3) complicated relations between migration and development, incomplete understanding of the interrelations between migration and various factors (demographic, economic, political, ecological, *etc.*).

The solution to these problems is decisive for the development of a well-grounded migration policy, for the decision-making on all urgent issues of interrelation between migration and development, for realization of opportunities provides by international migration for the development of countries of departure, transit and destination.

Regional Level of Migration Policy

Regional cooperation in the sphere of international migration management is conducted through official mechanisms, operating within regional integration associations (in particular, through the growing mobility of population as a part of integration processes), and regional interstate agreements (through realization of a uniform migration policy), and also using less formal mechanisms (*e.g.*, regional advisory councils).[2]

The most striking example of international migration management within a regional integration association is the procedure of a free movement of citizens and labor force within the European Union. Presently, citizens of the EU member-states can freely move through interstate borders within the EU for various purposes (including employment and business) with unlimited duration of stay in the territory of another EU member-state. The European Union also pursues a uniform policy in relation to immigration and accommodation of citizens of third countries, and strengthens partnership with the main countries of departure, develops and takes measures for ensuring an equal treatment of citizens of third countries living in the EU member-states. It should be noted that the European regulatory acts adopted so far generally define the rules of granting refuge and also aim at preventing illegal immigration, and only some of them deal with issues of legal immigration, including reunion of families, attracting students, researchers and highly-skilled migrant workers.

Various mechanisms of international migration regulation are also in operation within other regional integration associations, including the North American Free Trade Agreement (NAFTA), Association of Southeast Asian Nations (ASEAN), the Common Market of the South (MERCOSUR), the Commonwealth of Independent States (CIS), the Economic Community of West African States (ECOWAS), the Central African Economic and Monetary Community (CEMAC), and the Eurasian economic union, *etc.*

Regional interstate agreements represent official interstate cooperation agreements in the field of migratory processes management. According to the survey conducted in 2005 by the ILO, the interstate agreements generally deal with programs of invitation of labor

[2] As a rule, interstate agreements in the field of migratory processes management are concluded between countries of one region. However, there are also interregional interstate agreements. For example, there is an agreement between the EU and the USA according to which the citizens of the EU and the USA can move across the territory, respectively, of the USA and of the EU without a visa for no more than three months within half a year.

migrants; admission of trainees or young specialists; seasonal migration; questions of coordination of substantive laws and payments in the field of social security; re-admissions of undocumented migrants; questions of ensuring safe and timely money transfers by migrant workers. For example, in the Agreement of the CIS member-countries on cooperation in labor migration and social protection of migrant workers (1994), it is pointed out that 'the parties undertake necessary measures to prevent the employment of migrant workers by intermediaries without permissions from competent authorities of the country of departure for implementation of such an activity. Any person promoting a secret or unlawful immigration bears a responsibility according to the current legislation of the country of employment'. The Cooperation agreement of the CIS countries on the struggle with unlawful migration (1998) states that 'governments of participating states consider the cooperation in struggle against unlawful migration as one of important directions of migratory processes regulation'. Within the framework of formation of the Customs union and the Eurasian Economic Union in the post-Soviet territory, two important documents regulating labor migration were adopted in 2010: the Agreement on the legal status of migrant workers and members of their families and the Cooperation agreement on counteracting illegal labor migration from third countries.

It should be noted that the bilateral approach allows governments to work in a more responsive way comparing with general agreements within integration associations because the terms of each agreement can be formulated with the account of the situation in respective countries. However, the tracking of implementation of numerous agreements containing various provisions increases an administrative burden.

Since the early 1990s, the number of Regional advisory councils (RAC) which became a new form of regional cooperation, increased continuously. Starting from 1985, the intergovernmental consultations on the issues of accommodation, refugees, and migration policy in Europe, North America and Australia are held which became the first RACs. According to the UN, several such advisory councils including the Budapest Process, the Söderköping Process, and the Pan-European Dialogue on Migration Management, are conducted in Europe. As a rule, regional advisory councils have an informal character and their decisions, despite of the approval of participants, are not obligatory. Nevertheless, they promote a dialogue and gather official representatives of countries of origins and of transit and accepting countries to promote coordination and concurrence of actions not only at the international but also at the national levels.

Our analysis shows that *the dual character of migration policy at the regional level is manifested in two aspects*. The first is that, on the one hand, the actively developing integration processes into the modern world trigger a liberalization of migration policy due to 'transparent borders' within regional associations, free movement of population and labor force of citizens of member-countries through internal frontiers of these unions. On the other hand, there is a unification of legislation on international migration within integration associations, and also more and more drastic measures are taken against immigrants from 'third countries' which is conditioned by various aspects of national security (including struggle against threats of international terrorism, protection of national labor markets). The second aspect is that the interests and problems of integrated associations hardly coincide with or even contradict the interests of its individual member-states. For example, the position of Great Britain from the very beginning of accession into the EU (1973) had a somewhat peculiar and limited character which manifested in the refusal to sign the Schengen Agreement.

Nowadays, the British government considers a possibility of restrictive measures towards immigrants from other countries of the European Union, and also restrictions on their access to British social services and the system of social protection. In the North American free trade zone (NAFTA) between the USA, Canada, and Mexico, the freedom of travel of citizens, including migrant workers, is ensured between the USA and Canada while opportunities of labor migration to these countries for the Mexican citizens are significantly restricted.

National Level of Migration Policy

In different historical periods, different forms of migration policy (emigration or immigration) can prevail which define the essence of state migration policy during this period.

The UN special report on population policy, the World Population Policies Database, contains a separate information section on the national governments' views on migration and state policy in this sphere.

Tables 2 and 3 show that only 13 per cent of sovereign states (mostly located in Africa) do not regulate the immigration level. Whereas 45 per cent of states do not pursue the policy of emigration, generally, these are countries of Africa, Europe, and North America. At the same time, all developed countries realize measures in the field of immigration regulation whereas emigration is regulated only in 20 per cent of them.

Table 2. Views of national governments on immigration policy, 2011

Region	Policy in the field of immigration level			
	To reduce	To maintain	To raise	Without intervention
World	16 %	60 %	11 %	13 %
Europe	11 %	64 %	25 %	–
Africa	19 %	38 %	2 %	41 %
Asia	30 %	55 %	12 %	2 %
Latin America and Caribbean Region	12 %	79 %	3 %	6 %
North America	–	100 %	–	–
Australia and Oceania	–	94 %	6 %	

Table 3. Views of national governments on emigration policy, 2011

Region	Policy in the field of immigration level			
	To reduce	To maintain	To raise	Without intervention
World	24 %	22 %	9 %	45 %
Europe	18 %	14 %	–	68 %
Africa	25 %	15 %	2 %	58 %
Asia	21 %	29 %	29 %	21 %
Latin America and Caribbean Region	33 %	36 %	–	30 %
North America	–	–	–	100 %
Australia and Oceania	31 %	19 %	31 %	19 %

Source: International Migration Policies 2013. New York: United Nations, 2013.

Thus, an immigration policy becomes prevailing in the majority of countries today, and governments show a growing interest in what migrants are, and impose on those entering a country various requirements concerning an education level, profession, qualification, financial position, age, and marital status, *etc.* These characteristics are of special importance in respect of the situation of national labor markets, goals of population policy, and national security.

It should be noted that the largest changes in national migration policy since the end of the 1950s, are connected with immigration. For states which traditionally pursue immigration policy, the essence of changes consists in the adoption of laws encouraging immigration of highly qualified workers, and protecting from unwanted migration.

The analysis of laws adopted in the recent years and aimed at counteracting illegal immigration demonstrates a dual character of policy of receiving countries: on the one hand, policy for new immigrants becomes more and more restrictive, on the other hand, the policy of legalization is pursued with respect to those who entered a country earlier and found a job illegally. From 1980 to 2014, in developed countries amnesty was provided more than 30 times and over 10 million undocumented migrants were granted amnesty. Thus, actually the point is not the eradication of undocumented migration, but legalization of those who entered a country earlier and found employment. For example, in 2014, the US President B. Obama signed an executive order, reforming the US migration system which legalized about 5 million undocumented migrants. It should be noted that a number of experts argue against implementation of such campaigns since they would increase the potential scale of undocumented migration.

The duality of migration policy at the national level also reveals itself in contradictions of economic, demographic and geopolitical character. For example, it often seems necessary to hold a liberalization of migration policy for the sake of demographic and economic development, while national security quite often requires its toughening. The last contradiction has become especially obvious after September 11, 2001.

As for migration policy in Russia, on the one hand, a certain legislative base in the field of regulation of migratory processes has been created during the modern period of its development (from 1991 to 2014), while on the other hand, Russia still lacks a strategic vision of migration as a positive phenomenon. *The duality of migration policy in Russia* reveals itself in the ideas about the necessity to conduct a reasonable immigration policy and involve our compatriots from abroad and qualified legal manpower which are pronounced at the highest national level (in particular, in the Concept of the state migration policy of the Russian Federation, the President of Russia's Addresses to the Federal Assembly of the Russian Federation); nevertheless, at the executive level, the state regulation of migratory processes remains in many respects of a police-officer type, and migration itself is considered primarily as a threat to Russia's national security. This situation contradicts the interests of economic and demographic development of Russia which require a further improvement of the migration policy.

In conclusion it is necessary to point out that, in our opinion, to overcome the dual character of migration policy and use opportunities and resources provided by international migration one should implement a reasonable and strategically adjusted approach to international migration management.

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Globalization, Revolution, and Democracy*

Leonid E. Grinin and Andrey V. Korotayev

This article studies the issue of democratization of countries within globalization context, it points to the unreasonably high economic and social costs of a rapid transition to democracy as a result of revolutions or of similar large-scale events for the countries unprepared for it. The authors believe that in a number of cases the authoritarian regimes turn out to be more effective in economic and social terms in comparison with emerging democracies especially of the revolutionary type, which are often incapable to insure social order and may have a swing to authoritarianism. Effective authoritarian regimes can also be a suitable form of a transition to efficient and stable democracy. The article investigates various correlations between revolutionary events and possibilities of establishing democracy in a society on the basis of the historical and contemporary examples as well as the recent events in Egypt. The authors demonstrate that one should take into account a country's degree of sociopolitical and cultural preparedness for democratic institutions. In case of favorable background, revolutions can proceed smoothly ('velvet revolutions') with efficient outcomes. On the contrary, democracy is established with much difficulty, throwbacks, return to totalitarianism, and with outbreaks of violence and military takeovers in the countries with high illiteracy rate and rural population share, with low female status, with widespread religious fundamental ideology, where a substantial part of the population hardly ever hears of democracy while the liberal intellectuals idealize this form, where the opposing parties are not willing to respect the rules of democratic game when defeated at elections.

Keywords: *globalization, Near East, Egypt, democracy, revolution, reaction, extremists, counterrevolution, Islamists, authoritarianism, excessive expectations, military takeover, economic efficiency.*

Sociopolitical destabilization may be produced by rather different causes. However, sociopolitical transformations may be considered as ones of the most powerful among them. This may look paradoxical, but attempts of transition to democratic forms of government may lead to a very substantial destabilization of a society in transition. The present article analyzes the relationships between revolution, democracy and the level of stability in respective sociopolitical systems.

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There is a widespread opinion that globalization contributes to the spread of democracy. Besides, there is a conviction, which is more widespread among the politicians and ideologists than among the scholars that democracy contributes to a faster and/or more adequate economic growth. The following quotation passionately expresses this conviction: 'For the past three decades, globalization, human rights, and democracy have been marching forward together, haltingly, not always and everywhere in step, but in a way that unmistakably shows they are interconnected. By encouraging globalization in less developed countries, we not only help to raise growth rates and incomes, promote higher standards, and feed, clothe, and house the poor; we also spread political and civil freedoms' (Griswold 2006).

In this context, many supporters of democracy consider extremely disappointing that sometimes democracy does not work properly and the waves of democratization get weaker. Samuel Huntington (1993) called the period of a fast spread of democracy in the 1970s – early 1990s 'the third wave of democratization'. On the threshold of the twenty-first century, many researchers noted that the number of democratic regimes ceased to grow and that it would be a dangerous intellectual temptation for the democrats to consider that the world is inevitably moving towards some final natural democratic state (see Diamond 1999, 2004, 2008). In this situation, the trend has strengthened which promotes democracy in all countries with non-democratic or partially democratic regimes. This trend, on the one hand, is based on the global geopolitical goals of the USA and the West (see, *e.g.*, Brzezinski 1998), and on the other hand, relies upon an active support of a broad ideological and informal movement. And this justifies the efforts to support democracy and to encourage democratic opposition for the purpose of increasing chances of victory of democracy in case of the crisis of authoritarian regimes (Diamond 2000). The intensive efforts led to a number of interventions and color revolutions.

Undoubtedly, the globalization trend is anyway connected with the growing number of democratic regimes. One can hardly object that in the recent decades the general vector was moving towards the expansion of democracy. However, the connection between democratization and economic success it is not that evident as new democratic regimes failed to advance substantially either in economic or social sphere. That is why the intervention and propagation of democracy arouses much criticism. Besides, an increasing number of people support the idea that people should create their own democratic models which can significantly differ from the Western model (Weinstein 2001: 414).

Thus, we suppose that some delay in the spread of democracy in the 2000s was due to the formation of rather successful economic models of development which do not require democracy and even contradict it.

Thus, in practice it is not all that simple as the political philosophers, political scientists and politicians used to think. First of all, an explicit connection between a democratic regime and economic success is not always present; one would even say that it is present in the minority of cases. There are rather scarce studies which clearly demonstrate such a connection especially with respect to emerging democracies but at the same time there are abundant works that prove the opposite (see Polterovich and Popov 2007).[1] On the contrary, in most

[1] Even the UN Report stated that there is no direct relationship between democracy and economic growth (UNDP 2002). It is also noted that the total effect of democracy on the economic growth can be characterized as weakly negative (see Barro 1996).

cases it is precisely the authoritarian and semi-authoritarian regimes that achieve much economic success as they can better concentrate resources and invest (*Ibid*). Of course, the most telling example here is China where the authoritarian rule is the basis for the economic progress. Such countries as Vietnam, Iran, Turkey, Malaysia, and Kazakhstan are rather illustrative examples, as well as Egypt and Tunisia before the Arab Spring events. There is a peculiar enclave of monarchy regimes of the Gulf region that also achieved a rather salient economic success. [2]

Daniel Griswold (2006) claims

> In the past two decades, a number of economies have followed the path of economic and trade reform leading to political reform. South Korea and Taiwan as recently as the 1980s were governed by authoritarian regimes that did not permit much open dissent. Today, after years of expanding trade and rising incomes, both are multiparty democracies with full political and civil liberties. Other countries that have most aggressively followed those twin tracks of reform include Chile, Ghana, Hungary, Mexico, Nicaragua, Paraguay, Portugal, and Tanzania.

In fact, such transitions from authoritarianism to democracy did occur. But one can hardly define their way to democracy as a quick and easy one. Besides, it is important to keep in mind that such countries as Taiwan, South Korea and Chile achieved the main economic success right under authoritarian regimes. And it is far from certain that if a political democracy had been immediately established there (or preserved as in case with Chile) these countries would have shown the outstanding results at the onset of their rise (we can even suppose that this would not have come true). Finally, there are many examples when a rapid transition to democracy leads to economic and often social decline, to hard times in countries' history. Rather tragic events occurred in the development of the former USSR and a number of socialist countries among which Rumania and Bulgaria still remain in difficult situation. The revolutions in Ukraine under the banner of a great enhancement of democracy also have exacerbated economic difficulties. Here we can conclude that ideology aimed at introducing democracy in countries with non-democratic or partly democratic regime can bring drastic consequences for the peoples of those countries; it does not bring prosperity but on the contrary, can cost the country great and useless sacrifices. 'Democracy above all' is a dangerous slogan, and the policy supporting the radicals and revolutionaries does not hold true from the point of welfare for those countries to which revolution is exported or where it is introduced.

It was demonstrated quite some time ago that revolutions in general tend to impede rather than to promote the economic growth: 'One might expect revolutions to unleash great energy for rebuilding economic systems, just as they lead to rebuilding of political institutions. Yet in fact this rarely if ever takes place. For the most part, long-term economic performance in revolutionary regimes lags that of comparable countries that have not experienced revolutions' (Goldstone 2001: 168; see also Eckstein 1982, 1986; Zimmermann 1990; Haggard and Kaufman 1995; Weede and Muller 1997).

[2] On the other hand, the weakening of the economic engine in traditional democratic countries of Europe also leads to certain distrust to democratic institutions (see Lowi 1999). And what can be the result of the process which has already been considered, in particular by Robert Dahl who argues that extending the sphere of supranational activity reduces the citizens' opportunities to control their vital problems through the national means of rule (Dahl 1989).

Thus, one may conclude that there is generally a need in quite a long transitional period to democracy; and moreover, it may often turn that an authoritarian or semi authoritarian regime is capable of such a transitional function. So to evaluate a regime positively, one should estimate it not in terms of its concordance with democratic values, but in terms of its economic success and social orientation, as well as the efficiency of its state institutions contributing to order, stability, secure and consistent policy implementation (on the particular importance of a strong order, state institutions efficiency see among others Liew 2001; Barro 2000; Polterovich and Popov 2007). With a country's advancement toward larger opportunities for people, such regimes are very likely to move toward larger liberalization. Here it is sufficient to encourage the regime's actions contributing to liberalization but not to rely on the radical forces that can overthrow the regime under the banner of democracy, hurling a country into chaos.

One should note that the globalization context with a general recognition of the people's rights and condemnation of the violation of justice and law, with a demand for legitimacy (that is electivity) of government can by itself build a positive trend and in certain respects restrain authoritarian rulers. With decreasing illiteracy and with growing population's self-consciousness necessarily accompanied with enlarging personal political experience, a transition to democracy may proceed much easier, smoother and more effectively than the attempts to establish democracy through revolutionary ways.

The present article makes an attempt to show different variants of a transition to democracy (from time to time using the example of the recent events in Egypt), to show the costs and political, economic and social perils of the striving to establish democracy quickly and by radical means.

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The general mood in Egypt in July 2013 was exultant, the revolutionaries were exultant either and their slogans demanded true democracy. They were exultant because the Egyptian military had ousted the legitimately, publicly and democratically elected President.

Paradoxical, but the Muslim Brotherhood's post-revolutionary political rhetoric sounded incomparably more advanced, than their opponents' archaic political rhetoric. The secularists (as well as the military, supporting them) in an absolutely archaic manner identified the people with the crowd in Tahrir Square, the Brotherhood, in turn, appealed to formal legitimate democratic procedures.

Why were the revolutionaries excited with the overthrow of the legitimately elected President? What was this? An absurd, a paradox, a peculiarity of Egypt? No, it is just a common and quite expected outcome of revolutionary events. So the major issue to be discussed in the present article is whether the revolution and democracy are always closely related.

'Every revolution ends in reaction. It is inevitable, it is a law' wrote the famous Russian thinker Nikolay Berdyaev (1990: 29) who elaborated this profound idea through hard intellectual efforts and personal political experience. Of course, Berdyaev was limited by the historical background of the early twentieth century. The past and the present century have shown that the stability of democratic accomplishments of a revolution to a huge degree depends on the phase of society's modernization transition, on its cultural traditions, environment and a number of other factors. So successful democratic revolutions (or the reforms of a revolutionary kind) tend to happen in countries with a high level of sociocultural and economic development, and where a long period of fascination and disappointment in democracy (as well as cycles of democracy and authoritarianism) is already over; after such revolutions a rather stable democratic regime is established. One can set here the examples of 'the Carnation Revolution' in Portugal in 1974 or 'the Velvet Revolution' in what was then Czechoslovakia in 1989.[3] Besides, such successful revolutions – 'glorious', 'velvet' and usually non-violent – would proceed quite quickly.[4]

The history of such political overthrows starts from the Glorious Revolution of 1688 in England, but the recent decades of human history have witnessed a large number of them. If a society is not properly modernized (also in terms of demography[5]), there are many illiterate people, non-urban population constitute a large share, a strong influence of the traditionalists is present and so on, then 'Berdayev's law' of a revolution's transformation into reaction has large chances to come true. After some time, the idea of democracy can again start generating a new revolutionary explosion. Still there are historical precedents when democracy and authoritarianism alternated many times. Besides, one should point that in such societies a revolution faces really large-scale challenges, and respectively its intensity can provoke a strong resistance. Extending his idea, Berdyaev wrote: 'The more violent and radical is a revolution, the stronger is the reaction. The alternation of revolutions and reactions makes a mysterious circle' (Berdyaev 1990: 29). Rather a typical example here is China which after the first in its history democratic Xinhai Revolution of 1911 yielded to Yuan Shikai's dictatorship. Many times they tried to restore democratic institutions, but China eventually plunged into a long-lasting anarchy and civil war.

The path to a stable and sustainable democracy is rather long and complicated.[6] In any case, it requires a certain level of society's economic, social and cultural development. Let us emphasize again that liberal democracy as a rule (which still has some known exceptions) will not endure long in the countries with large illiterate cohorts, considerable share of rural population, and with low living standards. Modernization in (more or less large)

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[3] In addition, scholars also tend to characterize as such some other revolutions/revolutionary reforms in Eastern Europe in the late 1980s and the early 1990s, the 1986 Revolution in the Philippines, as well as the revolutionary reforms in South Africa in the early 1990s: 'Until very recently, revolutions have invariably failed to produce democracy. The need to consolidate a new regime in the face of struggles with domestic and foreign foes has instead produced authoritarian regimes, often in the guise of populist dictatorships such as those of Napoleon, Castro, and Mao, or of one party states such as the PRI state in Mexico or the Communist Party-led states of the Soviet Union and Eastern Europe. Indeed, the struggle required to take and hold power in revolutions generally leaves its mark in the militarized and coercive character of new revolutionary regimes (Gurr 1988). It is therefore striking that in several recent revolutions – in the Philippines in 1986, in South Africa in 1990, in Eastern European nations in 1989–1991 – the sudden collapse of the old regime has led directly to new democracies, often against strong expectations of reversion to dictatorship' (Goldstone 2001: 168; see also Foran and Goodwin 1993; Weitman 1992; Pastor 2001).

[4] In a certain sense even the French Revolution of 1870–1871 fits this model if to exclude the episode with the Paris Commune. At the same time, the experience of a number of successful countries, in particular of South Korea and Indonesia (to the degree it can be considered successful at present) show that at a certain stage of modernization the authoritarianism may contribute to its expansion. However, just in this case it objectively paves the way for its own limitation and consequent political democratization (for details see Prosorovsky 2009). Still one should note the authoritarian stage often becomes an extremely important and necessary.

[5] The structural-demographic factors regularly generating social explosions in the modernization process are thoroughly investigated in our previous publications (see, *e.g.*, Korotayev, Malkov, and Khaltourina 2006; Korotayev and Khaltourina 2006; Turchin and Korotayev 2006; Korotayev and Zinkina 2011a, 2011b, 2011c, 2014; Korotayev, Grinin *et al.* 2011; Korotayev, Zinkina *et al.* 2011; Korotayev, Khodunov *et al.* 2012; Grinin 2011, Grinin 2012a, 2012b; Grinin and Korotayev 2012a; Korotayev, Issaev, and Shishkina 2013, 2015; Korotayev, Issaev, and Zinkina 2015; Zinkina and Korotayev 2014a, 2014b; Korotayev, Malkov, and Grinin 2014); hence, we will not describe them here.

[6] Both in a particular country and in the world in general. It may seem paradoxical but in 1990, democratic regimes were established in approximately 45.4 per cent of independent countries of the world, that is almost the same rate as it was seventy years earlier in 1922 (Huntington 1993). On some factors affecting the genesis of democratic institutions see also, *e.g.*, Korotayev, Bondarenko 2000; Korotayev 2003.

countries always proceeds unevenly. As a result in modernizing countries a rather modernized 'core' is formed while periphery remains rather weakly modernized and prone to conservatism with the majority of population (the people) living here. In this context, it turns out that revolutionaries (who claim to care for the people), regularly get disappointed in the people and the people's conservatism, and in that at some point the people start voting in a way different from the liberals and radicals' expectations (see, *e.g.*, Korotayev, Issaev, and Zinkina 2015) and would prefer order and stability, and also familiar and clear forms to some unfamiliar political and ideological appeals; moreover, the people would prefer something material to superficially ethereal freedoms. One should go a long way, to gain own political experience of several generations, to gradually emancipate the consciousness, to support cultural-humanitarian development, so that freedoms and democracy would get the status of the values that are precious to the majority.[7] One should also realize that the stability of democracy does not depend on to what extent a constitution is democratic but on how political institutions and actors fit each other and are ready to play the game. An outstanding French sociologist Raymond Aron fairly notes in his profound study *Democracy and Totalitarianism* that 'the stability and efficiency are supported not by the constitutional rules as such, but by their harmony with the party system, with the nature of parties, their programs, and political conceptions' (Aron 1993: 125). This naturally takes much time to achieve. The similar ideas on high requirements to the society, its leaders and bureaucracy, were also pronounced by Joseph Schumpeter (1995: 378–385). In particular, he argues that for a successful functioning of the democratic system 'the human material of politics' (that is people who operate the party machines, work in the executive branch, and take part in broader political life) 'should be of sufficiently high quality'; it is necessary that the bureaucracy should also be of high quality and have a developed sense of duty and esprit (this notion will naturally exclude corruption and nepotism). There is also needed a 'democratic self-control' (*Ibid.*).

Thus, the people (or the majority of people) can eventually and unconsciously betray the ideas of revolution and the very notion of democracy. On the other hand, the population's sensible pragmatism can prove to be wiser than the educated radical and revolutionary minority's lofty ideals and aspirations. Then people by intuition choose a leader who (with all his drawbacks, vices and egoism) will generally choose for the country a moderate and more appropriate course (diverging in the most important aspects from the previous pre-revolutionary policy but at the same time not longing to implement at all accounts the revolutionary slogans). Napoleon III's activity serves a quite typical example here. But at the same time (as we witness it today in some Near Eastern countries) it can happen that even the revolutionary minority itself that has previously strived for power under the banner of establishing democracy can give up the democratic principles. Thus, the conservative majority can turn out to be more democratically-oriented. And this is not surprising. As already stated, in the process of modernization a country's core is modernized quicker and thus, the 'liberal-revolutionary' minority in 'capitals' turns out to be surrounded by the

[7] This means that one should first achieve the cultural-humanitarian level allowing a true democratic transformation, namely, there should be present an intellectual stratum, a certain level of borrowings from the world culture, and certain political forms. But to establish democracy an even higher cultural-humanitarian level is needed as well as a dramatic change in social situation. Besides, democracy is not just an idea but a mode of life; and to take the root it should become a really important part of everyday life. But since in newly democratic states the idea of democracy is quickly discredited, thus it fails to become a really important constituent of everyday life. Here we observe a vicious circle which can be broken only after several attempts and under certain social-economic conditions.

conservative, not to say ‘counterrevolutionary’, majority of provinces (*e.g.*, Korotayev, Issaev, and Zinkina 2015). Against this background, the increasing adherence to democracy on the side of the conservative (‘reactionary’) majority is quite natural as with fair election they have good chances to come to power through an absolutely democratic procedure. Meanwhile, among the revolutionary (‘progressive’) minority the adherence to democratic ideals can be undermined as for them fair elections are likely to end with defeat.

Even with an election falsification in the societies where democracy appears restricted through the manipulation of the ‘party in power’, quite a large share of society or even its majority is loyal to power (even if they are discontented with something) and consequently, conservative. The rulers can win even fair elections but certainly with less advantage than with the faked vote (with 80–90 per cent of votes). Put another way, in theory they could do without falsification but here the system of ‘controlled democracy’ starts operating in its own way and forces the local authorities to demonstrate their loyalty because an unconvincing majority at the elections is considered as a motion of no confidence to an authoritarian ruler.

Returning to the issue of a correlation between revolution and democracy one can remember that the brilliant politician Vladimir Lenin emphasized that ‘the key question of every revolution is undoubtedly the question of state power’ (Lenin 1958: 145). At the early stages of modernization the revolutionaries who are too devoted to their initial slogans inevitably fail because their appeals although being attractive and inspiring for the masses are still unrealizable under existing conditions. That is why the logics of revolution either makes the revolutionaries in power ignore the democracy and even suppress it (as it happened when the Bolsheviks dismissed the Russian Constituent Assembly), thus continuing escalation of violence; or those who are too devoted to democratic revolutionary ideals are substituted (in a non-democratic and less frequently, in a democratic way) by those who are less democracy-driven but are more prone to radicalism, to the deepening of forced changes and to reinforcing the power and themselves in power. The history of the Great French Revolution of 1789–1794 and Napoleon serves here as a classical example.

Pitirim Sorokin who studied history and typology of multiple revolutions in the ancient world (note that in Greek *poleis* and Roman *civitas* intense socio-political struggle between citizens for power and rights was much more frequent than peaceful periods) pointed that famine and/or a war often trigger a revolution (Sorokin 1992a, 1992b, 1994). Lenin also considered the ‘“aggravation of the masses” distresses below usual levels’ as one of the main attributes of revolutionary situation. However, the current researches demonstrate something different: revolutions are often preceded by a rather long period of growth of living standards (see, *e.g.*, Davies 1969; Grinin 2012a, 2012b; Grinin and Korotayev 2013; Grinin, Issaev, and Korotayev 2015; Korotayev 2014; Korotayev, Zinkina *et al.* 2011; Korotayev, Khodunov *et al.* 2012; on the Egyptian revolution see Korotayev and Zinkina 2011a, 2011b, 2011c). But such a growth often combines with exactly the same and sometimes with even larger increase of social inequality and stratification. This increases social tensions in society and brings to life the idea that the living standard achieved by a part of population should become the majority's property. At the same time, the modernization of society brings the formation of a more or less large stratum of intellectuals (and students/ recent graduates as its ‘striking force’) who strive for higher (adequate to their education level) living standards but, naturally, the number of lucrative positions is always limited.

It is of utmost importance that there emerge excessive expectations when the growth of living standards fails to meet the expectations of the majority of population; besides, the increasing inequality and violent breach of common justice on the part of the men in power 'fuels' the discontent. Here the most volatile situation occurs when after a period of sustainable growth there happens an interruption (which is often not the country authorities` real fault; after all, who can smoothly pass the modernization transition? Nobody can). In this case, the people's expectations (as well as those of the elite) continue to grow by inertia, while the real satisfaction level decreases (the so-called Davies' J-Curve [Davies 1969; see also: Grinin and Korotayev 2012b]). As a result the gap between expectations and their satisfaction reaches a critical level and triggers a social explosion. With respect to Egypt this refers both to Mubarak and to Morsi – it is just after the January 25 Revolution that the metropolitan citizens' expectations radically grew while their satisfaction drastically declined which brought the 'difference of potentials' which in many ways led to the dismissal of the first democratically elected President of Egypt. But the same 'difference of potentials' may also turn fatal for new Egyptian regimes.

In what way is the above-discussed related to democracy? First of all, democracy can become the opposition's key idea, a magic wand that is thought to help to solve social problems (naturally implying that democracy is a system that will inevitably bring 'right leaders', that is the oppositionists, to power). And since a rigid regime is in power (principally non-democratic or usurping the power) and naturally resists a quick establishment of democracy, then to overthrow this regime becomes a goal in itself. This regime embodies society's every evil (which is expected to disappear with the fall of the regime). The regime is claimed to have no positive, valuable, and advanced characteristics (everything positive made by regime is supposed to happen all by itself or it is even spoiled by the regime without which this good would have been even better).

However, in spite of the frustration widespread in society, the ideas of democracy actually penetrate the minds only of its some part which often represents neither the society's majority nor even its significant minority. For most people who have a limited cultural intelligence and relatively narrow vital problems, democracy is a mere word (or something established by someone but not necessary for the population to take part in).[8] Under certain circumstances, the ideology-driven minority attracts the majority which is indifferent to democracy (to democracy but not to personal problems) and in this case a revolutionary situation can arise there. But from here it is a long way to a strong democracy. Here it is appropriate to reflect on the correlation between the revolutionary minority and the majority within different contexts. The revolutionary minority is strong in its activity, persistence, ability to self-organize for joint actions *etc*. That is what brings it to the fore of the political scene of revolution; it is ahead and at first seems to represent the whole society. Besides, the radicals/liberals genuinely believe that they are the society, their aspirations

[8] The voting abstention in Russia even when the mass voter turnout could be decisive is quite a typical example. Moreover, a large number of voters (especially among the young) almost simultaneously with the right of voting get a steady ideological skepticism. Why voting? What is the use of it? Nothing will ever change. My vote means nothing. However, it seems easy to go and vote. But probably it is difficult as one should make a choice. On the other hand, there is some truth in this skepticism. The other part of the Russian population is accustomed to voting 'they say we should, then we will vote' but also not for the sake of a reasonable voting. In any case, it is out of question that the skepticism of one part of population and the promptness of the other part have been to the advantage of the party in power and of different kind of political chancers. This example explains how a political apathy may in a democratic way support certain forces in power. Karl Kautski called such masses involved in voting 'the political flock of sheep'.

are necessary for the society (here works the logics that anyone who is against 'us' is the enemy of revolution; who is not with us is against us). If the revolutions are 'superficial' and do not establish universal democracy (as it used to be in Latin America or Spain) then the most part of population stays out of politics. The revolutions are made by rather numerous but still a minority. Here, by the way, originates one of the most important causes of instability of the revolutionary governments since the masses would quite indifferently witness their overthrow. But if a fair (without falsifications) suffrage is immediately introduced then the relation between the revolutionary minority and the majority can significantly change. In such new situation, the latter actually becomes democratic but paradoxically it may still continue to be not convinced in the value of democracy. The example of Egypt proved this rather well. Against the background of meetings and exultation one can really think that all people expect radical changes in the spirit of Western democratic and liberal ideology, but it turns out that the major part of population has rather different values. But in a certain situation the democratic system can actually turn profitable to the conservative ('reactionary') majority and thus it becomes more popular amidst them; meanwhile it loses supporters among the revolutionary ('progressive') minority who strived for power under democratic slogans.

There can be no doubt that the revolutionaries' activity, their good organization, propaganda and persistence also play a great part at elections, but still it is less than it used to be when organizing meetings and actions. Outcries will not lead to an easy victory. The defeat of revolutionaries to a great extent is caused by their internal disagreements (which could seem quite unimportant for an external observer but crucial for the parties themselves).

As a result of such a turn, the democratic elections, for whose sake the revolution is actually undertaken, seem to bring victory to conservative forces and here comes the moment of truth. What is more important for revolutionaries: the democratic ideals or the revolution proper, that is, a constant overthrow and escalation of changes in society? The challenge is solved in different ways by different parties in different countries and situations. Some political forces are unable to reconsider situation and diverge from their absolutes. Thus, the Mensheviks during the Civil War in Russia hesitated to join either the Whites or the Bolsheviks, and disappeared as a political force by 1922. But quite frequently it is just the revolutionism (for the sake of rather vague revolutionary principles but with an ultimate urge for power) becomes of utmost importance. In recent decades, one considers as faked votes any defeat at elections where radicals who previously overthrew the government (or forced it to conduct free elections) failed to win elections (when the hated government actually gives them such an opportunity). The examples of 'color revolutions' in post-Soviet states, in Serbia and other countries prove this rather well. Thereafter, the revolutionaries insist on the solution by force. The logic is that it is not democracy proper that is of utmost importance but the opponent defeated at any cost.[9] This logic is quite clear and explicable. But this is the point where revolution and democracy diverge.

In short, in a society with uncertain democratic values the following principle works: 'We will support democracy if our candidate wins elections. If he does not, we do not need

[9] Revolution (as any kind of politics) is hardly a fair contest, in this or that way one uses provocations, disinformation, deceit, and backstage dealings. The provocations often imply stirring up enmity towards government and opponents through direct or indirect murders (shooting from within crowd or something of this kind; with respect to the Revolutions of 1848 and some other revolutionary events see Nefedov [2008]; recent examples can be found in Brazil or Ukraine) which evoke the escalation of violence, formation of military guards etc. Thus, violence and other rather precarious means become normal. Consequently, the violation of democracy is not considered as something terrible.

such a democracy'.[10] The ability to lose elections, to acknowledge the value of rules of democratic game irrespective of who comes to power, to wait for next elections and work hard to win – these are actually essential signs of social readiness for democracy.

Since revolutions often occur in societies unprepared for democracy, it often happens that at early and intermediate stages of modernization *the pathways of democracy and revolution eventually diverge*. Their conjunction at relatively early stages is an exception rather than a rule. Of course, as we said above, we remember 'velvet revolutions' in Czechoslovakia and some other Eastern European countries, the Glorious Revolution in England, the Carnation Revolution in Portugal *etc.* Of course, it is highly desirable that all revolutions follow the same scenario. However, at initial stages of modernization it can be hardly realized, as 'velvet' revolutions are already the end of a long-lasting social and political development.

Political opponents can make more or less active attempts to turn the revolution to their advantage through reduction, renunciation or abolition of democratic procedures and institutions established during the revolution. Sometimes they succeed; in any case attempts produce some effect. It often provokes a dramatic aggravation of the conflict.

Let us dwell on the question why the pathways of revolution and democracy in countries with unstable democracy should inevitably diverge? In addition to the above mentioned reasons (the unpreparedness of society, idealization of democracy *etc.*) there is a variety of causes.

Firstly, it appears that democracy by itself is insufficient to accomplish the purposes of revolution; you cannot do with democracy alone. Theoretically, democracy is a mean to replace a bad government by a good one which is supposed to automatically assure the county's prosperity. In reality it is certainly impossible. The arrangement of particular matters requires a specific and effective management. But revolutionaries as a rule do not possess such skills. They should either retain old functionaries and managers (who are anyway professional), but then the situation to a large extent remains the same with same abuses; or substitute them, and thus worsen the situation as revolutionary reforms usually aggravate economic situation (see, *e.g.*, Eckstein 1982, 1986; Zimmermann 1990; Haggard and Kaufman 1995; Weede and Muller 1997; Goldstone 2001: 168).

Secondly, since a rapid miracle and general improvement do not happen, and revolutionary actions and ample promises aggravate the situation, it is absolutely essential to find someone to blame and thus, to draw attention away. But then does the respect for democracy really count for? Will the revolutionaries (or radicals, if the moderate revolutionaries come to power) wait for several years to win the next election? Certainly, they will not. The revolutionary epoch is not the time for a quiet life. Everyone wants to obtain the targeted results immediately and without any compromises. If the radicals wait, they will lose their influence, their common followers will start asking hard questions and so on. In this case the democratically elected or a transitional (provisional) government finds itself between the hammer and the anvil (*i.e.* between the radicals, discontent with the worsening situation, and the conservatives displeased with changes and disorders).

Thirdly, the masses, whose main concerns are their concrete and immediate problems (*e.g.,* food for their children *etc.*) become disenchanted with democracy. In general, people gradually cease to connect the solution of acute social problems with an abstract idea of

[10] The elections in such Caucasian territories as Karachay-Cherkessia and South Ossetia, when the opponents renounce the win of the other party and thus trigger the political crisis, is a very illustrative example.

democracy, and instead they associate it with the struggle against enemies of the revolution, of the president, of the party, Islam, Socialism *etc.* It is clearer and more concrete. As a result conditions for radicalization and broadening of revolution emerge. However, as we remember, the more radical is a revolution, the more probably it will transform into reaction.[11] Among other important terms of stability of liberal regimes, Raymond Aron points out the necessity to limit people's demands in the initial period of development of a constitutional regime (Aron 1993: 141). He writes: 'Let us study the situation in France in 1848. The substitution of monarchy by a republic did not increase the society's resources and economic production. For the masses' income to grow it is insufficient to call the regime republican or democratic. The revolutionary changes naturally evoke hopes and demands. And the regime falls victim to discontent'. However, it is obvious that the revolutionary masses support revolution not to level down their demands and to wait for something. They think that they have already been waiting for too long. But since the rapid and excessive demands are difficult to satisfy, the country can slide into economic disaster while the democratic regime risks of being overthrown.

Fourthly, in this context it turns out that the number of the genuinely democracy-oriented people is very small in comparison with those who strive for power or welfare. In a modernizing, rather poor, narrow-minded and suffering from drawbacks society it cannot be otherwise. In corrupt undemocratic societies everybody abuses the law (although, perhaps, a bad law that often complicates life) and accuses of this everyone except for oneself. Everyone thinks in an undemocratic way, even those who struggle for democracy. Only a few people can stick to their principles, but they have little influence. However, one should realize that globalization can really strengthen the people's strive to change the political regime, but nothing can make up for the people's peculiar political experience which helps to transform political mistakes into political wisdom. This refers not only to insufficiently politically aware masses but also to intellectuals who need much time to strip away their illusions. Thus, globalization increases the gap between the rate of getting information and ideological attitudes from outside, on the one hand, and the accumulation of experience and creation of a necessary economic basis for a transition to stable democracy.

Fifthly, democracy as a political system, when people accept their defeat and work peacefully in opposition, has a generally limited social base. It can persist in one form or another, but reduced and misrepresented, though for a society such a substitution proceeds unnoticeable for some time.

Sixthly, genuine democratic institutions do not meet the purposes of revolution. Quite frequently radical revolutionary changes are realized through constituent assemblies, parliament *etc.* It works well in the beginning and with respect to the most urgent or consensual changes. But revolution often involves radical, drastic, grave, impetuous destruction. Common parliamentary procedures with their long discussions, procrastination and respect

[11] The 'reaction'/'counterrevolution' is usually considered to be a definitely negative phenomenon (while revolution is associated, though not so unambiguously, with something positive – among other things just because it is supposed to lead to democracy). But such an interpretation is not always reasonable. The reaction often plays a rather positive role preventing the aggravation of revolutionary upheavals and thus establishing more balanced and viable political institutions. Sometimes positive aspects of political reaction's processes are more pronounced, than the negative ones. For example, the Thermidorian reaction of 1794 can be considered just as an attempt of the French political leaders to mitigate rampage of the Jacobin Terror which caused the fierce civil war in many provinces and to form a new more viable social and political system. One can also point to a positive component in the Bonapartist reaction to the French revolution in 1848. History gives numerous examples.

for minorities do not satisfy the society. That is why assemblies, parliaments, councils, *majlis*es can issue laws and decrees to launch radical changes, but it is the dictatorial authority (a party, central committee, executive committee, leader *etc.*), relying on revolutionary source of power and, therefore, independent from the parliament, that should run the state. It is those authorities that solve the major problems and then submit the decision for approval. The democratic and pseudo-democratic decision-making process is quite often used to approve determining and fundamental documents and to consolidate the winning party's power. That is what Morsi did with the Constitution. In January 2014 Morsi's opponents did the same. In fact, the decree on the preparation of a new Constitution was almost the first step of Egypt's Interim President Adly Mansour in July 2013.

It is not surprising that dictators so like referenda which consolidate their power. *In fact, the democratic institutions turn out to be subsidiary.*

Thus, a genuine and full-scale democracy, that revolution strives to formalize, soon enough starts to contradict both the real purposes of revolution and other political (party, group and private) goals and conditions.

Democratically elected authorities (or even a transitional pro-democratic government) is either overthrown or separated in full or in part from democracy (transforming into a pseudo-democratic organization like the Long Parliament of England). As has been mentioned above, we speak about societies that have not completed modernization; meanwhile, more culturally developed and advanced societies can frequently transform a post-revolutionary regime in a firmly liberal one.

One should also keep in mind that the key issue of revolution is always the one of power, so democracy is acceptable as long as it supports the domination of the most powerful group, party, social stratum *etc.*

Since large-scale and omnipotent democracy does not fit the revolutionary transformations, and due to the lack of necessary institutions and ability to live according to democratic laws (as well as to the fact that revolution is always a struggle – sometimes illegal – between opposing forces, involving huge masses of people), *in the revolutionary and post-revolutionary period a pure democracy is reduced and transformed to a degree and in different ways* depending on society's peculiarities, results of political struggle and other factors. In societies which are ready for democracy and where modernization has been completed, this can be an insignificant reduction (similar to the prohibition to propose a candidate from among the former members of communist parties *etc.*). It is worth noting that universal suffrage, taken as a model today, was not legalized in a day, there often were applied voting qualifications. Even in the USA, whose comprehensive democracy fascinated Alexis de Tocqueville (1830), democracy was not perfect. The Amerindians, Afro-Americans, women and a considerable part of men (who acquired the right during Jackson's presidency) were deprived of electoral right. Moreover, the presidential elections were a staged procedure (quite real at that time). In the cradle of modern democracy, Great Britain, in 1830 only a small percentage of population had the voting right. In 1789, in France the part of the Estates-General, which at first declared themselves the National Assembly and then the National Constituent Assembly, passed many well-known laws. But one should remember that the election rules there had little, if anything, to do with the current notion of democracy.

Just as embryo passes certain development stages, the non-democratic societies, striving for democracy, go through stages of evolution of democracy associated with its limitation. *But in many cases democracy is limited because it fails to function to the full just due to the above-mentioned reasons.*

In the course of revolution, the restrictions can be associated with attempts to secure political advantages, and also with revolutionary and counterrevolutionary violence (we can observe both in Egypt), with activity of a powerful ideological or any other center (as for example, in Iran), with a dictatorial body, with an introduction of property or political qualifications, with assassination or arrests of the opposition's leaders (what has happened in Egypt recently), with curtailment of free speech and associations, formation of unconstitutional repressive bodies *etc.*

The post-revolutionary regime also restricts democracy or just imitates it. In contemporary world the most widespread forms of limitation of universal democracy (without which only a few governments perceive themselves legitimate) are different kinds of falsification of election results which often combine with repressions of political opponents (the recent example is Ukraine where one of the opposition political leaders was imprisoned), and constitutional and legal tricks (Russia shows remarkable examples). There are some peculiar cases when there is an unconstitutional or constitutional, but non-democratic, force which enjoys supreme authority (Iran). Other forms are possible as well. The most widespread one is still the military coup or attempts to conduct a revolutionary overthrow (Georgia and Kyrgyzstan provide numerous examples). The military forces step in when a democratic government decays or degrades or when a state reaches an impasse. Anyway, the course of democracy development is corrected. On the other hand, the military also cannot remain in power endlessly or even for too long without legalizing the regime, so they have to hand over authority to the civilian community and hold elections.

Thus, the general political course of modernizing societies follows the democratic trend (increasingly approaching the ideal), but the fluctuation along this trend can be severe and painful. The development can remain incomplete, oscillating within the controlled democratic system.

In Egypt, the last presidential elections (May, 26–28, 2014) were much less democratic (even in comparison with the previous ones) because the Muslim Brotherhood was proclaimed a terrorist organization. The path to genuine democracy is very long (it is necessary to eliminate illiteracy along with solving other problems), but the chance is rather good that there will be established a new dictatorship in the form of controlled democracy and military power, supporting the authorities.

Another important point explains why democracy cannot be established in a post-revolutionary society or quickly degrades there. 'Democracy is the worst form of government, except for all the others', said Winston Churchill. For the societies that just enter this path, the first part of the phrase is of utmost importance. Democracy (just as free market and private property) has numerous drawbacks. Mature democratic societies, among other things, have found some means to mitigate them. But in young democracies these drawbacks get excessive forms. And acquiring immunity against such 'infantile diseases' of democracy is a long and painful process. As a result, a society can turn out to be abnormal (as in the case with lack of immunity against private property and free market – actually, rather egoistic institutes if they are not restricted). It is clear that an introduction of formally democratic institutions is absolutely insufficient, since although including multi-party elections, they often conceal and even legitimate an actual dominance of authoritarian rule (Diamond, Linz, Lipset 1995: 8; see also Diamond 1999).

In conclusion, we should note that the transition from an authoritarian regime to democracy can occur in three main ways: through a revolution (quickly from below), a military takeover or coup d'etat, and a reformation (gradually from above). In previous epochs the reformative way was almost impossible, so the path to democracy was paved by revolutions and counterrevolutions. Still some rather successful examples of reformative transition to democracy (or just a step in this direction) can be observed as early as in the nineteenth century. For example, in Japan there the parliament was established from above (1889). In Germany Otto Bismarck introduced full male suffrage (1867), while in Prussia the election system proper was established by the Revolution of 1848. Some Latin American states experienced transitions from military dictatorship to democracy, but the latter could not be firmly established in this region, with a few exceptions. However, in the twentieth century, especially in its last decades, due largely to globalization, we can find numerous examples of voluntary dismantling of authoritarian and totalitarian regimes by the very military or other dictatorship (in Spain, Chile and other Latin American countries, South Korea, Taiwan, Indonesia, lastly the USSR). Some significant steps towards democratization were also made by the Arab monarchic states. Paradoxical at first sight, but on the eve of the Arab Spring most Arab monarchies appeared much more democratic, than the majority of the Arab republics (see, *e.g.,* Truevtsev 2011).

Such a non-revolutionary transition to democracy, ceteris paribus, can turn out to be more direct and secure. This is especially important against the background of the absence of any significant positive correlation between the democratic government and the GDP growth rates – what is more in authoritarian states higher GDP growth rates are more likely than in young democracies – let alone post-revolution systems (Eckstein 1982, 1986; Zimmermann 1990; Haggard and Kaufman 1995; Weede, Muller 1997; Goldstone 2001: 168; Polterovich and Popov 2007). And in the modernization context economic growth rates are of crucial importance.

Democracy, Revolution, and Counterrevolution in Egypt: An Analysis of Conflicting Forces

Our young Egyptian friends (a sort of 'leftist liberal revolutionaries') consider the post July 3 events in their country as 'counterrevolution'. And we would tend to agree with them – though with some important difference. Almost by definition, revolutionaries regard the 'counterrevolution' as something unequivocally negative; whereas we believe that the present-day political regime has serious positive respects (though, no doubt, its formation has led in the recent two years to a significant growth of the authoritarian tendencies). Yes, it may well be denoted as 'counterrevolution', as it returned to power that very block of military, economic, and bureaucratic elites that had ruled the country before the 2011 Egyptian Revolution. However, as we have already demonstrated this before (see, *e.g.*, Grinin 2012b; Grinin, Korotayev 2012a, 2012b: 251–289; Korotayev, Zinkina 2011a, 2011b, 2011c; Korotayev, Khodunov *et al.* 2012), it ruled Egypt in a rather effective way, securing in the years preceding the Revolution a rather successful (especially, against the global background) economic and social development of this great country.

However, it would be rather wrong to say that Egypt has returned now precisely to that very state where it was before the revolution. And some newly emerging features contribute evidently to the regime destabilization. This is first of all the radicalization of the

Muslim Brothers coupled with the emergence of their very strong media support in the form of al-Jazeerah's satellite channel 'Mubasher Misr'.[12]

On the other hand, there are much more of those features that have emerged during the Egyptian Revolution and the Egyptian Counterrevolution that contribute to the regime stabilization.

The Egyptian 2011 Revolution was able to achieve a rather easy victory due to the following two points:

First of all, this was a very strong elite conflict (that is so important for the success of revolutions in general [*e.g.*, Goldstone 2001] and that was especially important for the success of the Arab Revolutions in 2011 [see, *e.g.*, Nepstad 2011; Malkov *et al.* 2013; Issaev *et al.* 2013]). This was mostly the conflict between the military ('the old guard') and the economic elite ('the young guard') – a group of the leading Egyptian businessmen headed by Gamal Mubarak. The military group controlled (and controls) not only the Egyptian Armed Forces, but also a major part of the Egyptian economy. And these are not only military factories, but also large pieces of land, various real estate, fuel stations, construction and transportation enterprises, as well as various factories that produce not only military production, but also things like TV sets, refrigerators, spaghettis, olive oil, shoe cream and so on.[13] Estimates of the share of the Egyptian economy controlled by the military range between 10 and 40 per cent [14] (Roy 1992; Nepstad 2011: 489; Tadros 2012; Marshall, Stacher 2012). This group of the Egyptian elite was frightened by the ascent of the 'young guard' of the leading Egyptian businessmen (under the leadership of Gamal Mubarak) who controlled the economy block of the Egyptian government. Since 2004 this government had been implementing rather effective economic reforms that led to a significant acceleration of economic growth rates in Egypt (*e.g.*, Korotayev, Zinkina 2011a, 2011b, 2011c).

> Over the past decades, the Egyptian military has not limited its focus to security matters; it has also acquired valuable real estate and numerous industries. By one estimate, the military commands up to 40 per cent of the Egyptian economy. Before the events of 2011, Egyptian officers expressed concern about President Mubarak's plan to appoint his son Gamal as his successor. If Gamal took office, many believed that he would implement privatization policies that would dismantle the military's business holdings (Nepstad 2011: 489; see also Roy 1992; Tadros 2012; Marshall, Stacher 2012).

Indeed, there were all grounds to expect that in case of Gamal Mubarak's coming to power the leading Egyptian businessmen from his circle will establish an effective control over the generals' economic empire – and it would be rather easy to justify this indicating to (quite real) ineffectiveness of exploitation of the respective economic assets and the necessity to optimize it.

The Egyptian elite conflict allows understanding some events of the Egyptian Revolution that may look mysterious at the first glance. For example, throughout the revolution the army guarded quite rigorously all the official buildings, effectively blocking all the attempts by the protesters to seize them. However, already on the first days of the Revolution (on the 28th and 29th of January, 2011) the army let protestors seize, crash, and

[12] http://mubasher-misr.aljazeera.net/livestream/.

[13] Note that military factories (virtually possessed by Egyptian generals) have a clear competitive advantage, as they can exploit virtually free labor of the conscripts (see, *e.g.*, Tadros 2012).

[14] However, the latter estimate appears to be clearly exaggerated.

burn the headquarters of the ruling party of Mubarak's Egypt – the National Democratic Party. However, at a closer inspection one will not find here anything strange – as the real head of this party was just Gamal Mubarak; thus, the military elite delivered a very strong blow upon its archenemy with the hands of the protestors (see, *e.g.*, Issaev, Shishkina 2012).

Within the context of the still rather fashionable interpretation of the Egyptian events of January and February 2011 as a sort of 'confrontation between revolutionary people masses and the repressive authoritarian regime' one could hardly understand the apparently enigmatic (but extremely famous) 'Battle of the Camel', when there was an attempt to disperse the Tahrir protesters on the part of a motley crew of cameleers – workers of tourist services operating in the Pyramids area and engaged in renting horses and camels to tourists; the cameleers attacked the protesters while riding camels and horses (which, incidentally, rendered a specific exotic color to events of February 2 – and to the Egyptian 2011 Revolution, in general). However, if this was indeed 'the confrontation of popular masses and the repressive authoritarian regime', why was it necessary for the "authoritarian regime" to employ such strange amateurish figures, and not to use such a simple thing as the professional repressive apparatus? The point is just that already on the 2nd of February Tahrir protesters confronted not the professional repressive apparatus controlled by the 'old guard' (that took the position of friendly neutrality toward the protesters), but the economic elite clique that in order to counteract the protesters (who demanded the removal of the businessmen's leader) had to employ semi-criminal elements rather than professional repressive apparatus (see Essam El-Din 2011; Issaev, Shishkina 2012: 70–73; Issaev, Korotayev 2014 for more detail). Thus, already in early February 2011 the protesters in Tahrir were countered not by the repressive apparatus of the authoritarian state, but by a clique of the businessmen who were very rich indeed, but who did not control the repressive apparatus – which accounts for a very easy 'victory of the revolutionary masses' up to a very considerable extent.

The second point that secured an unexpectedly fast success of the protestors was the formation of an unexpectedly wide opposition alliance, which united in a single rather coordinated front very diverse forces including not only all the possible secular opposition groups (liberals, leftists, nationalists and so on), but also Islamists in general, and the Muslim Brothers in particular.

The situation that we observe now is *exactly the opposite*.

Firstly, the Egyptian Revolution made the Egyptian economic elite reconcile with the military, and in June 2013 they acted together in a well-coordinated front that allowed such a swift overthrow of President Morsi (see Issaev, Korotayev 2014 for more detail); whereas no serious cracks in the new coalition of the Egyptian military and economic elites (that was formed in the first half of 2013) appear to be visible yet. The economic elites have understood that for them it turns out to be extremely counterproductive to continue any serious attempts to get hold of any economic assets controlled by the military, that it is much better for them to recognize the dominant position of the military in the ruling block, as well as the immunity and inviolability of the generals' economic empire (among other things – through direct constitutional amendments). The economic elites have understood that any serious attempts on their part to get dominant positions in the ruling block may result in their losing incomparably more than gaining.[15]

[15] Emergent cracks in the ruling coalition (see, *e.g.*, Gulf News 2014) are rather connected with the participation in this coalition of some leftist secularists (first of all, Hamdeen Sabahi and his Egyptian Popular Current [*al-Tayyar al-*

Secondly, the Revolution with the subsequent Counterrevolution led to an extremely deep split in the January (2011) opposition 'macroalliance'. What is very important is that this split took place along many lines. Within this macroalliance even the Islamist alliance was split – as the July 3 coup was supported by the second strong Islamist party – the party of Islamist fundamentalists/salafis Hizb al-Noor (as well as a number of prominent Islamic figures outside this party). Of course, the support of secularist-military regime by the Egyptian Salafi Islamists needs a special commentary (a special commentary is also naturally needed for the fact that in July 2013 the archconservative Islamist Saudi Arabian regime acted as a faithful ally of the anti-Islamist alliance that included an exceptionally wide range of forces – liberals, nationalists, leftists, ultraleftists – up to Trotskyists [Abdel Kouddous 2013; Baer 2013; Nasr 2013; al-Alawi, Schwartz 2013; al-Rasheed 2013]). The main point here appears to be connected with the fact that Saudi Arabia acts as the main financial sponsor of Hizb al-Noor (Daou 2012; Lavizzari 2013). And as regards Saudi Arabia, the Muslim Brothers pose a real threat to the respective country's regime. In 1937 in the USSR it was much less dangerous to proclaim oneself a Slavophil rather than a Trotskyist (in 1937 the latter [but in no way the former] would have led to an almost immediate execution) – whereas for non-Marxists the difference between Stalinists and Trotskyists could look entirely insignificant. Similarly, for the Saudis Trotskyists are a sort of unreal exotics, whereas the Muslim Brothers for them are almost the same as the Trotskyists were for Stalin – they are precisely those leftist Islamists who question effectively the very basics the regime legitimacy and may even take concrete steps to overthrow it (Baer 2013; Nasr 2013; al-Alawi, Schwartz 2013; al-Rasheed 2013]). And against such a background one can easily understand the readiness of Saudi Arabia (+ the UAE and Kuwait that have similar problems) to ally with anybody (including anti-Islamist minded liberals and Communists, let alone Egyptian military and economic elites) in order to weaken in its own homeland the enemy that threatens the very survival of the Arabian monarchical (with the natural exception of the Qatar monarchy). On the other hand, for the Egyptian Salafis the removal of the Muslim Brothers from the legal political arena was somewhat advantageous objectively (irrespective of any connections with the Saudi interests), as it allows to strengthen significantly their own positions, including the potential further widening of its presence in the Egyptian parliament – as the present-day main legal Islamist party of the country.

The secular leftist-liberal alliance has been also split, as the majority of its members were so frightened by one year of the rule of Muslim Brothers, that continue to support the present regime. However, the forces that continue to oppose the regime remain deeply split – as the anti-regime leftist liberal-revolutionary youth still refuses any idea of a new alliance with the Muslim Brothers; suffice to say that one of its main slogans *Yasqut, yasqut illi khan, in kana `askar aw ikhwan* is translated as follows: "Down, down with all those who betrayed – be they military, or Muslim Brothers!" We believe that new revolutionary paradoxes in Egypt will not keep us waiting.

Thus, the revolutionary events often assume a paradoxical character. For example, one may sometimes get across such revolutions which the revolutionaries do not expect.

Sha`biyy al-Misriyy]), whereas the continuation of the cooperation of this part of the ruling alliance with both military and (especially) economic elites can in no way be guaranteed – one would rather expect to see eventually the final split between the left-wing and right-wing secularists in Egypt.

The revolutionary repressions may often turn against those who were actually meant to benefit revolution. And those whose names were on the banners when overthrowing the old power join on a mass-scale the counter-revolutionary camp. The zealous monarchists or the henchmen of authoritarianism suddenly turn into democrats, while those who considered democracy as the highest value get ready to establish a dictatorship.

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Approaches and Paradigms in Defining the Essence of Globalization*

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Lying at the core of Global Studies, globalization still remains among the most challenging phenomenon. Taking into account the complexity of the phenomenon itself, it is not surprising that scientific and popular scientific literature has been flooded with hundreds of different definitions of globalization. It is described as 'the compression of time and space' and 'the onset of a borderless world'; 'an ideological construct'; 'an inexorable integration of markets' and 'a worldwide integration of humanity'; 'the erosion of the nation-state', 'the triumph of the capitalist market economy' and 'McDonaldization of society' (al-Rodhan and Stoudmann 2006: 41–62). According to a famous globalization expert, Jan Nederveen Pieterse, 'globalization is like a prism in which major disputes over the collective human conditions are now refracted: questions of capitalism, inequality, power, development, ecology, culture, gender, identity, population, all come back in a landscape where "globalization did it"' (Nederveen Pieterse 2009: 7).

This colorful range of definitions, many of which are only indirectly (sometimes ambiguously, or even adversely) connected with one another, relates to a no less diverse set of paradigms and perspectives emerging in globalization studies. For instance, Swedish researcher Göran Therborn provides 'at least five major discourses … that usually ignore each other – competitive economics, social criticism, state (im)potence, culture and planetary ecology' (Therborn 2000: 151).

Apart from the inevitability of globalization, frequently disputed issues include its (ir)reversibility, its most likely future trajectories, and – perhaps the most widely debated question of all – its manifestations and implications for various involved actors, from the planet or humanity as a whole to particular individuals, lifestyles, traditions, economic activities, landscapes, *etc.* However, the answers to any of such specific questions posed by researchers of globalization – and even the wording of the questions themselves – depend on the definition of globalization chosen by a researcher. For this reason, let us try to outline the diversity of the existing definitions and interpretations of globalization, as well as the most relevant approaches to its study, and then determine our own position within this variety.

One of the earliest (and rather detailed) definitions was proposed neither by 'The Economist', nor by Bill Gates in his bestseller 'The Road Ahead', but – maybe surprisingly for the younger readers – by Karl Marx and Friedrich Engels in the 'Communist Manifesto', first published in 1848.

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Not mentioning the word 'globalization', they, however, pointed out a number of key aspects of this phenomenon, such as 'new industries', whose introduction becomes a life and death question for all civilized nations, by industries that no longer work up indigenous raw material, but raw material drawn from the remotest zones; industries whose products are consumed not only at home but in every quarter of the globe.

> In place of the old wants, satisfied by the production of the country, we find new necessities requiring for their satisfaction the products of distant lands and climes. In place of the old local and national seclusion and self-sufficiency, we have intercourse in every direction, universal inter-dependence of nations. And this refers both to material and to intellectual production. The intellectual creations of individual nations become common property. National one-sidedness and narrow-mindedness become more and more impossible, and from numerous national and local literatures, there arises the world literature (Marx/Engels 1848: 16).

The fact that many aspects of such a relatively recent phenomenon were accurately noticed more than 150 years ago makes one wonder about the true age of globalization and its historical antecedents – even though a truly massive surge of research interested in the diverse aspects of globalization occurred much later, starting in the 1980s and 1990s. Since that time, thousands of academic papers have been published (not to mention the popular scientific literature), addressing the very essence of globalization, its 'age' and its effects on various spheres of human life. Many of these offered their own definitions for the globalization phenomenon, more or less detailed, relatively general or highlighting some particular aspect(s) – and, of course, widely differing in meaning.

Typology of Definitions

Economic globalization

A major part of the existing definitions tend to interpret the phenomenon of globalization primarily through its economic dimension. We can note that 67 out of 114 definitions of globalization collected in a systematic review by Nayef al-Rodhan and Gérard Stoudmann are economic in their nature (al-Rodhan and Stoudmann 2006: 36, 41–62). The most frequently mentioned aspects of globalization include the following:

- global economic integration;
- increasing international (cross-border) economic activity;
- growing economic interconnectedness and interdependence of national economies: increasing sensitivity of local key economic variables to the mentioned changes at the regional and global level;
- rising global markets;
- increased international mobility of goods, capital, and labour;
- rapid expansion and growing influence of transnational corporations;
- international division of labour and global production chains; and
- common standards and global standardization.

Political globalization

Political definitions of globalization are closely connected with the growing influence of global governance, as well as its major institutions, such as the UN, WTO, IMF, World Bank, G-8 and G-20, *etc.* Although these institutions do not constitute a single structure, which could be called 'global government', the increasing expansion of their activity results in the rising political integration of transnational actors. Their most important responsibilities include defining standards and rules of interstate interaction; joint management of the collective efforts of national governments, non-governmental organizations, civil society and other actors in addressing global challenges; and joint development of solutions to problems involving the interests of more than one state.

One of the most debated aspects of political globalization is the weakening of nation-states through the reduction of their sovereignty due to the growing influence of global governance structures, MNCs and global capital markets, international law and legal institutions, and 'military blocks' (such as NATO) (Held *et al.* 1999: 212–222; Holton 2011: 124–132). One of the leading American sociologists, Michael Mann, shows that it is possible to encounter similar statements about the 'demolition' or 'marginalization' of the nation-state in the works of many representatives of different spheres of science and art – writers, philosophers, geographers, social scientists, and business economists, *etc*. (Mann 1997: 473).

Here we should underline two concurrent trends: 1) a number of economic, technological and other components of globalization undermine the sovereignty of states and their position as the main actors of international relations; 2) most states voluntarily and deliberately limit their sovereignty on certain issues (Grinin and Korotayev 2009: 489–505).

Cultural globalization

As a rule, socio-cultural definitions of globalization are more general in their wording than economic ones. Humanity still lacks a single, universal and comprehensive definition of culture (and things will most probably remain the same). So, one can hardly expect to encounter a comprehensive and universally acknowledged definition of cultural globalization (see Holton 1992: 182–185; Holton 2011: 189–192; Hopper 2007).

In general, there are three most important (and partly opposing) perspectives concerning the understanding of the relationship between globalization and culture. In the first one, globalization is considered as a process leading to unification and homogenization of culture around the world. These ideas are closely related to the idea of globalization as the worldwide spread of the Western or, more specifically, American cultural hegemony (see, *e.g.,* Ritzer 1993, 1998).

The second one is closely connected to the first and is based on the ideas about local cultures resisting the influence of the globally dominant culture. Cultures are emphatically juxtaposed in this paradigm, as well as their embedding societies. There are also abundant examples of scientific and popular scientific works in this field, among them the 'Clash of Civilizations' by Samuel Huntington and the 'Jihad vs. McWorld' by Benjamin Barber (1995).

However, the idea of a universal cultural 'Westernization' or 'Americanization', as well as the ideas of clash and confrontation of cultures have been subject to multilateral criticism due to their inconsistency with reality. Empirical evidence of the cross-national research showed a lack of global convergence of values. Thus, American sociologist and the leader of the World Values Survey covering 78 countries, Ronald Inglehart, once claimed: 'Globalization seems pervasive. So, one might think, the world's cultures must be converging into one homogenized global value system. But they aren't. Evidence from the World Values Survey indicates that the value systems of rich societies are moving in a common direction – but they are not converging (at least, not during the past 20 years, the period for which we have data). Religious differences and other historical differences continue to shape human values today' (Inglehart 2005).

It is possible to underline a number of large-scale trends that run contrary to the ideas of 'cultural homogenization'.

Firstly, getting into a different cultural environment, the representatives of Western culture often acquire new traits and new values, which differ from those in Western societies. An illustrative example is McDonald's restaurants in different countries, which include dishes based on the traditions of local cuisine and religious requirements in their menu.

Secondly, different regions may have their own dominant cultures, whose spread and influence on the surrounding cultures can be much stronger than that of 'Westernization' – indeed, 'for the people of Irian Jaya, Indonesianization may be more worrisome than Americanization, as Japanization may be for Koreans, Indianization for Sri Lankans, Vietnamization for the Cambodians' (Appadurai 1990: 295).

Finally, the spread of western multinational companies producing consumer goods, means not only (and not that much) cultural globalization, but economic phenomena: unified organization of production, methods of management and quality control, as well as uniform standards. Therefore, the question about the depth and nature of the impact of these changes on the culture of individual societies remains open (Holton 2011: 198–199).

In contrast, the third perspective, perhaps the most promising one for now, focuses on increasing cultural diversity due to the intensification of transnational cultural flows, increased frequency of contacts between different cultures (including between the geographically remote one) through their frequent encounters in media, *etc.* Thus, globalization leads to blending, interpenetration, and 'recycling' of particular elements of different cultures within various social frameworks. The concepts of 'global peripherization', 'creolization' and 'hybridization' proceed from this perspective in order to describe adaptation, domestication of local cultures to global cultural exchanges, trends and phenomena (see, *e.g.*, Appadurai 1996; Hannerz 1992, 1996; Nederveen Pieterse 2009). Cultural hybridization can also be perceived as an example of the phenomenon of 'glocalization' – a concept introduced by Roland Robertson (1992, 1995). Considerable attention is also given to the culture of new information technologies, such as spread of the Internet and creation of a global information environment.

Paul Hopper introduced one of the potentially most productive approaches to study cultural globalization, which rather focuses on practical implementation and verification of specific hypotheses than on theoretical concepts. He studies the phenomenon of globalization by dividing it in separate dimensions, such as the impact of global factors on dynamic changes of rules and practices, values, patterns, and symbolic forms of different cultures; spatial displacement (permanent and temporary migration) of those who represent other cultures than dominate culture, personal and virtual contacts between representatives of different cultures; especially the 'internalization' of new global cultures ideas and meanings, *etc.* (Hopper 2007: 41).

Environmental aspects of globalization and sustainable development

This discourse regards not the globalization *per se*, but rather its observed and projected impacts on the world development. It is within this discourse that humanity and global society started to be viewed as a part of a planetary ecosystem with all its resources. The pioneering works by Jay Forrester and his student Dennis Meadows are focused on global modeling and studying the interdependence of various processes in their dynamics.

'Limits to growth' (1972), which became the first official report of the Club of Rome, included warnings about serious global threats that may hinder the global development from being sustainable – such as the reduction of energy reserves and other resources as well as because of intense pollution. These findings resonated globally and attracted tremendous attention to environmental issues in the 1980s that resulted in the widespread introduction of energy-saving technologies (Sadovnichy *et al*. 2012: ch. 1).

Ideas Underlying the Concepts of Globalization

While looking into attempts to define globalization not through economy, politics, culture, social sphere, *etc*., but through the essence of its constituent processes and driving forces and their factors, we can distinguish three basic ideas around which a great part of the globalization discourse is concentrated.

'Compressed' World

This idea suggests that due to technological progress there is a 'compression' of time and space, which lies at the core of globalization (Harvey 1989). We mean here not the absolute geographical distance between countries, which, surely, has remained stable (setting aside the cases of border changes), but the 'relative distance', as due to the modern technology, people, goods, capital, ideas and knowledge nowadays are able to overcome distances much faster and cheaper (though we need to emphasize here that the cost and the speed decreased unevenly around the world).

Technological progress, particularly the spread of the Internet since the first half of the 1990s, inspired a number of research papers on the 'compression' of time and space and, more broadly, the transformation of their role in the globalizing world. In this respect, the classic work by Manuel Castells 'The Rise of the Network Society' (1996) should not be missed out. Having introduced the notion of 'timeless time', Castells claimed that the global society's independence from time is accelerated by new information technology. Therefore, the global economy (primarily, global capital markets) can function as a single organism, as a whole system in real time. According to Castells, further technological development can lead to the full independence of capital and culture from time.

The then-chief editor of *The Economist* Francis Cairncross presents an extreme point of view on 'the death of distance', claiming that 'the distance will no longer determine the cost of electronic communication. Once investment in a communication network (purchase of a computer or phone, or creation of a web site) is made – an additional cost of sending or receiving any information almost equals to zero. Any form of communication will be available for mobile or remote usage' (Cairncross 2001: xiii).

'Borderless' world

Many definitions of globalization coined in the 1990s, including the economic ones, focus on the growing easiness in overcoming national borders, on increasing cross-border flows and interactions: 'globalization is a process that encompasses the causes, course, and consequences of transnational and transcultural integration of human and non-human activities' (al-Rodhan and Stoudmann 2006: 36).

The idea of 'vanishing borders and barriers' is closely connected with the ideas of partial loss/limitation of national sovereignty of states through the expanding influence of global governance institutions, international law, and transnational economic actors, such as TNCs and global capital markets.

Equal to the reduced role of distances, the decreased role of national borders, and the growth of cross-border flows, connections and interactions are often attributed to the spread of modern technologies, first and foremost the Internet. In its extreme form, the idea of 'vanishing borders' means that the world (especially the global economic space) becomes 'a single, seamless unity' without any barriers (see, *e.g.*, Ohmae 1999, 2005).

'Interconnected' world and global networks

This idea proceeds logically from the abovementioned increase in cross-border linkages and flows, and the declining role of borders and barriers. Some definitions of globalization suggest that its essence consists in the increased connectivity of the global world, in strengthening global networks of relationships, flows and interactions. Jan van Dyck and Manuel Castells are among the authors of the concept of the network society; the latter introduced also the concept of the 'space of flows'. According to Castells, society, in other words the social space, is being formed around flows of capital, information, technology, organizational interaction, images, sounds and symbols. 'Space of flows' reflects the processes prevailing in the economic, political and cultural life of society, and produces the structure of this society. At the same time, elites of a network society are not tied to a particular geographic area, but to this very 'space of flows' (Castells 1996: 412–413).

Further research on global networks and flows has significantly enriched our knowledge of these concepts. Jonathan Friedman has identified globalization as a set of processes through which local economy is connected to the global information network and to the global market network (Friedman 2001). Christopher Chase-Dunn and his colleagues describe globalization as 'the increasing global density of large-scale interaction networks with respect to the density of smaller networks' (Chase-Dunn, Kawano, and Brewer 2000: 77). Leonid Grinin and Andrey Korotayev define globalization as 'the process by which the world becomes more connected and more dependent on all its actors. Consequently, there is as an increase in the number of common challenges for states and an expanding number and types of integrating subjects' (Grinin and Korotayev 2009: 495).

What is Missing?

Despite the voluminous globalization discourse, a number of crucial points are still lacking in our understanding of the phenomenon. First and foremost, we need a sufficiently comprehensive definition of globalization to serve as a starting point in verifying numerous globalization-related hypotheses and ideas on concrete data before we can consider them true, or false, or partially true, or true under certain conditions *etc.* The most vivid example of a widespread catchphrase with very ambiguous (or, even further, directly contradictory) data background is the idea of 'cultural homogenization' and 'cultural Westernization'. The absence of a comprehensive definition which could introduce the dimension of measurability into the complex phenomenon of globalization (and not just one or several of its aspects, such as the volume of foreign trade, or number of Ikea stores in a country – sometimes insignificant, frequently volatile – see Zinkina, Korotayev, and Andreev 2013).

In our opinion, such a definition, allowing for a multi-dimensional, systemic view of globalization and its constituent processes, can be borrowed from a prominent global politics and economics scholar George Modelski, who aimed at combining two approaches: the 'connectivist' approach, viewing globalization as the increase of transborder interactions, relations, and flows, and the institutional approach, which explains globalization as the emergence and evolution of global, planetary-scale institutions. Let us emphasize that 'institutions' is a very wide-encompassing term for Modelski, so this notion includes global free trade, TNCs, global governance, worldwide social movements and ideologies, *etc.* (Modelski 2008).

This approach can be enriched by the ideas of the Russian school of Global Studies, viewing the emergence and development of global (planetary) social institutions as a result of co-evolution of natural, social, and socio-natural processes (Ilyin and Ursul 2010, 2012, 2013a, 2013b; Ilyin, Ursul A., and Ursul T. 2013; Ursul and Ilyin 2010).

In our opinion, such a combined approach to defining and studying globalization allows for a whole new paradigm, posing globalization into a wider socio-natural context, as well as adding not just a historical, but an evolutionary dimension.

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BRICS: Prospects of Cooperation*

Oleg A. Alekseenko

In the present article BRICS is considered as a form of integration with peculiar geographical and functional characteristics which allows considering it as a new type of interstate cooperation. The main focus is on the interaction between the BRICS member countries and their role in the contemporary international relations.

Keywords: *BRICS, integration, international organizations, international affairs, policy, new world order, globalization.*

The current geopolitical trends indicate that today the center of decision-making on global issues is gradually shifting to some new inter-state associations. On the one hand, there emerge regional organizations which promote interests of their members and seek to offer a consolidated position in solving international issues. On the other hand, the former and new centers of power conduct a formal and informal dialogue on the controversial issues in their relations. BRICS represents a framework for a dialogue between countries with different social and economic models, and moreover, belonging to different civilizations. In this context it is essential to analyze both, the commonalities and contradictions between the BRICS member countries.

China

China considers BRICS-cooperation as instrument for the formation of a new, just, and rational world order which will provide favorable conditions for the country's further development. The PRC officials as well as the Chinese authoritative expert centers regularly confirm this point in their statements (Yuan 2007).

The Chinese urge the BRICS member countries 'to pay attention to security issues, to strengthen cooperation on major regional affairs and to deepen cooperation in all areas' (Zhen'min Zhibao 2012b). This is the evidence of China's concern with the political pillar of the association. The Chinese leaders consistently emphasize that cooperation and common development with the BRICS countries (alongside with the G20 and SCO) is the priority of the country's foreign policy (Zhen'min Zhibao 2012a). China promotes the institutional formation of BRICS as an informal dialogue, implying the creation of specialized areas of cooperation among member-states in all relevant spheres. China regularly emphasizes the essential economic complementarity between the BRICS countries. It is noteworthy that at the same time the PRC constantly highlights that it is the largest economy of the BRICS-cooperation; consequently, following the logic that 'economic power determines political influence', it strives to be the leading actor of the group.

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The establishment of cooperation within the BRICS format occurred during the period of China's search for and development of a new and more active political strategy in the international arena. It was triggered by the fact that in the context of a rapid economic growth and increasing political influence, the issue of more effective international political activity had acquired a particular urgency for China. Chinese experts and diplomats focused on the revision of Deng Xiaoping's foundations of China's foreign policy. ‘Deng's legacy’ was treated as a dialectical balance of two principles: the principle of traditional restrained statehood (taoguang yanghui) and the principle of worthy actions (yousuo zuowei) (Yuan 2007). In the 2000s, there were debates among the Chinese experts on the issue why the strategy implemented in the 1990s with its prevailing restraints and numerous tactical and subordinate actions turned into a failure. Finally, a new model of active participation was developed, involving worthy actions which are, nevertheless, in line with Deng Xiaoping strategies claiming that there is no need ‘to lead’ by all means and one should try to focus away from oneself (Yang 2011).

The new Chinese strategy fits well into the BRICS format, which promotes interests similar to the Chinese ones, and at the same time there is no emphasis on the role of the group leader. Moreover, it is claimed that the emergence of BRICS has made the Chinese economic and political growth less irritating for the rest of the world (Global Times 2012).

Russia

Similar to China, Russia's participation in BRICS meets the country's own national interests. However, Russia's claims to be one of the current global political poles conflict with a number of political and economic indices (The Comparative Characteristic of Economy of G-7… 2014) which are often applied to attribute Russia to the developing countries. The economic cooperation with partners in the association determines Russia's participation in the BRICS framework. However, the main objectives and tasks are primarily concerned with foreign policy. Russia considers the BRICS-cooperation as an effective tool to counteract the influence of the USA and its Western partners' policy in those regions of the world which are traditionally associated with the Russian sphere of interest.

The supporters of Russia's participation in the association proceed from the assumption that BRICS member-states will become centers of global economic growth in the nearest future. The economic influence will gradually transform into political one and promote the formation of a new polycentric world order, and BRICS will provide via its collective position more favorable conditions for its members in different spheres of global politics and economy. However, one should note that Russia is already among the actors that determine the agenda in international political arena. Thus, Russia plays a role of a responsible mediator within BRICS (Sergeev and Alexeenkova 2010: 27).

The sceptics of Russia's participation in the association proceed from the analysis of the same data on the resources and opportunities of economic development which are used by the supporters of Russia's participation. In spite of the overall economic potential, the statements on Russia's outsider position within BRICS are based on the fact that the economies of BRICS member-states are resource-exporting economies with some exceptions. In this context, the skeptics consider Russia's position to be rather weak. The major obstacles to investment opportunities are the lack of real innovation potential, a strong dependence on hydrocarbon exports and impossibility to efficiently increase the production facilities.

One should note that the skeptical conclusions on Russia's failure within the association are made based on economic indicators. However, the BRICS skeptics often ignore

Russia's military, social, cultural, and geopolitical potential. The Russian economic growth rates are inferior to those of China and India, but the real GDP growth, inflation, and economic dynamic make Russia comparable with the economies of Brazil and South Africa (Borisfen Intel 2013). Russian GDP per capita is much larger than of the other BRICS countries, and the index of human development (HDI) and the level of education far surpass similar indices of the other BRICS members (Human Development Report 2014).

Thus, in their assessments of Russia's position in BRICS, skeptics and optimists hold diametrical positions while proceeding from the same economic indicators. The optimists believe that Russia will become one of the political centers in the new polycentric world. The skeptics base their assertions on the outsider position of Russia in BRICS due to resource-based exports, the outflow of foreign investments and capital, a high level of state regulation, widespread corruption, poor production and transport infrastructure, and inefficient reforms towards modernization.

However, in 2014–2015, the exclusion of Russia from the G8, going hand in hand with Western economic sanctions, changed the global political landscape and Russia's place in it. The debate about the BRICS took a different character. The statements of Fortaleza Declaration (Fortaleza Declaration and Fortaleza Action Plan 15 June, 2014) and of the Ufa Declaration of the BRICS summit prove this (The Ufa Declaration and The Ufa Action Plan 2015).

The increasing pressure from the West indicates the strengthening of Russia's political position, which has been successfully following the path of creating alternative international institutions. Russia's participation in BRICS meets national interests of the country since it provides a wide range of opportunities in the international arena. Thus, Russia considers BRICS as an instrument of strengthening its position in the international system. The country has a vast experience in dealing with global issues and it possess necessary foreign policy concepts, behavior models and strategic culture, as well as the experience of creation, albeit mostly at the regional level, of a new system of international relations. China acknowledges that Russia is an experienced political player which is strategically important during the formation of the association as the world political agent.

Brazil

Brazil is the state with clear and thoroughly formulated foreign policy attitudes, which has a peculiar position in Latin America due to its largest territory, population and economy on the continent. Brazil is a vast market, which accounts 25 per cent of industrial and 32 per cent of agricultural production in the BRICS-area, more than 50 per cent of scientific and technological potential of Latin America. About 40 per cent of foreign direct investment in the region go to Brazil (64 bln dollars in 2013), which is inferior only to China and the United States (Sadovnichiy *et al.* 2014: 77). Brazil had been interested in BRICS long before the actual entering the association. In the late 1990s, a well-known Brazilian diplomat Helio Jaguaribe de Mattos, in *Politica Externa*, the official journal of the Brazilian Ministry of Foreign Affairs, suggested establishing a 'preferential cooperation of the Giants' referring to Brazil, Russia, India, and China, to which, in his opinion, Argentina, Turkey, Mexico, and Indonesia could join in the future (Martynov and Ivanovskiy *et al.* 2013: 85). The visit of Russian Prime Minister Evgeny Primakov to Brazil in November 1998 was an important step towards creating a new format of cooperation. Another event happened in December 2002, when Brazilian President Luíz Inácio Lula da Silva came forward with an initiative of preferential cooperation of the 'big four'. Thus, for Brazil the participation in BRICS was a logical continuation of the country's foreign policy strategy aimed at strengthening its role in the world economy and politics to ensure favorable external conditions for development.

In the 2000s, following the country's GDP growth, as well as the solution of social problems, and development of large hydrocarbon deposits on the continental shelf, Brazil actively increased its participation in new forms of dialogue. Significant resource, economic, scientific and technological opportunities together with the leading position in the region created a necessary basis for a comprehensive economic development and political cooperation with BRICS countries in Latin America. One can say that Brazil and most Latin American countries take a common stance on major global problems, which, in turn, is similar to the position of the other BRICS member states. Thus, one can naturally expect some successful joint actions of the BRICS and Latin America leading countries (Sadovnichiy *et al*. 2014: 88).

It is worth noting that Brazil, as well as other BRICS nations has its own geopolitical projects. Thus, one can distinguish three main directions within the general strategy, namely: Latin American, South Atlantic and global, the latter today is mainly associated with obtaining a permanent UN Security Council member status. Brazil pays much attention to cooperation within the BRICS framework in all these three spheres.

We can assume that Brazil will prefer to maintain a long-term status of a regional leader representing Latin America within BRICS group. However, experts note that the geopolitical situation in Latin America will preserve an element of bipolarity due to the United States' influence on Mexico, the countries of Central America and the Caribbean (Sadovnichiy *et al*. 2014: 89).

Regarding Brazil's relationship within the group of BRICS partners, most part of common interests lies in the solution of global problems, in the reform of the global financial system to increase the quota of the emerging economies in the international financial institutions (IMF and the World Bank), as well as in the creation of a new reserve currency and transition to payments in national currency.

It is also appropriate to recall the idea of a 'South Atlantic community' (Martynov, Ivanovskiy *et al.* 2013: 91), consisting of Brazil, South Africa, and India (which form the IBSA), aiming at joint decision-making in foreign policy and strengthening economic relations between the member states, as well as at conducting regular political consultations in the framework of IBSA and joint maneuvers (IBSAMAR) in the South Atlantic and the Indian Oceans.

Brazil focuses on strategic cooperation within BRICS, which indicates its fundamental interest in further strengthening this format and in deepening mutual understanding to solve a number of important global issues. Brazil focuses on those security issues which should be common and indivisible in all spheres: military, political, financial, information, and environmental, *etc.* Brazil proposes to put the most contradictory tactical issues of cooperation to other levels (the UN, G20, WTO, and IBSA) (Martynov, Ivanovskiy *et al.* 2013: 94).

India

As for India, it is also one of the key players in modern geopolitics. The Indian economy is actively advancing in automobile, pharmaceutical, textile, and aerospace industries. Outsourcing has become a visiting card of India, as well as export of services in the field of computer technology and programming. The state takes an active role in a number of international cooperation formats.

Speaking about the significance of BRICS for India, the Foreign Secretary Shivshankar Menon noted on the eve of the summit in Yekaterinburg that India attaches great importance to a regular exchange of views on global financial and economic issues with the leaders of the member-states. The preparatory work and meetings at the academic level are also considered important since they positively influence the agenda and open the way to a discussion on a wide range of issues and, therefore, to a more effective cooperation.

Within bilateral relations with BRICS partners, India is interested in relations with Russia in the spheres of trade energy, and space industry, *etc*. Together with China, India is actively pursuing infrastructure projects on the African continent, providing loans to African countries on reasonable terms. India is developing cooperation with Brazil in the fields of metallurgy, oil production, aircraft and automobile industry, conduct joint development in military and technical field. India's relations with South Africa are based on an active mutual trade. After the President of India, Pratibha Patil, visited South Africa in May 2012, the mutual trade turnover between both states increased from 10 bln dollars in 2012 to 15 billion dollars in 2014 (Xinhua 2012) which proves the success of activities within BRICS framework.

It is worth noting that local and regional perceptions of key problems of global politics are rather typical for India, which finds its expression in the interaction between India, Brazil and South Africa within the IBSA framework (Volodin 2013: 122).

South Africa

South Africa is one of the influential states in the world. On December 24, 2010 the Minister of International Relations and Cooperation of South Africa, Maite Nkoana-Mashabane, received a letter from the Minister of Foreign Affairs of China, Ya Jiechi, in which China, presiding the BRICs at that time, in coordination with other member states, invited the South African Republic to join the BRIC. And in the beginning of April 2011, Chinese President Hu Jintao invited Jacob Zuma, President of South Africa, to participate in the BRIC's summit in Sanya (Arkhangelskaya 2013: 142).

South Africa's ambitions in world politics do not accept the role of a satellite, thus, the country advocates for an equitable representation of the ‘South’ in all international institutions, while being the only representative of the African continent in the G20. South Africa does not seek to become a global power and positions itself as a regional political center. With regard to international financial institutions, South Africa tends to limit their interference; however, like other BRICS member-states, South Africa committed $US 2 billion to International Monetary Fund from their foreign exchange reserves. The Republic actively strives to gain a permanent membership in the UN Security Council and it has been twice elected its non-permanent member.

Regarding the relations with other BRICS members, they are mainly based on the elaboration of economic cooperation. The South African relations with China acquired the greatest dynamics; thus, in 2009 China became even the largest South African trading partner. It is worth noting that in the trade balance between the countries, imports from China exceed exports from South Africa more than twice.

There is an obvious imbalance between political and economic components in the relations between Russia and South Africa. The reason is that trade and economic cooperation between Russia and South Africa were hardly developed the first ten years after the government of 'black majority' had come to power. It was only in 1999 that Mandela visited Moscow and the return visit of the Russian President occurred in 2006.

In the area of economic and political relations one should point out the cooperation between South Africa and Brazil with 'Africa – South America' summits, talks on the ratification of the Agreement on preferential trade between MERCOSUR and the UTS (Yakovets 2012). South Africa is Brazil's major partner in Africa. In turn, Brazil accounts to 41 per cent of South Africa's turnover with Latin America (Sadovnichiy *et al*. 2014: 92). Both countries interact efficiently within the WTO, IMF, the World Bank and various international dialogue formats.

Thus, South Africa's participation in BRICS confirms the importance of the African constituent in the modern system of international relations. The involvement of the African state in the association enhances the power and status of BRICS, provides its engagement, influence and trade opportunities on three continents, which should also contribute to BRICS relationship with the African Union and other organizations on the continent. The advantage of South Africa lies in its excellent infrastructure which allows it to play the role of a 'gate' in the promotion of trade and investment to other countries in Africa; besides, South Africa itself is the largest supplier of mineral resources and has a considerable scientific and technical potential. According to Jacob Zuma, having entered BRICS in 2011, South Africa can adequately represent the entire African continent in the 'club' (SFRnews 2011).

In turn, BRICS allows South Africa to raise its international status and role in the emerging polycentric world order. It is an important factor for the country to have a potential opportunity to strengthen its position as a representative of the African continent in the international arena. South Africa looks forward towards developing sectorial networks within BRICS, as well as towards attracting investments and developing infrastructure both in the territory of the Republic of South Africa and on the whole continent.

* * *

Thus, the interactive format of BRICS is a historically new model which accounts the diversity in contrast to uniformity, the model which is equally acceptable to both developing and developed countries. Within the general format, each member-state represents a large geopolitical area where it has leading positions. However, there can hardly be an undeniable leader within BRICS since leadership in BRICS is multifunctional and based on various aspects.

In addition, today, each of the BRICS members is also supported by large regional associations: China by the East Asian Summit (EAS); India by South Asian Association for Regional Cooperation (SAARC); Russia by the Customs Union and the Eurasian Economic Union (EEU); Brazil by the Union of South American Nations (UNASUR); and South Africa by the Southern African Development Community (SADC). One should also point out the existing multilateral organizations such as the Shanghai Cooperation Organization (SCO) and the Union of India, Brazil and South Africa (IBSA).

This implies that BRICS countries under the condition of further development of appropriate strategies will trigger a greater coordination among numerous regional and subregional organizations, and promote their gradually increasing role in the system of international regulation.

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Globalization Political Processes in Their Dynamics and Development*

Ilya V. Ilyin and Olga G. Leonova

Today, the global community discusses a great number of scenarios and alternatives of the future development. Russian scholars and experts are also actively involved in global political forecasting which is reflected in the proceedings of International Congresses on Globalistics held by the Faculty of Global Studies at Lomonosov Moscow State University.

The developmental trends of global political processes result from the nonlinear character of the global political system, its transformation and partial dysfunctions and bifurcations. Today we observe a discrepancy between the old twentieth-century trends of political development of the 'global world' and the new trends of formation of a polycentric world. The collision between old and new trends and a qualitative transformation of the world political system into a new global system generates a new content of political processes of globalization.

Presently, the analysis and *forecasting of trends of the development of political globalization* become more and more relevant and important. In what follows we describe the most evident and significant trends of political globalization (see also Chumakov 2013: 32).

'The Global Character'

In the global world, we deal with 'different phenomena and processes that obtain a global character' (Chumakov 2013: 32).

We believe that 'the global character' is a qualitatively new characteristic of the world political system which gradually evolves into a global political system. This new 'global character' means a transformation of the system of international relations, a change in the nature and content of world connections and relations, as well as a change in the geopolitical status of individual states and global actors, *etc.* Globalization leads to structural changes in the world political system and to reconstruction of the whole system of international relations.

One of the manifestations of the global character of the world political system is the interaction between global political processes at different levels – global and regional, global and local, regional and local, – that takes place, first of all, in economic, informational, and ecological and, in the last turn, in political sphere. Through this interaction and interrelation the world gradually becomes globally integrated.

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New Structure of the Global World

The global world of the twenty-first century will be structured based on different principles from which a new hierarchy will emerge. Thus, different foundations will define the global actors' geopolitical status.

The global world hierarchy comprises the following structural elements: centers of power, candidates for the status of the world's center of power, economic, political, military, and civilization poles, global powers, and regional powers. This hierarchy of structural elements, more precisely, a contest for an appropriate position in it, will define the course of global political processes and scenarios of future development (Ilyin and Leonova 2013).

It is often argued that the global world is not a community of equal nations, but a system of subordination, a rigid hierarchy of states and regional political systems. With the emergence of new economic, military, and political poles, a new configuration of the global world will gradually arise which, in its turn, will be characterized by 'mobility of the world system structures' and 'variable rules' of its functioning (Grinin 2013: 73).

The global world structures will be mobile, and the rules of functioning and principles of activity will be changeable. It is not the rules and international law but the global actors' economic and geopolitical interests which may be rather egoistic and not defined by international rules and laws, that will become of major importance. This trend will be strengthened by the increasing scale of globalization processes which will expand to large and peripheral (in terms of globalization) territories alongside with a growing number of global actors (including large multinational corporations, non-governmental organizations, terrorist organizations, and criminal syndicates, *etc*.).

The Change of Geopolitical Landscape

The formation of a new structure of the global world will trigger the change of its geopolitical landscape. One of the significant trends of the twenty-first century, as Valentin I. Seguru-Zaytsev (2011) forecasts, will be 'a continental, and later a transcontinental crystallization and consolidation of the world geopolitical space' in which the scenario of the future will be not the 'clash of civilizations', but 'a competition of civilizations' which is 'natural for the market economy'.

The nuclear weapons can level the political weight of countries and blocs; otherwise, if some of them lack such weapons, a hierarchical distance will deepen.

The USA Remains the Center of Power of the Global World

On the basis of this forecast we can assume with a big degree of confidence that in the twenty-first century the USA will still remain the center of power of the global world.

Although recently much has been written about an obvious weakening of the USA's hegemony, these forecasts turned out to be obviously premature; however, Leonid Grinin is right, arguing that '*a change of the leader in the world can hardly occur, there is no equal absolute favorite to replace the USA*'. He believes that '…though the USA will lose their positions, nobody will be able to become an absolute leader of the new world'. It seems prophetic when he says that 'today the United States concentrate political, military, financial, monetary, economic, technological, ideological, and even cultural leadership, –

all at the same time. Meanwhile, there is – and in the near future there will be – no single country or group of states in the world that could unite several aspects of leadership. Besides, neither China, nor India or someone else will be able to charge themselves with such a heavy burden due to the lack of economic opportunities, possible political risks, or because of the lack of experience and necessary associations, and also due to their ideological weakness' (Grinin 2013: 65, 73; Grinin and Korotayev 2014).

Nikolay S. Rozov also believes that 'the USA, despite all the debts and diverse difficulties, possess unsurpassed scientific, educational, technological, military, and political potential and, therefore, will preserve global leadership for a long time' (Rozov 2010: 90).

Polarization between Modernization and Geopolitical Strategies

The trend of 'polarization between modernization and geopolitical strategies' (the term introduced by Alexander S. Panarin) is observed in the globalizing world. In his works, Panarin notes the alternative character of the two models in the Far East region: Japanese and Chinese, Atlantic and some 'alternative'.

Eurasia gradually becomes rather diverse in its structure since the Asia-Pacific system is developing on the basis of the strategy of the Atlantic Western modernization (with the USA and Japan as its leaders), while the new continental system is searching for an alternative (where China is leading, but vacancy for Russia is still open).

Panarin forecasts in a prophetic way a 'new geopolitical delimitation between rimland and heartland: between Japan (remaining within the framework of the Atlantic model) and the West, on the one hand, and China and Russia – on the other hand'. Such delimitation, in his opinion, will become an 'accelerating factor of the forthcoming polarization' (Panarin 2008: 62). Today such polarization of forming systems takes place not only in the Far East region but also in the entire globalizing world, and in the sharpest and polarized form – in Eurasia.

Instability of the Global World and Growing Extensity and Intensity of Conflicts

Due to the dynamics of globalization processes, the political aspect of the global world will be characterized by changing the status of the global actors within the hierarchy and general instability of the hierarchical pyramid. The former centers of power and poles of the global world will yield to the new, more dynamically developing, and energetic candidates for these statuses which have obvious competitive advantages. The complication of global political processes will only increase instability.

Besides, the subjective factors start to play an increasing role; and these are not even the political leaders' personal preferences, but their involvement and passion in establishing the political order, as well as the character and methods of political management.

The evolution of international relations and global political system will be accompanied with growing instability and uncertainty which will contribute to the formation of a multipolar and polycentric system of the global world. This system will probably lack general 'rules of the game', principles and standards of global actors' behavior, and institutions and organizations that could effectively regulate and control the interaction between various poles and centers of power of the global world.

When analyzing the model of a polycentric global world, Vladimir V. Shlyapnikov comes to a conclusion that 'multipolarity by itself does not guarantee stability… It will be even more difficult to support the balance of powers and a strategic stability in the twenty-first century. In the situation when the UN and other international institutions are actually ineffective, a multipolar chaos becomes rather possible' (Shlyapnikov 2011: 204).

The increasing range of the conflicts and their growing intensity is an already evident tendency. Alongside with traditionally problematic territories of Africa, conflicts have spread to many regions of the global world: Israel and Palestine, Iraq, Libya, Syria, Yemen, and Ukraine, *etc*. An absolute majority of current conflicts is connected with a fight for limited resources, especially for fossil fuels. While in the twentieth century the cause of many conflicts was an access to oil, in the twenty-first century it is the competition for access to territories with prospects for shale gas production. This struggle will take the forms of 'clearing of territories' and elimination of 'redundant population' about which Panarin wrote so eloquently in his book 'Global Political Forecasting' (1999).

Inefficiency of International Structures

International structures, such as the UN, the European parliament, OSCE, the Group of Seven and the Group of Twenty, the World Bank and the International Bank for Reconstruction and Development, *etc.* show inefficiency with respect to an adequate response to challenges of political processes of globalization. They were established during a different historical epoch and allocated with different functions, not connected with monitoring and management of global political processes. Therefore, it is not surprising that they turned out to be unprepared and functionally incapable to solve tasks set by the globalizing world.

From a certain point in time, to be exact, when 'the global state' and changing format of the international political system started to emerge, the existing international institutions and structures, which used to be efficient in the past, proved to be very imperfect tools. Today, one can maintain that international institutions for management and control of the development of the global political system do not keep up with the speed, dynamic and scale of unfolding political processes of globalization. Later on, their further degradation is rather possible.

Difficulties in the Formation of Global Management Mechanisms

The inefficiency of international institutions and structures proves an actual absence of mechanisms of management of the formed global political system, which Alexander Chumakov repeatedly emphasizes in his works. In the absence of such mechanisms of global management and control over global political processes, the centers of power of the global world become the most effective agents of global management. As long as global political processes are volatile, they will be directed and controlled by the global political leaders.

We can agree with Chumakov's idea that just as before, the global world 'with a great variety of closely interconnected and, at the same time, actively opposing actors, remains self-regulated and, moreover, generally spontaneous, and absolutely deprived of any management…' (Chumakov 2013: 34). But we agree only with the first part of his statement. Self-regulation defines freedom of action and the right to defend national interests. However, this freedom and right are presently under a rigid control of still the only center of power of the global world – the USA. In the future, the global world can become polycentric, and new centers of power will emerge in Asia, Latin America, Eurasia, and may be in Africa. And then the global space will be divided between spheres of their interests, and instead of global management there will be contractual processes between centers of power concerning the division of spheres of influence and control over them.

When contradictions grow at the peak of competitive fight between the operating centers of power and candidates for this status, wars will be waged. For certain centers of power these will be wars to secure their achieved status in the global hierarchy, for others – to force out competitors and to occupy their place. Today it is already obvious that wars will be in the format of regional conflicts and outside the competitors' territory.

The Formation of New Blocs. The Era of New Coalitions

The phenomenon of global regionalization observed in the global world objectively leads to the formation of regional systems and subsystems of international relations (Leonova 2013). The maturization of these regional systems and subsystems will inevitably promote the formation on their basis of economic, political, and military and strategic blocs, associations and coalitions.

The authoritative researcher Leonid Grinin points out an interesting trend. He believes that '*an era of new coalitions*' starts in the new global world. 'During the search for the steadiest, most favorable and adequate organizational supranational forms, various and the even quickly changing intermediate forms can emerge since the players on the world and regional political arenas will look for the most favorable and convenient blocs and agreements'. '…At the same time, those will win who pursue the most active policy of forming blocs and entering new associations and can get the maximum number of partners in different spheres. A country's influence will increase, conditionally speaking, through "earning" points from participation in one or another union and block' (Grinin 2013: 73, 74).

A vigorous competition for limited natural resources makes countries' economic interests become decisive in many respects and define the vectors of foreign policy, thus, becoming prioritized over ideological goals. The instability of the global political system will increase in the situation of growing conflict intensity in the world. Consequently, the geopolitical and economic interests that underlie the formation of coalitions and blocs will be very dynamic, unstable, and quickly changing. It will be manifested in a rapid change of priority vectors of foreign policy, partners, allies, and enemies.

Thus, it is possible to denote this trend as 'a formation of new blocs', a historical stage when there will be many unstable and constantly reformatted blocs, coalitions and associations. However, this does not at all mean a split of the global world and its further fragmentation. Today in many regions of the world we observe processes of active integration which lead to the formation of large regional systems. Elsewhere we wrote that alongside 'hot' or latent conflicts in the global world, we observe more and more a competition between regional associations, each headed by a regional power (the USA, the EU, China, Russia, Brazil, India, the Republic of South Africa, *etc.*). Previously neutral states are involved into the sphere of attraction of the country – a regional leader, – or are forced to choose among the competing blocs. The states with considerable resources – raw, power, strategic, including those holding advantageous geopolitical position, demographic, *etc.* – find themselves a focus of attention of the leading powers and become objects of competition for a sphere of influence through the inclusion in a regional system or a corresponding political (economic, strategic) bloc (Ilyin, Leonova, and Rozanov 2013). We can observe a growing scale of such blocs due to the involvement of new members or partners (including observer states or the so-called associated members), leading to a geopolitical expansion of the blocs.

Geopolitical Pluralism

One may point to an expanding geopolitical pluralism in the globalizing world as well as to a differentiation of geopolitical positions and interests of regions especially in Latin America, Southeast and Northeast Asia, and Africa.

Recently, Russia has also increased its 'geopolitical pluralism' trying to redefine its traditionally prioritized relations with Central Asian countries in the post-Soviet territory. The Russian Federation has also tightened connections and increased the dynamics of relations with the countries of the Middle East and the Asian-Pacific region. At the same time, for a long time the European vector of foreign policy remained for Russia the most important and significant. Russia has also shown an obvious interest in development of partnership with the Latin American and African countries, which is often presented as 'a return' of Russia to these continents.

After it became clear that 'reloading' relations between Russia and the USA was rather a failure, one often speaks about the change in Russia's geopolitical codes and the turn towards the East, first of all to a strong partnership with China. The active interaction between Russia and the countries which used to be beyond the priority vectors of its foreign policy strengthens a trend to *flexibility and polyvariance* of the globalization of political processes.

Conflict between the State's National Interests and Globalization. The Realization of National Interests in the Globalizing World

However, the trend of decreasing interest of independent in states' sovereignty is opposed by another trend of globalization of the twenty-first century, namely *an increasing conflict between the state's national interests and globalization*. This marks a conflict which seems to be especially acute in the political sphere. At the end of the twentieth century it seemed that the role of the nation-state started to weaken while the economic aspect of globalization developed, manifesting in strengthening economic interdependence between countries, in the increasing role of multinational corporations, in the development of international financial markets, and in the internationalization of capital and business. The dismantling of the nation-state seemed inevitable and was a matter of the near future. However, when an increasing number of functions of the state were transferred to the supranational level, it became more and more obvious that there were a number of serious problems which could be hardly solved within the framework of interstate structures (the UN, OSCE, the European Parliament, *etc.*). These are issues and tasks affecting countries' national interests whose solution remains a prerogative of a national state.

That is why the expected hollwoing out or even a decline of the state has not taken place yet, and will hardly take place in the near future. Figuratively speaking, its funeral was premature, and a funeral march was played inappropriately.

The problem of national interests of individual states in the global world remains the subject of disputes and reflections. *National interest is an objective restraint for the process of political globalization*. Perhaps this obstacle will be eliminated in the future, but if so it will occur gradually within the search for a balance between national interests of every country and the global system of political interdependence and hierarchy of states.

Competitiveness between the Authoritarian States

The global financial and economic crisis has revealed another challenging trend of globalization – a demand for, and competitiveness between the authoritarian states.

In the course of the world economic crises a number of states whose political system is commonly referred to as authoritarian, showed their economic and political efficiency, and proved to be worthy competitors of the European democratic states. Moreover, in the twenty-first century, a unique *competition is observed between the traditional democratic states which developed within the framework of the liberal and democratic model, and countries whose regimes are customary referred to as authoritarian*. And today, after a number of global financial and economic crises countries with authoritarian regimes demonstrate their economic and political efficiency, and are worthy competitors of the democratic states with a liberal economy.

This trend has been denoted as a 'Return of Great Authoritarian Powers' (meaning that they are among leading global actors), and many analysts and experts already ask a question as to what is more effective in the conditions of globalization – 'dictatorship or democracy'.

It seems that over the twentieth century, democracy, apparently, proved its efficiency. But in the twenty-first century, it appeared that not only the liberal and democratic way of development may be successful. Authoritarian regimes where the state plays a dominating role in economy and politics also have prospects and future in the context of the global trends of development.

In this regard, new prospects open for Russia which has not yet been admitted into the 'club' of democratic states with market economy.

The Changing Role of the Periphery of the Global World, and Effective Geopolitical Strategy of Developing Countries

As a result of unfolding globalization processes, especially their economic aspect, the development of the periphery has considerably accelerated. The moving of economic growth pole and of financial streams to the Asian-Pacific region, to the countries which until recently were considered as the periphery of the global world, becomes obvious.

These countries of the former periphery become an important bloc of the world system and gaun an important function: not only that they provide the world economy with raw materials and industrial goods, but gradually they become investors in the Western countries.

The growing economic development and economic contribution of the global periphery countries into the world economy involves the increase of their political 'weight' in the global political system, and raises their status in the world hierarchy.

Panarin believes that the geopolitical strategy of the developing countries (including those which used to belong to the 'second world' and the ones that during globalization were pushed aside into the 'third world') will consist in the 'geopolitical development' connected with the search for ways of growth and effective alternatives to industrialization trends. This strategy will be formed, most likely, as an anti-western one.

The growing role of economies of Asian and other countries of the periphery, and, as a result, an increase in their political influence will lead to a situation when they will define the new rules, norms and standards of behavior of the Western countries in the global world or even, although it may sound extremely fantastic, will dictate the global scenario of development. It is quite possible that many political standards and norms of political development of the global world will be as well defined by growing economies not by the western countries led by the USA.

Thus, in the twenty-first century not only western, but also other civilizations will be centers of power of the global world.

The Enhanced Role of the Ummah in Global Political Processes. Transformation of the Ummah into a Collective Global Actor

Dmitri Efremenko forecasts that globalization will gradually 'lead to the end of the economic, cultural and technological dominance of the European civilization that has been lasting for more than five centuries' (Efremenko 2009: 162).

Political processes of globalization have considerably affected the diverse and fragmented Islamic world, generating a trend of strengthening its unity. The need to find adequate responses to challenges of globalization promotes a unity and a unique synthesis of various currents of Islam, not in religious and dogmatic but in socio-cultural aspect (though at present the contradictions between different currents and groups of Muslims are increasing).

One can question the forecasts about the possible creation of 'the new Caliphate'. One thing if out of question: the globalizing world system as an entity with developed information and communication technologies promotes the formation of a unique 'Islamic International' with participation of many thousands of Islamic financial, political, cultural and spiritual and educational organizations, united by the common ideology, goals, and view on global problems. Gradually, the ummah turns into a quasipolitical bloc or coalition of states which is actively resisting and counteracting westernisation and globalization in its western version.

Supported by numerous Muslim Diasporas in the Western countries, Islamic non-governmental organizations and public centers may strengthen the political position and role of the ummah in the global world. In the twenty-first century, the ummah will become an influential global actor that will actively participate in developing a scenario for the global world and whose opinion Western countries will have to consider.

In this context, Russia meets new geopolitical prospects and challenges. One of them is a search for a constructive political interaction with the Muslim world.

The destruction of centuries-old moral traditions of Christian and Muslim civilizations, hollowing out ethical standards. With this, the substitution of ethical ideals has reached a scale of becoming one of the urgent global problems for the humankind. This causes alarm and concern not only among Muslims, but also among orthodox Christians, including the Russian Orthodox Church which makes its contribution to the solution of this problem.

'Our Orthodoxy, – Alexander Panarin writes, – gives Russia good chances to establish fruitful contacts with the Muslim type of spirituality. Russian culture, which is Orthodox Byzantine by its origin, similar to Islamic religion, is mainly ethical-centric. In the territory of Russia one can observe a phenomenon of a world-wide and historical value, namely, the emergence of a civilizational and geopolitical system which is a product of joint creativity of the Christians and Muslims. Nowhere in the world can one find such a steady synthesis of the kind!' (Panarin 2008: 72)

Reflecting on the problems connected with global political processes one can agree with the famous scientist Pavel Tsygankov who emphasizes an *artificial and even subjective character of the developmental trends of the global world which are arising and gaining strength*. 'The most developed and strong international players use objective processes and trends to further strengthen their positions, and also to manage or even to create ("construct") the for them most favorable directions' (Tsygankov 2011: 200).

Summarizing the trends of globalization in political processes, one can make a conclusion about the *variability of global development* which potentially contains a number of possible directions. This variability is ensured by a large number of global actors with different characteristics, aspiring to realize their economic and geopolitical interests.

In the global world, new vectors of development, new dimensions, key problems and points of bifurcation constantly emerge. The global world is changing through the shifts in its structure, hierarchy global actors' activity and relationship between them, values, ideals, goals and prospects of development.

In conclusion, we would like to remind of Alexander Panarin's observation that *'the preservation of the global civilization and geopolitical balance between the East and the West still depends on Russia'*. A strong Russia, despite all upheavals in its politics, will keep holding the torch of *political and spiritual leadership* in Eurasia. Any attempts to weaken and especially to ignore Russia as a political actor of the world threatens with a direct collision between the Western, Muslim, and Pacific worlds in their fight for repartition of the oikumene' (Panarin 2008: 77).

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Part II. GLOBAL HISTORY AND MODERNITY

Swimming Upstream: Universal Darwinism and Human History*

David Christian

This essay discusses Universal Darwinism: the idea that Darwinian mechanisms can explain interesting evolutionary change in many different domains, in both the Humanities and the Natural Sciences. The idea should appeal to big historians because it links research into evolutionary change at many different scales. But the detailed workings of Universal Darwinism vary as it drives different vehicles, just as internal combustion engines differ in chain-saws, motor cycles and airplane engines. To extend Darwin's ideas beyond the biological realm, we must disentangle the biological version of the Darwinian mechanism from several other forms. I will focus particularly on Universal Darwinism as a form of learning, a way of accumulating information. This will make it easier to make the adjustments needed to explore Darwinian mechanisms in human history.

Keywords: *Universal Darwinism, collective learning, information, Big History.*

> Countlessness of livestories have netherfallen by this plage, flick as flowflakes, litters from aloft, like a waast wizard all of whirlworlds. Now are all tombed to the mound, isges to isges, erde from erde.
>
> *Finnegans Wake*, Ch. 1

James Joyce's strange masterpiece, *Finnegans Wake,* is fractal. You can read it at many different scales, but you always have the eerie feeling that you are hearing a story you have already heard somewhere else. A mathematician might say the stories are 'self-similar'. You may think you are reading about the wake for a drunken bricklayer who fell to his death from a ladder; but you are actually reading about the fall of humanity and the expulsion from Paradise; and then again the story is *really* about Dublin and the many rises and falls of that city's history, people and landscapes. Something similar happens in the emerging discipline of Big History (see Christian 2004, 2010). Big History surveys the past at the scales of cosmology, physics, geology, biology and human history. Each discipline tells its own story, but as you get to know the stories, they start to overlap, and we begin to see each discipline refracted in the others. Like *Finnegans Wake*, Big History is 'self-similar'. And like *Finnegans Wake,* Big History derives much of its power from the synergies that arise when you glimpse unexpected connections across different scales and domains.

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This paper explores one of these fractal phenomena: 'Universal Darwinism'. In biology, the Darwinian paradigm describes a distinctive form of evolutionary change that generates adaptive change through repeated copying of selected variants. Universal Darwinism is the idea that similar mechanisms may also work in many other domains. If so, do they always work as they do in biology? Or can we distinguish between a core machinery and the modifications needed to drive it in different environments?

Universal Darwinism

Richard Dawkins coined the phrase 'Universal Darwinism' in an essay published in 1983. If we find life beyond this earth, he argued, it will surely evolve by 'the principles of Darwinism' (Dawkins 1983: 403). But there will also be differences. For example, the replicators may not be genes. Dawkins suggested that human culture might offer an example in the 'meme', an idea or cultural artifact such as a song or fashion that varies, that replicates through imitation, that travels in sound or images, and colonizes human minds when selected from a population of rival artifacts (on meme theory see Blackmore 1999). More generally, he suggested that, 'Whenever conditions arise in which a new kind of replicator *can* make copies of itself, the new replicators *will* tend to take over, and start a new kind of evolution of their own' (Dawkins 2006: 193–194).

Universal Darwinism treats natural selection as one member of a family of evolutionary machines that generate adaptive change through repetitive, algorithmic processes. Always we see variation, selection and replication. Some variations are selected, then copied and preserved with slight modifications, after which the process repeats again and again.

Here is a description of the basic machinery by a physicist, Lee Smolin,

> To apply natural selection to a population, there must be:
> - a space of parameters for each entity, such as the genes or the phenotypes;
> - a mechanism of reproduction;
> - a mechanism for those parameters to change, but slightly, from parent to child;
> - differentiation, in that reproductive success strongly depends on the parameters (Smolin 2005: 34).

And here, to illustrate slight variations in our understanding of the basic machinery, is a description by a psychologist, Susan Blackmore:

> Darwin's argument requires three main features: variation, selection and retention (or heredity). That is, first there must be variation so that not all creatures are identical. Second, there must be an environment in which not all the creatures can survive and some varieties do better than others. Third, there must be some process by which offspring inherit characteristics from their parents. If all these three are in place then any characteristics that are positively useful for survival in that environment must tend to increase (Blackmore 1999: 10–11).

Repeated many times, these simple rules yield interesting evolutionary change. Variation creates diversity, but by selecting some variations over others you steer diversification in a particular direction. You ensure that surviving variations will fit the environment that selected them, so they will be 'adapted'. In this way, the Darwinian machinery steers change away from the random mush ordained by entropy and the second law of thermodynamics. And if by chance some selected variants are slightly more complex than others, then we have, in Universal Darwinism, a way of increasing complexity. Indeed, Lee Smolin argues that natural selection provides the *only* scientific way to explain how complexity can increase against the tide of entropy (Smolin 2005: 34). (As I write this paper, I watch myself selecting some ideas, words and metaphors, and rejecting others; and I know that eventually the paper itself will have to take its chances in a competitive world populated by many other academic papers.)

So powerfully does the Darwinian machinery steer biological change that many find it hard to avoid imagining that there must be a designer. Surely, organs as beautifully designed as wings or brains must have been, well, designed! Yet natural selection needs no cosmic project manager. This is what Daniel Dennett called 'Darwin's Dangerous Idea': operating without purpose, the Darwinian algorithm creates the appearance of purposefulness (Dennett 1995). From camels to chameleons, species fit their environments so precisely that they seem to transcend the laws of entropy. Yet they need no teleology and no driver. Darwin's ideas threatened theism because they explained the appearance of direction without needing a divine director (*Ibid.*).

Even in Darwin's time, some wondered if the same machinery could work outside the domain of biology. In a section on language in Chapter 3 of *The Descent of Man,* Darwin wondered if languages evolved like living organisms. After all, he noted, languages vary, they are reproduced, and their components – words, grammatical forms and even particular languages – are subject to selection for their 'inherent virtue'. Darwin concluded that, 'The survival or preservation of certain favoured words in the struggle for existence is natural selection' (Darwin 1989: 95). Darwin's friend, Thomas H. Huxley, suggested that there might be evolutionary competition between different bodily organs, while William James extended the idea of evolution to learning in general (Plotkin 1994: 61–64).

But it was in biology that Darwin's ideas really triumphed. In the 1930s and 1940s, several lines of research converged in the 'neo-Darwinian synthesis', which fixed several weaknesses in Darwin's original theory. For example, Darwin assumed that inheritance was blended, an idea that threatened to eliminate successful variations by driving all variation towards a mean; Darwin also feared that natural selection worked too slowly to generate today's biodiversity, particularly on a planet he believed to be less than 100 million years old. The neo-Darwinian synthesis used the work of Gregor Mendel to show that inheritance works not by blending but by copying discrete alleles. August Weismann showed the importance of distinguishing between phenotype and genotype, between characteristics acquired during an organism's lifetime, and those inherited through the germ line, which ruled out intentional or 'Lamarckian' forms of evolution; and this suggested that genetic mutations had to be random rather than purposeful. Finally, population geneticists such as Ronald A. Fisher and John B. S. Haldane proved mathematically that successful genes could spread fast enough to generate all the variety we see today, and geologists showed that the earth was almost 50 times older than Darwin had supposed (Mesoudi 2011: 40–51). Just as James Watt's modified steam engine made it industry's standard prime mover, so the neo-Darwinian synthesis turned Darwinism into biology's standard explanation for biological change. The discovery of DNA and the evolution of genetic research consolidated Darwinism's paradigm role within biology.

Paradoxically, the success of the neo-Darwinian synthesis inhibited its use in other fields by creating the impression that all Darwinian machines had to be neo-Darwinian. Replicators had to be particulate; they had to be distinct from the entities in which they were tested (phenotypes or bodies); and variation had to arise randomly. Outside of biology, the neo-Darwinian model worked much less well than it did within biology. Historians and social scientists resisted Darwinian models for another reason: applied carelessly or too rigidly, they seemed to encourage Social Darwinism. The idea of Social Darwinism attracted scholarly attention after the publication of Richard Hofstadter's, *Social Darwinism in American Thought,* in 1944 (Hofstadter 1944). For Hofstadter, Social Darwinism's primary meaning was 'biologically derived social speculation'; but others associated it more closely with racist theories, though even Hofstadter had warned that '[Darwinism] was a neutral instrument, capable of supporting opposite ideologies' (Leonard 2009: 41–48). These fears helped preserve the gulf between the humanities and the natural sciences that Charles P. Snow bemoaned more than 50 years ago (Snow 1959).

In the late twentieth century, scholars in several fields returned to modified Darwinian models of change. They found them at work in immunology, in economics, in the history of science and technology, and even in cosmology, where Lee Smolin has proposed a theory of 'cosmological natural selection' (Smolin 1998; Nelson 2006; Campbell 2011). In Smolin's model, new universes are born in black holes. Information about how to construct universes resides in basic physical parameters, such as the power of gravity. Reproduction generates variation because daughter universes may inherit slightly different parameters. Variations are 'selected' and preserved because they will survive only if they generate universes complex enough to form black holes and reproduce. So cosmological natural selection does not generate a random mix of universes, but only those universes with just the parameters needed to create complexity. Our own existence proves that some universes will be complex enough to yield planetary systems, and life and creatures like us. Here we have a Darwinian explanation for the existence of a universe such as ours whose parameters seem exquisitely tuned for complexity.

Wojciech Zurek and his colleagues at the Los Alamos National Laboratory have even detected Darwinian mechanisms in quantum physics (Campbell 2011: 89ff.). When a quantum system interacts with another system, perhaps by being measured in a lab, just one of its many possible outcomes is selected and launched into the world, in the process known as 'decoherence'. We have variability of the initial possibilities, a selection from those possibilities, and a copying of the selected possibilities from the quantum to the non-quantum domain. 'This Darwinian process allows a quantum system to probe its environment searching for and selecting the optimal low entropy states from all those available, thus allowing greater complexity to be discovered and survive' (*Ibid.:* 154). (The author of this paper makes no claim to understand these processes except in the most superficial way. The point is that Darwinian mechanisms may be at work even at the quantum level.)

Darwinian ideas have also returned to the humanities and social sciences, attracting the attention of anthropologists, linguists, psychologists, game theorists and some economists, political scientists and historians of technology (see Mesoudi 2011 on cultural evolution; Fitch 2010 on language origins and Nelson 2007: 74 on Darwinian models in other fields). Such explorations may get easier because the neo-Darwinian synthesis is loosening its grip within the core territory of biology. When the human genome was deciphered in 2003, it turned out that humans have far fewer genes for the manufacture of proteins than had been expected, little more than 20,000, fewer than in the rice genome. This discovery reminded biologists and geneticists that DNA is not a lone autocrat; it rules through a huge biochemical bureaucracy, whose agents often manage their ruler, as civil servants manage politicians. Mechanisms within cells control how and when the information in DNA is expressed, and occasionally they even alter DNA itself, if only to repair it. Even more striking, some of these changes seem to be hereditable. Through this modest backdoor, Lamarckian inheritance is creeping back into biological thought. In a recent survey of these changes, Jablonka and Lamb write that 'there is more to heredity than genes; some hereditary variations are nonrandom in origin; some acquired information is inherited; evolutionary change can result from instruction as well as selection' (Jablonka and Lamb 2005: 1).

These debates within biology may help us stand back from the biological form of the Darwinian machinery and see how different variants work in other realms, including human history.

Information and Universal Darwinism

Darwinian machines run on information: they replicate patterns, and that means replicating *information* about those patterns. So to understand their general properties, we need the idea of information. But information is a mysterious and ghostly substance that sometimes appears to float above reality, so we must define it carefully (accessible surveys include Floridi 2010; Gleick 2011; Lloyd 2007; Seife 2007).

The idea of information presupposes the existence of differences that matter. To an antelope it matters if the animal behind the tree is a tiger or another antelope. Information reduces uncertainty by selecting one of several possible realities. This is why Donald MacKay described information as 'a distinction that makes a difference' (Floridi 2010: 23). A difference matters if other entities can detect and react to it. They may be able to detect it directly; but if not, they can often detect it indirectly, by secondary differences that correlate with the initial difference. This is where information steps in. When two differences are correlated, the second can carry a message from the first to any receiver able to interpret the message. In this way, causal chains carry potential information, whether or not there is a mind at the end of the chain. An antelope may detect a nearby lion by its shadow, and that should remove uncertainty about the danger. Run! But an electron can also be said to detect and react to a proton through its electric charge. Inserting a conscious entity into the chain simply adds one more link. It may add uncertainty, but all links do that. In this way information can travel along causal chains because we infer differences that are hard to detect from others that are easier to detect. Information is embedded in chains of cause and effect. '[It] is not a disembodied abstract entity; it is always tied to a physical representation. It is represented by an engraving on a stone tablet, a spin, a charge, a hole in a punched card, a mark on paper, or some other equivalent' (Rolf Landauer, cited in Seife 2007: 86).

When information travels through long causal chains, it can lose precision. The second, and third and fourth differences are not, after all, the same as the first. So we can judge a message by how well it represents the original difference. Faulty genes trick cells into making cancer cells, and an antelope can take a trick of the light for a tiger's shadow. But some chains transmit information more efficiently than others. As a general rule, digital or particulate information carriers detect differences better than continuous or analogue carriers, because they *have* to discriminate. That is why DNA employs genes, languages use words, and computers prefer on/off switches. Effective transmission systems can partition the smoothest of changes.

We can also judge a transmission system by the amount of information it carries. Claude Shannon, the founder of 'Information theory', showed that information increases precision by reducing uncertainty (Floridi 2010: 37ff.). You can measure the amount of information in a message by the number of alternative realities it excludes. 'There is a tiger behind the bush' is helpful advice; it reduces uncertainty. But if a friend adds that the tiger is hungry and in a bad mood, that should eliminate any doubts you had about running away. If, from all the possible things that might have happened, a message selects a tiny, not-easily-predicted sub-set, then it eliminates a vast number of other possibilities and a huge amount of uncertainty. Each rung on a molecule of DNA can exclude three out of four possible futures; so the entire molecule, with billions of rungs, can exclude a near infinity of possible creatures. It tells you how to build just one, say, an armadillo. Not an amoeba, or an archaeopteryx, but an armadillo. In information theory, 'the amount of information conveyed by [a] message increases as the amount of uncertainty as to what message actually will be produced becomes greater' (Pierce 1980, Kindle edition, location 461).

We have seen that information does not need minds. However, words like 'meaning' make sense only when the causal chain *does* include a mind. Only then can we describe information as *semantic*. And when the information is complex it makes sense to call it knowledge. Luciano Floridi writes,

> Knowledge and information are members of the same conceptual family. What the former enjoys and the latter lacks … is the web of mutual relations that allow one part of it to account for another. Shatter that, and you are left with a pile of truths or a random list of bits of information that cannot help to make sense of the reality they seek to address. Build or reconstruct that network of relations, and information starts providing that overall view of the world which we associate with the best of our epistemic efforts (Floridi 2010: 51).

We needed this digression on information because Universal Darwinism builds complexity by accumulating, storing and disseminating information about how to make things that work. Darwinian machines generate unexpected outcomes, like armadillos or human brains, because they accumulate information that is *not* entropic mush. So wherever they are at work, unexpected things happen – whether in the immune system or in DNA, or in human history or entire universes (Blackmore 1999: 15). Darwinian machines learn (a classic summary is Campbell 1960: 380). This is why Karl Popper described the growth of knowledge as: 'the result of a process closely resembling what Darwin called "natural se-lection", that is, *the natural selection of hypotheses:* our knowledge consists, at every mo-ment, of those hypotheses which have shown their (comparative) fitness by surviving so far in their struggle for existence' (Plotkin 1994: 69).

Three Darwinian Learning Machines

Seeing Darwinian machines as learning machines will help us understand how they may shape human history. On this planet, living organisms learn in three distinct ways. All are Darwinian, but they use different variants of the same basic engine.

Genetic Learning and Natural Selection. The first variant is natural selection. Biologists have studied this engine for a long time and they understand it well. It explains how molecules of DNA accumulate adaptively significant information. DNA codes information about how to manufacture proteins using four nitrogenous 'bases': Adenine, Thymine, Guanine and Cytosine. Differences in the order of the letters really matter. Exchange one A for a T in the code for a protein with 146 different amino acids and you get sickle cell anemia. DNA stores information that is rich because it is specific, impossible to generate randomly, and therefore it is unexpected. Over time, billions of new genetic recipes for building proteins and whole organisms accumulated in the world's stock of DNA to generate the species we see today.

Generation by generation, packets of DNA are sieved as their products enter the world. Mutations, copying errors and recombination during reproduction create random variations in genes and in the organisms they give rise to, so that slight modifications on the original instructions are continually being tested. Only those packages that produce viable organisms will survive and reproduce. Much of the information they contain tells cells how to choose the tiny number of biochemical pathways that resist entropy. For example, it may include recipes for enzymes that steer biochemical reactions along rare but efficient pathways, or that help export entropy outside the organism (Campbell 2011: 102). In each generation, that information can be updated. This explains why living organisms have an uncanny ability to track changing environments.

DNA preserves information because it acts like a ratchet (on the 'ratchet effect' in human history, see Tomasello 1999). Mechanical ratchets allow a gear-wheel to turn in only one direction because the 'pawl' catches on the cogs and prevents the wheel from turning backwards. By only copying information that works, DNA ensures that the gear wheel of evolution normally turns in the direction that accumulates viable variations. Without an information ratchet, the wheel of evolution could turn in either direction, viable variations would survive no better than any others, and biological change would drift with the flow of entropy. That is why it makes sense to suppose that life itself began with DNA or its predecessor, RNA. Before the evolution of DNA or RNA, parts of the Darwinian machine already existed: there was plenty of variation within pre-biotic chemistry, and variations could be selected for their greater stability. But only after DNA evolved (possibly preceded by RNA) could successful variations be locked in place so that genetic information could accumulate. With DNA preventing any backsliding, life was off and running.

To summarize key features of genetic learning: information accumulates as it is locked into the biochemical structures of DNA molecules. Most variations arise randomly during reproduction. Variations survive only if the DNA molecules they inhabit are copied. Genes are particulate, but when working together, they can create the impression of a 'blending' of characteristics. Because most variation arises during reproduction, genetic learning is non-Lamarckian; it does not preserve 'acquired variations', variations generated during an individual's lifetime. Random variations are tested, one by one, surviving only if they create organisms that fit their environment. These are the rules of the neo-Darwinian synthesis.

Individual Learning. The other two forms of learning have been studied less closely than the genetic machine, and we do not understand them as well.

I will call the second machine 'individual learning'. It works not across species or organisms but within the neurological system of a single individual. It is at work in species as varied as cephalopods, crows and chimpanzees. It works even in simple organisms, which can learn to detect and react to gradients of light or warmth or acidity. But individual learning is most impressive in animals with brains. Imagine our antelope glimpsing a lion near a waterhole. Was that really a lion? Should it make for another waterhole? With no guidance, it might have to choose randomly, as young animals often do. It will soon find out if its gamble succeeded. But intelligent animals also have better ways of choosing. They accumulate memories of past experiences associated with pain, fear, anxiety or with a sense of pleasure and ease. If any of those memories are similar to what is happening right now, they may provide guidance. Trying out possibilities in memory is less dangerous than trying them out in the real world, and the accompanying sensations, installed over time by genetic learning, will provide better than random criteria for repeating or avoiding particular experiences. Alasdair MacIntyre reports that if a young cat catches a shrew, it will eat it as if it were a mouse. It will then become violently ill, which is an unpleasant experience. But it has learnt a difference that matters and from now on it will avoid shrews (MacIntyre 2001: 37). A memory that should help the cat survive has outcompeted a memory that once caused it misery.

Put more generally, an intelligent organism undergoes experiences that carry information about the outside world, if they can be stored and interpreted. Memory provides an information ratchet as it encodes experiences in neurological networks. It accumulates useful information within an individual's lifetime. Faced with an important choice, the organism can refer to its memory bank and look for experiences that had happy or unhappy outcomes. As it replays memories with their associated experiences of pleasure or pain or fear or comfort, it learns to make better choices. Significant memories are selected by being reinforced (through repetition or association with other strong experiences), while memories that are not reinforced will fade away (Campbell 2011: 119–120). The criteria for selection – repeated reinforcement or strong association with experiences of pain or pleasure – will have been built into the organism by genetic learning, which teaches you to cherish parents and shun predators. Here we have the complete Darwinian cast: varied experiences that are encoded in memories, only some of which are selected for preservation.

So individual learning is a Darwinian machine. But it does not work quite like the machinery of the neo-Darwinian synthesis. Its arena is the individual brain, rather than the outer world. Individual learning preserves useful memories acquired during an individual's lifetime, but those memories can also change; unlike genes, memories are not fixed from the moment of their birth. So individual learning can be Lamarckian. It contains no simple analogue to the neo-Darwinian separation of genotype (which does not change during an individual's lifetime) and phenotype (which can change within a lifetime). Variation arises mainly from the diversity of individual life experiences, though some may arise from mistakes in coding or assessing those experiences. In individual learning, the primary information carriers are neurological networks, and memories, their psychological correlate. Both are more diffuse and variable than genes and subject to constant minor changes as they join or separate from other networks and memories. Selection occurs through reinforcement rather than reproduction, as networks are selected for their strength and connectedness, which depend on the number and strength of the synapses from which they are constructed. Networks that are reinforced strongly because they are repeated often ('*that* waterhole is safe') or are particularly shocking ('nearly got caught that time!'), will survive, while the rest will dwindle and fade. The criteria for selection do not reside in the outer environment, but are built into the organism by genetic learning. But selection is not purely mechanical. Sometimes it demands a judgment call '*that* waterhole is safe but the water does not taste as good, Hmmm'. At this point we may conclude that animals ponder alternatives before selecting consciously and with intent. Selection is beginning to look purposeful.

So here we have a Darwinian machine that lacks the bells and whistles of the neo-Darwinian synthesis but can still generate new, non-random and significant information. It also sports some glossy new features. It is very fast; it can accumulate new information in seconds, while genetic learning gets to test new variations just once in a lifetime. Individual learning is also specific; instead of producing generic adaptive rules for millions of individuals, it tells a particular individual how to live in a particular time and niche. But individual learning is also ephemeral; it cannot survive outside the arena of the individual brain. A lifetime of learning evaporates on the death of each individual, so every generation starts from scratch. Individual learning is Sisyphean; it cannot accumulate information at time scales larger than a lifetime, so it does not lead to a long-term change. That is why it cannot generate what we humans call 'history'; change at scales larger than a single lifetime.

Darwinian Machines in Human History: Collective Learning

Our third Darwinian machine *does* generate long-term change. I call it 'collective learning', and it seems to be unique to our species, *Homo sapiens* (for brief discussions see Christian 2004, 2012).

Collective learning happens when you join individual learning to a sufficiently powerful system of communication. It depends on the ability of individual learners to share what they have learned with others, and to do so in such volume and with such precision that new information accumulates at the level of the community and even the species. As Merlin Donald writes, 'The key to understanding the human intellect is not so much the design of the individual brain as the synergy of many brains' (Donald 2001: xiii).

Collective learning uses a new and more powerful information ratchet. Unlike individual learning, it stores information in many minds over many generations, so that information can outlive the individuals who created it. If a fraction of that information improves how individuals exploit their environments, collective learning will tend to increase the ecological power of whole communities. Like all animals, humans exploit their environments to extract the energy and resources they need to survive; but only humans keep discovering and sharing new ways of exploiting their environment, so that over time they can extract more and more energy and resources. Our ecological creativity explains why humans are the only species that has a history of long-term changes in behaviours, social structures and ecological adaptations. Like individual learning, collective learning also works much faster than genetic learning. That is why, within just a few hundred thousand years we have become more powerful than any single species in the 3.8 billion year history of life on earth, so powerful that some geologists argue we have entered a new geological epoch, the 'Anthropocene' (see Steffen *et al.* 2007).

By sharing ideas, information, gossip and beliefs, collective learning creates human 'culture', which Mesoudi defines broadly as 'information that is acquired from other individuals via social transmission mechanisms such as imitation, teaching, or language' (Mesoudi 2011: 2–3; for a similar definition see Distin 2011: 11). Of course, humans are not alone in having 'culture' in this sense. Songbirds, chimps and whales all share information. The difference is in the degree of sharing, but that small difference really matters. Animal languages lack an efficient information ratchet, so in the animal versions of 'telephone', information leaks away within a few exchanges and has to be constantly relearned. This is why knowledge accumulation has little impact on any species except ours, and that is why no other species has a history of long-term change over many generations. Alex Mesoudi sums up a broad consensus among those who study animal culture:

> Although numerous species exhibit one-to-one social learning and regional cultural traditions, no species other than humans appears to exhibit cumulative culture, where increasingly effective modifications are gradually accumulated over successive gen-

> erations. This might therefore be described as the defining characteristic of human culture (Mesoudi 2011: 203).

There is a narrow but critical threshold between individual and collective learning. To appreciate its significance, imagine pouring water into a bathtub with no plug. A trickle of water will deposit a thin film at the bottom of the bathtub. But the level will not rise because water leaks away as fast as it pours in. Increase the flow and the water level will rise and settle at a new level. (We see something like this in species such as *Homo erectus,* or in some species of primates.) Increase the flow just a bit more and suddenly the level starts rising and keeps rising as water enters faster than it leaves. You have crossed a critical threshold beyond which there appears a new type of change because now the water level will keep rising without limit (until it overflows the bathtub).

How did our ancestors cross the threshold to collective learning? We do not really know, though we have plenty of suggestions. Many changes led our ancestors towards the threshold of collective learning (for recent discussions, see Tattersall 2012; and Fitch 2010). They included larger brains; insight into the thinking of others (a 'theory of mind'); some ability to cooperate; the ability to control vocalizations and interpret the vocalizations of others; the use of fire to cook and pre-digest food, which, as Richard Wrangham points out, gave access to the high quality foodstuffs needed to grow brains. Many other species share some of these qualities and abilities (Tomasello 1999, 2009; Wrangham 2009; MacIntyre 2001: chs 3, 4). So, as Richerson and Boyd put it, we can imagine several species gathering at the barrier before collective learning, until eventually one broke through (Richerson and Boyd 2005: 139). Our own history suggests that the lucky species would then deny passage to its rivals: 'humans were the first species to chance on some devious path around this constraint [the difficulty that culture works only within a community of skilled social learners], and then we have preempted most of the niches requiring culture, inhibiting the evolution of any competitors' (Boyd and Richerson 2005: 16). Since humans broke through, our closest hominine relatives, from Neanderthals to Denisovans, have perished and our closest surviving relatives, the chimps and gorillas are approaching extinction. Even if several related species arrived almost simultaneously at the barrier to collective learning, there was apparently room for only one species to sneak past it.

But the speed of the change – we, humans, began our climb to world domination less than 500,000 years ago, a mere second in paleontological time – suggests that a single push shoved us through. Perhaps, it was a glitzy new neurological gadget, some form of Chomsky's 'grammar' module, or a new form of the FOXP2 gene that pushed us through. Or perhaps, as Terrence Deacon has argued, it was symbolic language (Deacon 1998). Some have argued for a slower transition. But, as a recent article argues, even if human language evolved 500,000 years ago, in evolutionary terms, that is a 'flash in the pan', implying that 'language abilities were relatively rapidly cobbled together from pre-adapted cognitive and neurophysiological structures' (Dediu and Levinson 2013: 10). Whatever the explanation, we should expect to find a single, critical change, because it defies reason to suppose that all the necessary pre-adaptations could have converged simultaneously on a single point in paleontological time. As Michael Tomasello writes: 'This scenario [of a single switch] solves our time problem because it posits one and only one biological adaptation – which could have happened at any time in human evolution, including quite recently' (Tomasello 1999: 7).

Suddenly, humans began to communicate not just in semantic fragments ('Tiger!'), but in organized and contextualized strings of information ('Yup, it's got the same markings as the one that got Fred, and it's behind the same bush!'). They began to use large, coherent packets of symbolic information, words like 'family' or 'gods' that compressed a world of experience into a few sounds, and linked those sounds into precise relationships using grammar (Deacon 1998). Human language locked up cultural information as tightly as DNA molecules locked up genetic information. As Tomasello puts it, 'The process of cumulative cultural evolution requires … faithful social transmission that can work as a ratchet to prevent slippage backward – so that the newly invented artefact or practice preserves its new and improved form at least somewhat faithfully until a further modification or improvement comes along' (Tomasello 1999: 5). That is why some anthropologists describe cultural accumulation as 'cultural ratcheting' (Pringle 2013).

Once the switch for collective learning was thrown, our ancestors could start building new knowledge, community by community, accumulating local knowledge stores that steered each group in different directions to generate the astonishing cultural variety unique to humans. At the same time, our inner world was transformed as ideas washed from mind to mind. We do not just learn collectively; we *experience* collectively. The anthropologist, Clifford Geertz, descried this realm as, 'that intersubjective world of common understandings into which all human individuals are born, in which they pursue their separate careers, and which they leave persisting behind them after they die' (Geertz 2000: 92). A simple thought experiment illustrates the power of this mental sharing. Look inside your head and do a quick census of everything that is there. (It takes just a few seconds.) Then ask the question: how much of that stuff would be there if you had never had a conversation with another human? Most will agree that the correct answer is: 'Very little'. And that 'very little', mostly produced by individual learning, hints at the inner world of chimps. While chimps learn alone or in ones and twos, humans learn within teams of millions that include the living and the dead.

When did our ancestors cross the threshold to collective learning? In paleontological time, the crossing took an instant, but in human time it was probably smeared out over tens of thousands of years (a paradox captured in the title of McBrearty and Brooks 2000, 'The Revolution that Wasn't'). And even when the engine of collective learning spluttered into action, it took time to pick up speed. So we cannot easily judge when human history began. But we do know what to look for. We should look for sustained evidence of humans adding ideas to ideas to form new ideas. We should look for sustained innovation and ever-increasing cultural diversity. We should look for new and more diverse tools, and signs that humans were exploiting many new niches. And if, as Terrence Deacon and others have suggested, the breakthrough was the acquisition of symbolic language, then we should also look for evidence of symbolic thinking in art, body painting or signing (Deacon 1998).

The first speakers of a fully human language may not have belonged to groups normally classified within our own species, though they were surely very similar to us (Dediu and Levinson 2013). If they did belong to our species, we can date human history to at least 200,000 years ago, because that is the date of the oldest skull generally assigned to *Homo sapiens*. It was found in Omo, in Ethiopia in the 1960s (Tattersall 2012: 186).

But what we really need is evidence of new behaviours. In a comprehensive survey of African evidence from the Middle Stone Age, published in 2000, Sally McBrearty and

Alison Brooks found hints of collective learning from as early as 250,000 years ago (McBrearty and Brooks 2000; and for a brief update see Pringle 2013). The Acheulian stone technologies associated with *Homo ergaster* were replaced by new, more delicate and more varied stone tools, some of which may have been hafted. The new tools are associated with species that few anthropologists would classify as *Homo sapiens,* so the technological speed up may have preceded our own species. By 150,000 years ago, when members of our species were surely around, McBrearty and Brooks find hints that some groups were using shellfish and exchanging resources over long distances. We also see evidence of regional cultural variations. Ecological migrations are important because they show a species with enough technological creativity to move further and further from its evolutionary niche. Early in our history, new knowledge counted most at the edge of a population's range, where people faced the dangers and opportunities of testing new plants or animals. Before 100,000 BCE, we have tantalizing hints that some humans had entered deserts and forests (McBrearty and Brooks 2000: 493–494). After 60,000 such evidence multiplies; humans appear in Europe, in Australia and then in Ice-Age Siberia and, by at least 15,000 years ago, in the Americas.

Language leaves no direct traces, but archaeologists have found many hints of symbolic thinking. More than 260,000 years ago, early humans near Twin Rivers in modern Zambia used hematite (red iron oxide), possibly to paint their bodies (Stringer 2012: 129). Later evidence is less equivocal (for a good survey see Pettit 2005; on Blombos cave see Henshilwood *et al.* 2011). At Pinnacle Point in South Africa, in sites dated to about 160,000 years ago, we find the earliest evidence for the use of shellfish, along with signs of composite tools and lots of hematite, of a particularly brilliant red, which points to symbolic uses (Stringer 2012: 129). By 115,000 years ago, similar evidence turns up in modern Israel, where, in Skhul cave, archaeologists have found evidence of symbolic burials. But the best evidence of all for rich symbolic activity comes from the marvellous South African site of Blombos cave, whose remains date from almost 100,000 years ago. Here, Chris Henshilwood and his team have found delicate stone tools, seashell beads, and lumps of ochre carved with wavy lines that could almost be an early form of writing (*Ibid.*: 129–130).

Evidence for early signs of collective learning will surely come into sharper focus, but in the meantime, these hints suggest that if human history began with collective learning then something had cranked up the motor certainly by 100,000 years ago, perhaps, as early as 250,000 years ago and possibly 500,000 years ago (Dediu and Levinson 2013).

Collective Learning as a form of Universal Darwinism

Collective learning launched and sustained our species on its astonishing journey towards planetary domination. If this argument is right, it seems that some form of Universal Darwinism has driven human history. We see *variation* in the ideas and information of different human societies, from their technologies to their religious rituals, from their art and clothing to their cuisine and entertainment. Individuals and whole societies *select* some variants and reject others. And selected variations are *preserved* as they flow between minds.

But in detail, collective learning works differently from genetic learning and individual learning, and any Darwinian accounts of human history must take these differences into account. As Alex Mesoudi writes,

> …many of the details of biological evolution that have been worked out by biologists since [*The Origin of the Species*], such as particulate inheritance (the existence of discrete particles of inheritance, genes), blind variation (new genetic variation is not generated to solve a specific adaptive problem), or Weismann's barrier (the separation of genotypes and phenotypes such that changes acquired in an organism's lifetime are not directly transmitted to offspring), may not apply to cultural evolution (Mesoudi 2011: x).

Why does collective learning work so much faster than genetic learning? In part because it builds on the machinery of individual learning, which works with neurological impulses rather than entire organisms. A genetic mutation must wait a generation before it effects change; a suddenly triggered memory can have you swerving in a second. Collective learning also copies fast. It can transmit new ideas on the fly, as they evolve, and can broadcast them to many brains at once because it works with sound waves (in speech) or light waves (in signaling and imitation). Like genetic learning, collective learning is auto-catalytic, so it has generated better ways of storing and transmitting information, from writing to printing to the telegraph and internet. Auto-catalysis explains why collective learning generates not just change, but *accelerating* change. Finally, collective learning, like individual learning, builds on acquired as well as inherited variations. While genetic learning gropes randomly in the dark, collective learning can probe more purposefully.

How do variation, selection and reproduction work in collective learning?

In collective learning, as in genetic learning, some variation is blind, arising from mutation and drift; but these variations arise from misunderstandings or simple blurring of meaning rather than from biochemical glitches. Much more important is another source of variation: deliberate innovation. Richerson and Boyd call this 'guided variation' (see the taxonomy of cultural evolutionary forces in Richerson and Boyd 2005: 69). Individuals deliberately add what they have learnt to the common pool of knowledge, or tweak and modify existing ideas. A little more salt in the soup, or tautness in the bowstring, or even a separate boiler for the steam engine. Moment by moment, and often with a sense of purpose, individual learning adds new information to a shared pool of knowledge, whereas genetic learning receives its variations at random.

Selection, too, can be conscious and purposeful in collective learning. Richerson and Boyd describe purposeful selection as 'biased transmission'. We select using 'content-based' biases when we choose an idea or cultural variant on its merits, for its beauty or precision, perhaps. Other forms of selection are deliberate but less thoughtful. In a conformist or lazy mood, we often choose the most accessible idea or behaviour, or we choose ideas or behaviours associated with admired role-models. In the taxonomy of Richerson and Boyd these are called 'frequency-based biases' or 'model-based biases'. Either way, selection is trickier in collective learning because cultural variations are fuzzier than genes, though often, when we choose one word or another or vote for one political party rather than another, we chop up the cultural flow.

Reproduction is fuzzier and more complex than in genetic learning. Ideas have many parents. They can also replicate in their thousands at religious festivals or political rallies or through mass media. Most important of all, in collective learning reproduction is less tightly bound to the reproductive success of particular individuals than in genetic learning. This is why humans often select variations that are *not* adaptive under the rules of genetic learning. For example, they may choose to have fewer children than possible, thereby reducing their reproductive success (Richerson and Boyd 2005: ch. 5). This makes no sense under the rules of genetic evolution, which measure success by the number of genes passed on to the next generation. Even worse, humans sometimes risk their lives for others who are not even close kin. Genetic reproduction can just make sense of sacrifices on behalf of close kin (who do, after all, share genes with you). But it cannot explain sacrifices on behalf of strangers or people you may never have met. Collective learning can explain such behaviour, because collective learners live within shared flows of ideas, information and motivation that create a sense of shared meaning and purpose, and magnify the importance of reciprocity. We inherit ideas and values from dead strangers and living teachers as well as from parents and grandparents, and we cannot always distinguish clearly between the two types of inheritance. So collective learning allows behaviours that, from the perspective of genetic learning, seem like errors, such as the choice of a group of ducklings to treat Konrad Lorenz as their mother. Symbolic thinking blurs the line between genetic and imagined kinship. And where meanings are shared so, too, are their emotional charges. Flags and national anthems can motivate us as powerfully as family, particularly if cultural differences sharpen our sense of shared community. Richerson and Boyd have shown that in such environments models predict the rapid spread of altruistic behaviours. This is particularly true where cultural selection is 'conformist', where people choose values because they are normal within their community (*Ibid*.: ch. 6).

In short, a sense of shared meaning blurs the distinction between individual and group success. In collective learning, the viability of ideas (and sometimes of the humans who carry them) depends as much on the reproductive success of entire groups as on that of individuals. So where collective learning is at work, group selection may be as important as individual selection, because with the flourishing of human culture, genes are no longer the primary shapers of behavioural change. Group mechanisms including shared cultural norms and social structures clearly play a profound role in explaining human behaviour. So we should not be surprised to find that humans collaborate so effectively in bands, tribes and nations as well as in families. Though the idea of group selection is fiercely contested at present (for two different positions see Pinker 2013 and Wilson 2007), something like group selection is surely at work in the evolution of human culture.

Finally, and most mysteriously, collective learning generates an entirely new form of change, cultural change. Like information, cultural change often seems to inhabit a limbo between the physical and mental worlds. John Searle, who has spent much of his career trying to explain cultural phenomena, argues that the cultural realm arises from 'shared intentionality', or the shared sense of meaning created by collective learning (not his term) (Searle 2010: 3–8 and passim). 'Shared intentionality' explains why only humans can assign conventional meanings or functions to people and objects. It matters if they agree to call a piece of paper a twenty-dollar bill. The agreement creates rights, obligations and possibilities; it motivates behaviours that go well beyond our sense of individual wants or needs. Searle argues that such agreements are the foundation of all social relations and institutions. They are what make human societies different.

Conclusion: Different Versions of the Darwinian Machine

Wherever we see change swimming against the flow of entropy, we should suspect that a Darwinian machine is at work. Human history represents a spectacular example of this kind of change, so we should expect to find a Darwinian machine lurking somewhere within the discipline. Most historians have rejected this possibility, partly from fear of Social Darwinism, partly because the neo-Darwinian synthesis fit human history so poorly. But as we have seen, Darwinian machines come in different versions. A clearer appreciation of these differences may encourage historians, too, to explore the possibility that Darwinian mechanisms of some kind can help us explain the remarkable trajectory of human history. But they may also help us see human history itself as part of a much larger story of increasing complexity, most of which (perhaps all of which) was driven by Darwinian mechanisms of some kind.

'*Mutt.—Ore you astoneaged, jute you?*
Jute. – Oye am thonthorstrok, thing mud' (Finnegans Wake, Ch. 1).

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Eastern Europe within the Ancient World-Systems*

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Eastern Europe is considered as a space of the world trade systems expansion/contraction process in the early world-systems from Chalcolithic to early Iron Age. The author identifies system-forming agents and six major periods in the development of the trade relations in the ancient world which involved Eastern Europe. The paper shows the relationship between the boundaries of early exchange systems and metallurgical provinces.

Keywords: *early world-systems, expansion/contraction of world-systems, Eastern Europe, system-forming subjects, the basic trade-system element, metallurgical provinces, Balkan-Carpathian, Circumpontic, Trans Eurasian, Greek and Roman trade systems.*

In recent decades there have been many works devoted to the origin of the world economic system and to the role of early civilizations in the formation of the foundations of long-distance trade (Frank 1993; Frank, Thompson 2005; Gills and Thompson 2006; Chase-Dunn and Manning 2002; Chase-Dunn *et al*. 2010; Chase-Dunn and Hall 1997; Hall *et al*. 2009; Abu-Lughod 1989; Barfield 1989; Grinin, Ilyin, and Korotayev 2012; Grinin and Korotayev 2012). Unfortunately, the authors of the world-system approach – Andre Gunder Frank, Barry Gills, William Thompson, Janet Abu-Lughod, Christopher Chase-Dunn, Thomas Hall and others – commonly pay little attention to the regions located in the north of the early civilizations and, in particular, to Eastern Europe. For example, Frank and Thompson excluded Eastern Europe from the list of areas of economic expansion, when highlighting their indicators of the world-systems 'expansion/contraction' in the early Iron Age (Frank and Thompson 2006: 144). However, in the fifth millennium BC, this region was a part of the Afro-Eurasian chalcolithic cultural and economic exchange belt. We also know from Herodotus that in the first millennium BC, the Northern Black Sea area with adjoining steppe and forest territories was one of the most attractive regions for the development of the Greek transit trade.

The archaeological findings indicate the presence of relatively stable relations between Afro-Eurasian regions since the late fifth/early fourth millennium BC. In the Eneolithic era, copper became the basic element for the development of the trade system. The first copper mining sites and metalwork centers defined the initial contours of the fu-

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ture world-system. One can say that the wide spread of metals fueled the long-distance trade in the ancient times.

The present article is devoted to Eastern Europe as an area of world-economic meaning during the Bronze and early Iron Age, especially as bridge between different regions. We can distinguish six major periods in the development of the trade-economic relations in the ancient world, which involved Eastern Europe. The first four periods can be described only via archaeological and ethnographic data. After the first millennium BC, there exist written records of the history of the region.

Table 1. Eastern Europe in the early world-systems

<table>
<tr><th>Period</th><th colspan="2">Archaeological era</th><th>World-economy</th><th>System-forming subject</th></tr>
<tr><td>4500–3500/3200 BCE</td><td colspan="2">Chalcolithic</td><td>Balkan-Carpathian</td><td>copper</td></tr>
<tr><td>3200–2500 BCE</td><td rowspan="3">Bronze Age</td><td>Early</td><td>Circumpontic I</td><td>bronze</td></tr>
<tr><td>2400–1800 BCE</td><td>Middle</td><td>Circumpontic II</td><td>cattle</td></tr>
<tr><td>1700–1200/900 BCE</td><td>Late</td><td>Trans Eurasian</td><td>tin</td></tr>
<tr><td>800–200 BCE</td><td colspan="2" rowspan="2">Early Iron Age</td><td>Greek</td><td>grain</td></tr>
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Eastern Europe within the Chalcolithic Exchange System (4500–3200 BCE)

According to archaeological data, copper products were used in the territory of the Great Russian Plain from Transnistria to the Lower Volga region and in the Caucasus since the end of the fifth and the beginning of the fourth millennium BCE.

The source of metal technologies in Eastern Europe was the Balkan-Carpathian metallurgical center, where in the fifth millennium BC the so-called metallurgical revolution took place. We denote as 'metallurgical provinces' those areas where peculiar technologies of metal processing were developed and a certain range of manufactured goods was produced (see Chernykh 1978). We can suppose that the territory of metallurgical provinces roughly coincided with the territory of the ancient trade-economic systems (world-economies). One can find the earliest centers of East-European metallurgical industry in the Balkan-Carpathian metallurgical province.

In Eastern Europe the two oldest areas of metallurgical distribution were located in the south (the southern lands of the Russian plain from the lower part of the Dniester River to the Lower Volga region) and in the southeast (North Caucasus and Transcaucasia).

The south-western area of the Eastern European metal industry was directly linked to the Balkan-Carpathian region, which was the source both of technologies and products, and also of copper (in the form of bullion or of ore). Fur, fish, honey, agricultural products, leather, and livestock were delivered in exchange from the Russian Plain. At that time the cattle-breeding was not widely developed in the southern Russian lands. The Eneolithic communities were engaged mainly in hunting and floodplain farming. Until the Holocene cooling in the second half of the fourth millennium BCE, the climate conditions were quite favorable for this.

The largest East-European socio-economic entity of that period was the chalcolithic Trypillian (named after Trypillia village near Kiev); its western part was located in the territory of modern Romania and Moldova and the eastern part – in the Volga-Don interfluve (about the culture with respect to social-political and economic processes see Drennan *et al.* 2011: 155–159). Those territories were united into a stable system of relationships which provided a distribution of technological innovations and preservation of social and cultural characteristics. The direction of the relationships in this territory can be defined by the vector from the Balkan-Danube region to the lower Volga region.

The southeastern area (the North Caucasus and Transcaucasia) was associated with Eastern Anatolia with its ancient centers of metal processing (Çatalhöyük *et altera*). This can be traced by the type of houses, ceramics and other objects of materialised culture.

In the second half of the fifth and the beginning of the fourth millennium BCE, we find in the North Caucasus Pricked Pearls Pottery culture (the most ancient metal products found on the territory of the Caucasus can be attributed to this culture) which had links both with Trypillian culture and with Transcaucasia.

Transcaucasia, which originally had been just a mining area for the metallurgical centers of Western Asia, gradually became a place of metal processing. The most ancient Eneolithic culture of Transcaucasia – the Shulaveri-Shomutepe culture – was during its decline period connected with Eastern Anatolian centers of copper mining and processing (Ergani-Maden and others).

The final phase of this cycle is associated with the collapse of the Balkan-Carpathian metallurgical province. Most historians believe that it was triggered by the end of the so-called Holocene climatic optimum (between 7000 and 3500/3200 BC) and the beginning of the Cold Epoch, which caused a concentration of population previously inhabiting the Russian Plain in the areas adjacent to the Black, Azov and Caspian Seas. As a result of the collapse of the Balkan-Carpathian metallurgical province many metalworking techniques, typical for the Balkan-Carpathian period, were lost; some types of products also disappeared. All this indicates a serious transformation in the structure of global economic relationships (Christian 2011).

Eastern Europe in the Early Bronze Economic Systems (between 3500 and 2500 BCE)

At the turn of the fourth and third millennium BCE a new stage in the development of the global economic relations started. It was connected with the emergence of urban civilizations and marked the beginning of the Bronze Age. During this period, new systems of long-distance trade started to develop to replace the old Eneolithic system. This new system was formed by the urban centers of bronze civilizations. Alongside with bronze itself, the basis of the trade exchange was constituted by copper, arsenic and some other ores, used for the production of bronze.

When copper is mixed with other metals (*e.g.*, with lead, arsenic, zinc, antimony, and later – with tin) the resulting alloys are relatively low melting, so it was rather easy to transport the bronze ingots to the places of metallurgical production. The bronze technology had greatly expanded the area of metal processing which resulted in a rapid economic growth in the regions of bronze dissemination.

To the north of the region of the earliest civilizations there were centers of crafts and trade, which were gradually involved in the process of further exchanges. Eastern Europe was one of the most promising areas for cultural and economic expansion of the bronze centers.

Archaeologists think that during that period the southern part of Eastern Europe was related to the so-called Circumpontic (widely around Black Sea) metallurgy province which included the Balkan-Carpathian region, Asia Minor, Eastern Mediterranean, the Caucasus, and southern Russia with Caspian regions and the Southern Urals (Chernykh 1992).

Within the entire Circumpontic province one can observe relatively common manufacturing techniques of bronze, including the set of tools and manufactured products, as well as the presence of stable relations between the regions of metal ores mining and metal processing. In the same period, in the vast territories of the Russian Plain from the Urals to the Dnieper, and from the Sea of Azov to the Middle Volga existed a vast cultural and historical community. It is often called 'Pit-Grave culture' (or Yamna culture from 'yama' [pit]) (though in fact, this culture is an amalgamation of several cultures). It is believed, that the members of this particular cultural and historical community brought the ranching traditions to the steppe zone. Under the conditions of a cold climate animal husbandry was a more effective form of farming than agriculture. Cattle leather, along with the products of hunting and gathering, was exported on a large scale from these territories.

The peculiarity of the period was the emergence of a large number of copper and arsenic mines, indicating the formation of centers of local industry. In the Caucasus, Southern Urals, and the Donbass region, mining was actively developed. During this period, rich Kargalinsky deposits of copper ore and sand were discovered in the South Urals.

In the North Caucasus an amazing Maikop culture developed (comparable to the craft cultures of Mesopotamia and the Levant of that time), the Kura-Araxes culture originated in the Caucasus, and southern Russian steppes used Balkan-Carpathian and local ore materials. All these centers of metal production were functioning within a single large world-economy.

Eastern Europe in the Middle Bronze Age World-System (between 2400 and 1800/1700 BCE)

In the middle of the third millennium BCE, a new cycle of the Eastern European cultural and economic development started. For unknown reasons, in the second half of the third millennium BCE a rapid population growth started in the belt of the early civilizations and in the territories to its north. This led to an increase in the number of permanent settlements, and fostered cultural and technological exchanges. Almost continuous flow of spices, fruit, cattle, fur, wood, ocher and other goods had been moved from the centers of civilization to the periphery. In the Afro-Eurasian territory several large exchange systems were formed, characterized by the stable economic relations and the direction of trade flows to a common center. The trade flows in East-European territory at that period were focused on the Balkan-Anatolian economic center, flowing around the Black Sea from the west (through the Danube) to the east (through the Caucasus).

In Eastern Europe a sharp rise in the mining and metallurgical industry was observed, the amount of objects made of bronze and copper that dated to this period, increased almost by ten times.

The main object of exchange at this period was cattle since the rapidly increasing livestock of cattle allowed intensifying socio-economic processes. In the southern borders of Eastern Europe a number of cultures developed highly artistic craftwork. Products made of gold, silver, and precious stones became the objects of extensive exchange. In the North Caucasus, the Maykop culture flourished, while in the Caucasus the great Trialeti culture was formed. Both these cultures were characterized by rich burial mounds and were closely connected with each other and with the highly developed civilizations of Asia Minor.

The Black Sea cultures passed their achievements to the steppe regions of the Dnieper and the Don-River where animal husbandry was actively practiced. The Volga-Don communities (where breeding sheep, cows, and horses dominated) maintained ties with their neighbors not only via the waterways, but also by land. During this period wheeled vehicles were invented. A large four-wheeled carriage was found in the catacomb settlement in the Rostov region.

The intensification of social and economic processes led to the collapse of a unified Circumpontic province with relatively independent technological branches and, in general, to the reorientation of the exchange flows. By the beginning of the second millennium BCE, many older copper ore centers, for example the one of Kargaly one, had stopped functioning, along with the decline of many trade routes.

Eastern Europe in the Late Bronze World-System (between 1800/1700 and 1200 BCE)

In the second half of the second millennium BCE, several new major systems of exchange were formed in the territory of Afro-Eurasia as a result of processes of colonization and resulting from the transition to the Late Bronze technologies based on the use of tin. This period witnessed the emergence of the first transcontinental system of relationships which involved the territory from the Atlantic to the Pacific Ocean and from the African Nubia to the White Sea. During this period Eastern Europe became an active agent of the world-economy; through its territory a strategically important Trans-Eurasian Tin road was outlined which supplied the eastern part of the former Circumpontic province with raw materials. It is most probable that the second strategic commodity for Eastern Europe – horses – also moved along the Tin road. During this period, the late primitive communal system of relations was spread in the territory of the Russian plain.

After the collapse of the Circumpontic metallurgical province, technologically mainly characteristic by the usage of arsenical bronze, several new metallurgical provinces emerged, each establishing close links to different mining and metallurgical centers.

The western regions of Russian Plain joined the *European* metallurgical province; the eastern regions became parts of the *Eurasian* metallurgical province formed at that period. In both provinces tin was used for the production of bronze and complex alloys. The Caucasus remained as an independent metallurgical province, where arsenic bronze was still used.

The so-called *carcass culture* spread, which used the classic copper-tin bronze spread in the area spanning from the Dnieper to the Lower Volga. For its production the local ore and materials imported from the Urals, Western and Eastern Siberia, Kazakhstan and Central Asia were used. During this period, the powerful mining centers were developed in the Altai Mountains and in the Transbaikal region. The Siberian cassiterite (tin ore) was transported to the south – to the Mongolian steppes and further to China, and also to the west – across the Ural to the Volga region. The Siberian tin even reached the Dnieper region, where it competed with tin coming from Central Europe. Large mining centers emerged in the northern Kazakhstan. At that time the copper (malachite and azurit) mines of Dzhezkazgan and Kenkazgan extracted about two million tons of copper ore.

In the Late Bronze Age the demand for horses sharply increased, although they continued to be a very rare and expensive commodity. The horse trade gave a serious turnover and occupied the second place in the Eastern European market after the metal trade.

In the west of the Russian Plain the 'solar stone' (amber) trade flourished (Gimbutas 2004). Along the Eastern Europe border were offshoots of the Amber Road for the transfer of amber from the Baltic Sea to Rome. Within Eastern Europe amber moved to the Volga region, the Caucasus, Iran, the Urals, Siberia, Baikal, and China.

The so-called Seima-Turbinsky phenomenon (from Seima settlement in the Nizhny Novgorod region and Turbino settlement in the Perm region) also dates to this period (Kovtun 2012). This phenomenon consists in the existence of a certain similar cultural and technological tradition in technological practices in the area from the Ob-River to the Oka-River during the second half of the second millennium BCE. A thorough study of this phenomenon led to the discovery of powerful migratory movements, which went from the Altai to the west across the Urals to the Middle and Upper Volga via two flows along the border of taiga and steppe. Perhaps, these migration flows played a certain role in the formation of the Eurasian metallurgical province and the Trans-Eurasian tin way.

The second heyday of the Kargaly mines dates to this period. In the territory of a few hundred hectares a large number of ancient mines with deposits of copper and sandstones was found, annually providing several tons. The bronze production progressed to the north-west of Eastern Europe, reaching the Lake Onega. In the center and north-west of the Russian Plain during this period the Fatyanovskaya culture (named after the settlement Fatyanovo in the Yaroslavl region) emerged whose members possessed the skills of manufacturing copper and bronze. However, the findings of metal products in Fatyanovo are quite a few. Archaeologists believe that the inhabitants of this region had some links with the cultures of western Russia, although they used also the local Volga copper for their products. Somewhere to the south, the Middle Dnieper culture was located which was close to Fatyanovo.

Meanwhile, serious changes took place in the Caucasus. In the middle of the second millennium BCE in the Caucasus there started the construction of cyclopean structures (stone towers and fortresses) whose emergence is associated with the transition to the early urban type of settlements. The Transcaucasian cities became important strongholds along the trade routes connecting the Caucasus and southern Russian steppes with the Persian economic centers.

The peculiarity of the period is the scale of exchange processes. In Eastern Europe numerous treasures dating to the fifteenth to twelfth centuries BCE are found, including the objects of the Siberian, Aegean, Central European, Mesopotamian, and Chinese origin.

During this period, in the south of Eastern Europe there appeared the Cimmerians, who roamed in the northern Black Sea coast at the threshold of the second and first millennia BC. The Cimmerians were just the first who tried to monopolize transit trade of the bronze civilization with Eastern Europe.

By the end of the second millennium BCE a recession worsened and caused at the turn of the second and first millennia BCE deep crisis of economic relations between the Russian Plain communities and the neighboring regions. The collapse affected the former economic centers, and affected the peripheries of the world-economies.

Between the eleventh and the ninth centuries BCE, there was a sharp collapse of cultural and technological exchanges in the whole territory of Afro-Eurasia, including Eastern Europe. The conversion to the iron industry had undermined the existing system of exchanges, making the foundation of the ancient trade – trade in metal – ineffective. The widespread availability of iron ore, including its accessibility in the forest zone, slowed down the process of social stratification, and led to a reduction of trade and economic activity. In Eastern Europe the demographic decline started sharply reducing the number of trade and craft centers, trade routes and also mining and metallurgical industry.

Eastern Europe within the Greek World-Economy (between 800 and 200 BCE, Early Iron Age)

Between the end of the ninth and beginning of the eighth centuries BCE, there occurred a revival of trade. In the western part of Afro-Eurasia several trade and economic systems were formed, the largest of which were the Phoenician, Greek, and Assyrian/Persian systems. In the first millennium BCE the maritime trade produced major/important turnovers. The invention of an oblique sail during this epoch made it possible to go in crosswind. The Phoenician and Greek ships sailed across the stretches of the Mediterranean, went out into the Atlantic Ocean and the Black (Euxine Pont) and Azov (Maeotian Lake) seas.

The driving force of the formation of a new trade and economic system in the former Circumpontic region was the Great Greek colonization (between the eighth and sixth centuries BCE). In the territory of Eastern Europe the exchange processes come into life, as well as the flourishing trade. The main trade moved to the coasts of Pontus and Meotida where a network of Greek colonies, involved in transit trade, emerged. The wealth of the cities in the northern Black Sea coast such as Olvia, Panticapaeum, Hersonissos, Feodosia, Gorgippia, and Tanais, indicate the activity of trade exchange. Eastern Europe had become a part of the Greek world-economy.

Between the eighth and seventh centuries BCE, the Iron Age enters into force on the whole territory of Eastern Europe, including the northern outskirts of the forest zone. Between the eighth and sixth centuries, the iron production increased by an order of magnitude. The use of iron tools significantly increased the productivity in agriculture, which, in turn, stimulated the development of handicrafts and trade.

The main commodity which produced a turnover in the Greek world system was *grain*. In addition to grain, the Greeks exported from Eastern Europe cattle, leather, furs, honey, fish, eggs, amber, precious and semiprecious stones. An important item of export from Eastern Europe remained horses. With the development of sailing timber became an important subject of trade. The started usage of the Caucasian oil and bitumen for construction purposes refers to the same period. In their turn, the Greeks exported olive oil, wine, ceramics, and fabric, the trade of metals and metal products continued to develop; thus, they were actively involved in transit trade.

The questions about ancient slave trade remain hotly debated. The 'era of classical empires' that started in the mid-first millennium BCE was accompanied by numerous bloody wars and campaigns of conquest, as well as by the development of trans-regional routes and ambitious urban constructions; this was the era of 'classical slavery'. Many sources evidence the existence of slave markets and prospering human trafficking. However, the main commodity in the exchanges in the Greek Black Sea area in the early Iron Age was not slaves, but grain which constituted the basis of the Pont market.

A characteristic feature of this phase was the introduction of monetary trade. The first coins are believed to be introduced in Asia Minor Lydia in the seventh century BCE, and the Lydian king Croesus is credited to set the standards of gold and silver coins, introduced in the sixth century BCE. There also appeared coins in the Greek Black Sea coast. Alongside with money, an important element of the world-economy was the system of weights and measures. In the middle of the first millennium BC, the Greek system of weights and measures was established in the areas adjacent to Aegeide and it was used in Eastern Europe too.

The Kingdom of Bosporus with its capital in Panticapaeum (now Kerch) played a significant role in the development of the network links in the Northern Black Sea. Formed in the fifth century BCE around the Kerch and Taman peninsulas, the Kingdom of Bosporus was the most important exporter of goods from the Black Sea to Greece. In the first century BCE, the Kingdom moved under the authority of Rome.

In the first millennium BC, in the lands of the semi-nomadic tribes of the south Eastern Europe there appeared pre-state and, possibly, early state formations (Rybakov 1993). It is unknown to what extent the Cimmerians who dominated in the region before the seventh century BCE approached the level of state formation. The Scythians who replaced them were at the stage of late archaic or early state system. In the sixth century BCE, the Scythians carried out military campaigns to Asia Minor and were at war with Persia. In the fourth century BCE, the Scythians developed/maintained a steady political unity, of which the prerogatives spread throughout the whole territory of the north-western Black Sea. During the reign of Ateas, in the fourth century BCE, they successfully fought the Macedonian kings and governors besieging their borders from southwest. The Scythians controlled the core trade with Greece, thus, competing with the mighty Bosporus. The power of the Scythians was undermined by the invasions of the Sarmatians in the third century BC who displaced the Scythians to the Crimea, where they continued to control successfully the grain trade in the western Black Sea region before the invasion of the Goths in the third century BCE.

The first millennium BCE is the first period in the history of Eastern Europe which is documented by written sources with the works of Herodotus (*c.* 484–425 BC) being the most important among them. According to the 'Father of history', the Northern Black Sea Coast and the lands to the north-east Maeotis were inhabited by the Scythians:

> The closest from the Borysthenes trade harbor (Olbia) (and it lies approximately in the middle of the whole earth Pontic Scythians) live Callipydes – the Hellenic Scythians; next to them there is another tribe called the Halizones. They, together with Callipydes, have the same lifestyle as other Scythians, but they sow and eat bread, onion, garlic, lentils, and millet. Further to the north from the Halizones live the Scythian farmers. They sow grain not for their own subsistence but for sale. And beyond the Scythians live the Neuri, and to the north, as far as I know, there is already the uninhabited desert. These are the tribes along the river to the west of Hypanis Borisphen (Herodotus IV, 17).

Speaking about the Scythian legends, Herodotus several times mentioned the sacred golden objects, which indicated a peculiar meaning of this metal for the Scythians. Numerous findings of magnificent golden objects confirm the high level of the Scythian metalwork technologies and material culture in general.

The main flow of goods was by the Borysthenes (the Dnieper), which became the main commercial artery of Eastern Europe. It was the route both for the 'gold' of the Greek Black Sea trade and for corn trade. Apparently, the trade flow along the Tanais (the Don River) led to the steppe regions of the Lower Volga, where one could cross the steppe and confluents and reach the Volga, and then get through the Kama to the Urals. These lands were rich in cattle, fish, eggs, honey, copper ore, gold, and stone. Perhaps, tin was occasionally delivered from beyond the Urals for manufacturing bronze, although the Trans-Eurasian tin route had virtually declined by that time. The wide spread of the Scythian culture areas in the first millennium BC – from the Dnieper region to the Yenisei – evidences the existence of functioning links between the Northern Black Sea and the Urals and Siberia.

The trade relations were actively developed in the Caucasus. Through the seaside settlements, the North Caucasian lands had strong ties with the Greek world, through the Caucasus and the Caspian Sea to Persia. The Koban culture (from seat Koban in North Ossetia) became a notable phenomenon with extensive links with steppe cultures of the Northern Black Sea and with Transcaucasia and Persia. First, the Kobans (farmers and pastoralists) borrowed the samples of horse harness from the inhabitants of the steppe and brought them further to the regions of Asia Minor. During this period, the horse became the object of the status property for the Kobans and other mountaineers. Parts of horse harnesses are found in tombs of rich people. The boom was achieved in the middle of the millennium, when the Scythians attacked Persia, while the Greek colonies flourished on the Pont coast, and the Kingdom of Bosporus originated. The weakening of the Greeks' colonization activity, the great Greco-Persian confrontation, the crisis of the classical polis system and a number of other factors caused the stagnation of economic development of the era of classical antiquity.

After the campaigns of Alexander the Great attempts were made to create a unified system of relationships throughout the whole western territory, supported by political and legal institutions, while the economy continued to exist within the framework of individual systems established in the middle of the first millennium BCE. Between the third and second century BCE the socio-economic development of the region passed through a serious crisis associated primarily with the fierce struggle between tribal and government organizations for control of strategic areas.

Eastern Europe within the Roman World-System (between 200 BCE and fourth century AD)

Between the end of the first and the beginning of the second millennium BCE, Rome became not only a political but also an economic center around which a stable system of world-economy was formed (Gills and Thompson 2006). This system was based on a centralized circulation of silver.

Eastern Europe was included into this system in the first century BCE after the Romans had defeated the Pontic King Mithridates's troops. The heyday of the Eastern European periphery of the Roman world-economy occurred in the second century AD under the reign of the Roman Emperor Trajan. Since that time, Roman silver became the basis of exchange in Eastern Europe and its amount allows it to be the equivalent of almost all goods circulating in the region.

Between the first century BCE and second century AD, the territories along the Black Sea coast and related trade routes began to get involved into a new trade and economic system. Unlike the Greek system, which was built on the principle of a network of coastal colonies engaged in transit trade, the Roman system functioned mainly within a single empire, as well as in the adjacent territories. *Silver* was important product of the Roman export. Large quantities of silver were brought to Rome from all parts of the empire as taxes, and then silver was used as an equivalent of the value of all goods in the state as well as in the trade with external agents. Huge amounts of silver circulated in Rome and one can hardly even approximately estimate its amounts. We can only note that thousands of small (a few coins) and large (multikilogram) treasures with Roman coins as well as with products made of Roman silver have been found in Europe. A large number of them have been found in Eastern Europe, primarily in the areas adjacent to the water trade arteries.

Within the empire a developed network of roads, including bridges, ferries, postal stretches had been highly functional, and uniform laws and trade regulations had been in place. In the center and the periphery of the Roman world-economy a unified system of weights and measures had been established. Some of the elements of these weights and measures systems survived in tsarist Russia until the twentieth century.

Rome established its world-system fairly quickly – within a few decades, 'during incomplete fifty years', as Polybius wrote.

The main opponent of Rome on the way to hegemony was the Phoenicians' Carthage, controlling the south and west of the Mediterranean. On the continent, the main focuses of expansion were the Gallic lands. Having conquered the Gauls, the Romans implemented their own rules in the territory from Marseille to Normandy and Brittany. With the defeat of Carthage the Mediterranean Sea became the Inland Sea, and Rome became the sole leader in the western part of African-Eurasian region and the center of the new trade and economic system. It was quite easy for the Romans to subdue the Black Sea territories. 'Veni, vidi, vici' Caesar said after a swift victory over the Bosphorus state.

At the threshold of the old and new era a fairly stable bipolar system of Imperial Rome and China was established in the African-Eurasian territory. The lack of real competition for several centuries provided prosperity of both world-economies. It was during this period that the permanent connection between Rome and China was established, although as sources confirm 'no Roman merchant of imperial era contacted Chinese merchants personally'. Silk, porcelain and other products from China were delivered, passing from hand to hand. All interested mediators sought to maintain stability of the system, quickly restoring its equilibrium in case of vibrations caused by political reasons or intersocietal conflicts (about Silk Road see Benjamin in this volume).

Here is an illustrating example of the Bosphorus kingdom. At the turn of the second and first century BC the kingdom of Bosporus, which controlled the transit trade in the north-eastern sector of the Black Sea, became the arena of a series of powerful social explosions, the largest of which was a slave revolt led by Savmak. King of Pontus Mithridates Eupator who came to help the Bosphorus rulers actually seized the power in Panticapaeum, de facto attaching the land to his own state. Mithridates, who had created a large power, was virtually the only strong opponent of Rome in Asia Minor and the south-eastern Black Sea region. Having launched the attack on the Romans in Macedonia, Mithridates was defeated and his territory became the Roman province. So the Northeastern Black Sea region and, consequently, the whole related business chain became the part of the Roman world-economy.

In the second century AD under the reign of the Emperor Trajan, the western part of Eastern Europe joined the Roman world-system. After crossing the Danube and establishing terminals, Trajan ensured continuous and direct penetration of the Roman tools of political and economic expansion into the Carpathian region and Eastern Europe. It was then that a significant mass of Roman silver had been brought into the central lands of Eastern Europe, reviving trade and economic activity. 'The Trajan era' which coincided with the global warming and favorable conditions for agriculture remained for a long time in the memory of the people who inhabited the south-west of the Russian Plain as the era of prosperity and wealth.

Concluding Remarks

Thus, the territory of Eastern Europe repeatedly became the zone of expansion/ contraction of the world economic systems which emerged and declined in the territory of Afro-Eurasia. The rise and the decline of these systems took place due to a number of factors: technological revolutions which changed systems of agricultural and handicraft production; climatic fluctuations which seriously affected the productivity and population growth; large migration waves which swept at this period from east to west over Afro-Eurasia, and also weaker backflows moving from west to east.

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Big History, Collective Learning and the Silk Roads[*]

Craig G. Benjamin

The Silk Roads are the quintessential example of the interconnectedness of civilizations during the Era of Agrarian Civilizations, and the exchanges that occurred along them resulted in the most significant collective learning so far experienced by the human species. The primary function of the Silk Roads was to facilitate trade, but the intellectual, social, and artistic exchanges that resulted had an even greater impact on collective learning. The Silk Roads also illustrate another key theme in Big History – evolving complexity at all scales. Just as the early universe was simple until contingent circumstances made it possible for more complex entities to appear, and that the relatively simple single-cell organisms of early life on the planet were able to evolve into an extraordinary, complex biodiversity, so human communities and the connections between them followed similar trajectories. The comingling of so many goods, ideas, and diseases around a geographical hub located deep in central Eurasia was the catalyst for an extraordinary increase in the complexity of human relationships and collective learning, a complexity that helped drive our species inexorably along a path towards the modern revolution.

Keywords: *Silk Roads, Collective Learning, Agrarian Civilizations, Afro-Eurasia, trade.*

Introduction

During the Era of Agrarian Civilizations (*c.* 3000 BCE – 1750 CE) human communities did not exist in isolation. As confederations of pastoralists, states and large-scale agrarian civilizations expanded and stretched their boundaries, they joined together to form larger systems. Sometimes they joined up simply because their borders met and merged, but more often they joined in a looser sense as people from one region traded with, or traveled to, or borrowed ideas from, or fought with people from other regions within and beyond agrarian civilization. Because of this regular commingling the very idea of distinct agrarian civilizations with rigid borders is misleading. Borders that we identify on maps are, for the most part, modern inventions. The borders of agrarian civilizations were more often vague regions within which the control of rulers fluctuated or was contested by the claims of neighbors or local rulers.

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Despite the complexity and fluidity of these processes, the slow linking up of different agrarian civilizations was immensely important because it facilitated a dramatic expansion in the size and diversity of collective learning, which can be described as the human capacity to share ideas so efficiently that they accumulate in the collective human memory from generation to generation. From the very beginning of human history the exchange of information and ideas between diverse peoples and cultures has been a prime mover in promoting change through this process of collective learning. As the smaller exchanges of the Early Agrarian Era began to expand, the enhanced collective learning that followed led to more and more significant changes in the material, artistic, social, and spiritual domains of human history. Eventually within the Afro-Eurasian world zone in particular, every human community was connected together within a vibrant web. This was true within each of the individual world zones, although not between them. Significant linkages developed during the era in the Americas, Australasia, and the Pacific, but the four zones were so isolated from each other that human populations in each remained utterly ignorant of events in the others.

The most influential of the intensified Afro-Eurasian exchange networks emerged around a trading hub located deep in Central Asia, along the Silk Roads. The trans-civilizational contacts that occurred through this exchange resulted in the most significant collective learning so far experienced by the human species. The first important period of the Silk Roads was between roughly 50 BCE and 250 CE, when material and intellectual exchange took place between the Chinese, Indian, Kushan, Iranian, steppe-nomadic and Mediterranean worlds. The demise of the Western Roman, Parthian, Kushan and Han Chinese empires resulted in several centuries of less regular contact, but the second 'Silk Roads Era' subsequently operated for several centuries between *c*. 600 and 1000 CE, connecting China, India, Southeast Asia, the Dar al-Islam, and the Byzantines into another vast web based on overland and maritime trade. The primary function of the Silk Roads during both periods was to facilitate trade. Not only material goods were carried along the Silk Roads, however, but intellectual, social, and artistic ideas as well, which together had an even greater impact on collective learning (Christian *et al.* 2013: 174–175).

An early example of intellectual exchange, which took place before the Silk Roads had started to operate with real intensity, was the spread of Greek and Hellenistic culture from the Eastern Mediterranean to Central Asia and India. This happened because Greek merchants and colonists followed in the footsteps of Alexander and spread Greek language, art, religion, philosophy, and law throughout much of the region. Perhaps, the most important spiritual consequence of material exchange was the spread of religions across Afro-Eurasia, particularly Mahayana Buddhism, which moved from India through Central Asia to China and East Asia. An example of cultural exchange that led to enhanced collective learning was the spread of artistic ideas and techniques, particularly the diffusion eastwards of syncretistic sculptural styles that developed in the second century CE in the workshops of Gandhara (in Pakistan) and Mathura (in India), where the first ever representation of the Buddha was conceived (*Ibid.*: 176).

The major biological consequence of Silk Roads trade was the spread of diseases and plague. Not only did the passing of disease bacteria along the Silk Roads by traders play a significant role in the depopulation and subsequent decline of both the Han and Roman Empires, but the exposure of millions of humans to these pathogens meant that antibodies spread extensively throughout the Afro-Eurasian world zone, and important immunities were built up within populations. These immunities proved of great significance in the premodern age, when Muslim, Chinese, and particularly European traders and explorers carried Afro-Eurasian diseases to the other world zones, with disastrous consequences for native populations (McNeil 1998). These four brief examples all support the claim that the Silk Roads profoundly affected the subsequent shape and direction of all human history.

Commercial and cultural exchange on this scale became possible only after the small river valley states of the early era had been consolidated into substantial agrarian civilizations, a process that was largely the result of warfare. Continuing expansion by the major civilizations meant that, by the first Silk Roads Era, just four imperial dynasties – those of the Roman, Parthian, Kushan, and Han Empires – controlled much of the Eurasian landmass, from the Pacific to the Atlantic. The consolidation of these states established order and stability over a vast and previously fragmented geopolitical environment. Extensive internal road networks were constructed, great advances were made in metallurgy and transport technology, agricultural production was intensified, and coinage appeared for the first time. By the middle of the last century BCE, conditions in Afro-Eurasia were ripe for levels of material and cultural exchange – and collective learning – hitherto unknown (Benjamin 2009: 30–32).

Also critical in facilitating these exchanges were the pastoral nomads, who formed communities that live primarily from the exploitation of domestic animals such as cattle, sheep, camels, or horses. The exact chronology of the origins and spread of pastoralism remains obscure, but certainly by the middle to late fourth millennium BCE the appearance of burial mounds across the steppes of Inner Asia indicates that some communities that were dependent upon herds or flocks of domestic animals had become semi-nomadic. There were varying degrees of nomadism, ranging from groups that had no permanent settlements at all to communities like the Andronovo that were largely sedentary and lived in permanent settlements. The highly mobile, militarized pastoralism of Inner Asia, associated with the riding of horses by the Saka/Scythians and other groups, probably did not emerge until early in the first millennium BCE (Christian *et al.* 2013: 177–178).

In Afro-Eurasia, by the time the first cities and states appeared, the technologies of the secondary products revolution had generated more productive ways of exploiting livestock, some of them so productive that they allowed entire communities to depend almost exclusively on their herds of animals (Sherratt 1981: 261–305). The more they did this, however, the more nomadic they had to be, so that they could graze their animals over large areas. The result was that there developed, over several millennia, entire lifeways based mainly on pastoralism, capable of exploiting the arid lands that ran in a long horizontal belt from northwest Africa through Southwest Asia and Central Asia to Mongolia.

By the middle of the first millennium BCE, a number of large pastoral nomadic communities had emerged with the military skills and technologies, and the endurance and mobility, to dominate their sedentary agrarian neighbors. Some of them, including the Saka, Xiongnu, Yuezhi, and Wusun, established powerful state-like confederations that formed in the steppe lands between the agrarian civilizations. These confederations demonstrated the ability of pastoral nomads to prosper in the harsh interior of Afro-Eurasia. Once such communities emerged, they facilitated the linking up of all the different lifeways and communities. Prior to the success of pastoralists in these more marginal zones, agrarian civilizations were considerably more isolated from each other. Ultimately it was the role of pastoralists as facilitators and protectors of trade and exchange that allowed the Silk Roads and other networks to flourish (Christian *et al.* 2013: 177–178).

First Silk Roads Era (*c.* 50 BCE – *c.* 250 CE)

With these preconditions in place, it was the decision by the Han Chinese to begin to interact with their western neighbors and engage in long-distance commerce that turned small-scale regional trading activity into a great trans-Afro-Eurasian commercial network. The Han became involved in the late-second century BCE after Emperor Wudi dispatched envoy Zhang Qian on a diplomatic and exploratory mission into Central Asia. When Zhang Qian returned after an epic journey of twelve years, he convinced the emperor that friendly relations could be established with many of the states of the 'Western Regions' because they were 'hungry for Han goods' (Benjamin 2007b: 3–30). Those that were not eager to trade could be subdued by force and compelled to join the Han trade and tributary network. Within a decade the Han had established a tributary relationship with dozens of city-states of Central Asia, and mercantile traffic began to flow out of China along the ancient migration routes into Central Asia. Half a century after the Han began to engage with their western neighbors, Augustus came to power in Rome following a century of civil war. This restored peace and stability to much of Western Afro-Eurasia, leading to a sharp increase in the demand for luxury goods in Rome, particularly for spices and exotic textiles like silk (Benjamin 2009: 30–32).

The major Chinese export commodity in demand in Rome was silk, an elegant, translucent, sensual material that soon came to be regarded as the last word in fashion by wealthy patrician women. The Chinese, realizing the commercial value of their monopoly on silk, carefully guarded the secret of silk production, and border guards in Dunhuang searched merchants to make sure they were not carrying any actual silk worms out of the country. The Han iron was prized in Rome for its exceptional hardness. Fine spices were imported into the Roman Empire from Arabia and India, notably nutmeg, cloves, cardamom, and pepper, prized as condiments, but also as aphrodisiacs, anesthetics, and perfumes. Trade with China and Central Asia for such high-value goods cost the Romans a fortune. In 65 CE, Roman Senator Pliny the Elder wrote that trade with Asia was draining the treasury of some 100 million sestercii every year (*Ibid.*: 30–32). Even though Pliny's figure is undoubtedly exaggerated, it provides evidence of the incredible scale of Silk Roads commercial exchanges. In return for their high value-exports, the Chinese imported a range of agricultural products (including grapes), Roman glassware, art objects from India and Egypt, and horses from the steppes.

The major Silk Roads land routes stretched from the Han capital, Chang'an, deep into Central Asia by way of the Gansu Corridor and Tarim Basin. The animal that made Silk Roads trade possible in the eastern and central regions of Afro-Eurasia was the Bactrian camel. Native to the steppes of Central Asia, the two-humped Bactrian camel is a supreme example of superb evolutionary adaptation. To survive the harsh winters, the camel grows a long, shaggy coat, which it sheds extremely rapidly as the season warms up. The two humps on its back are composed of sustaining fat and its long eyelashes and sealable nostrils help to keep out dust in the frequent sandstorms. The two broad toes on each of its feet have undivided soles and are able to spread widely as an adaptation to walking on sand. The bulk of overland Silk Roads trade was literally carried on the backs of these extraordinary animals (Christian *et al.* 2013: 178).

In western Eurasia, the major land route departed from the great trading cities of Roman Syria, crossed the Euphrates and Tigris Rivers, then climbed across the Iranian Plateau toward Afghanistan (then known as Bactria). Significant information on the geography of the western part of the Silk Roads has come to us from a document produced early in the first century CE – *Parthian Stations* – written by a Parthian Greek merchant Isodorus of Charax (Benjamin 2009: 30–32). Around the time *Parthian Stations* was being composed, the amount of trans-Afro-Eurasian trade taking place by sea was also increasing, particularly between Roman Egypt and the coast of India. The survival of the first century CE seaman's handbook, the *Periplus of the Erythrian Sea*, has provided historians with a detailed account of maritime commerce at that time (*Ibid.*: 30–32). The *Periplus* demonstrates that sailors had discovered the secrets of the monsoon 'trade' winds. The winds blow reliably from the southwest in summer, allowing heavily laden trade ships to sail across the Indian Ocean from the coast of Africa to India. In winter the winds reverse, and the same ships carrying new cargo would make the return journey to the Red Sea. Whether by land or by sea, however, no traders we are aware of ever made their way along the entire length of the Silk Roads during the first era of its operation. Instead, merchants from the major eastern and western civilizations took their goods so far, then passed them on to a series of middlemen, including traders who were operating deep within the Kushan Empire.

At the heart of the Silk Roads network, straddling and influencing both the land and maritime routes, was the Kushan Empire (*c.* 45–225 CE), one of the most important yet least known agrarian civilizations in world history (Benjamin 1998, 2009). By maintaining relatively cordial relations with Romans, Parthians, Chinese, Indians, and the steppe nomads, the Kushans were able to play a crucial role in facilitating the extraordinary levels of cross-cultural exchange that characterize this first Silk Roads Era. The Kushan monarchs were not only effective political and military rulers; they also demonstrated a remarkable appreciation of art and were patrons of innovative sculpture workshops within their empire. The output from these workshops reflects the sort of synthesis typical of the intensity of collective learning during the Era of Agrarian Civilizations.

The sculpture produced in the workshops of Gandhara and Mathura during the first two centuries of the Common Era was created by the combined talents of Central Asian, Indian, and probably Hellenistic Greek artists who placed themselves at the service of a resurgent Buddhist spirituality and created a whole new set of images for worship. Until this moment the Buddha had never been depicted in human form, but had instead been represented by symbols including an umbrella or footprints in the sand. The first ever representation of the Buddha, which appeared in Gandhara (in modern-day Pakistan), was influenced by depictions of Greco-Roman deities. This physical representation then spread along the Silk Roads, penetrating south to Sri Lanka and east to China, Japan, Korea, and Southeast Asia (Benjamin 1998, 2009).

An equally striking example of this cross-fertilization of ideas and traditions is the spread of Buddhist ideology along the great trade routes. Buddhism first emerged in northern India in the sixth century BCE. Eight hundred years later, according to ancient Chinese Buddhist documents, the Kushan king, Kanishka the Great (*c.* 129–152 CE?) convened an important meeting in Kashmir at which the decision was taken to rewrite the Buddhist scriptures in a more popular and accessible language. This helped facilitate the emergence and spread of Mahayana (or Great Vehicle) Buddhism, partly because the scriptures were now written in a language the common people could understand, and not one that could be read only by religious elites (Benjamin 2013).

The well-traveled trade routes from India through the Kushan realm and into China facilitated the spread of Buddhist ideas which, because they offered the hope of salvation to all regardless of caste or status, was already popular with India's merchants and businessmen. The Chinese merchants active in the silk trade became attracted to the faith, too, and returned home to spread the Buddhist message. Chinese edicts of 65–70 CE specifically mention the spread of Buddhism and opposition to it from imperial scholars devoted to Confucianism. By 166 CE, the Han emperor himself was sacrificing to the Buddha, and the Sutra on the 'Perfection of the Gnosis' was translated into Chinese by 179 CE. By the late fourth century, during a period of disunity in China, much of the population of northern China had adopted Buddhism, and by the sixth century much of southern China as well. The religion also later found ready acceptance in Korea, Japan, Tibet, Mongolia, and Southeast Asia (Benjamin 1998, 2009).

The Silk Roads also facilitated the spread of Christianity, Manichaeism and, later, Islam. Christian missionaries made good use of the superb Roman road and sea transportation networks. The Christian missionary, Paul of Tarsus, may have traveled as many as 8,000 miles along the roads and sea-lanes of the eastern Roman Empire preaching to small Christian communities. Christianity eventually spread further to the east along the Silk Roads, through Mesopotamia and Iran, into India, and eventually into China. One branch of Christianity, Nestorianism, became particularly strong throughout the central and eastern Silk Roads. The Central Asian religion of Manichaeism also benefitted from the silk routes after it emerged in Mesopotamia in the third century CE. Its founder, Mani (216–272 CE) was a fervent missionary who traveled extensively throughout the region and also dispatched disciples. Like Buddhism, Manichaeism was particularly attractive to merchants, and eventually most of the major Silk Roads trading cities contained Manichaean communities (Christian *et al.* 2013: 180).

During the third century of the Common Era, the Silk Roads fell gradually into decline as both China and the Roman Empire withdrew from the trans-Afro-Eurasian web. Ironically, Silk Roads trade itself was at least partly responsible for this disengagement, because it contributed to the spread of disastrous epidemic diseases. Smallpox, measles, and bubonic plagues devastated the populations at either end of the routes, where people had less resistance. Population estimates from the ancient world are always difficult, but the population of the Roman Empire may have fallen from 60 million to 45 million between the mid-first and mid-second centuries CE. As smallpox devastated the Mediterranean world late in the second century, populations declined again, to perhaps 40 million by 400 CE. In China, populations fell from perhaps 60 million in 200 CE to 45 million by 600 CE (Bentley and Zeigler 2010: 282).

These huge demographic losses, which happened at the same time as the decline of previously stable agrarian civilizations (the Han Dynasty disintegrated in 220 CE, the Kushan and Parthian Empires collapsed under pressure from Sasanian invaders a decade or so later, and the Roman Empire experienced a series of crises throughout the first half of the third century) meant that, for the next several centuries, the prevailing political situation in many parts of Afro-Eurasia was not conducive to large-scale commercial exchange. However, with the creation of the Dar al-Islam in the eighth and ninth centuries CE, and the establishment of the Tang Dynasty in China at the same time, significant Silk Roads exchanges along both land and maritime routes revived.

Second Silk Roads Era *c.* 600 – *c.* 1000 CE

Both the Tang Dynasty (618–907 CE) and its successor, the Song Dynasty (960–1279 CE), presided over a vibrant market economy in China, in which agricultural and manufacturing specialization, population growth, urbanization, and infrastructure development led to high levels of internal and external trade. New financial instruments (including printed paper money) were devised to facilitate large-scale mercantile activity. At the same time, Arab merchants, benefiting from the stable and prosperous Abbasid administration in Baghdad, began to engage with Chinese merchants in lucrative commercial enterprises. Large numbers of Muslim merchants actually moved to China where they joined communities of Byzantine, Indian, and Southeast Asian migrants in the great Chinese trading cities. As maritime trade gradually eclipsed overland trade in volume, merchants and sailors from all over Afro-Eurasia flocked to the great southern port cities of Guangzhou and Quanzhou (Christian *et al.* 2013: 180–181).

The recent discovery of a sunken ninth-century CE Arab ship – the so-called Belitung Wreck – in the waters of Indonesia has provided historians with tangible evidence of both the intensely commercial nature of Chinese-Muslim trade and the significance of maritime routes in facilitating it (Worrall 2003: 112ff.). The dhow was filled with tens of thousands of carefully packaged Tang ceramic plates and bowls, along with many gold and silver objects. The Tang bowls were functional and intended for the ninth-century equivalent of a 'mass market'. Their almost factory-like manufacture demonstrates the existence of a well-organized commercial infrastructure. The bowls required the use of cobalt for blue coloring, which was imported by the Chinese manufacturers in significant quantities from Iran. The firing date of the bowls was carefully noted in the ship's manifest. The cargo also included large quantities of standardized inkpots, spice jars, and jugs, clearly export goods manufactured for specific markets. Decorative patterns painted or glazed on the various items – including Buddhist, Iranian, and Islamic motifs – show the specific market the goods were intended for. China and the Dar al-Islam were clearly engaged in intense commercial exchanges during this second Silk Roads Era, and Arab mariners undertaking lengthy seagoing voyages were maintaining this vibrant trans-Afro-Eurasian web late in the first millennium of the Common Era.

As with the first Silk Roads Era, although the material exchanges were important and impressive, the cultural exchanges seem in retrospect of even greater significance. As noted above, long before the Tang came to power, many foreign religions had made their way into East Asia. With the advent of Islam in the seventh century and the establishment of substantial Muslim merchant communities in the centuries that followed, mosques also began to appear in many Chinese cities. Yet of all the foreign beliefs that were accepted in China, only Buddhism made substantial inroads against Confucianism. Between 600–1000 CE, thousands of Buddhist stupas and temples were constructed in China. With its promise of salvation, Buddhism seriously challenged Daoism and Confucianism for the hearts and minds of many Chinese, and in the end the syncretic faith of Chan Buddhism (Zen Buddhism in Japan) emerged as a popular compromise (Christian *et al.* 2013: 181).

Conclusion

The Silk Roads, both the land and maritime variants, are the quintessential example of the interconnectedness of civilizations during the Era of Agrarian Civilizations. Along these difficult routes through some of the harshest geography on earth traveled merchants and adventurers, diplomats and missionaries, each carrying their commodities and ideas enormous distances across the Afro-Eurasian world zone. Each category of exchange was important, but perhaps the most significant consequence was the spread of religion, particularly Buddhism, which became one of the key ideological and spiritual beliefs of South and East Asia during the Era. To this day Buddhism remains one of the great cultural bonds shared by millions of Asian people, one of the many legacies that the modern world owes to the Silk Roads. As a result of this interaction, despite the diversity of participants, the history of Afro-Eurasia has preserved a certain underlying unity, expressed in common technologies, artistic styles, cultures and religions, even disease and immunity patterns, a unity that was to have profound implications for subsequent world history.

Silk Roads exchanges play an even more significant role in the big history narrative. The physical contexts that made the Silk Roads possible were the product of billions of years of geological change and biological evolution. Geography made it possible for the first agrarian civilizations of western Eurasia and northeastern Africa to form cultural and commercial connections, but geography also prevented Chinese civilization from joining these developing networks in any substantive way. Only with the biological evolution and then human domestication of the silk worm and the Bactrian camel did the Chinese have an export commodity valuable enough, and a transport mechanism hardy enough, to justify and facilitate the expensive and complex expeditions necessary to allow the Chinese merchants to join the pre-existing Afro-Eurasian exchange network. This joining together of previously separated human communities led to a steep increase in levels of collective learning and complexity that had regional and global ramifications.

The development of the Silk Roads is also an example of another key theme in Big History – evolving complexity at all scales. In the same way that the early universe was simple until contingent circumstances made it possible for more complex entities to appear, and that the relatively simple single-cell organisms of early life on the planet were able to evolve into an extraordinary, complex biodiversity, so human communities and the connections between them followed similar trajectories. The commingling of so many goods, ideas, and diseases around a geographical hub located deep in central Eurasia was the catalyst for an extraordinary increase in the complexity of human relationships and collective learning, a complexity that drove our species inexorably along a path towards the modern revolution.

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Classifications of the Ways to Statehood and Democracy

Sergey V. Tsirel

A new classification of early and modern polities, the ways of statehood and democracy formation is offered. The situation in modern Russia together with the possibility of a democratic state formation are dealt with in detail.

Those polities whose formation is considered more or less natural (meaning possession of technological and organizational maturity while transforming into states) are entitled primary polities whereas those not possessing such maturity but forced into becoming states because of danger emanating from their more advanced neighbors (or the desire to rob them) are, as it were, forced into immature, secondary statehood whose goal is fighting against their more advanced neighbors. Secondary polities, as a rule, exhibit instability of forms, hyperactive military energies and the like. At the same time it is these polities which have produced the existing variety of contemporary states and even cultures. It is those secondary polities (formed by independent merchants/brigands) which formed first protodemocratic states and then, repeating the process, contemporary democracies of Western Europe.

The other issue of the secondary way to statehood is the formation of, so to speak, 'warm cultures' in which people (unlike the usual 'cold cultures', eastern as well as western) unable to reach a consensus about general rules of behavior in standard situations are forced to compensate for their non-existence by personal relations. Warm cultures are exemplified, first of all, by Russia and Latin America. As it seems, warm societies are, in a way, analogous to amorphous solids or solidified hyperviscous liquids which outwardly look like true crystals. Russia has yet to go through the process of crystallization in the future (which, as it seems, is taking place in Chile and Uruguaway) and the nearest decennaries will determine whether a cold crystallized Russia will become an eastern or western country.

Keywords: *statehood, democracy, warm cultures, cold cultures.*

When classifications of various major historical phenomena, of stages, formations, civilizations, *etc.* in the first place, are being constructed, two principles of their construction come into collision.

First principle – a combination of communities of the same level of development (for several or at least one parameter) into one class or some other taxon.

Second principle – a combination of simultaneously coexisting and in some way interacting communities, or at least those impacted by the same factors (*e.g.,* climate), into a common taxon.

Let us consider the well-known Marxist classifications as an example. Classical Marxism definitely preferred the first principle[1], although with many exceptions. The modern world-systems Marxism is clearly focused on the second principle. Coexisting and interacting communities of clearly different levels of development are united into a common system, though often having different ways of transformation, for that matter.

Let us note that the basic principles of biological taxonomy are fairly close to our first principle, and ecology and adjacent disciplines focus on the second principle; thus, approaches are put apart from each other, but in the historical disciplines, unfortunately, such a complete separation is impossible.

One can indicate two fairly obvious correlations between the two principles.

Firstly, the more ancient the history and the more distant (geographically) the location of the comparable communities, the less close is the relationship between them and the more important is the first principle. And, vice versa, the closer to the present, the more important is the role of the second approach. For the very ancient and remote communities the first principle is decisive, – it is in terms of development that we compare the communities of the Old and New Worlds, although it is not always convenient and not at all productive (the paths of transformation of the New and Old World communities were not strictly the same), but we simply do not have any other possibility.

Secondly, despite the apparent opposition of the two principles of classification, very clear in biology, there is, in fact, no such clarity in boundaries for history.

As an example of a society, let us consider the classical notion of the Bronze Age. On the one hand, all societies of the Bronze Age were united by a pronounced common feature of technological development (of the productive forces in Marxist terminology). Thus, this seems to be a classification based on the first principle, but in reality is somewhat different. Levels of development of the social structures of societies that used bronze tools, could differ significantly, they could have built cities or not, may have had written language and state or not, *etc*. Even their general level of technological development could have varied significantly, and these differences could have touched upon the use of bronze objects themselves, which is the basis for the determination of the Bronze Age. Some communities could have been leaders in industry and/or production of bronze tools and ornaments, whereas others just used the products of foreign craftsmen.

As a result, the classical classification according to the tools material is closer to the second principle than the first; *i.e.* it rather brings together the existing and directly or indirectly interacting communities, than the communities of one stadial level.

However, although even a classic example turned out to be difficult for our classification, there is no reason to abandon it completely in the analysis of earlier periods; for the Neolithic period it works much better. Naturally, it is most difficult to be applied to the modern world, where everything is closely related and mixed with each other. I will not consider such a difficult case, and will return to an earlier era – the time of formation of early polities, the first states in particular.

In the works of many researchers there are different classifications of early polities (*e.g.,* Claessen and Oosten 1996; Grinin 2004; Grinin and Korotayev 2009). In drawing such classifications, the authors, as it seems to us, considered various ways of early poli-

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[1] The productive forces determine the relations of production, and with them together constitute the basis of a society, on which the superstructure depends, the one that presents a totality of social, political and, above all, the legal relationships and forms of social consciousness.

ties' formation, but in the first place proceeded from the fact that they all had quite similar levels of development of technologies and social structures, or at least some of the parameters that characterize technologies and social structures. A multitude of options was mainly a habit of evolution (let us look upon it as a kind of personalized entity) to act by trial and error. Therefore, to find the best form of organization of social life of most densely populated human societies evolution had to sort out a lot of options and discard the bulk of them as unjustified. This process has many analogues in biology, – for example, the emergence of the classes of birds (class Aves), mammals (class Mammalia), *etc.* happened about this way. Both appearance and disappearance of the diversity of early polities corresponds to Sedov's law (the law of 'hierarchical compensations'), which alleges that in a complex hierarchical system increase of diversity at the top level is provided by limitation of diversity at lower levels and, vice versa, increase of diversity at the lower level [of the hierarchy] destroys the upper level of the organization (Sedov 1993; Nazaretyan 2010; Tsirel 2005). It is important to specify, that in the beginning the first polities represented the basic (concurrently the upper) level of the hierarchy, represented by a set of options that filled the newly formed niche of social devices (the so-called 'archaic diversity' (Mamkaev 1991)). But, in order to form some superstructures (*e.g.,* court and police) over the few best (and most tenacious) forms, selected by way of 'natural selection', the less tenacious forms get marginalized or, more often than not, die out. But for all that, the state remains to be one of the basic levels of classification of social institutions, over which in the course of social evolution different forms of government (monarchy, oligarchy, democracy, ...) are built, and a tree structure of institutions of different levels spreads out. Alternative forms of polities remain as half-dried twigs with stunted leaves, although hierarchically they are at a state level.

But, oddly enough, in this case the described pattern is just one of the reasons for the diversity of early polities, belonging to the first principle classification construction. There is a second reason, belonging to the second principle, which is only briefly addressed in articles and books; *i.e.* the two principles also have the meaning of two ways of generating the diversity of forms, both principles are incomplete not only when taken separately, but also without a genetic approach, which describes the origin of the phenomena. Therefore, in the future the introduced classifications will take into account not only these principles, but, first and foremost, the genesis of the phenomena classified.

Works of N. Kradin and P. Turchin (Kradin 2008; Turchin 2009) as well as of other researchers point to a clear and significant correlation between the size of societies of nomads and sedentary agricultural empires, with which they were to fight (a fight here, of course refers to wars and raids from both sides). Increase in size of the nomadic communities had been caused by the development of social structures of the nomads only to a small extent. This is indicated by pre-state traditions that prevailed in the heart of the great nomadic empires, and the lack of proper writing. And, even more, complete degradation of many of them to decay, and loss of ties with settled empires, to struggle with which they had been created. Nomadic polities almost completely degraded from huge empires (the Mongol Empire), the Xiongnu Empire, the Rouran Khaganate, both Turkic Khaganates, *etc.*) to pre-state communities.[2] All these phenomena confirm the conclusions drawn by N. Kradin and P. Turchin, that the main reason for the creation of huge analogues of public entities was the response to the formation of empires.

[2] Although, of course, the great historical past has never fallen out of the 'cultural baggage', and sometimes manifested itself in unexpected ways at historical turning points.

It makes sense to assume or even to state that this kind of response is typical not only for the relatively late nomadic communities. If more advanced neighbors united in the state, though not very large, but with a fairly organized army and a system of collecting tribute, they gained a great advantage in trade exchanges, and military skirmishes. Then the tribes, neighboring with them, also had to unite their efforts, despite the low readiness for statehood.

The assumption that was put forward allows us to offer a non-traditional approach to the classification of primary and secondary early polities, taking into account the reasons for their appearance. As a rule, the division into primary and secondary polities and cities is based on the time of their appearance and the assessment of the levels of adoption from the already existing cultures. The level of adoption (as well as an opposite in meaning characteristic of 'degree of autonomy') is a value that is difficult to measure. Therefore, lists of primary polities vary for different authors, minimalist lists only include Egypt, Sumer, China (Shang or hypothetical Xia) and two civilizations in the New World. Maximalist lists brought the number of primary states up to a dozen or even two dozen. In the most rigid version those considered primary are not even polities themselves, but cultural areas or civilizations, – the Middle East (the Near East), the Far Eastern and the American ones.

We will proceed somewhat differently and will define the primary and secondary states not by the magnitude of adoptions, but by the reasons of their aspirations for statehood and by the equally difficult to describe natural way of their transformation. Beginning with the works of Robert Carneiro (Carneiro 1970), it has become a widespread view, that the most important factors influencing the formation of primary early polities were demographic pressure and circumscription – increase in population density and conflicts with neighbors, due to the limitation (indivisibility) of natural resources exploited on a common basis. At the same time, the secondary polities were formed mainly by adopting the achievements of the primary polities.

In our view, the secondary path is a path in which the formation of a 'large polity' was mainly caused by the need to resist to more developed neighbors, or by the desire to profit from their accumulated wealth (these motives are often quite mixed with each other, so we will not try to draw any moralistic distinction for them). We will not consider the causes of wealth of the existing polities either, – really in more advanced technologies (a higher level of productive forces), or in a higher level of culture and/or more organized production and greater consumption of excess product (one that is necessary to meet more complex needs than physical survival). For our purposes these dubious distinctions are less important than other factors.

In order to clarify the image, we will present two extreme cases. The first case: early state formation (*e.g.*, Egypt) in a world of pre-state polities. It is natural to assume, that most important in the formation of Egypt as a whole (for separate nomes the situation was different) were internal processes.

The opposite situation is a pre-state, relatively early culture, caught between the established or still forming states. If we try to look for examples in close proximity to Russia, it is possible to specify the fate of various Finnish and Baltic tribes in the tenth – thirteenth centuries. Of these, only Lithuania speedily managed to create quite a strong state, whereas all the others were conquered by their more developed and powerful neighbors. We are not going to discuss either the reasons for these differences, or their long-term consequences. Let us just note these differences.

Now let us consider the basic situation. There exists some early or even not very early polity X (as well as, perhaps, polities Y, Z, *etc*.), and next to it there exist tribes, chiefdoms and other pre-state formations. If polity X (and its developed neighbors Y, Z, ...) is not in a state of complete decay, then it is at the same time a grave danger and a tidbit for the weaker and more backward neighbors. To protect themselves and/or implement their own selfish intentions, 'backward' neighbors must quickly improve their organization to such a level, that they are able to present an army of about the same number of soldiers with about the same level of armament. Obviously, the further course of events depends on their level of organization, relationships and chosen tactics (let us use this word in the plural, for plans and circumstances may vary).

Some neighbors of X are close to X not only geographically, but also close in culture, language and level of development. Then they have two extreme tactics: to submit to X on honorable terms, or, vice versa, quickly turn into X № 2 and start a battle with X № 1. Despite the enormous political differences of both ways, for us they are close to each other. Both are just pushing ahead the natural process of creating a new state (or its equivalent) and a culture akin to X, or a natural extension of X, which includes the adoption of cultural elements of assimilated peoples. Therefore, from our point of view, both options are natural primary processes, which expand and enrich the culture of polity X.

Now let us pay attention to other neighbors of X, those who are poorer and more backward, as well as more distant from X in language and culture. Of course, they can also try to negotiate with them about yielding under honorable conditions. However, the chances of observing these conditions are very weak, and the most honorable conditions may turn out to be very difficult for the majority of the population that imagines itself more or less free. In addition, they may not generally manage to do anything, before on their lands the X army starts hunting down all living creatures, including themselves.

But let us suppose a more optimistic scenario. In view of these or other reasons, history has provided enough time to respond to real or imaginary schemes of X. Then, to confront X, 'backward' neighbors can voluntarily come together under the leadership of the most powerful chiefdom (or the chiefdom with the most charismatic leader). Or, vice versa, the most powerful chiefdom or the most ambitious and charismatic leader may try to override the weaker neighbors. In any case, either in the process of uniting, or in the process of fighting for a union, they will require new forms of organization, which they did not have in their former independent position. The source of these forms can be X (who is a better source for drawing secrets of organization and the art of war from if not a strong and successful enemy?), or may develop from their own cultural elements that had not been developed so far; or they may be formed ad hoc in the complex process of association. In addition, there may be some distant examples, *e.g.,* real or imagined opponents and predecessors of X, *etc.*

In any case, the newly created state-like customs are primarily the customs of the highest ranks of the victorious chiefdom or chiefdoms united, rather than the general population, not ready for quick changes, if only they do not bring about immediate benefits.

This approach seems to encompass one of the ways of resolving contradictions between different ways of explaining the emergence of democratic societies. The underlying nature of the conflicting approaches to this subject, in our opinion, is largely due to the complexity of the relationship between liberalism (in the classic sense) and democracies.

As it is known, some political scientists argue that democracies (Dahl 1989; Collins 1999 *et al.*) are formed while clans, that have been struggling for power for a long time, cannot beat each other, and eventually conclude an armistice and agree upon more or less peaceful methods of struggle for power, involving more or less extensive groups of population. When these arrangements are successful and become a tradition, a democratic society gets formed after that. Although it remains unclear, why centuries' or even millennium long habits of personal power gets forgotten to such an extent, that no charismatic leader is able to appeal to tradition and disregard some elite agreement that crosses out ancestral customs.

In any case, on all post-Soviet space in general and in Russia in particular, this way to democracy has not been a success so far. Democratic features of some Russian regions, generated by a balance of forces in the struggle of elites (Gel'man 1999), have not survived the anti-democratic changes of the last decade. Moreover, with huge contrasts in the level of education and living standards of various Russian regions (with a Russian-speaking population), the progress of socio-economic and even of value changes is common to all of Russia.[3] Differences in living standards by 3–5 times for only 1–2 years (3 at most), slow down or speed up the general tendencies, but are unable to change them.[4]

The latest example, showing the ineffectiveness of such a way, is: changes in the Ukraine after the victory of Yanukovych in the presidential election, when even a deep internal split of the Ukraine has not become an insurmountable obstacle for the development of authoritarian tendencies.

Other scholars, such as historians or researchers studying contemporary societies (Putnam 2000, 2002; Welzel and Inglehart 2005; Tilly 2007 *et al.*) do not agree with them and believe, that political scientists describe only one of the mechanisms for implementing an advance to democracy.

A real basis for the formation of stable democratic societies lies in democratic traditions, customs, institutions, *etc.* of various peoples (Welzel and Inglehart 2005). The second point of view seems to be more convincing, but at the same time, one must admit, that with such an approach the enigma of the formation of democratic societies is substituted by the mystery of the formation of democratic institutions, customs and traditions. Inglehart (Inglehart and Welzel 2005) points to the previous economic successes of the future democracies and the reduction of the role of the concerns of a physical sur-

[3] Comparison of the Russian regions (with Russian-speaking population) to the U.S. states shows, that the former differ greatly from each other in socio-economic characteristics, but are much closer to each other in value concepts and the dynamics of transformation. Given that even in the nineteenth century the classics of Russian literature had noted great regional differences, and the civil war at the beginning of the twentieth century had split the country in two, the Soviet unification process of attitudes and values (as well as the language) of the Russian population within such a short period of time requires special consideration.

[4] For example, a high level of education and welfare of Moscow city-dwellers and liberal views (as was said) spread among them, did not prevent either mass vote rigging during the election campaign or the charismatic power of the corrupt government of Luzhkov, but it also did not interfere with his emphatically rough resignation. At the same time, in the richest regions of Russia, primarily in Moscow, consumption of vodka (the main cause of mortality in Russia) is reduced, the number of people involved in sports starts to grow, the number of victims of violations of traffic regulations begins to reduce. Thus, in the richest regions the beginning of the 'second demographic transition' and the spread of post-material values is combined with the submission to authoritarian rule, political apathy, corruption, indifference to social injustice and environmental problems of the country, as well as with a minimal distribution of other civil virtues. With some delay this combination extends to the population of other cities.

vival in favor of a more complex ('post-material') requests as one of the explanations for this.

However, a comparison of the countries rich in raw materials (mainly oil) with the poorer countries of Eastern Europe shows the limitations of such an explanation with regard to commitment to democracy, at least for short periods of time. In any case, as Inglehart points out, major changes require a change of generations and cannot be achieved in a short period of time. According to the hypothesis put forward earlier (Tsirel 2008), the first real steps towards democratization in Russia may begin no earlier than in 2035–2040, when a new generation, the generation of children of the first post-perestroika generation, will come into the political limelight.

Though the descriptions of the paths to democracy, put forward by various modern scholars, look like almost the opposite, in fact, they all share a common idea, – that a more or less stable democracy should follow the propagation of liberal values.

At the same time, a difference or even a contrast of liberal values to the democratic way of governing has historically been commonplace for many political thinkers (beginning with John Locke or Thomas Jefferson), who did not believe in the interest of the poor and uneducated people in the liberal freedoms. However, the relation of democracy to liberalism has also been mentioned by many classical authors, from which, first and foremost, Rousseau and, of course, and A. de Tocqueville should be mentioned.[5] But it would be even more correct to refer to the fact that, in spite of all the complexities of combining democracy and liberalism, ancient Greece, and especially the republican Rome, were both a homeland for democracy and for liberalism; this does not preclude the presence of deep contradictions between them, though. In contemporary political science literature this issue was highlighted by Fareed Zakaria in his brilliant book 'Illiberal Democracy' (2003).

The main difference between the two approaches lies in the fact that the first group of political scientists believes, that the spores of elites are able to implement liberal values in their environment, and then in the whole society in a fairly short time. And the basis of the transition may be a relatively random factor, – the inability to identify the winner by force and a compelled use of softer methods of struggle, based on the opinions of the population in general. From their point of view, such changes, as well as restrictions on the rights of winners, worked out over time comparable with the duration of the struggle, lead to changes in the entire political culture and to the spreading of liberal values.

The second group insists on the need for a long-term functioning of liberal (semi-liberal), customs or even the need of the shortest possible illiberal practices.

Currently, as the examples of Eastern Europe, of some countries in Latin America and especially East Asia show, there is a third way, when the authoritarian government itself, logically the main enemy of liberal ideas and practices that limit its power, looking at the success of the liberal-democratic countries, in one way or another propagates alien habits. Not all authoritarian countries, of course, go along this way (in Russia, we rather see the usual opposite way, except for short periods of reforms), but this road to democracy is evident in the modern world, though so far it has not brought any country to the final goal.

[5] With all the differences of their range of interests and philosophical views, it should be noted that both in one form or another pointed to the role of religious beliefs, relevant education or the natural desire for freedom and solidarity not necessarily common to all peoples at all times.

In our opinion, the described above mechanism of the formation of early polities sheds some light on the problem of one or another way to liberal democracy. If tribes[6] not ready yet for the formation of classical forms of monarchical power are forced to unite to confront their 'early state' neighbors, then, when united, they rely heavily on their proto-democratic customs. Thus, these analogues of early states often have many democratic features. And some of them retain them for a long time in their institutions and traditions.

Let us note, that this statement does not in any way contradict the classical political science approaches. The formation of a large polity was an imperative, and there was simply not enough time for its implementation in the form of a convincing victory of one of the clans, in securing it in the form of a monarchy and monarchical institutions. To speed up the process, it was necessary to fix proto-democratic institutions and considerable rights of ordinary fathers of families. If a proto-democratic form of government defeated a more developed *X* state (otherwise the proto-democratic society under discussion would not have left distinct traces in the narrative or archaeological sources), then this was an important step towards a more mature democracy.

After all these words, which could be understood as praise to proto-democratic analogues of early states, I should note that an absolute majority of proto-democratic communities, generally speaking, have been predatory. We are talking about the ancient Greeks and the Vikings, the Malay pirates and the highland peoples of the Caucasus mountain region (on the frequency of democratic norms with highland peoples, see Korotayev 2005). In such communities each armed robber (or a small gang leader) fancied himself an independent predator and did not wish to obey the chief's or imperial power, typical for more mature communities.

It is these proto-democratic, as well as early democratic societies, that are characterized by the simultaneous existence of the category (categories) of people that are unusually free and have the rights of citizens, alongside with another big category of people, who are absolutely not free, even without any human status. Examples of this include ancient slavery, slavery in the European colonies and in the United States of the nineteenth century; human traffic (hostage-taking), practiced by many peoples of the Caucasus, stands in the same row.

Concluding the topic of the formation of early democratic societies, we would like to add, that Western European feudal societies were not only initially formed in the same way, but, unlike the others, followed the examples of Greek and Roman democracies (and to some extent, the era of the Judges of ancient Israel). Although, of course, examples of ancient democracy were somewhat distorted by the realities of the empires of Diocletian and Constantine and the whole of Byzantine history (which Western thinkers have rejected, although made use of the Code of Justinian and of many cultural achievements of the Byzantine Empire). But, nevertheless, the ancient democratic ideals and laws inspired the European history for a long time, sliding into the shadows and re-emerging to the forefront at times of low and high Renaissance.

Thus, stable societies of the western type formed in case of coincidence of two conditions.

1) The first condition common to all proto-democracies is the proximity of a people with a tribal organization and trade-and-predatory practices to major early states and the need to resist them (both for self-defense and for robbery).

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[6] Here the concept of 'tribe' is opposed to the concept of 'chiefdom'.

2) The second condition was realized only in Europe, it was the presence of great ancient examples of not just only autocratic empires, but successful democracies as well.

It seems to us, that it was the presence of revered traditions of the great democracies of the ancient world that saved Europe from regeneration into an oriental empire (for example, in the fifteenth-sixteenth centuries, during the period of Spanish domination) that has been the end for all the other well-known democracies and proto-democracies, including Greece and Rome. We would like to stress, that both conditions are necessary. Other heirs of ancient democracies that lacked the support of Celtic or German proto-democratic customs were not able to keep to the same path. Byzantium and North Africa got easternalized (the first gradually, the second in one jump). Another direct descendant of Rome, the Venetian Republic, was, despite the name of its form of government, one of the most oligarchic states of Europe; whereas a quasi-feudal era of Zhou in China preceded an extremely severe and brutal autocracy of Qin Shi Huang.

However, the presence of a proto-democratic past or just a few proto-democratic customs in the past, though does not overlap the return to the general line of development, to communities of an oriental type, still leaves indelible traces in the culture of these countries. For example, Turkey, Lebanon and Tunisia, despite the very long imperial periods in their history, have more democratic customs than most Muslim countries.

Even more clearly can be seen the traces of proto-democratic past on the Far Eastern outskirts of the Chinese civilization. Japan, Hong Kong, and especially Taiwan and South Korea under the influence of the West got westernized much more than mainland China (where the differences also remained of a more authoritarian and 'state-like' North and a more liberal South). Let us note in passing, that in Korea not only liberalization and democratization, but also Christianiazation has involved a significant part of the population.[7]

But, on the other hand, the insufficient taking root of the liberal tradition leaves ways back to undemocratic forms of government. Most obvious is the experience of the European 1920–30s, when, in the process of mass urbanization, the urban society was diluted by former peasants that had lost their traditional base for existence. In the period before World War II, not only they or the inhabitants of the Eastern outskirts of Europe, but also the leading intellectuals of the old liberal democracies were willing to reject democracy in favor of left-wing or right-wing authoritarianism and totalitarianism. In our view, for the preservation of Western liberal democracies we should above all be most obliged to the mass fear of the horrors of German nazism, as well as a number of random contingencies.

Therefore, the aforementioned way to democracy through a voluntary concession of authoritarian governments is based only on technical, economic, military and geopolitical success of Western countries that had de-legitimized other forms of government.

Economic and geopolitical setbacks of the U.S. and the EU, and vice versa, the success of illiberal China and other authoritarian countries may turn the efforts of authoritarian governments in the opposite direction and slow down, halt or even reverse the wave of global democratization. We can see the precursor of this movement in Russia and the neighboring CIS countries.

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[7] According to the 1995 census, the percent of Christians in South Korea is somewhat higher than of Buddhists (26 per cent vs. 23 per cent), although the Chinese tradition to perform rites of several religions simultaneously and a huge percentage of respondents who called themselves atheists (49 per cent of the population) of course show, that this not a sign of complete Westernization, but rather an indication of its great influence.

At the same time, the well-known appraisal of Przeworski (Przeworski *et al.* 2000) shows, that the democratic changes that have occurred in periods with relatively high living standards and were accompanied by their rise are highly resistant. The reasons that force people to violate ancient customs, as indicated by Inglehart (1997), lie in the fact, that with an increase of welfare and personal safety there happens a shift from survival values to 'post-material' values of self-expression, as well as in the formation of 'privacy', so uncharacteristic of the traditional oriental way life. Therefore a stop of democratization is more probable than the reverse movement. However, there has been no really tough test of liberal and democratic changes in the Oriental countries, whereas the European examples of the first half of the twentieth century are not very encouraging.

Returning to the original topic of this article, let us again focus our attention on the fact, that an abundance of options and analogues of early states were formed not only and not so much because of the 'habit' of evolution to act by trial and error, but because of the need of insufficiently mature tribes and chiefdoms to withstand the early polities.

For the second type of polities the following things are by no means mandatory, but rather characteristic:

– hypertrophied military function;

– often a large size (and a large population), characteristic of more developed countries;

– poor development of other non-military functions (such as specific institutions, veizla, or poliudie, a mounted patrol of their lands instead of regular tax collecting);

– a lot of imitative or simply copied institutions;

– a high rate of formation and often a large decay rate, accompanied by complete degradation.

However, not all such communities have completed their way with a collapse accompanied by complete degradation. Another way, described above, was to become a well-developed polity with mature institutions of a western or eastern type.

We would like to note in passing, that those were great secondary polities that turned out to be the least stable ones. The disappearance of powerful enemies and/or charismatic figures of their founders (*e.g.,* Attila) led to the disappearance of the polities themselves. At the same time, rather frequent was the case when certain customs and forms of government, not being able to hold the ground at an imperial level, proved more tenacious at local levels. Relatively large proto-states or super-chiefdoms of Early Europe (including Kievan Rus') had broken up, and the small principalities, tenements, counties, *etc.* that had formed inside of them, remained and survived.

At first glance, the list of ways of formation of early states, which have already been discussed, exhausts all possibilities. Nevertheless, there remains at least one option that does not fit in the scheme of 'West-East'. An immature polity with ill-formed institutions could have been influenced by polity *X*, which would have certain customs, after that by polity *Y* with other customs, and, finally, by polity *Z* with customs of a third type. If an immature polity has resisted a variety of enemies (whether due to militancy and solidarity of its people, due to geographical features, or just by luck), experiencing all this time a heterogeneous impact, then the immaturity and instability of the institutions can become a strong tradition in itself.

We call such cultures 'warm' as opposed to conventional 'cold' cultures with stable institutions (Fig. 1).

Now let us introduce a more stringent definition. Cold societies are societies, where people have agreed upon the rules of the game (no matter how they are called, – laws, customs, traditions, sacred commandments, *etc.*) and no longer need to establish personal relations to resolve standard situations (closest to this definition are West European countries and countries of South-East Asia). In such societies the main variety of institutions is concentrated on the upper levels of their hierarchy and is intended to resolve difficult situations. With some exaggeration we can say, that in cold societies in simple and standard situations (in a shop, a cafe, at a post office, station, *etc.*) in the first place we observe an interaction of social functions and not of people.

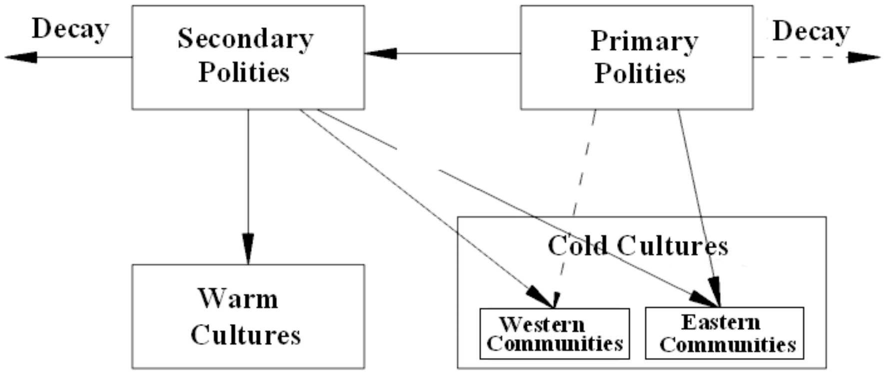

Fig. 1.

Warm societies are the ones where people, by contrast, were unable to agree on common rules. People are forced to compensate the absence of common rules (in other words, the simultaneous existence of different rules) by personal relationships or temporary draconian rules and a personal mystical virtual communication with the leader. Moreover, even corruption, which brings chaos and disorder to the functioning of cold societies, often serves not only as a transgression in warm societies, but is also a source of some (illegal) order, in which the performance of official duties turns from personal services into a paid job.

A typical example of such an order are the well-known from Russian history 'Feedings' [*i.e.* resources provided by those interested in their area of business], in which a certain field (a kind of activity, institution, *etc.*) were given under control of an official (boyar, governor), with the subaudition that he would not only manage, but also collect tribute in his own favor from the residents and workers. As a result of the state territorial reform of 1555–1556, the system of 'feedings' has been eliminated, but acting elements of this institution survived even in the twenty-first century.

A lack of effective laws makes it necessary to have a permanent access to their primary sources, including the notions of justice, and for this reason justice is often understood as universal equality of income, or even equality of lawlessness, and holds a high place on the scale of values. At the same time the lack of a regulator of justice (of law, custom, *etc.*) very often leads to greater injustice and greater stratification than in warm societies. Currently, it is even possible to specify the formal economic criterion of warm societies, –

the value of the Gini coefficient ≥ 0,45.[8] If you try to compare this opposition to the classical opposition West vs East, it is easy to see, that the opposition of West vs East characterizes the type of institutions in the first place, and the opposition of 'cold society' *vs.* 'warm society' the number of institutions and their sustainability.

It is easy to see, that Russia in the first place, as well as countries close to it, and Latin America too, belong to the category of warm cultures. Countries of tropical Africa could also be listed in the same category, but they are so young that many of them are closer to the secondary early polities rather than to the warm cultures, that have preserved some of their features.

Also we have tried to define position of present Russia in 'world classification' by means of the cluster analysis, using indicators from world socio-economic databases (World Economic Forum, Global Competitiveness Report, The Global Information Technology Report, World Development Indicators *etc.*). Since it is difficult to settle upon an indisputable method for choosing grouping rules and separation measures, multiple cluster analyses were conducted using various rules and measures. Unfortunately, the use of cluster analysis did not lead to the definition of a group of countries, to which Russia may be unambiguously assigned with respect to the analyzed formal indicators. Nonetheless, since the results of the analysis were quite interesting, we shall briefly review them here. The entire classification tree, including Russia's position, changed significantly, depending on the choice of grouping rules and separation measures. The varying positions found for Russia can be summarized by a few instances.

1. Russia forms a small cluster with Ukraine, Belarus and Bulgaria, often with the addition of Romania in the same cluster, or, less frequently, Latvia and Lithuania. This cluster either stands completely apart, or has as its near neighbor a cluster of other East European countries or a cluster of Latin American countries.
2. Russia is in a large cluster of East European countries, which includes the abovementioned countries and, frequently, Poland, Greece, Estonia, the Czech Republic and Slovakia.
3. Russia is in a large cluster, including several East European countries, as well as some countries of Latin America and the Middle East.
4. Russia is in a cluster of non-European developing countries, most often together with some Latin American countries (Uruguay, Jamaica, Guatemala, *etc.*) and less frequently with Nigeria and Jordan.

The obtained data, in our opinion, it is possible to interpret as follows:

– Russia has profound nearness with the orthodox countries of Eastern Europe, strengthened by the general Soviet inheritance (from high level of corruption to good mathematical school education).

– To a lesser degree the essential nearness is inherent in all countries of Eastern Europe especially entering into the Soviet block (decreasing on a measure forgetting the Soviet period).

– All warm cultures, despite distinctions of a historical way, have the generalities, and the generality of Latin America and Russia is shown especially strongly.

In warm cultures instability of basic institutions prevents the formation of institutions of a higher level. It is natural, that with the 'institutional poverty' and weakness of the

[8] The only exception to this rule is Hong Kong, with its specific economics. And at present, of course, the cold society in the U.S. is approaching this value, which apparently leads to a weakening of traditional American institutions.

warm societies' self-organization the most characteristic type of government for them is authoritarian (and sometimes – even totalitarian), which brings the warm societies closer to the Eastern ones and makes many social scientists rank the warm cultures among those of the Oriental type. However, there are many differences that prevent such confusion.

– While the authoritarian governments in the warm societies are more stable than in the democratic ones, they are unstable if compared to monarchies and dictatorships of the cold Eastern societies, are prone to frequent and strong transformation and may even at times give way to democratic or quasi-democratic rule.

A graphical analysis of the trajectories in the phase space of 'prosperity (GDP per capita)' – 'level of democracy', carried out by J. Goldstone and A. Kocornik-Mina (2010), identified two types of trajectories (Fig. 2), where the vertical lines up and down (I) denote the movement of warm societies[9] (see examples in Fig. 3), and the right arrow above (II) denotes the movement of cold societies. A more detailed path of the cold societies is shown on the right sidebar below, where the upper curve above the Lipset line (Lipset 1960) is more typical for communities of the Western type, and the lower curve – for communities of the Eeastern or semi-Eastern type.

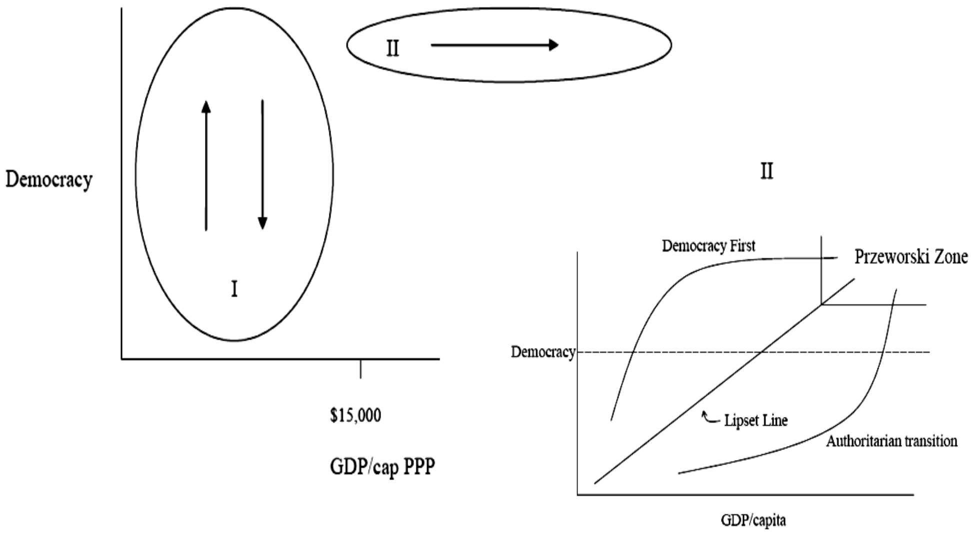

Fig. 2. Goldstone and Kocornik-Mina 2010.

[9] The author has discussed this issue in his private correspondence with J. Goldstone, and we generally agreed upon the fact that societies with complex motion paths represent a special type of cultures with unstable institutions.

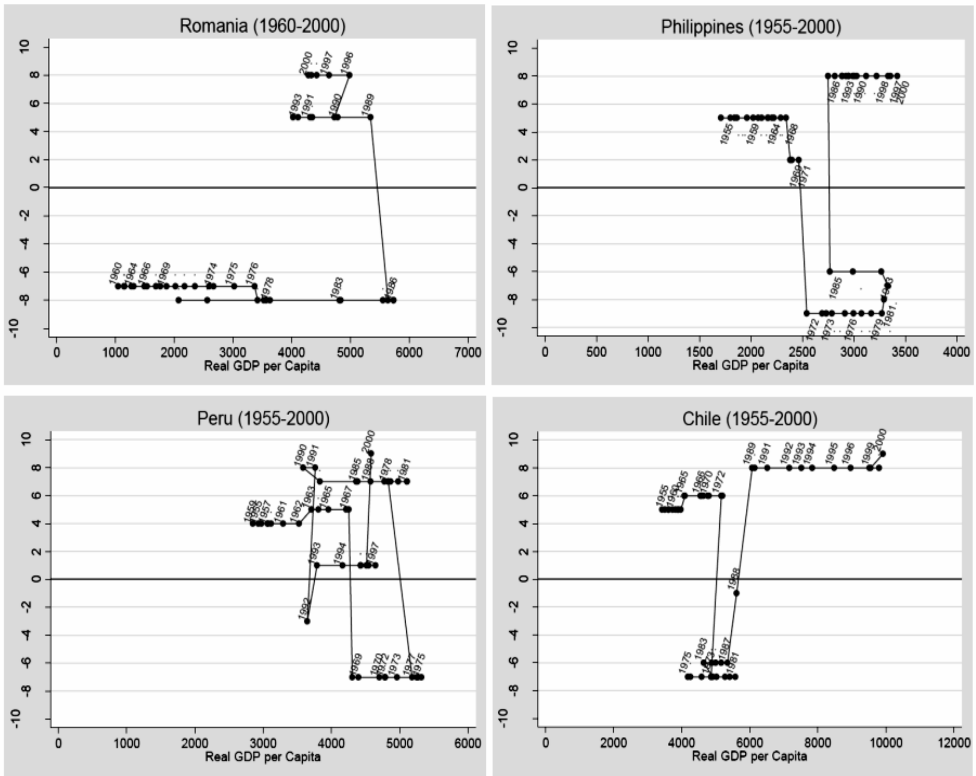

Fig. 3. Examples of chaotic motions of warm societies in the coordinates of 'level of democracy' – 'GDP per capita' (Goldstone and Kocornik-Mina 2010)

Cultures of warm societies are also subject to transformation, are often split, first one, then another discourse come to the foreground. Various conflicting views about the nature of their society coexist within the elite, gaps and contradictions prevailing over agreement among the prevailing autocratic institutions and cultural traditions. Despite the authoritarian nature of power, excepting the periods of the worst repressions, people of the warm societies have considerable freedom, often manifested in areas not typical of cold societies of any kind. For example, the freedom to break rules and laws, the ease of obtaining forgiveness from the society for the most unworthy actions, the freedom to lie and not fulfill promises, the mobility of any deadlines (by the way, including deadlines for handing in papers and abstracts). Not without reason, it is quite a common point of view in Russia, that Russia is the freest country in the world. And those saying these words are not so wrong; they simply appreciate other kinds of freedom, different from those of the cold cultures.

Some people in Russia, on the basis of these peculiarities, believe that Russia is ahead of other countries, and such freedoms, sometimes actually contributing to creativity, are the future of mankind. But, taking into account the need to comply with the rules for high density of residence in the first place (traffic rules, rules of conduct in society, rules of preserving the natural environment, *etc.*), it is difficult to accept this point of view. Moreover, this type of freedom, bordering on chaos, for the bulk of the population is not just a privilege, but an increasing burden. Warm countries stand out by security or, rather, the absence of security in the streets[10] (see Fig. 4). Not without reason demands for order in Russia (and to some extent in Latin America) that are not accompanied by requirements of law not only restrict the specific freedom of disobedience, but also block the attempts of constructing a liberal democracy.

Fig. 4. The level of security in the streets according to the estimate of the population[11] (English and Ray 2010)

Most likely, a warm society is an analogue of an amorphous material, stiff viscous fluid, outwardly hardly distinguishable from a truly crystalline solid substance. Russia still has to go through a crystallization process (which, apparently, is taking place in Chile or Uruguay). And, judging by the trends and norms of the modern world, if the crystallization occurs in the coming decades, the cold crystallized Russia will become a western democratic country.

However, if the crystallization is again postponed (as is likely), the crisis in the West will start again in 10–12 years, in accordance with the schedule of Kondratiev cycles (which is also very likely; see Korotayev and Tsirel 2010), and the progress of China and other East Asian countries will not stop and not slow down (which is less likely), it is more logical to expect that Russia will become a cold crystallized modernized Eastern autocracy. Or, at best, democracy of an Eastern type, yet not really formed in any country.

However, what country, Eastern or Western, will the crystallized Russia be, and when the expected crystallization will take place, depends not only on global processes, but even more on what is happening in Russia itself, and on us personally as well.

[10] However, in periods of harsh dictatorships streets in these countries may be quite safe (if you do not take into account the possibility of arrest or assassination by the secret police).

[11] http://kireev.livejournal.com/599071.html.

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Another, Simpler Look: Was Wealth Really Determined in 8000 BCE, 1000 BCE, 0 CE, or Even 1500 CE?

William R. Thompson and Kentaro Sakuwa

Olsson and Hibbs (2005) and Comin, Easterly, and Gong (2010) make persuasive theoretical and empirical cases for the persistence of early biogeographical and technological advantages in predicting the distribution of national economic wealth. However, these results are challenged with an examination of sixteen observations on economic complexity, GDP per capita, and city size spanning as much as ten millennia and eight to eleven regions. The regional complexity / wealth hierarchies are relatively stable only for finite intervals. Early advantages, thus, have some persistence but do not linger indefinitely. The rich do not always get richer or even stay rich, and the poor sometimes improve their standings in the world pecking order dramatically. Early advantages are important but need to be balanced with the periodic potential for overriding them.

Keywords: *economic growth, early advantage, biogeographical advantage, technological advantage, city size, societal complexity.*

Introduction

We live in an era fraught with the potential for tectonic changes in relative economic positioning. The United States, long the leader in technological innovation and economic growth, is combating symptoms of relative decline and an increasingly visible challenge from China, a state emerging rapidly from a long period of relative underdevelopment. Japan, thought to be the most likely economic challenger to the United States less than two decades ago, is mired in relative stagnant growth and facing a serious population aging problem. Russia, once a challenger to the United States, experienced an economic meltdown when the Soviet Union fragmented. But Russia is re-emerging as an economic competitor of sorts by exploiting the sale of raw materials. A state adjacent to China, India, equally populous, seeks to catch up and surpass China. The region that the United States once overtook, Western Europe, remains affluent but is confronted currently with the prospect of the world's one successful regional integration experiment breaking up. Throughout all of these potential changes in the making, a large number of states remain poor and have few prospects for any change in the near, or perhaps distant, future.

It is hardly surprising, then, that the question of how economies grow fast and slow and why some economies get ahead of others while others fall back is popular.[1] Many of

[1] In the past decade or so, Diamond (1997), Wong (1997), Frank (1998), Landes (1998), Pomeranz (2000), Maddison (2001), Clark (2007), Findlay and O'Rourke (2007), Morris (2010, 2013), Galor (2011), Parthasarathi (2011), Rosenthal and Wong (2011), among others, have appeared.

the arguments that have surfaced focus on more recent developments and yet many of these remain untested empirically. Olsson and Hibbs (2005) and Comin, Easterly, and Gong (2010) are remarkable exceptions to these generalizations. Not only do their studies encompass thousands of years, they go to some lengths to test their perspective on long-term economic growth. Olsson and Hibbs find that Diamond's (1997) argument, predicated on the technological advantages associated with diffusion possibilities linked to continental axes and the distribution of edible plants and large mammals prior to the advent of agriculture, predict well to current national incomes. The strong implication is that the world's distribution of income was determined even before the advent of agriculture. Comin, Easterly, and Gong find that technological adoption in 1500 CE predicts well to national income in the current period and that knowing about the distribution of technology in 1000 BCE and 0 CE predict respectively to technological distributions in 0 CE and 1500 CE. They conclude that the world's distribution of technology has been quite persistent. Wealth distributions, to the extent that they are predicated on technological attainments, were not strictly determined in 1000 BCE but the extent of path dependency is quite strong. Areas that have been technologically ahead in the past tend to continue to be technologically ahead in the present.

Ambitious and largely unprecedented analyses, however, are likely to be characterized by various empirical and design problems. Attempting to capture changes in economic development over thousands of years is never easy or straightforward. Assuming then that there will always be some problems, the question is whether the problems appear to strongly influence the outcome. In this case, the answer is that assumptions made in the research design appear to have biased the conclusions significantly. We do not dispute Olsson and Hibbs (2005) and Comin *et al.'s* (2010) specific findings as much as what we should make of them. If the central question is whether technological differences persist over long periods and the answer lies in the affirmative, there are at least several major caveats that need to be advanced based on the long-term analysis of uneven economic development. By more than tripling the length of the Comin *et al.'s* examination (from three millennia to ten millennia), expanding the number of observations (to sixteen across the ten millennia), changing the unit of analysis (from contemporary states to regions), and simplifying the indicators relied upon (substituting a different index of complexity for prehistorical times and gross domestic product per capita and city size for historical times), a more comprehensive picture of long-term development emerges. The persistence of earlier technological advantages does not disappear. On the contrary, it is quite evident. But so too are major departures from persistence. We should not emphasize one dimension over the other. Instead, we should strive to integrate both dimensions in understanding long-term changes.

The Persistence Analyses

Our problems with the two earlier studies differ by study. The Olsson and Hibbs (2005) study develops, elaborates, and operationalizes Diamond's (1997) argument well.[2] Fig. 1 summarizes their theory and empirical model. Favorable climate, larger continental size, and an east-west axis that permits diffusion of seeds, animals, and technology increases the availability of plants and animals that are suitable for agriculture. The greater is the

[2] The analyses of Chanda and Putterman (2005, 2007), Putterman (2008), and Bleaney and Dimico (2011) reinforce Olsson and Hibbs' finding that an earlier start on agriculture is beneficial to income levels much later.

availability of plants and animals, the greater is the opportunity to experiment with agrarian techniques. Agrarian and industrial revolutions should occur earlier in such areas than in less favored regions. The earlier is the timing of agrarian and industrial revolutions, the greater should be the contemporary level of income per capita.

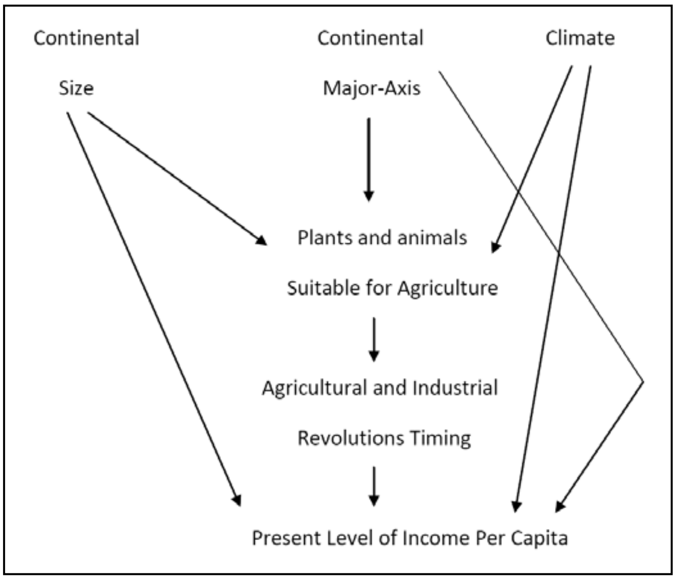

Fig. 1. Logical structure of Olsson and Hibbs' theory (2005: 928)

One can balk at various aspects of the Diamond argument or not but our main criticism of the Olsson and Hibbs examination is that the tested argument relies on one set of observations.[3] Areas favored by geographical size, climate, continental axes that do not block pan-continental diffusion, more large mammals that can be domesticated, and more plants that can be cultivated and consumed will develop earlier. This argument implies that Eurasia will be favored over Africa, Australia, and the Americas – a quite reasonable starting point for economic growth analyses.[4] It helps to explain, for instance and with some substantial help from the spread of European diseases to the Americas, why Spanish conquistadors could defeat the Aztecs and Incas.[5] It does not really specify why different parts of Eurasia have fared much differently on economic development criteria – a topic on which Dia-

[3] See Acemoglu and Johnson (2012: 51–56), among others, for a critique of the Diamond argument. Olsson and Paik (2012) develop and test a very interesting argument about the timing of agriculture that substantially modifies the idea of early biogeographical advantages. Basically, the idea is that the earliest adopters of agriculture tended also to adopt highly autocratic political systems which subsequently led to poor or poorer than might otherwise have been anticipated economic performance. Later adopters tended to develop different, less extractive, institutions and, therefore, enjoyed better economic development.

[4] See Turchin and Hall (2006) for an extension of the argument to imperial development.

[5] There is no question that Eurasia is the largest populated continent and that it encompasses more plants and large mammals that can be used for economic development purposes. Unlike the north-south alignment of Americas and Africa with major, mid-continental blockages to diffusion, it is not only possible for plants, animals, and technological innovations in one end of Eurasia to travel to the other; it is difficult to account for Eurasian development without tracking the diffusions. Parts of Eurasia certainly experienced earlier agricultural and industrial revolutions than elsewhere.

mond (1997) waffles.[6] Nor does it explain why Eurasia writ large has not linearly developed faster than Africa, Australia, and the Americas. Thus, if we use observations based on ten thousand years ago to predict to the present, we skip much of what happened (or may have happened) in between.[7]

The Comin *et al.'s* analysis (2010) looks at some of the things that happened in between the advent of agriculture and the contemporary period but there are at least six problematic sources of bias. The first problem is ignored almost entirely by the 2010 analysis. From the most macroscopic vantage point conceivable, economic development was first manifested most spectacularly in Sumer, and, later, Egypt and the eastern Mediterranean. The structural axis of Eurasian growth then was transformed into a 'dumb-bell' shape with the Mediterranean on one end and China on the other. Both dumb-bell ends went into decline around the same time but China re-emerged more strongly in the Sui/T'ang/Song era (roughly between eighth and thirteenth centuries CE) than did the Mediterranean, although the dumb-bell structure was initially rebuilt in terms of exchanges between the now-Islamic Middle East and China. China then stagnated, thanks in large part to the Mongol takeover, but its economic innovations were diffused across Eurasia to Europe thereby establishing a foundation for subsequent industrial revolutions that catapulted first Britain and then other parts of Europe into the economic lead after the eighteenth century CE. More recently, a few areas settled by British and European migrants in large numbers have moved ahead of Europe in terms of technological development and economic wealth.

Most of this story makes some tangential appearance in the Comin *et al.* discussion but it does not figure very prominently in the analysis or conclusions. If technology advantages are persistent, why did the Persian Gulf area (Sumer) not maintain its lead? Why did the Rome-Han exchange between the two most advanced parts of the world collapse? Why did China surge ahead only to stagnate in the same period Europe was catching up and forging ahead? Why was Europe the initial beneficiary of industrial revolution but later eclipsed by the United States? Put differently, why did some European colonies outperform their one-time metropoles? We have various answers for these questions, although many remain contested areas of inquiry. Comin *et al.* (2010) concentrate primarily on the role of European migration in the post-1500 period which helps to answer one of the questions (the near-contemporary and highly selective, colonial catch up with the metropoles) but do not really address the earlier historical questions.

The problem here is that the European migration to less populated North America and Australia / New Zealand was a fairly unique phenomenon.[8] We know a fair amount about how and why a few of the colonies attracted a disproportionate share of migrating labor and how that was then parlayed into disproportionate shares of international capital investment and global trade integration, in conjunction with optimal locations (in terms of climate and oceans) and natural endowments.[9] But while large-scale migrations did occur

[6] At one point, Diamond (1997) suggests that any part of Eurasia might have seized the development lead but later suggests that western Eurasia was favored over eastern Eurasia.

[7] Actually, Olsson and Hibbs (2005) say that their initial observations are based on 11,000 BCE because it is around this time that unequal levels of development began to emerge due to population migrations that had started in Africa some 70,000 years earlier and climate change that melted glaciers thereby making agriculture possible in the northern hemisphere.

[8] Perhaps the main exceptions are the 'out of Africa' movements 50 to 100, 000 years ago in which our species colonized the world and Greek and Phoenician colonization in the first millennium BCE.

[9] See, for instance, the analyses reported in Acemoglu, Johnson, and Robinson (2001, 2002); Sachs, Mellinger, and Gallup (2001); and Krieckhaus (2006).

in earlier periods, they cannot explain the decline of Sumer, Egypt, Rome, Han China in ancient history or the fall of various empires in medieval history.[10]

The second bias is that the analysis hinges on comparing observations at only three time points – 1000 BCE, 0, and 1500 CE. If the analysis is to be restricted to three observations, analysts need to be careful that the selected observations are relatively neutral in their implications for economic growth assessments. The three chosen by Comin *et al.* are not exactly neutral. Towards the end of the second millennium BCE, the most economically advanced centers in the world were located in the eastern Mediterranean littoral and China. The initial observation date, 1000 BCE, encompasses a period of 'dark age' depression in the Mediterranean area that had begun around 1200 BCE and lasted roughly through 800 BCE. The depression in economic and population growth had been brought on by a combination of extensive drought, massive migrations, urban destruction, and considerable conflict. China was not in much better shape. The Western Chou regime in this time period was retreating from tribal pressures in the west, becoming the Eastern Chou regime in the process, and initiating a period of fragmentation that led to the Warring States era in the second half of the first millennium BCE. The year 0 is a bit of a chronological contrivance but, in marked contrast to 1000 BCE, it captures the high points of the Roman and Han empires, ostensibly the economic growth leaders of the ancient world. The third observation point, 1500 CE, of course, passes over a millennium and a half of interesting developments vis-à-vis relative economic growth but it also marks more or less the starting point of European oceanic voyaging. If one of the main indicators of technological growth for this time period is ships with guns and only one small corner of the world has ships with guns in 1500, the observation point is hardly neutral.[11] For example, if the same indicator had been used in, say, 1400 CE, merely a hundred years earlier, only China then possessed ships with guns. Europeans were still limited to firing arrows from their ships at that time.

A third problem is associated with the unit of analysis. Comin *et al.* (2010) carry out most of their analyses examining 104–130 current states and backdating their attributes based on geographic location. The awkwardness here is that earlier observations are based to some extent on prominent empires. All current states that were once located in the Roman Empire, for instance, receive the same score in the year 0. That means Libya, Syria, Romania, France, and the United Kingdom are scored exactly the same. More generally,

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[10] In some of these cases, migrations of 'barbarian' tribes are part of the decline explanations. However, it is easier to argue that imperial decline or weaknesses attracted the migrations and that because of the decline, the migrations were more difficult to manage than it is to contend that migrations were either the or a principal cause of the decline. Yet many of the countless tribal migrations did not involve individuals with technological skills moving into low-tech environments. It was often the other way around although tribal warriors did sometimes possess superior weaponry technology – as illustrated by the Hyksos early second millennium BCE movement into Egypt with chariots and stronger bows. However, exceptions on the order of the Phoenician founding of Carthage certainly occurred.

[11] One of the Comin *et al*. (2010) technology indicators for 1500 is ships with 180+ guns. It seems highly unlikely that any ship in the world carried (or could carry without sinking) 180 guns or cannon as early as 1500. At this time, Portuguese ships were armed with artillery that more closely resembled mortars more than cannons but the naos were fairly small and only a few pieces of artillery could be carried on board ship. On the other hand, if the opposition possessed no maritime artillery, as in the Indian Ocean, a few guns often (but not always) sufficed. Henry VIII of England did have several very large ships constructed in the second decade of the sixteenth century and at least one (The Great Harry) carried 184 guns. But most of these guns were too small to do damage to ships and were used to repel boarders. The ships proved hard to sail, at least one capsized in part due to the heavy guns carried, and by the 1530s, the surviving ships were carrying fewer guns. See Hogg and Batchelor (1978: 11) and Archer *et al.* (2002: 262–263).

empires tended to cover large territories in which some areas were more economically advanced than were others. The Comin *et al.'s* approach treats imperial peripheries as equivalent to imperial centers. It also implies that imperial technologies persisted. In some senses, they did as exemplified by roads and canals that were modified over the years. In other respects, however, the technologies survive only in the form of scattered ruins that attract curious tourists.

Relying on the Peregrine (2003) *Atlas of Cultural Evolution* source for coding technology creates a fourth problem.[12] The *Atlas of Cultural Evolution* (ACE), a database that provides systematic information on societal complexity in all prehistorical areas, is indispensable for places less well known. Yet once an area moves from prehistorical to historical, ACE ceases to code its complexity levels. If one begins an analysis in 1000 BCE, a respectable part of the ancient world has already moved beyond the ACE codings which were designed mainly for earlier, less developed, pre-written history circumstances. Using ACE in the year 0 is even more difficult to defend.

All efforts to enumerate technology run into the problem of filtering what is included and excluded. For instance, more recent efforts to measure the pace of change in industrial innovation, on occasion, have given equal weight to ball point pens as they do to jet engines.[13] Ball point pens and jet engines do not figure in the Comin *et al.'s* study but they do abandon ACE for the 1500 CE observation and apply a 24 item scale to measure technological development. However, a fifth source of problems concerns the fact that eight of the twenty-four indicators are military in nature. They include standing army, cavalry, firearms, muskets, field artillery, warfare capable ships, heavy naval guns, and ships with 180+ guns. Are these indicators of technology or military power? If the latter, the more straightforward interpretation, the explanation has been altered substantially. Is it military technology that predicts to contemporary economic wealth? It is not clear, moreover, why some things are double- or triple-counted (two measures of firearms and three measures of naval capability for instance).[14] Another three indicators in the transportation category capture ships capable of crossing the Atlantic, Pacific, and Indian Oceans respectively which means one-fourth of the indicators privilege states with commercial maritime capability. In 1500, there was very little in the way of state navies (Modelski and Thompson 1988: 53). Only a few states such as Venice, Portugal, and England maintained state fleets. Commercial vessels were more likely to be pressed into military service when necessary. One can certainly imagine rationales for giving maritime capability heavy weight in technology measurement but no explicit argument is advanced. Similarly, mixing military with non-military technologies can be viewed as problematic if there exist ongoing arguments about whether it was military technology per se that enabled the Europeans to dominate what used to be called the Third World.[15] At the same time, all sources agree that the European military advantage in 1500 was very rudimentary.

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[12] ACE is based on the nine-volume *Encyclopedia of Prehistory* (Peregrine and Embers 2001).

[13] See, for instance, the list of innovations examined in van Duijn (1983: 178).

[14] While there is no reason to spend a great deal of time on a single indicator, the technological significance of cavalry, at least on or after 1500, is questionable. At one point, the adoption of cavalry and, later, the stirrup, reflected significant changes in military technology but in places that had access to horses these changes long preceded 1500 CE. Central Eurasian nomads led the way but did not necessarily create standing cavalries. Assyrians began to emulate their practices early in the first millennium BCE, as did the Chinese some 600 years later. After 1500, the maintenance of large cavalry units in Eurasia were more likely to signify aristocratic and agrarian constraints on technological development. Thus, as a 1500 CE indicator, it really only serves to differentiate places that had horses and those that did not (the Americas, the southern half of Africa, and Australia).

[15] Compare Parker (1988) and Thompson (1999) on this question.

Finally, there are 14 tables in Comin *et al.'s* work (2010), most of which are devoted to regression analysis involving data pertinent to the three observation points. Perhaps not surprisingly, somewhat different outcomes are associated with each of the tables which complicate summarizing accurately and simply the bottom line of the empirical effort. But putting that issue aside, two tables focusing on descriptive statistics probably deserve more attention than they receive. Table 1 synthesizes the core information of the two tables on average scores for technology adoption in selected continents and civilizations.

Table 1. Average overall technology adoption by selected continents and civilizations

Continent	1000 BCE	0 CE	1500 CE	Current
Europe	.66	.88	.86	.63
W. Europe	.65	.96	.94	.71
Africa	.36	.77	.32	.31
Asia	.58	.88	.66	.41
China	.90	1.00	.88	.33
Indian	.67	.90	.70	.31
Arab	.95	1.00	.70	.43
America	.24	.33	.14	.47
Oceania	.20	.17	.12	.73

Source: This table combines and simplifies tables 4 (on continents) and 5 (on civilizations) in Comin *et al.* (2010: 77).

Table 1 demonstrates a simple pattern. All areas indicated a peak in the year 1 and then decline. The Europeans decline least. The Americans and Oceanians make a comeback in the current time period while Africans and Asians are showing as continuing to decline. Whether or not this pattern makes historical sense, it suggests that there are very real limits to the technological persistence argument. If the data are 'right', we need to explain what happened to China, India, and the Arabs, all of whom were technological leaders at one time and then far from it at other, later times, especially after 1500. Table 1 suggests that the question should not be one of asking whether technological advantages persist in general, but why are they sometimes lost and sometimes gained.

A Different Approach and Indices

We prefer to follow up on the tantalizing simplifications of Table 1. We first recreate a Diamond/Olsson-Hibbs index for a very early biogeographical advantage. Using ACE data on development complexity for four observations: 4000 BCE, 3000 BCE, 2000 BCE and 1000 BCE, we then switch to Maddison's data on gross domestic product (GDP) per capita which begins in year 1 CE and continues through 1000 CE, 1500 CE, 1600 CE, 1700 CE, 1820 CE, 1870 CE, 1913 CE, 1950 CE, 1973 CE, and 2003 CE. Sixteen observations should be better than one or three. Rather than attempt to create a different technology scale for each observation, we rely primarily on summary biogeographical and ACE indexes for the BCE period and a standardized index of economic development for the CE era.

Instead of looking at current countries, we use calculations for eight 'regions' (Western Europe, Eastern Europe, the USSR, Asia, Japan, Latin America, Africa, and the Western Offshoots) that remain the same from 8000 BCE to 2003 CE. There is no claim made here that either regions in general or these particular regional identifications are ideal units of analysis. Maddison's aggregations are more than a bit idiosyncratic. Yet using his older data means using his choice of aggregations because dis-aggregated numbers are not made available. They do offer, however, several advantages. Regions could be said to more closely approximate ancient empires than do countries, although there is distortion either way.[16] Current regions do at least resemble ancient regions with little distortion. Maddison (2007: 382) makes regional GDP per capita data available back to the year 1. One can certainly argue that the data are fabrications but an effort has been made to justify and standardize them as meaningful and systematic fabrications. Moreover, Maddison (1995: 21) raised a similar issue to the present concern by stressing that the regional hierarchy of economic growth performance changed very little since 1820. The regions that were ahead in 1820 have remained ahead. Similarly, the regions in the hierarchical cellar were still at the bottom nearly 200 years later. This affords us with the opportunity to not only re-address Comin *et al.'s* persistence question with Maddison's data but to also extend Maddison's version of the persistence question backwards in time to 8000 BCE. If the regional hierarchy has been stable for the past two centuries, can we say the same for the past ten millennia? If the hierarchy is more stable in the 'short-term' (*i.e.,* centuries) than it is in the long-term (millennia), what does that tell us about technological persistence?

One disadvantage of the Maddisonian regional approach is that it does distort ancient history in the sense that the regions with which we are familiar today, and the ones Maddison relied on, were regions before but they were not as important as regions as they have since become. To give full justice to ancient history, we would prefer data on Sumer to the Middle East (also not in Maddison's geographical lexicon), Indus to India, or China to Asia.[17] Maddison's regions become more awkward and heterogeneous the farther back in time we go but there is little choice once a decision has been made to utilize Maddison's GDP per capita constructions and wed them with ACE complexity scores in order to encompass ten millennia.[18]

Switching to GDP per capita also obscures the Comin *et al.'s* emphasis on technology somewhat.[19] A more straightforward measure of technology across time would be preferable but hard to imagine. With sixteen observations across ten millennia, one would have to create a new technological complexity scale for each observation. While it might be possible to do that, it seems preferable to simplify the task by relying on ACE indices for the BCE period and Maddison's index for the CE era. Relying on GDP per capita as a crude proxy for technological complexity is certainly not uncommon. Yet these indicator simplifications only suggest that our interpretation of the problem will not be the last word on the subject, any more than was Olsson and Hibbs' (2005) or Comin *et al.'s* (2010).[20]

At the same time, we can examine this question of path dependency in an entirely different way and one that avoids the problems associated with using Maddison's data. If Maddison's regions are thought to be idiosyncratic and highly heterogeneous and his older GDP per capita estimates are difficult to verify, we can avoid these liabilities by examin-

[16] Switching from states to regions does not eliminate the center-periphery problem but there does seem to be some tendency for regions to become more homogenous over time in terms of existing levels of economic development.

[17] Maddison seems to have preferred to ignore the Middle East as much as possible in his data collection efforts. Presumably, that tendency reflects a desire to evade the problems associated with small, oil rich states and, perhaps, poor data for the poorer members of that region. To the extent that he dealt with this region, it is usually considered as a western extension of Asia. He classifies Egypt as an African state.

[18] That is to say that Maddison's older data are not available independent of his regional aggregations.

[19] Yet consider Comin *et al.'s* (2010).

[20] However, see as well the very strong correlations we find between regional GDP per capita and regional technological standings and report in the Appendix.

ing city size data regionally aggregated in more discrete geographical aggregations. City size data (Chandler 1987 and Modelski 2003) are available back to the beginning of cities and the assertion that regions with more large cities are/were wealthier and more technologically advanced than regions with fewer large cities seems easy to advance. Networks of cities, after all, have provided the basic infrastructure of the world economy for millennia.[21] All large cities do not work exactly the same. Some have served as agrarian hubs while others represent coastal, commercial nodes. But economic development historically has been manifested in the urbanized centers of political-economic wealth and power ever since the rise of Sumer and extending to the Pax Britannica and Americana, centered on London and New York, respectively. The only caveat is that this argument can no longer be sustained in the contemporary era due to the emergence of very large third world cities that confuse the issue of what large cities currently represent.

To operationalize this alternative, we isolate the 25 largest cities between 3700 BCE and 1950 CE at 23 points of observation.[22] Each city is assigned to one of eleven regions; Mesopotamia/Iran, Southern Mediterranean (extending from Constantinople to Morocco), Northern Mediterranean / Western Europe (initially extending from Greece to Spain and later farther north), South Asia (primarily the areas that became Pakistan and India), Central Asia (encompassing states now designated as 'stans' except for Pakistan), Eastern Europe (east of Berlin and Vienna and including what became Russia), Southeast Asia (essentially the areas that became Burma/Myanmar to Vietnam and south), East Asia (encompassing China, Korea, and Japan), North America (basically the United States), Central America (basically Mexico), and South America (the continent south of what is now Panama).[23]

Once a city is assigned to a region, its population is aggregated with other cities in the same region.[24] Each region's relative share of the total population of the top twenty-five cities then serves as an indicator of its relative regional standing. Initially, the Mesopotamian/Iranian region monopolizes the large cities but urbanization gradually diffuses to the east and west. Some regions, such as East Asia, fluctuate in significance while others attain significance only early or late. Our question is whether knowing something about the relative standing of a region at one point in time is very useful in predicting its standing at successive points in time.

Creating a biogeographical index within the context of Maddison's regions requires some adjustments. To be faithful to the Diamond/Olsson and Hibbs argument, the maximal set of ingredients for such an index should include observations for climate, continental size, continental axis direction, numbers of large mammals and plants that were domesticated, and the onset of agriculture. But if we are differentiating within continents (Mad-

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[21] On this subject, see Chase-Dunn and Willard (1994); Chase-Dunn, Manning, and Hall (2000); Chase-Dunn and Manning (2002); Modelski (2003); and Chase-Dunn, Hall and Turchin (2007).

[22] Choosing to look only at the top 25 is arbitrary but in older periods, cities tend to become fairly small as one moves beyond the first 25. Restricting our focus to the top 25 thus reduces some of the noise that might be introduced by casting the net farther down the size line. It also helps that Chandler (1987) provides more locational information for the first 25. However, Chandler identifies sources of imperial control whereas we are focused on geographical location.

[23] There are a small number of large cities that do not fit in any of these regions (for instance, a few cities rise to make the top twenty-five threshold in the Arabian Peninsula) but their relative prominence tends to be too short-lived to expand the number of regions.

[24] Only one city changes its regional location. We code Constantinople as Northern Mediterranean prior to the arrival of the Ottoman Turks and Southern Mediterranean thereafter.

dison has five Eurasian regions: Western Europe, Eastern Europe, the former Soviet Union, Asia, and Japan), continental size is no longer an issue. Climate is another casualty because most regions in our study are characterized by very different climate zones.[25]

Differentiating east-west axes (Eurasia) from north-south axes (Americas, Africa, and Australia) is not difficult.[26] Olsson and Hibbs (2005) provide information on plants and large mammals for most of the regions, as indicated in Table 2. Dates on the timing of agricultural revolutions in specific areas can be linked to regional locations without too much distortion. The dates in parentheses are estimates based on discussion of the spread of agriculture to areas in which it did not originate (Smith 1995; Imamura 1996; Thomas 1996; Frachetti *et al*. 2010). To create a single biogeographical index, the binary axis information is scored as 5 points if a region is in the vicinity of the Eurasian east-west axis and 0 points if the region is not located within Eurasia. The distribution of plants and mammals is trichotomized as high (Western and Eastern Europe), medium (Asia and the former Soviet Union), and low (all other regions). High scores were assigned 10 points, the medium scores received 6 points, and low scores were turned into 2 points.[27] For the agricultural revolution timing, the regional timing date was first subtracted from the Near Eastern timing of 8000 BCE and then divided by 1000.[28] An aggregate regional score is then constructed by simply adding the axis, plant-mammal, and agricultural revolution scores – reported in the last column of Table 2.

The biogeographical, rank order outcome puts Eastern Europe (13), Western Europe (12), and Asia (10.5) in the early lead, with Eastern Europe in the first rank largely because agriculture diffused there from the Near East before it reached Western Europe.

Table 2. Constructing a biogeographical index

Region	EW Axis Direction	Plants	Large Mammals	Agricultural Revolution	Score
1	2	3	4	5	6
Western Europe	Yes	33	9	(6000–4000 BCE)	12.0
Western Offshoots	No	2–4	0	2500 BCE	–3.5
Eastern Europe	Yes	33	9	(6000 BCE)	13.0
Former Soviet Union	Yes			(2200 BCE)	5.2

[25] Another problem is that some regions have experienced climate changes over the last ten millennia. See, *e.g.*, Burroughs (2005).

[26] A reviewer, contrary to Diamond, has argued that Africa has a long east-west axis stretching across the Sahel to the Horn. We do not find this axis very compelling because of the difficulties in crossing (we know French soldiers had problems making the crossing to set up the 1898 Fashoda crisis) and the limited historical traffic actually traversing it (at best, presumably, small groups of desert nomads). More important, large and urbanized population centers at both ends, which may be the most critical factor in differentiating between east-west and north-south interactions even though it goes beyond the Diamond argument, are missing in the African case. Eurasia's east-west axis was not all that easy to traverse but traders at least had strong profit incentives to make the effort. Just how important people were as carriers to the diffusion of seeds and animals across Eurasia is not entirely clear. Nonetheless, we will check our results to see how critical the presence or absence of an African east-west axis is to the outcome.

[27] We did not give equal weight to the continental axis and plants/mammals indicators because Eurasia already scores relatively highly on the distribution of domesticated flora and fauna. In some respects, the irony is that the super-region or continent that experienced the most diffusion needed it least. The exception to this observation is the much later diffusion of industrial technology from China to Europe in the first half of the second millennium CE. On this point, see, among a number of others, Modelski and Thompson (1996).

[28] In cases in which the timing is indicated as falling within a range of years, the middle point between the high and low timing dates is used for this calculation.

1	2	3	4	5	6
Latin America	No	2–5	0–1	2600–2500 BCE	–2.5
Africa	No	4	0	2000 BCE	–2.0
Asia	Yes	6	7	5750–6500 BCE	10.5
Japan	Yes			(2500–2400 BCE)	–0.55

Note: Cells left blank by missing data required estimation.

The former Soviet Union (5.2), part European and part Asian, falls in the middle of the regional pack. Lowest ranked are Japan (–0.55), Africa (–2.0), and Latin America (–2.5). The outcome certainly mirrors Diamond's (1997) argument about the advantages of Eurasia over the rest of the world.

To measure complexity in the fourth, third, second and first millennia BCE, we employed the ACE aggregate complexity score for some 289 prehistorical groups which were first assigned to one of Maddison's regions and then averaged.[29] The complexity score simply adds the sub-scores for 10 indicators: writing, residence, agriculture, urbanization, technology, transportation, money, population density, political integration, and societal stratification. The scales for each indicator are reported in Table 3 to give a better sense of what is involved in this computation.

One of the less expected byproducts of this analysis is that the western end of Eurasia is portrayed as relatively rich in biogeographical and societal complexity terms. Europe is often thought of as a backwater that suddenly became rich and prosperous only in the last half millennium. A longer term perspective suggests otherwise. Keeping in mind that these regional aggregations are heterogeneous and the scores are averages across multiple groups residing within their boundaries, Europe comes across as fairly consistent in its rankings across ten millennia.[30] The temporary exception is the long period of decline after the fall of the Western Roman Empire.

Table 3. The ACE complexity score components

	Indicator	Scale
1	2	3
1	Writing and Records	1 = none, 2 = mnemonic or non-written records, 3 = true writing
2	Residence Fixity	1 = nomadic, 2 = seminomadic, 3 = sedentary
3	Agriculture	1 = none, 2 = 10 % or more but secondary, 3 = primary
4	Urbanization (largest settlement)	1 = fewer than 100 persons, 2 = 100–399 persons, 3 = 400+ persons
5	Technological Specialization	1 = none, 2 = pottery, 3 = metalwork (alloys, forging, casting)
6	Land Transport	1 = human only, 2 = pack or draft animals, 3 = vehicles
7	Money	1 = none, 2 = domestically usable articles, 3 = currency
8	Population Density	1 = less than 1 person per square mile, 2 = 1–25 persons per square mile, 3 = 26+ persons per square mile

[29] Ideally, we might have weighted the averaging process by the size of the group but this information, unsurprisingly, is not available.

[30] Olsson and Paik's (2012) argument and findings, for example, suggest differentiating Southern from Northern Europe in terms of the timing of adopting agriculture and its implications.

1	2	3
9	Political Integration	1 = autonomous local communities, 2 = 1 or 2 levels above local communities, 3 = 3 or more levels above community
10	Societal Stratification	1 = egalitarian, 2 = 2 social classes, 3 = 3 or more classes or castes

The main results of our multiple observation approach to the long-term persistence question are reported in Tables 4 through 8.[31] Table 4 reports the actual biogeographical, ACE and average GDP per capita scores for the eight Maddisonian regions. Biogeographical advantage puts Western Europe, Eastern Europe, and East Asia in the earliest lead. In 4000 BCE, all five Eurasian regions are scored as about equally complex, with Japan lagging slightly behind. In the next several millennia, the European region scores steadily improve. The two Asian regions fluctuate and fall behind both their European and South American / African counterparts. The other parts of the world register consistent gains in average complexity, with North America and Australia / New Zealand (the Western Offshoots) showing only marginal improvements.

Table 4. Biogeographical advantage / complexity / GDP per capita averages (dates BCE are in italics)

Date	Western Europe	Eastern Europe	Former USSR	Western Offshoots	Latin America	Asia	Japan	Africa
8000	12.0	11.1	5.2	–3.5	–2.5	10.5	–0.6	–2.0
4000	18.5	18.5	18.5	11.4	13.0	18.3	17.1	13.7
3000	22.3	22.3	22.3	12.0	16.2	19.6	16.1	14.1
2000	27.8	27.8	27.8	12.9	17.8	20.1	17.3	15.7
1000	50.0	50.0	50.0	13.0	19.4	15.5	13.0	20.3
1	576	412	400	400	400	457	400	472
1000	427	400	400	400	400	466	425	425
1500	771	496	499	400	416	572	500	414
1600	889	548	552	400	438	576	520	422
1700	997	606	610	476	527	572	570	421
1820	1202	683	688	1202	691	577	669	420
1870	1960	937	993	2419	676	548	737	500
1913	3457	1695	1488	5233	1493	658	1387	637
1950	4578	2111	2841	9668	2503	639	1921	890
1973	11417	4988	6059	16179	4513	1225	11434	1410
2003	19912	6476	5397	28039	5786	3842	21218	1549

Switching to the GDP per capita measure indicates a different story that suggests that ACE complexity scores probably cannot necessarily be translated directly into GDP per capita terms. On the other hand, 1000 years have passed between 1000 BCE and 1 CE. In the West, the Greek city state complex had given way to the Roman Empire. In the East, Chinese fragmentation had been reversed by the rise of the Qin/Han Dynasties. In the year 1, accordingly, Western Europe and Asia are in the lead, Africa is third, and the other regions are rated as roughly equal. In 1000 CE, Asia retains its former lead, followed by Western

[31] Space considerations preclude reporting the full correlation matrices. Thus, only significant correlations are shown. The full matrices are available from the authors on request.

Europe, Japan and Africa (all three with near-identical averages), with all other regions scoring at the 1 year minimum.

By 1500 CE, however, Maddison's data have Western Europe once more in the lead with Asia a distant second. The USSR, Japan, and Eastern Europe fall in the middle of the regional hierarchy. Latin America demonstrates some slight gain while Africa manifests steady decline. North America and Australia's position and wealth/technology level is shown as remaining unchanged for 1500 years. Then the scores change dramatically. The western European GDP per capita almost doubles by 1820. The Western Offshoots (North America and Australia / New Zealand) are not far behind. Eastern Europe, the USSR, and Latin America have made some progress with development levels that are about half those of the leaders. Average 1820 Asian and African GDP per capita are little changed from their 1500 levels. By the end of the 20th century, the Western Offshoots, Western Europe, and Japan have created strong leads. Latin America and the USSR are in the middle of the hierarchy but considerably behind the leaders. Eastern Europe, Asia, and Africa occupy the bottom of the regional hierarchy.

Table 5 reports the same data in regional rank order. The long-term outcome encompasses several significant shifts in relative standing. Western Europe is an early leader but falters in the Medieval Era before rising to the lead after the industrial revolution – a lead it does not maintain beyond the 19th century. The Western Offshoots remain in the technology/growth cellar throughout most of the ten millennia period studied before seizing the lead in the last century. Asia begins in the middle, rises to the lead in the first millennium CE, and then falls back toward the bottom. Japan's position oscillates – initially middle, then falling back to low, then to high, back to the middle, and then back to high. Eastern Europe and the USSR begin relatively high and decline to the middle. Latin America starts low and never exceeds a middle ranking. Africa tends to stay near the bottom except in the first millennium CE.

Scanning rank orders is one thing. We can improve on this form of data inspection by calculating Spearman Rank Order coefficients from observation to observation, as is done in Tables 6 and 7. Table 6 reports significant coefficients without any modification of the rank orders. Table 7 corrects for the more recent European migrations, following a technique utilized by Comin *et al*. (2010).[32] In Table 6, there are basically four clusters of coefficients.

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[32] Comin *et al.* (2010) utilize Putterman and Weil's (2009) matrix on post-1500 migrations to correct 1500 and onward outcomes by the proportion of national population that has migrated into the country. We do the same for regional aggregations. Putterman and Weil's original migration matrix includes information of the migration from 1500 to 2000 for 165 countries. This state-level matrix was converted to a regional-level matrix, so that the modified matrix gives the proportions of each region's population in the year of 2000 that resided in its own and other regions in 1500. As in Comin *et al.,* pre-1500 regional rankings were generated by pre-multiplying the 'raw' vectors of wealth/technology scores by the modified (regional) migration matrix. The resulting historical rankings thus reflect the post-1500 migration on the regional basis. For details of the migration matrix, see Putterman and Weil (2009, 2010).

Table 5. Regional rank orders

Date	Western Europe	Eastern Europe	Former USSR	Western Offshoots	Latin America	Asia	Japan	Africa
8000	2	1	4	8	7	3	5	6
4000	1	1	1	8	7	4	5	6
3000	1	1	1	8	5	4	6	7
2000	1	1	1	8	5	4	6	7
1000	1	1	1	7	5	6	7	4
1	1	4	5	5	5	3	5	2
1000	2	4	4	4	4	1	3	3
1500	1	5	4	8	6	2	3	7
1600	1	4	3	8	6	2	5	7
1700	1	3	2	7	6	4	5	8
1820	1	5	4	1	3	7	6	8
1870	2	4	3	1	6	7	5	8
1913	2	3	5	1	4	7	6	8
1950	2	5	3	1	4	8	6	7
1973	3	5	4	1	6	8	2	7
2003	3	4	6	1	5	7	2	8

Table 6. Significant Spearman rank order coefficients (only entries with $P < 0.05$ are shown; column numbers correspond to row numbers)

Date		1	2	3	4	–	8	9	–	11	12	13	14	15
8000	1													
4000	2	.93												
3000	3	.85	.93											
2000	4	.85	.93	1.0										
1000	5		.77	.81	.81									
1	6													
1000	7													
1500	8		.71											
1600	9		.85	.85	.85		.93							
1700	10		.90	.93	.93		.79	.91						
1820	11													
1870	12									.85				
1913	13									.92	.88			
1950	14									.95	.91	.88		
1973	15										.83		.74	
2003	16										.76	.76		.91

The first cluster encompasses coefficients in the BCE era and indicates that the rank orders were similar between 8000 and 1000 BCE.[33] A second cluster suggests significant similarity in the rank orders between 4000 to 2000 BCE and 1500–1700 CE. The third cluster indicates little change in the rank orders between 1500 and 1700 CE. Finally, the fourth cluster singles out the period between 1820 and 2003 CE as roughly similar in terms of rankings.

If we control for the well-known impact of the early modern and modern European migrations, not too much changes. Table 7 still shows an early cluster in the BCE era and

[33] This first cluster is much diminished in terms of the number and size of the coefficients if Africa is coded as possessing an east-west axis.

the second cluster of similarity linking the BCE era to the second period spanning from 1600 to 1913.[34] The third cluster, focusing on 1500–1700 CE in Table 4, disappears in Table 7. The modern fourth cluster, however, remains evident.

Table 7. Significant Spearman rank order coefficients adjusted for migration (only entries with *P* < 0.05 are shown; column numbers correspond to row numbers)

Date		1	2	3	4	5	6	–	–	11	12	13	14	15
8000	1													
4000	2	.74												
3000	3	.83	.86											
2000	4	.76		.93										
1000	5			.81	.93									
1	6													
1000	7													
1500	8						.74							
1600	9		.91	.74	.85									
1700	10		.88	.88	.76									
1820	11				.73									
1870	12				.76					.85				
1913	13				.76	.71				.92	.88			
1950	14									.95	.91	.88		
1973	15										.83		.74	
2003	16										.76	.76		.91

Whatever these data represent, they do not support an argument for unmitigated technological and economic wealth persistence. To put it another way, it is rather hard to argue that in general national wealth was determined in 8000 BCE. The unadjusted regional rank order correlation in that year is –.143 (with the migration adjustment, the correlation is still only .286. The first-ranked region in 8000 BCE has slipped to number three ten thousand years later. The lowest-ranked region has climbed to number one. One thousand BCE is no more determinative (the unadjusted spearman coefficient is –.356 and .214 with an adjustment for migration). As in 8000 BCE, the two lowest ranking regions in 1000 BCE were in the lead by 2003. Africa, in the middle in 1000 BCE, has been at the bottom of the hierarchy for the past 500 years. Eastern Europe and the USSR, once among the ACE leaders, have struggled to stay in the middle of the rankings. Only the Asian and Latin American positions in 2003 closely resemble their 1000 BCE rankings.

What if we shift our focus to the year 1? The ability to predict from 1 to 2003 is about the same as when we use 8000 or 1000 BCE. The Spearman coefficient is –.380 if unadjusted and .262 if corrected for migration. Western Europe, Eastern Europe, the USSR, and Latin America have similar rankings at the end of the twentieth century that they held in the year 1. Asia, Japan, Africa, and the Western Offshoots do not. Shifting to a predictive base in 1500 yields a better outcome. Although the unadjusted rank order coefficient is –.238, the adjusted correlation is .619. All but Asia and the Western Offshoots have similar rankings in 2003 that they held in 1500. What is missed, however, is that the mispredicted regions include the most populous (Asia) and the richest (Western Offshoots)

[34] The first cluster almost disappears when provision is made for an east-west axis in Africa. The second and third clusters remain roughly the same.

groups. Focusing on rank orders also downplays the size of the gap between the leaders and followers in 1500 and 2003. In 1500, the West European lead represented about a 2:1 lead over the lowest average GDP per capita in Africa and the Western Offshoots (then, of course, far less western and more indigenous North American and Australian). In 2003, the Western Offshoots lead is 19 times as large as the lowest regional GDP per capita (Africa).

But Comin *et al.* (2010) also encountered problems in using 1000 BCE and 0 CE data to predict to the current period. What about earlier shorter predictive capability? Between 4000 BCE and 1000 BCE, as noted earlier, there are few changes in the regional complexity hierarchy. All of the positions are not identical but they are very close. Between 1000 BCE to 1 CE, five regions retain similar positions, while three (Eastern Europe and the USSR decline, Asia vaults to a leading position) change their respective rankings. In the transition from 1 CE to 1500 CE, there is again little change. Only Africa falls substantially in the rankings.

Thus, the Maddisonian regional rankings are fairly stable in what might be called the 'short' or intermediate long-term, if we permit what is considered short to become shorter over time since the observations are not equally spaced. With sixteen observations over ten millennia, the rankings tend not to change all that much when one moves three observations forward in time. Attempts to predict beyond three observations, especially very long forecasts, work less well. That would suggest that technology and wealth distributions persist to some extent, but not indefinitely. With the partial exception of Latin America, none of the regions examined occupies a roughly similar position across all sixteen observations. Nor does it preclude substantial deviations from the persistence expectation. Asia was once very high in the hierarchy and then very low. Conceivably, it might be very high again, as demonstrated in the case of Japan (and perhaps China sometime in the future). The western offshoots, once at the bottom of the hierarchy for a very long term, eventually took the lead. Even if the offshoots should lose that lead, they are likely to remain near the top of the hierarchy for some time to come. Granted, the western offshoots generated their remarkable shift in the growth hierarchy initially through a combination of technological borrowing and endowment, their subsequent growth was due in part to the development of new technologies. Technological persistence, according to the Maddisonian data, is not destiny.

But what if we put the debatable Maddisonian data aside and look only at the city size data which are grouped in more defensible aggregations and which represent something more than one analyst's best retrospective guesstimate. The correlation pattern that emerges in these data (see Table 8) is both different and simpler than the one generated by Maddisonian GDP per capita figures. Yet, substantively, it leads to similar conclusions.

Three clusters are prominent. The first cluster encompasses 3700 BCE to 2000 BCE and represents the most ancient Mesopotamian concentration of cities. A second cluster began to emerge half way through the first millennium BCE and persists through 1800 CE. We might call this cluster the Silk Road grouping of cities stretching from the Mediterranean through South Asia to East Asia. The names and precise locations of the cities in each region that are most prominent in any given year vary but the regions retain their relative standings more or less, as demonstrated in Fig. 2.

The third cluster has a short life span (1900 and 1950). It represents the ascendance of the West and the technological leadership of Britain (London, Birmingham, Glasgow) and the United States (New York, Boston, Chicago, Detroit, Philadelphia, and Los Angeles). However, even by 1950, the large third world cities such as Calcutta and Bombay are also entering the top twenty-five cities in the world.

So, Table 8 demonstrates persistence as well. The first cluster predominated for 2000 years and then disintegrated, largely due to an inability to feed its expanded population with declining grain productivity. The second cluster of cities stretching from the Mediterranean to East Asia persisted for another 2000 years as the central armature of the world economy but was eventually overtaken by technological changes that had first traveled the Silk Roads but became concentrated in northwestern Europe and North America.

Table 8. City size correlations across time

	3700	*3000*	*2000*	*1000*	*430*	*200*	100	361	500	622	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900
3000	.975																					
2000	.982	.975																				
1000																						
430				.859																		
200					.703																	
100				.823	.959	.856																
361				.829	.895	.729	.929															
500				.845	.976	.645	.919	.916														
622				.701	.943	.622	.877	.751	.912													
800				.785	.921		.815	.662	.878	.947												
900				.809	.954		.856	.777	.952	.935	.957											
1000				.854	.882		.854	.866	.845	.799	.765	.789										
1100				.774	.931	.819	.945	.811	.877	.936	.885	.883	.827									
1200				.803	.765	.741	.806	.664	.679	.750	.764	.686	.786	.893								
1300				.749	.807	.677	.814	.619	.695	.825	.849	.729	.797	.891	.943							
1400				.667	.793	.681	.805		.668	.826	.837	.719	.765	.880	.886	.983						
1500				.631	.836	.835	.890	.685	.742	.877	.814	.742	.708	.942	.866	.923	.936					
1600				.716	.803	.781	.871	.700	.685	.781	.751	.657	.795	.883	.911	.961	.955	.946				
1700				.790	.848	.635	.849	.716	.748	.832	.828	.735	.892	.878	.912	.974	.952	.889	.962			
1800				.697	.763		.751	.603	.647	.775	.775	.647	.844	.791	.849	.948	.938	.837	.929	.979		
1900																						
1950																						.837

Note: Only entries with $P < 0.05$ are shown. Pairwise, year-to-year, correlation coefficients are obtained based on the analysis of each region's share of city population. Years BCE in italics.

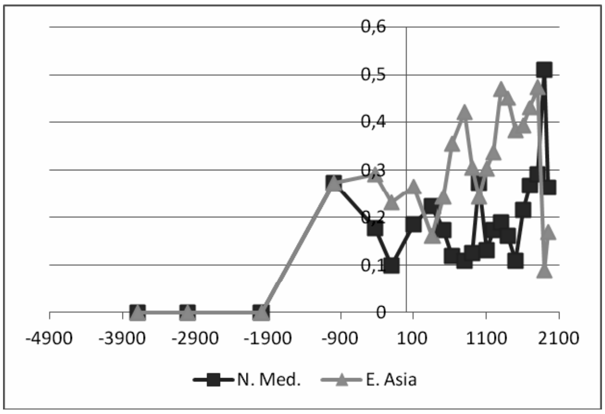

Fig. 2. Northern Mediterranean / West European and East Asian regional city share scores

The third cluster seems unlikely to retain its prominence for another 2000 years. If nothing else, city size is no longer a reliable instrument for capturing wealth and technological leadership as it once was. But the diffusion of wealth and technology is taking place faster than it once did (Comin and Hobijn 2010). The persistence of relative regional standings, as a consequence, must also be expected to change to varying extents as some once low ranking areas rise in the rankings. Yet there is also no reason to assume that all low-ranking regions will rise equally. In that respect, some mixture of persistence and change should be anticipated.

Since the patterns that emerge vary by indicator, do we need to pick and choose which one seems to have the greatest validity? The city size data demonstrate what we earlier described as largely missing from the earlier analyses of Olsson and Hibbs (2005) and Comin, Easterly, and Gong (2010). The city data isolate the Sumerian starting point for relatively large cities and underscore the 'dumb-bell' interaction between the Mediterranean and East Asia across Diamond's east-west axis. They also capture the post-1800 shift in cities due to industrialization. In these respects, the city size data most clearly conform to our understanding of the major shifts in, and evolution of, world history. Yet as long as all our indicators underline the limitations of persistence, there is really no reason to focus on one index alone. Multiple indicators show roughly similar mixtures of persistence and abrupt change.

Conclusion

Our point throughout has been that there are important limitations on path dependencies in historical economic growth patterns. Diamond's argument about east-west axis and the number of plants and large mammals certainly helps explain Eurasia's advantages over Africa and the Americas. It does not tell us too much about what happened within Eurasia after the creation of the world's continents. Whether we use biogeographical, societal complexity, GDP per capita, or city size indicators, there are very clear limits on the ability to predict in the long term who will be ahead in one year. Some places have been advantaged over others but not to the extent of predetermining economic growth well into the future. We cannot predict who precisely within Eurasia will get ahead based on Eurasia's initial advantage. Nor could we have predicted how long any Eurasian advantage might persist, except to say that it did not last forever. Using our indicators, we cannot predict who will be on 'first base' in 1 CE based on information in 1000 BCE. We cannot predict who will be ahead in 1950 or 1998 based on information in 1500. These prediction failures are not based on volatility in the data. There is substantial persistence across selected intervals. But there are also substantial shifts due ostensibly to leads and lags in technological leadership, demographic differentials, migration, climate change, disease, and warfare.

If we grant that human existence on planet Earth is characterized by some tendencies toward the stickiness of wealth and technological persistence subject to strong temporal limitations, the most interesting questions involve why these persistence tendencies fail to bar very substantial changes in regional and national rankings in economic wealth. We probably understand the reasons for technological and wealth persistence best. We do less well explaining how these characteristics are overwhelmed or in predicting how they may change in the future. It is conceivable, but by no means guaranteed, that an emphasis on very long-term shifts in technology and wealth will give us a better perspective on why the rich do not always get richer (or even stay rich) and why the poor sometimes improve their standings in the world pecking order.

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Validation Appendix

Any examination of behavior over multiple millennia is apt to rely on questionable assumptions and data. There are at least four possible threats to the validity of our results. One is that the Maddison data, especially for the earlier periods, are not very accurate. The problem, however, is that we lack alternative estimates of a similar nature to be able to assess Maddison's guesstimates about GDP per capita. Whether we will ever have alternative data, other than the city size data, encompassing the same period remains to be seen. In the interim, we have utilized what is available. Better estimates in the future would of course be very welcome. Similarly, using Maddison's older data forces us to use his regions as well. That is the way the data are made available. Would we like to experiment with different regional identifications? Certainly, but, again, we cannot at this time do so without abandon the GDP per capita scheme altogether.

However, there are two other debatable assumptions that we can assess. We use gross domestic product (GDP) per capita data to assess a question that is framed by Comin *et al.* as a matter of technological development. If we move away from indicators of technology per se, either in terms of societal complexity in the BCE era or GDP per capita in the CE era, have we modified substantially the argument at stake? We cannot do much more with the BCE era but there is a way to assess the relationship between GDP per capita and technological development in the more recent CE era. Less substantively perhaps, we also rely on rank orders to evaluate regional movement. Rank ordering in this case loses information by imposing an ordinal hierarchy on raw interval data. Why not just look at the raw interval data? The answer is that rank ordering simplifies the presentation of the findings. But it is worthwhile to check whether this simplification makes any meaningful difference to the analytical outcome.

We can make use of the Cross-Country Historical Adoption of Technology (CHAT) dataset developed by Comin and Hobijn (2010) and available at http://www.nber.org/data/chat. This data set focuses on the annual development of over 100 technologies in over 150 countries since 1800. We extracted a sample of some of the more important technologies of the past two centuries: steam ships, passenger trains, telegraph, telephone, electric power, cars, passenger planes, cellphones, and computers to create an overall technology score based on average, standardized scores on these nine technology foci. To preclude possible problems in interpreting the data, we also calculated scores based on the same data without technologies that had been introduced more than 100 years earlier. We also computed the relationship between overall technology scores and GDP per capita at the country and regional level, as shown in Table A1.[35]

The overall technology level is calculated in the following procedure. First, we take 'raw' technology indicators from the CHAT dataset which includes quantities such as the number of cars registered. We then normalized the raw values to population in order to obtain per capita indicators for the nine technology foci. Population data are taken from the National Material Capabilities dataset version 4 (Singer, Bremer and Stuckey 1972 [2010]). Second, the standardized score of each technology item *k* for country *i* is obtained as $Z_{ik} = (X_{ik} - \overline{X_k})/\sigma_k$, where $\overline{X_k}$ is the mean value. Finally, overall technology level of country *i* is calculated by averaging Z_{ik} over all *k*'s.

Table A1. Technology-GDP per capita correlations

	Country-level		Regional-level	
	Original	Adjusted	Original	Adjusted
1870	0.840	0.840	0.867*	0.867*
1913	0.850	0.850	0.954	0.954
1950	0.798	0.854	0.949	0.953
1973	0.760	0.778	0.940	0.884
1990	0.898	0.884	0.918	0.896
1998	0.910	0.915	0.991	0.994

Note: The adjustment involves removing technology that is older than 100 years from the calculation. Statistical significance is < 0.05 except for the two correlations with asterisks where p = <.10.

The outcome is that since 1870 at least, the general relationship between technological development and GDP per capita is quite high, especially at the regional level. It does not seem to matter if we control for old technology, the outcomes are quite similar. The possession of a high gross domestic product per capita indicates a high technological development score and *vice versa*. Of course, we do not find these relationships surprising in

[35] The 1870–1998 interval is dictated by the absence of much earlier and more recent information in CHAT. In addition, one has to be careful in using CHAT data because there are some problems with data listed in non-equivalent units that can be traced back directly to the sources that were utilized. We attempted to correct these problems prior to the analysis.

the contemporary period. The correlations do not test our assumption that a similar linkage between technological development and wealth holds over the long term but they do buttress our ability to make the assumption.

When we replace rank ordering with the raw scores suitably standardized, Table A2 summarizes the statistically significant correlations over time. The outcome looks much like the outcome reported in Table 6 using rank orders. There are some clusters of stability in the regional hierarchy, most notably demonstrated in the BCE era and in the post-1870 era. In between, there is not all that much correlation outside of the 1500–1700 CE period. It would appear that our finding that there are strong constraints on regional hierarchical stability in the really long term is not due to using rank ordered data. Similar outcomes emerge from the raw data as well.

Table A2. Regional hierarchy correlations over time with adjustment

	–8000	–4000	–3000	–2000	–1000	1	1000	1500	1600	1700	1800	1820	1870	1913	1950	1973
–8000																
–4000	.853															
–3000	.888	.903														
–2000	.835	.835	.977													
–1000	.695	.636	.849	.941												
1																
1000																
1500	.743					.815			.989							
1600	.741		.718	.707		.804			.947	.978						
1700						.744										
1800																
1820																
1870												.964				
1913												.941	.984			
1950												.875	.943	.980		
1973												.845	.847	.873	.851	
2003												.818	.811	.835	.796	.976

Note: Only correlations significant at the < .05 level are reported.

The Elementary Structures of International Institutional Evolution*

Mikhail A. Kaverin and Sergey Yu. Malkov

The present article analyzes the international institutional system through the prism of evolutionary institutionalism and the theory of X- and Y-structures. These structures incorporate fundamental institutional principles which provide societal security and development. Institutions in the context of globalization accommodate the elements of both structures which can be explained with the help of the model of interrelations and transformations of institutional structures. The successive changes occur in the institutional system with the emergence of world polity which is constrained in resources. The security and development of this global system is based on the integrated set of norms and rules, and also on the universal elements of culture.

Keywords: *international institutional development, evolutional institutionalism, institutional stability, globalization, global governance.*

The current transformations of global political system are rooted in the changing power context and corresponding institutions on a global scale, accompanied by increasing international tensions and necessity to reconsider and update the principles of international institutions. The primary political aim of international institutions is to effectively maintain security and growth. The study of these phenomena in the framework of evolutionary institutionalism can help to reveal the mechanisms of current institutional evolution, namely, of its overall system dynamics, of the extent of alterations and creation of new norms and rules.

Globalization processes are characterized by increasingly complicated interdependence between all elements of global system which leads to the development of socio-natural integrity and emergence of the global political system. This is a system of globally stratified world political actors, and also a range of interacting and interdependent global institutions of political power and governance (Ilyin, Leonova, and Rozanov 2013). The global governance is a comprehensive, dynamic and complex process of coherent decision-making in the system of global politics, which is constantly evolving. It is designed to respond to the changing world (Karns and Mingst 2010). According to the UN, global governance includes a set of formal institutions and informal mechanisms, regulating intergovernmental and non-governmental organizations (Gromyko 2013).

An institution is a set of interconnected rules and practices that prescribes behavior on particular issues (Abbott, Green, and Keohane 2014). Institutions reflect the history of relations codified in principles, which summarize past decisions and allow predicting future

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relationships (Keohane 1988). Organizations are the institutions whose activity allows them to make strategic choices (Abbott, Green, and Keohane 2014). The development of international institutions is a complex process of adaptation to internal and external changes of global politics and a search for new opportunities to control these changes. Institutions do not only affect the structure and evolutionary path of global politics, but they themselves go through processes of selection and change.

According to historical institutionalism, the international institutions are capable to maintain a sustainable cooperation even in the ever-changing world politics (Finnemore and Barnett 2004). Historically specified factors become the most relevant to the following aspects of the process of institutional development (*Ibid.*): to the duration of certain types of activity and interactions; to the plurality of solutions for the problems from which advantages can be gained, and to complementarity of functional coordination and development of regulatory systems.

According to the theory of evolutionary institutionalism (North 2005), the life cycle of institutions consists of certain stages, depending on initial conditions and the developmental path. Culture is the basis for norms and the limits of social interaction, which reduces the costs of these interactions (Alston, Eggertsson, and North 1996). In the frame of civilizational components of social relations, historical experience is transferred and consolidated via material culture. Humans can change the environment by means of education and reason, thus, compensating the speed of biological evolution. New ways of adaptation emerge and later they are fixed in cultural norms.

Some biological concepts are used to study the institutional development (Ostrom 1990). In practice, a self-organizing system of governance fails to analyze all the changes that are necessary to reconfigure its rules, which is also true for many biological systems. Such a system has a two-tier structure, explained by the concepts of phenotype and genotype. The phenotypic structure reflects the behavior of individual organisms in a particular environment, the predetermined situation of interactions with the given number of players, available information, costs and opportunities, specific stimuli and results. The genotypic structure contains a set of coded instructions necessary for the reproduction of an organism with peculiar phenotype. The configuration of rules emerges as set of instructions on the means of reproduction of the system of relations between players in a particular situation influenced by biophysical world, the nature and culture of community.

It is rather difficult to create institutions intentionally, because they develop on the basis of 'natural selections', adaptive learning and self-organization. Institutions evolve in the course of actions of many people not aiming to the development of these institutions – these unintended consequences are effective and desirable (Hayek 1978). This evolutionary process occurs in a certain environment, which allows the development of institutions to be effective in this environment.

In order to describe the mechanisms of international institutional evolution at the very fundamental level, two concepts are used, which include ambivalent elements that organize the existence of societies. A comprehensive example of such concepts is the theory of X- and Y-structures developed by Sergey Yu. Malkov (2004, 2009, 2013). These structures are studied in the context of macrohistorical analysis. It is assumed that the X- and Y-structures are capable both to transformation and to coevolution over time.

Institutions as elements of culture are designed to support sustainability of society. The so called X- and Y-structures are characterized by the greatest resistance to various external and internal destabilizing factors, which is confirmed by the studies of socio-economic systems with different institutional arrangement (Kirdina 2004; Korotayev 2006; Malkov 2004). Depending on the purpose and external environment, a society formulates relevant principles of cooperative and regulatory framework. The X-structures originate if the main aim is security in the situation of resource scarcity, while Y-structures are created if the priority is the development under the conditions of abundant resources (Table 1).

Table 1. Distinctive features of the X- and Y-types of social structures (according to Malkov 2013)

Characteristic	X-structure	Y-structure
Institutional Features	1. Regulated economy 2. Directive centralized management system 3. Collectivism in the socio-psychological sphere	1. Liberal economy 2. Adaptive (democratic) management system 3. Individualism in the socio-psychological sphere
Conditions of Formation	– serious external threat; – scarcity of resources	– no serious external threats; – abundant resources
Nature of Competition	competition of societies (survival of the fittest society)	competition of individuals (survival of the fittest individual)
Goal	survival and security of the society	improving of individual welfare
Means of Achieving the Goal	unity of the weak with the strong one (strong central authority)	unity of the weak against the strong one (weak central authority)
Priorities	– improved governance; – ensuring social cohesion	– initiation of internal competition, pluralism, economic activity
Ethical System	'declaration of good' (ideological unity)	'prohibition of evil' (freedom of actions within the law)
System Threats	– disintegration (loss of social cohesion); – bureaucracy, corruption	– monopolisation of power; – property stratification
Object of Protection	social organisation (the state)	individual rights and freedoms

Table 1 illustrates that the principles of organization within X- and Y-structures are directly opposite (what is good for one structure is bad for the other and vice versa), which makes it difficult to reconcile these two elements in one socium. Nonetheless, a combination of the X- and Y-elements always exists, because any society has to solve the problems of security and development simultaneously. Within the X-society there exist systems organized according to Y-principles (*e.g.*, a market-trade segment in agrarian societies), and in the Y-societies there can be found sub-systems with X-principles (*e.g.*, army and security forces, the system of state social security in the modern Western states).

At the same time, the proportion between the X- and Y-elements does not remain the same in a particular society. Certain changes in a given proportion occur depending on the development goals and resource supply in a specific context of political relations. Such phenomena resemble the mechanisms of transmission of genetic information and the development of a living organism as a system with its gradual and complex transformations of elements. The key mechanisms of institutional evolution can be described by the following phases:

1. Emergence of institutions is determined by the demand in governance in the frames of existing limitations and opportunities to overcome them, including the use of innovations;

2. Functioning of institutions improves the ability of social systems to survive while interacting within their environment;

3. 'Testing' the effectiveness and sustainability of institutional development which is manifested in the increasing number of organizations that support the institution and strengthens its legitimacy (David 1994);

4. Reconfiguration of the conglomerate of institutions in a system and its development;

5. Transformation of the institutional system into a qualitatively new one under the influence of the global system.

The transition of global development parameters from exponential to logistic trends in the twentieth and twenty-first centuries significantly transforms the existing international institutions and influences the world political, social and economic structure; one can compare this with the final stage of the 'Axial Age' (between the thirteenth and third centuries BCE according to Karl Jaspers [cited in Malkov 2004]). Comparing the quantitative patterns of the world development and the evolution of sociocultural systems during the 'Axial Age' and in the second half of the twentieth century, one can notice that the systems attained the largest qualitative changes during these relatively short historical periods, when a rapid growth of material culture was accompanied by the emergence of various forms of non-material culture, which exist until today (Table 2). It is the improved living standards that contributed to the creation of complex forms of social relations, including the political ones. Fig. 1 illustrates the dynamics of urbanization over the past six thousand years, thus, reflecting the processes of politogenesis (Korotayev 2006; Malkov 2009).

The periods of world growth with predominant Y-structures are accompanied by the emergence of new political forms (city-states, centralized states, nation-states and international institutions as the evidence of political internationalisation and globalisation), whereas the periods of stable development are characterized by the existence of X-structured political forms (these are primarily the large empire states). It should be noted, that on a global scale when the limits to growth are achieved due to resource constraints, there will presumably be a unification of the two types of structures, which is already observed in social states and supranational integration entities.

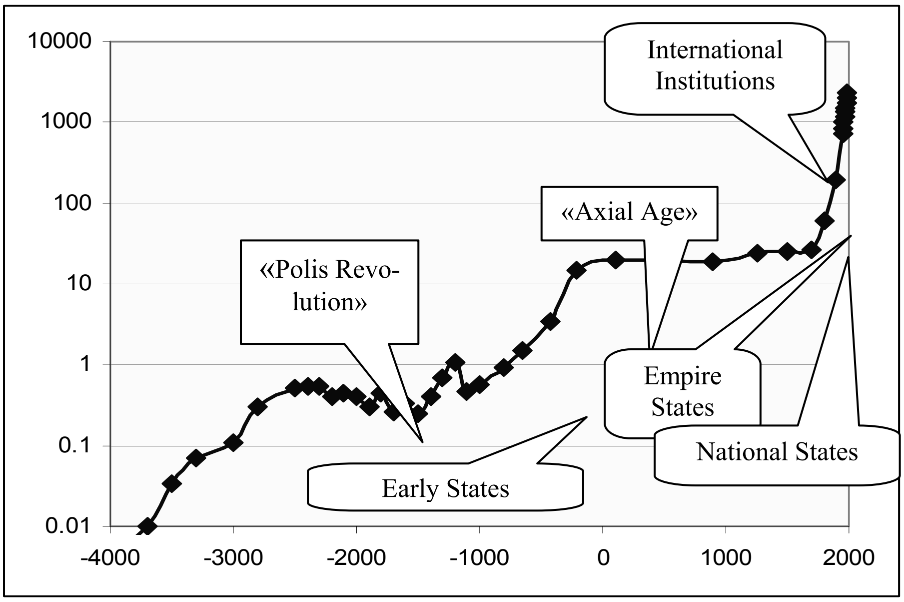


Fig. 1. The world urban population at a logarithmic scale, in millions (for cities with population over 10,000 people) (Korotayev 2006)

Table 2. Key technological and cultural changes during the Axial Age and in Modern times

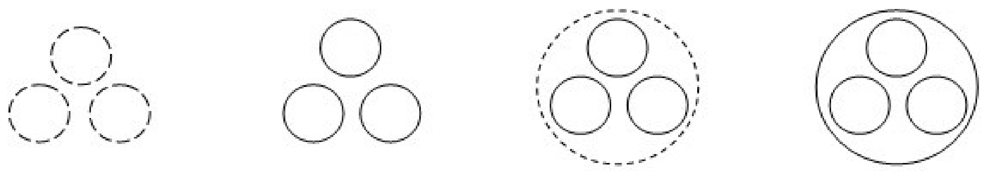
Axial Age (from the eighth to third centuries BCE)	**New and Modern History (from the nineteenth century CE to the present)**
Wide diffusion of iron weapons and tools	Technological revolution, the development of industrial mass production
Emergence of mass armies, sharp increase of invasions and conquests	Introduction of the mechanized armies with high-tech innovative weapons
Development of communications and transport infrastructure	Emergence of radio, telegraph, telephone, rail-roads, automobiles, aviation, astronautics
Emergence of world religions	Introduction and development of mass ideologies, the increasing influence of media

The characteristics of international institutional development in the twenty-first century can be considered in the context of X- and Y-structures and basic ideas of theories of institutional evolution. One of the major political challenges in institutional development is the contradictions and consequences of neoliberal globalization, associated with the global proliferation of relevant norms and principles. By the end of the twentieth century, globalization has led to numerous imbalances, dysfunctions and conflicts in most of the countries and societies despite the fact that it is the only 'global' political project in international relations. International institutions were created and maintained by the developed states when the latter had achieved a certain level of political development within international system with the aim of carrying out their own policy. The other states' opportunities are strongly limited by the existing international standards and mechanisms of decision-making in the major international organizations. This situation is likely to become a source of increasing global contradictions. In these circumstances the models of cooperative informal blocks of developing states within major international organizations show a relative efficiency, as well as the practice of establishing their own international institutions. The most significant challenge for the international institutional development is the necessity to create joint institutions by the international actors which possess incomparable political influence and power.

Up to the present moment, the quantitative stabilization of international institutions is observed (Kaverin and Malkov 2014), alongside with the fact that institutions become more diverse and complex due to globalization processes, development of global relations and international organizations, and transformations of power structures in the interstate system. The transparency and legitimacy of formal international organizations have hardly increased. Almost all the international, regional and even national organizations established in the twentieth century and responsible for the governance of the highly complicated and integrated world are characterized by the lack of democracy (Nye 2011). In general, for most countries of the world the scarcity of democracy in international institutions will be one of the major problems of institutional development, alongside with the lack of appropriate political culture of institutional establishment and participation.

The multilateral structures and 'hard' international regimes of the twentieth century are increasingly unable to function properly. Preferences are given not to the regulation, binding rules, multilateral forums and bureaucracy, but to the 'soft' forms of cooperation: consultations, codes of conduct, regional and national initiatives (Governance 2025). In turn, it is the formal multilateral institutions that provide mechanisms for the resolution of international dispute, as well as the solutions with universal legitimacy and norms which establish predictable relationships based on reciprocity (*Ibid.*).

In the context of globalization, norms and principles of the X- and Y-structures tend to integrate as a result of the search for a balance between security and development common to all societies. In this case, one can speak about the origin and initial formation of global governance institutions. Generally, the dynamics of interactions and transformations of institutional structures is related with the change of development priorities – security (leading to the formation of X-structures) or growth (giving rise to Y-structures). The range of rules and principles within each structure slightly varies over time.



a) b) c) d)

Fig. 2. Interrelations and transformations of international structures: a) dominance of Y-structures; b) dominance of X-structures; c) Y-globalization; d) X–Y-globalization

Fig. 2 illustrates the development of social interactions in terms of X- and Y-structures. The emergence and rapid development of communities proceeds on the basis of Y-structures.

X-structure elements start to appear when the relative limits of growth are achieved and relationships between participants of the system of redistribution become significant. Over time, when relations between communities strengthen, it becomes necessary to build formal institutions and common rules that bind this system of relations together (Fig. 2c). In the twenty-first century, the existing institutions based on Y-principles start to transform into the X–Y-structure (Fig. 2d) because of resource limitations to the global development. This integrated structure represents a significant extension of the content of political relations.

To sum up, the basic mechanisms of international institutional evolution can be explained in terms of X- and Y-structures in the framework of evolutional institutionalism. These structures can be identified in the macrohistorical data of politogenesis. An interchange of principles between these structures and their coevolution is observed in the context of globalization processes and forecasted limits of the global development. These processes are explained by the following model of interrelations and transformations of international structures: the dominance of Y-structures – dominance of X-structures – Y-globalization – X–Y-globalization. The necessity to solve problems at the global scale leads to reconfiguration of existing institutional system and emergence of new structures relevant to the relations between major actors with the aim of formation of a political system that will provide and maintain global security and development.

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The Need for New Management*

Vladimir Maslov

The present article reflects on the need for new management in the context of globalization. The author shows that within the emerging knowledge-based society and innovative economy it is only the labor of new-type, that is of intellectual employees (which sometimes are also referred to as talented employees), that can ensure the survival of corporations.

The new role of talented employees requires a reversal of Taylor's approach to ... and the transition to leadership at all levels, which implies a broad delegation and the development of entrepreneurial mind of all employees, not only its managers. The term 'heterarchy' is introduced to denote a new management paradigm which is neither market-oriented, nor hierarchical. The author also grounds the necessity for a new motivator which is the involvement based on the personnel's intellectual links and emotional adherence to values of the company. The article also gives a brief description of knowledge society which requires an innovative type of corporate culture. Finally, the author emphasizes the crucial importance of education for society's and company's competitiveness in the globalization era.

Keywords: *talented employees, knowledge economy, management.*

Introduction

The present article analyzes the new requirements for management in the twenty-first century, resulting from expanding globalization which demands a new approach to individual's position in the organization in order to build a competitive economy based on the employees' intelligence and knowledge. The main reason for the imbalance between traditional organization's management approaches and its personnel are the changes in society and economy brought by globalization. The essence of the newly emerging society is rather accurately described by the term *knowledge-based society*, and also by knowledge-based economy. Within this new type of economy the employees of a new type, that is the intellectual employees, start to play a critical role. One can hardly consider them only as company's resources (even the most valuable). The intellectual employees are both objects and subjects of modern management, where it is not the management of individual's performance as a function that is effective, but of individuals as a personality.

1. Problems in Management in the Twenty-First Century

Management in the twenty-first century faces new challenges. The practitioners expect theorists to answer the question 'What are we supposed to do in the contemporary flexible

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world?' The approaches that used to be effective, do not show any results nowadays. 'The reason for this situation is that the old-established management system does not work anymore, but most people still use it and will hardly change their minds in one night' – points Professor Peter Senge, business-guru of modern management. 'On the contrary, they will try to use these old methods again and again, putting much effort to them and using even more tough measures, pressing the employees and concentrating on current tasks.'[1] Such an approach can bring even flourishing companies to bankruptcy. In 2008, many corporations, including the giants of American automobile industry, proved Senge's statement.

However, the necessity of a new management paradigm was mentioned by the founder of Matsushita Electric Industrial Company Konosuki Matsushita as early as in 1988. He claimed, addressing the Western entrepreneurs:

We will win, and you will lose. And you will not be able to tackle this, because your loss will be the result of your inner problems. Your companies are based on Taylor's principles. What is more, your heads are also full of Taylor's methods. You strongly believe that the term 'management' means a manager from the one side and an employee from the other side, the first one thinks only and the second one works only. Management is from your point of view an art of free transmission of manager's ideas to the hands of workers.

We have passed Taylor's approach. We understand that business has become too complicated. Survival is something very uncertain in an environment that is full of risks, eruptions and competence… We know that the intelligence of some technocrats, even very capable ones, is absolutely sufficient to deal with this challenge. Only combined intelligence of all employees can enable the company to face all ups and downs in compliance with requirements of the new time. Yes, we will win and you will lose. You are unable to relieve your minds from old-fashioned Taylor's methods, you have never possessed (New Competition 2002: 9).

These words would seem firm, offensive, and unpleasant for the Americans or Europeans. But the further development proved that the forecast has been accurate. Ever more companies and countries realize nowadays that previous management approaches are ineffective within the new context of the twenty-first century. The crisis (economic, political, and financial) which has already lasted for seven years, favors the search for solutions not only within new management approaches, but also for changes in society's values. In 2013, at the Second World Cultural Forum in China it was pointed out that 'a deep moral and ethical crisis stands behind economic, financial and climatic crises, which influences large parts of the world' (The Results… 2013: 3).

In the end of the twentieth century, some European scientists paid attention to the necessity for new approaches to management. Thus, the German scholar Hans-Jürgen Warnecke wrote in 1999: 'One of the most important requirements to the future-oriented productions is the ability of all the departments and all the employees to think and act like entrepreneurs' (Warnecke 1999: 159). According to the German author, the entrepreneurial mind means answering four questions:

1. Why do I want (!!!) to create this new product?

2. What will I achieve by doing this? – To meet my urgent need. Thus, the main aim of management is to bring up creators, not executors.

3. How should I create this new product? – Therefore organizations educate professionals-innovators, implement the system of lifelong education and development of the personnel.

[1] http://www.hhmagazine.ru/contents/publication.do?publicationId=617.

4. What are the results of the entrepreneurial idea?

The practitioners all over the world did not receive any answers from theorists. As a result, the old management paradigm (which does not imply the presence of thinking and creative employees) has continued to prevail. It is executor-oriented mindset. Management means the domination of executives over subordinates. As Kenneth Cloke and Joan Goldsmith argue, 'traditionally management implies managers' egocentrism, authoritarian style of decision-making processes, incompetence of management, limitation of supervisors, and the employees' unwillingness to develop responsible labor relations. Management kills relationships, moral values and motivation' (Cloke and Goldsmith 2004: 31).

Nowadays/under the current conditions the significance of the most important factors of company's mission is blurred. Nowadays the priorities should be ranked in a different way: personnel, goods, and profit. Both Russian and foreign schools of management place the personnel according to its priority at best on the second place after profit (and this also happens in practice!). The concepts are usually prioritized in the following way: profit, goods, and personnel. The same refers to most Western organizations. As a result, Russia – as well as other highly developed countries – faces a crisis of personnel management.

First and foremost, the unwillingness to work is growing. The essential role of employee and organization has changed considerably. In the past an *employee* operated the *system*. This was exactly what Frederick Taylor's as well as Edward Deming's system of common quality management focused upon. In the knowledge-based society the *system* is supposed to 'serve' an *employee***.** What does a successful university do? It attracts the best professors and scholars and, what is the most important, gives them an opportunity to develop skills, teach effectively and conduct scientific research. The motto of business in the knowledge-based society is 'Employees may be our greatest liability, but people are our greatest opportunity' – as Peter Drucker wrote (cited in Cloke and Goldsmith 2004: 102).

The requirements for innovative management have also changed in the knowledge-based society. Peter Drucker notices: 'Nowadays the organization should not only be innovative, but it should become a *leader in changes*. If nowadays the organization is not the leader in changes, it won't be able to aim constantly at innovations. And innovations should be permanent. By the way, often innovations are very unpredictable' (*Ibid.*: 83). It is very difficult and sometimes impossible for a manager to control them. Managers were not used to this situation since being subordinates they were under control. However, it is necessary to abandon the division between managers and executors. Employees in contemporary organizations are not subordinate specialists, but *personalities***.** Business success depends on effective performance of intelligent workers and people which are fond of and involved in their activities. In this case the employees' energy works in a certain direction, they support each other and fulfill duties in a complementing way. D. Kunis and J. Ioffe, entrepreneurs from St. Petersburg, claim that the competitive advantage of a modern company is 'creative capacities of the employees being fully involved in work. It is likely to be the main resource in modern life, 'which is the reason for tough competence, and whoever "wins" it, becomes successful' (Cloke and Goldsmith 2004: 11–12). It is important that the Russian practitioners accept this as a fact.

All current problems in management are caused by changes both in economy and in society. Running a company with the help of old methods means dooming it to fail. Today old management methods create hierarchical relations and bureaucracy, autocracy and injustice, inequality and privileged positions of some groups. Cloke and Goldsmith state:

'It can be predicted that management will block self-actualization, restrict personal freedom, and undermine the principles of ethics and identity. It oppresses the spirit, kills the soul, and tries to enslave and devastate the environment which is favorable' (Cloke and Goldsmith 2004: 63).

Research conducted in Russia and abroad shows that new modes of management are based on leadership and delegation. Volker Jaute, one of the leading European specialists in the sphere of personnel management, says: 'The most important thing for a manager is to imagine the whole picture of the company's situation. What type his employees belong to, whether they are independent and responsible for their decisions and actions, whether they can be partners. If there is partnership, mutual respect and responsibility, independence and innovations, we can call this a confidence-based management. If there are no such things and management is based on orders, the term "anti-management" can be used'.[2]

According to William Edwards Deming, *new management* is based on the delegation of responsibility and opportunity to teams in order to make products meet standards. According to his model, the leader encourages members of teams to achieve better results via supporting them by different bonuses. The rule 'Quality depends on every employee' becomes common practice.

One of the companies from 'Fortune 500' list has reorganized its production departments into self-governing teams. Modernization of the manufacturing processes helped to reduce the amount of operations required for producing one product from 387 to 4 in a year. Moreover, the quality of the products increased significantly. The enterprise owes this fantastic result to self-governing teams, which worked out and implemented absolutely independently a modernization plan, reduced the number of mistakes, waste and equipment failures almost to zero (Cloke and Goldsmith 2004: 95–96).

Actually the point is the new management paradigm, which is neither market nor hierarchy-oriented. According to American sociologist and economist David Stark heterarchy is a new kind of organization that overcomes limits of market and hierarchical approaches. Hierarchy implies dependence, while market implies independence, and heterarchy suggests interdependence (Stark 2002: 49–95). The peculiarity of heterarchy is the horizontal power formation unlike the usual vertical delegation within organization (hierarchy). The most common form of heterarchy is virtual organization, whose main advantage is the high speed of decision-making process. F. Kotler thinks that the most important principles of a virtual organization's ideal activity are:

1. Outsourcing some work or services to companies, that can do it cheaper and better.
2. Involvement of distance employees and implementation of programs, which automate conventional processes.
3. Consolidation of company's customers. Purchase of goods by virtual communities.
4. The main benefits of any virtual organization are intangible assets such as know-how and brand (see Gaisin 2005: 5).

The main aim of the transition to this new management paradigm is an effective management of new employees, who are the most important factor of company's activity within knowledge-based society. Let us consider this issue in more detail.

2. Peculiarities of Managing Modern Employees

The success of companies in the knowledge era depends on the managers' ability to cope with tasks of recruiting, managing and retention of intelligent employees. It is not enough

[2] http://www.e-xecutive.ru/community/articles/741669/index.php?ID=741669.

today to provide only material impetus; modern employees appreciate social recognition and promotion opportunities in the organization. It has become increasingly common that only significant changes in employee's status can make him or her stay in the organization. 'This can be achieved only by placing lower level subordinates into positions of senior managers, from position of an ordinary employee (even with a high salary) into position of business partner' – notices Peter Drucker (2007: 37). This has become common practice in the company *Instrum-Rand* (Pavlovo, Nizhegorodsky region, Russia) and also in many globally well-known companies working in different industries.

New Place of Employees in the Organization

Nowadays companies face staffing problems – the competence on the labour market is increasing, while there is a lack of professionally qualified personnel. According to the research of VTsIOM (February 28, 2008) 52 per cent of Russian companies say that qualified workers are hard to find. The situation even worsens alongside with continuing global talent crisis.

Across the globe we see organizations fighting to find employees with necessary skills and training. As the economic recovery continues, companies struggle to get the talent they need – particularly in science, technology, engineering, and mathematics. And with the widening skills gap likely to become worse before it gets better, we are facing something of a perfect talent storm. It is good to see that this issue has become a subject of mainstream debate for media, politicians and corporates alike.3

It becomes more difficult to attract talented people, but without them it is impossible to become a competitive organization. It is difficult to recruit new employees but it is even more difficult to make them stay with the company. It is necessary to show that you are the best employer. However, this is not simple for a company and requires the implementation of new approaches to personnel. Intelligent employees do not focus only on the proposed salary and remuneration package. They are much more interested in the opportunities that a company can offer (such as self-fulfillment and career growth) and in the corporate culture in this company. Respecting the employee's opinion, willingness to educate him or her and help to improve his/her performance is what new employees appreciate. An ideal company is a company where employees are glad to come to work every morning, a company where employees are delighted and have many opportunities. Modern companies should pay attention to such expectations of their employees and make everything possible to ensure loyalty and become more attractive for specialists. And these are not only words. Results of the survey 'The Best Employers' conducted in different countries by *Hewitt Associates*, show a direct correlation between most financial indices and the new factors of motivation, such as *personnel involvement*. Stakeholders of companies, where the average level of involvement exceeds 60 per cent, get a revenue that is 2.5 times larger than the revenue in other companies.

Research shows that companies know that engagement has vital implications for performance. Gallup's global research across industries shows that engagement leads to improved profitability, increased productivity, and better customer metrics while the turnover decreases.

But talent is also a prerequisite for success. Gallup's research reveals that about one out of ten employees can become a good manager if s/he engages team members and cus-

[3] See http://www.hays-index.com/2013.

tomers and creates a culture of high productivity. And last but not the least, their contribution to the profit of their companies is about 48 per cent higher than the contribution made by average managers (Herway and Dvorak 2014). Gallup's research reveals that when companies add a well-being focus to their engagement, it has an accelerating effect. Together, these two approaches help establish a workplace culture which enhances employees' lives. In a company that supports employees' well-being and engagement, workers are more likely to be flourishing, which helps boosting their individual, team and organizational performance. We should recognize that it is necessary to implement the new approach to personnel: people management (McPheat n.d.). In 2012, Gallup reported in two large-scale studies that only 30 per cent of US employees are engaged at work, and staggeringly low 13 per cent worldwide are engaged. In the past decade little has changed (Sorenson 2013).

Personnel involvement is more than just an interest in working. It also does not only mean satisfaction with work. *Involvement is based on intellectual links and emotional adherence of personnel to the company's values.*

Firstly, involvement encourages behavior, oriented at achievement of the organization's strategic aims. Employees need to understand the essence of the strategy and its meaning in their day-to-day lives. This is the basis of the first of two main components: the intellectual link. It means that employees need to know what, why, and how they should work to achieve success within the organization.

Secondly, involvement motivates people. Nowadays companies value employees not only for their diligence. Creativity and imagination are important since they contribute to solution of problems, innovations and growth. Sense of purpose is also significant since it encourages employees to work in one direction as a team. Intellectual links and emotional adherence cannot be specified, controlled, and managed by job description. But when employees are involved in the working process, a company is full of energy.

We can define six main factors influencing the involvement of modern employees in the working process (see Fig. 1). There are no factors which can be considered as more important than others. All six factors should be optimized, and only in this case the involvement of intelligent employees in company's work can be achieved.

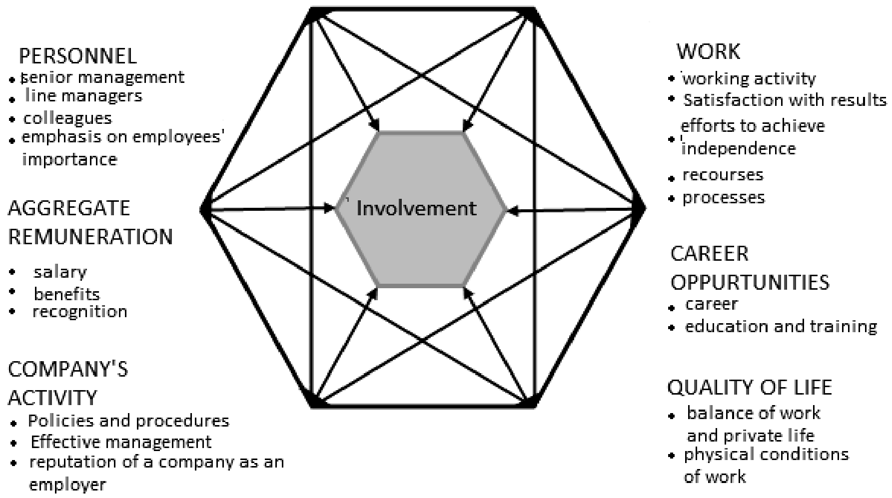

Fig. 1. Which factors do influence the involvement of employees?

The key to a sharp increase of company's efficiency is, on the one hand, an understanding and sharing of its goals and values, and, on the other hand, the activity performed to achieve these goals. Nowadays corporate culture is effective only when it involves and units employees, providing answers to three questions which are of great importance for any company:

- Where do we want to be?
- Why do we need to be there?
- How are we going to get there?

The results of research on involvement are illustrated by Figs 2 and 3.

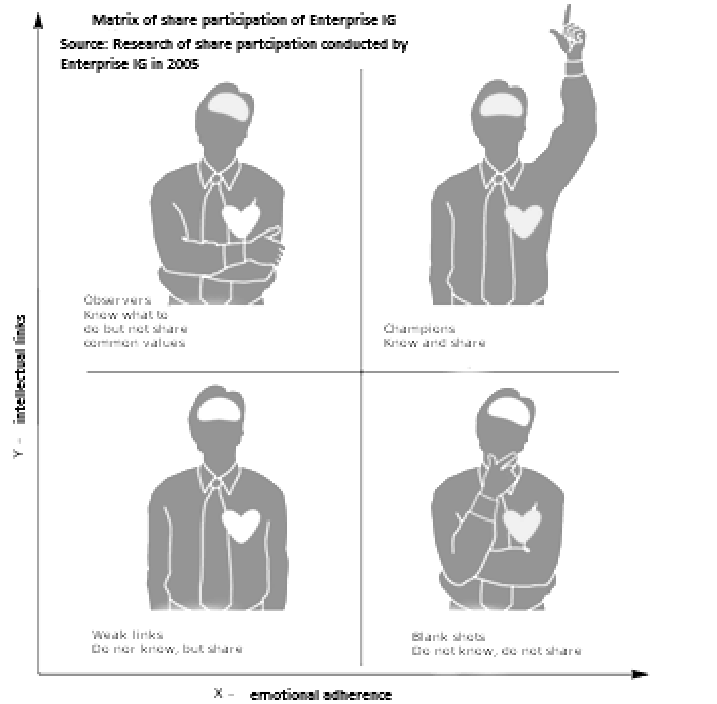

Fig. 2. Four main categories of intellectual and emotional involvement

Research conducted by Enterprise IG in 2005 has shown that nowadays only 29 per cent of employees know what they should do and share company's values, which means they are involved in their work (Fig. 2).

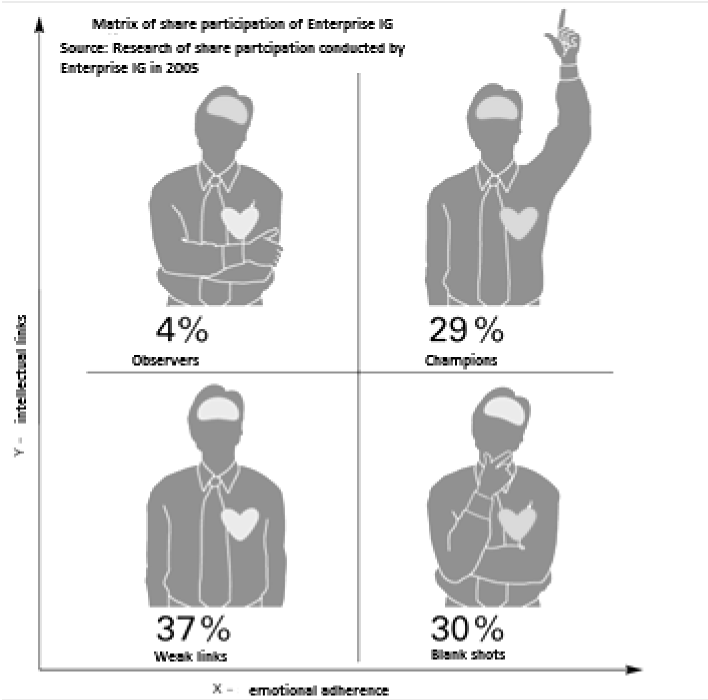

Fig. 3. The share participation

Research conducted by *Gallup* in 2004, shows that indifferent personnel costs the USA about 300 billion dollars annually in the form of drop in productivity. In Germany, according to similar research conducted in 2002, 69 per cent of German employees perform professional but have a disinterested attitude to labor. This led to economic losses of 220 billion Euros a year, which can be compared to the annual budget of the whole Germany (246.3 billion Euros).[4] Thus, one needs an appropriate recruitment and motivation of employees. The key to increase the company's efficiency is its personnel's ability to understand and share company's goals and values and their *desire* to make everything possible in order to achieve current and strategic goals of the organization.

The idea to involve personnel in sharing company's aims and strategies has existed for decades. Different terms such as ‘internal communications’, ‘internal marketing’, and ‘internal brand’ have been introduced. A lot of time, money, and efforts have been spent to motivate employees, to build a corporate culture which would really bring workers together, making them energetic and enthusiastic.

Let us give the example of Senn Delaney, a *Heidrick & Struggles*, a company that is widely recognized as the leading international authority and successful practitioner of culture shaping that enhances the spirit and performance of organizations. Founded in 1978, Senn Delaney was the first firm in the world to focus exclusively on transforming cultures. Many Fortune 500 companies and Global 1000 CEOs have chosen Senn Delaney as their trusted partner to guide their cultural transformation. Senn Delaney has developed a com-

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[4] Mittelbayerische Zeitung, 11.09.2002.

prehensive and proven culture-shaping methodology that engages people and measurably impacts both the spirit and performance of organizations.[5]

But even today corporate culture separates managers from employees. Managers conceal the real situation from workers, and employees are no longer satisfied with being under control (subordinates). Therefore, in most companies the involvement in the management process is impossible. Thus, talented employees will at best be diligent. And of course, they will seek for a new job, where they would be demanded not only as professionals but also as personalities. Certainly, this implies a conversion from personnel management (or ever human recourses management) to the management of the people in social organization.

In 2007, the study of involvement was conducted in Russia and covered 64 companies including 36 Russian and 28 international companies. Thus, we can analyze what issues are of great importance for the Russian employers and employees. Who is the best in the market today from modern employees' point of view?

According to the results of the research, the average level of involvement in Russia in 2007 was 59 per cent. Among the contributing factors, meeting the Russian workers' expectations most of all, one can name the relations with colleagues, company's reputation as employer, line management, and a non-hazardous workplace. The standard of received benefits, career opportunities, salary and emphasis on employees' importance for the company were named among the critical factors, which *practically do not* meet the Russian employees' expectations.

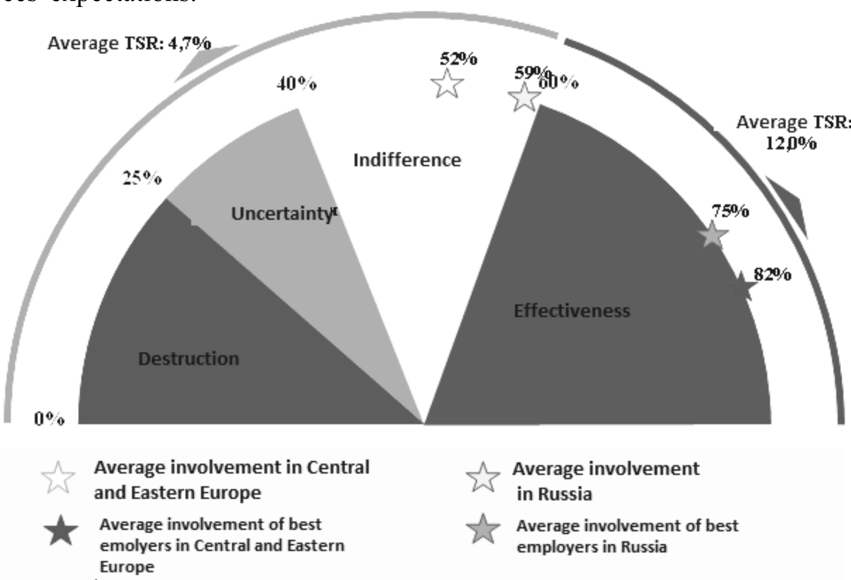

Fig. 4. Most critical factors causing the increase and decrease in the level of employees involvement

Note: * TSR (Total Shareholder Return) over a period is defined as the net stock price change plus the dividends paid during that period.

[5] www.senndelaney.com

Indeed, in compliance with the opinion of almost 60 per cent of employees, only the best Russian employers have well settled the most critical issues of corporate culture, such as the care of employees, recognition of workers and emphasis on their importance for the organization, and a fair remuneration system (Fig. 5).

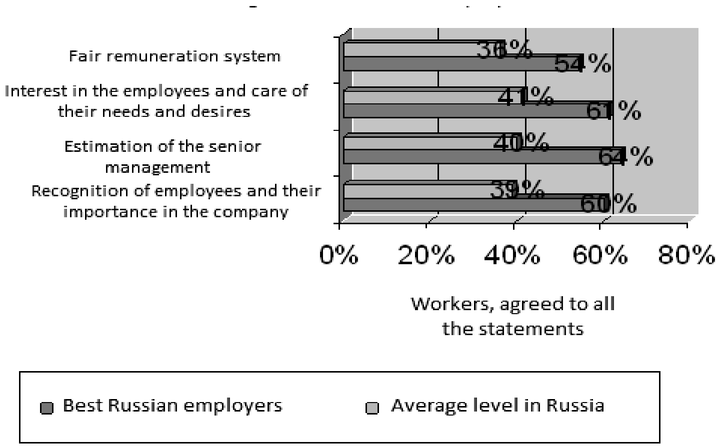

Fig. 5. Advantages of the best Russian employers (2007)

In accordance with a survey conducted in 2013 in Russia, in the opinion of 10,000 Russian students, the best employers are presented in Table 1. One may notice that four of ten best companies in Russia are oil and gas companies.

Table 1. Rating of the Russian companies[6]

Business				
Company	**2013**		**2012**	**Change in rank 2012 *vs*. 2013**
	Place		Place	
Gazprom	1	0	1	0
Sberbank of Russia	2	0	2	0
McKinsey & Company	3	8	11	8
Google	4	3	7	3
Unilever	5	0	5	0
Lukoil	6	–3	3	–3
Rosneft Oil Company	7	–1	6	–1
VTB24	8	0	8	0
PwC	9	9	18	9
Procter & Gamble	10	3	13	3

[6] http://www.e-xecutive.ru/knowledge/announcement/1831787/index.php?PAGE_NAME=read&FID=12&TID=16097

In the past decades, a *new management policy* plays the most important role in successful companies all over the world. This policy is based on an active involvement of the employees and their loyalty. A vivid example of a new management success, meeting the demands of modern intelligent workers, is *Toyota*, which has outranked the US giants of automobile industry – *General Motors* and *Ford* which in 2008 needed a large governmental aid to prevent their bankruptcy.

Many managers have not realized yet the end of the industrial era. In industrial economy all that was needed to increase productivity was to put workers to machines and control their performance. And it was normal when employees worked carelessly and have had a mechanist approach, because feelings and emotions would interfere with their technical functions. But nowadays more and more companies understand that machines can neither foresee the future and offer alternatives, nor work creatively, nor be sympathetic with others, nor be motivated and feel the destination, in other words, they lack characteristics that can strengthen companies and increase their competitiveness. In this case employees should get an absolutely new position within the organization. An employee today is not an object of management, but both object and subject of management, a business partner. However, the changes in the relations between a manager and an employee become evident; nowadays a manager depends more on intellectual employees and their features than the employee depends on his manager. The terms 'superior' and 'subordinate' characterize the outdated management style.

The guru of management Peter Drucker wrote: 'Intellectual employees are a workforce, whose features are much more different from those of less professional workers. It is true that intellectual employees are minor in the whole working force structure. But they have already become the main producers of material goods. The success in business and even survival is more and more dependent on the effectiveness of this group performance' (Drucker 2007). And furthermore: *'The task of a company in the intellectual era is to make ordinary people create exceptional things'* (*Ibid.*: 139; italics in the original). Within the new management paradigm a strategic approach to management becomes the main task of companies' administration. 'The biggest success of Jack Welsh, the ex-general director of General Electric is his ability to closely monitor the current development of the organization (a three-year long period is considered) and at the same time the ability to pay attention to strategic development of HR policy. He was making investments in personnel development for 7 years', – noticed Drucker (*Ibid.*: 88–89).

Gallup's assessment of 2,500 US entrepreneurs shows that the higher levels of entrepreneurial talent significantly increase the likelihood of the success of the enterprise. Highly talented entrepreneurs, compared with their less talented peers, are:

- three times more likely to build large businesses and to expand them significantly;
- four times more likely to create jobs;
- four times more likely to exceed profit goals;
- five times more likely to exceed sales goals.[7]

A battle for talents has been held everywhere – in the sphere of high and low technologies, in developed and developing countries. Managers face some difficult tasks: How to choose the best among applicants? How to keep valuable workers? What reasons and benefits will make people who can refer to various alternative options stay?

[7] Business Journal, January 22, 2015.

Apart from demographic decline there are some other difficulties. First of all we see the *crisis of loyalty*. In the 1990s, many Russian companies reduced their staff and changed the structure. Many companies abandoned social protection of their employees, considering this to be burdensome. As a result, nowadays employees have no reasons to be loyal. They leave easily, accepting more profitable offers. Secondly, there is a gap between graduates' knowledge and requirements to the applicants. Even good educational establishments produce few scientists and engineers, and it is very difficult to find a specialist in ordinary schools. This means that any company will have to spend money to educate new workers. Having educated them, it is important to keep them without any compulsion, but with the help of attractive values of corporate culture. Otherwise, a company will appear to spend lots of money to provide valuable employees for competitors.

Nowadays effective corporate culture is not a luxury but a prerequisite in the changing world of knowledge-based society. Only those companies where employees work as if it is their own company have a chance to win in the tough competition in a globalizing world.

CEO and President of Senn Delaney Company points

> What company in the world has not been going through sudden shifts wrought from major, disruptive change? IBM, Intel, HP, Nokia, RIM are just a few iconic brand names that spring to mind. These companies are all grappling with the need to radically change to survive and compete. They are responding in many predictable ways: changing CEOs and leadership teams, shifting strategies, rolling out new product lines, increasing innovation, cutting costs, restructuring. All good things to do to react to change, but these actions treat the symptoms of a chronic illness without curing the underlying cause. CEOs may be missing out on the most important strategy of all: creating a culture of agility (Hart 2013).

Without necessary changes at a behavioral and cultural level, no systems, processes and technologies will realize an organization's strategic ambitions for sustainable future success.

Besides, even nowadays intellectual workforce is the most important advantage of any country or company. New management is necessary to operate effectively, and it should be different from Taylorist approaches.

3. Main Features of Knowledge-based Society

The current problems in management are caused by a new type of economic growth. It can be described by several terms: scientific and technical or innovative. This type of growth caused the development of a new society, which is frequently called the knowledge-based society. The main features of such a society are:

* common creative ability, changing the attitude to self-actualization, risks, initiative and search;
* entrepreneurial behavior, aimed at mastering high technologies;
* modification of ownership in large corporations (internal ventures);
* transforming character of management.

The corporate culture has changed accordingly. Economic growth has to respect this shift towards the new context. *Traditional technocratic type of culture* is characterized by:

* distinct chains of command and hierarchy in the management system;
* dominance of regulated executor's behavior;
* rational economic motivation;

* specialization of governing bodies in fulfilling organizational, economic, and creative functions.

This type of culture prevails in many organizations of Russia, Northern America, Europe and (partially) Japan. In the past such corporate culture enabled companies to manage personnel and organization.

Knowledge-based society requires innovations to become a principle which presupposes a different corporate culture.

An *innovative type of culture* is characterized by:

* significantly higher levels of employees' education;
* creative environment, innovation;
* constant improvement and experimentation;
* willingness to take risks; and
* dynamism.

The corporate culture of new type is based on shaping an environment in the organization which encourages creation. To stay competitive in the knowledge-based society, it is not enough to perform settled instructions in a professional way and to reproduce something that already exists. The main value of new culture is the opportunity to work creatively. It is an important motivator for intellectual employees, because in this case they are motivated by the work process itself. At the same time the development of personnel within particular organizations is extremely important for the development and realization of new management. *Development of personnel* (not only education) is necessary, because knowledge should be updated every 3–4 years. New employees should *know* and *desire* to obtain new skills and knowledge. Only then will they be demanded. This must be the main purpose of higher education.

The condition for an *innovative culture* is first of all the development of a new *organizational structure of management.* It should be based on the principle of quick response, on the ability to perceive everything new, which is a prerequisite for surviving in terms of constant unpredictable changes of the environment. That is why project or result-oriented structures are developed which are integrated with traditional structures.

There are some peculiarities in management systems of innovative organizations:

* They are characterized by distinct and clear strategies going alongside freedom of search within the system. Such strategies help to restrict the field of research and alternative designations with real opportunities and needs of the company. Quantitative goals also motivate, for instance when the percentage of sales of new goods should not be lower than 25 per cent of all the sales.

* There is a need for the creation of a definite system (formal or informal) to collect specialized information, a system of laboratories' external links, the exchange of personnel, active search and estimation of new ideas. Therefore not only scientific departments become research centers, but also design, planning, marketing, and production departments, namely almost the whole organization.

* The support of developing temporary teams that are geared to fulfill a clearly defined task (as a rule it takes 2–3 years) – this is widely used, while the experience of scientific research is mixed with the groundwork of product or process engineers.

* The *system of motivation* is based on the satisfaction with the work process, its compliance with personal interests of employees, personality, prestige, and material incentives, depending in most cases on final results. Promotion and payment depend directly on creative capacities of employees, although the extent of this correlation is different in dif-

ferent cases. For instance, Japanese companies differentiate the salary according to the creative capacity of employees less than Americans. From my point of view Japanese experience is more suitable for Russia.

* Managing innovative activities on the internal level importantly depends on creating entrepreneurial autonomy, namely, to make certain structures of the company independent from each other in order to stimulate them to take risks when implementing innovations – this may also be called entrepreneurship on a sublevel.

In the highly developed countries such specialized departments are fully involved in creative work, established far away from the main line of production. They receive large amounts of money, comprising 3–10 per cent of sales volumes (*e.g*., Hitachi spends 8.3 per cent, Canon – 9 per cent, Honda – 5.4 per cent). Japanese companies usually have these departments centralized and subordinated under the central management. This provides prospects for problem solution, independence of requirements of immediate profitability, and better opportunities for creating project teams for different periods of time for research.

Flexible forms of team work are also widely used. For instance, in *Canon* such groups consist of 10–15 people; they conduct research in new fields, work out the corporation strategy and design projects for production departments.

Table 2 describes the preconditions for innovations.

Table 2. Preconditions for innovations

Company characteristics	Management principles	The characteristics of managerial behavior
Social and psychological climate	High confidence; Culture of accepting mistakes	More impulsive, intuitive behavior; Taking risks and admission of probable mistakes; Active creative search and great potential response from efforts made by employees; Belief in one's own creative capacity and informal actions
Communication systems	Free flow of communication; Clarity of policies; Open strategy and planning process	More direct contacts; Opportunity of offering unconventional ideas and proposals; High emotionality and liveliness of conduct; Proper feedback in all aspects; Interaction and opportunity to promote one's own ideas.
Purpose setting	Allowing independent formulation of objections allowed and self-estimation of employees	Rewards for additional risk taking and creative activities; Sharing responsibilities and cooperative suggestion of new ideas; Variety of search efforts and decrease of conformism.
Control mechanisms	Connected with other management components; Internal self-control is allowed; Coordination with life-parameters of employees.	Use of alternative forms of working and organizing; Possibility of disagreement and functional conflict; broadening the scope of innovation; Priority of diversity and creativity to monotony and timeserving.

The main strategic motto of an ordinary enterprise can be formulated as 'More and better' (common motto of entrepreneurs in the twentieth century). The motto of innovative strategy should sound like 'New and different'. This is the motto of organizations in a knowledge-based society.

The main result of a culture of innovation is that an enterprise works in such a way that change becomes common practice. In terms of constant changes of environment such a culture can make a company competitive and adapted to the external environment.

Information Economy as a Material Basis of the Knowledge Society

Nowadays, the highly developed countries require staff development and intellectualization of labor, which is connected with implementation of high technologies and with the broadening scope of information services. The emergence of a new information economy (prior to the knowledge based economy) has led to the rise of absolutely new enterprises. The information economy forms the basis for the information society (Fig. 6).

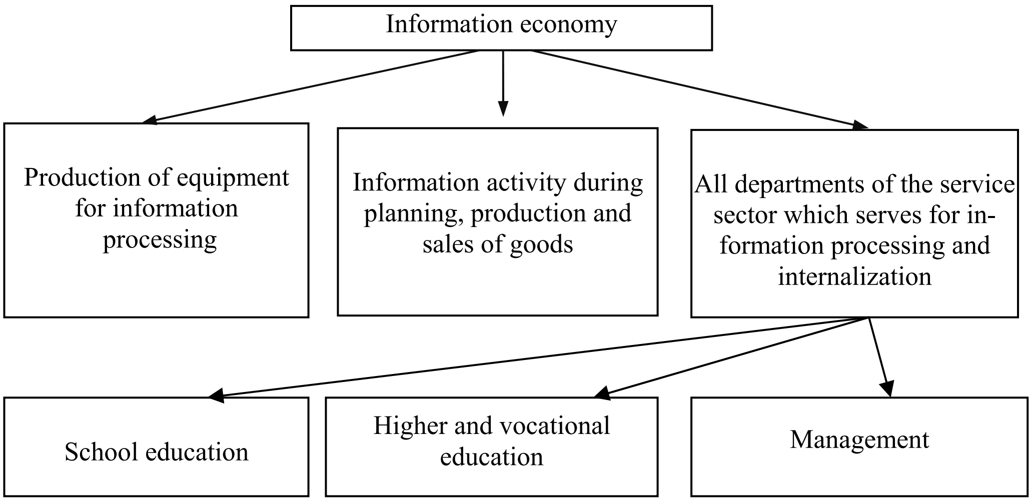

Fig. 6. Information economy

Creative activities including management alongside with different types of education play a peculiar role in the information economy. In recent years *commercial* significance has been acquired by the sphere of new knowledge, implemented in new technologies and equipment production, as well as training programs and the organization of work processes in the sphere of information economy. In Western countries they make up for more than 80 per cent of GDP growth. According to expert estimations, the annual turnover in the market of new technologies and science-intensive products is several times higher than the turnover on the market of raw materials, including oil, gas, and wood. In question are not just billions but trillions dollars.

This leads to serious social transformations. The number of people employed in industry and in farming decreases. According to some forecasts, in some years only one of ten workers will be occupied in industry in highly developed countries. The centre of gravity in the sphere of employment has shifted from industry to services, and in business activity – from material production to financial and some other transactions. Fictitious capital bubbles grow and advertising is artificially exaggerated while trade does not meet customers' needs, but overrides them and increase prestigious and in this case fictitious consumption. Many people are occupied in bureaucratic management what is also observed in Russia. Popular culture has been established which undermines human creative capacity instead of developing it.

By the way, as Alexander V. Buzgalin claims

> the key problem of progress of human society in the twenty-first century is the separation of creative activity from forms imposed by the fictitious sector, expelling the latter and usage of resources for the advancement of creatosphere – the world of culture, generally accessible creative activity and correspondingly the spheres which create cultural values and create, educate and develop a human as an independent and comprehensively evolving personality (Buzgalin 2001: 83).

Many philosophers of the past claim the development of personality (going beyond education, training and retraining) to be the ultimate goal of society. Nowadays practitioners also speak about that. ‘Only training and all-round education combined with the formation of all-round educated personality make real capital of our society’ writes Eberhard von Kuenheim, the ex-President of automobile producer BMW (Germany). He also emphasizes that only the realization of this triple task will enable Germany to hold positions in the group of leaders in highly developed countries.[8] Germany seems to ignore von Kuenheim's appeal. People continue to underestimate the importance of this trinity: education – training –construction of identity. As a result the quality of German graduates' education hardly meets the requirements of market. Besides, the quality of graduates' knowledge in German universities is very low. According to the results of international surveys (‘Pisa-Studien’) they take worldwide the 32nd rank . The manager of the German section of McKinsey, Jurgen Kluge, expresses anxiety: ‘The situation with German education is critical. Even if we tomorrow - by magic - have the best education system, it would take us 20 years to get the results. For these years a young man would finish school and get a degree in university. That is why we must act quickly, because the backwardness of the German educational system leads us to a serious economic crisis’ (Kluge 2003). Our scientist has a broader approach to the estimation of the role of education: ‘Education and training become “the first” constituent of public activity in terms of culture’ – says Alexander V. Buzgalin. Besides, education and training as a single process of human development will become ‘the first field’ of creatosphere to the extent, to which they will ensure the *formation of personality* with *creative capacity*. They are to assist in shaping an individual, capable to face problems and contradictions of the modern world, to find new combinations of well-known elements and to create new components, so that a creative flash of inspiration could give birth to new cultural activity. To borrow the language of Erich Fromm, such an individual should be, not have. Leontiev's School of Psychology (in Moscow State University) makes a particular emphasis on the active side of an individual, not only on the abilities to exist.

At the same time ‘the formation of a professional, his or her activity, consumption of a pop culture or narrow-purpose knowledge become components of integrated operating process of pseudoculture, pseudoeducation and pseudotraining, or, to be more precise, culture, education and training in the artificial forms, which are characteristics of modern information society or professionals' society’ (Kluge 2003: 91–92). Indeed, there are problems in the arising knowledge-based society. The division of labour goes further, profes-

[8] Welt am Sonntag, 10.11.1996, S. 56.

sionalism of the minority increases alongside with the degradation of the majority (Schmidt 1998).

A worker employed in the tertiary sector nowadays means more to the economy than a worker occupied in the primary and secondary sectors. Those, who want to get power, do not only aim on possessing means of production, but also at possessing means of communication. This is the reason for political competition for new means of communication. Between 2000 and 2004, Russia faced this vivid competition between influential 'oligarchs' and the authorities. Nowadays this competition has only been increased.

In the mid-1980s, our scholars noticed that the third industrial revolution leads us to the new era. 'Our descendants will live in an information-based society', – wrote Gennady Vorobyov. – 'This means that most future professions will be connected with information production and processing, and this will require great changes in terms and methods of labor, and even in the lifestyle' (Vorobyov 1979: 3). We can conclude that *intelligence and imagination become the most significant productive factors in information-based society.*

Intelligence, information and *engagement/identification with the tasks* become the basis of information societies instead of land and labor (Maslov 2001). At the turn of the twentieth century, in highly developed countries the emergence of new society which was called at first post-industrial, than informational (with many varieties: society of professionals, knowledge-based society *etc.*), became almost general. According to Buzgalin, the main features of this society are the following: the 'know-how' production and especially the information technologies become the key factor of progress (economic flourishing, geopolitical power); services sector substitutes for the industry; the production structure changes; the institutional system is transformed (particularly, the new characteristics of companies and management systems); professionals and 'production' centers become the key parameters of development (Buzgalin 2001: 75).

Different fields of information economy gave rise to the demand for specialists of especially high qualification who are scarce in many countries of the world including Russia. In particular, most of new vacancies that will appear in ten years will demand applicants with higher education. This poses a new challenge for the society, which will have to move to *common higher education* as a critical prerequisite for further employment of its citizens and competitiveness of its economy in the global market. Certainly, all stages of education should be free of charge for students. Nowadays, the law about common higher education exists only in Japan. In 2011, the Free Higher Education Act was implemented in Turkey. Students of Germany have also 'won' the abolition of tuition fees, so from September 1, 2013 higher education in Germany is free.

'Investments made in people are very important for growth, because an educated and healthy population is critical for the realization of all the advantages of society's economic potential', – report specialists of the US President's Council of Economic Advisors (Economic Report… 2003: 372).

Thus, education and training become the main and necessary conditions of emergence of new managers and employees, who are innovators, creators, and not executors. In the era of globalization a country has no other alternatives.

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Resistance to Socio-Political Instability as an Indicator of the Country's Successful Development*

Sergey Yu. Malkov, Stanislav Ye. Bilyuga, Olga I. Davydova and Dmitry S. Malkov

One of the most important indicators of a country's successful development is the resistance of the state and society to socio-political instability coming both from internal and external destructive forces. The destabilization can manifest in the emerging protest movements, extremist views, fundamentalist organizations, nationalism, etc. The relevance of the analysis of country's resistance to socio-political destabilization increases due to the fact that nowadays numerous attempts are made to undermine the political situation in many regions of the world, including in Russia, via soft power. Accordingly, there is a growing need in a scientific interpretation of logic processes of political instability in society in order to resist the possible instability.

The report describes the logical-mathematical model designed to:

– Analysis and computer modeling of the sustainable socio-political structures;

– The timely identification of risks of social and political instability;

– The research of possible ways to overcome them.

The model is verified on historical material (the history of Russia, Great Britain, and France) and used to simulate the specific situations of social and political destabilization (contemporary events in the Middle East, Ukraine, separatist movements in several countries).

Keywords: *mathematical modeling, socio-political systems, chaos and destabilization, synchronization, forecasting, risk management.*

Social systems are the amalgamations of actors (individuals and legal entities), which on the one hand, have different interests (which show their subjectivity), and on the other hand, when making decisions they have to take into account each other's interests, and to negotiate and mutually coordinate the actions (only in this case one can speak about the existence of a single social system).

The actors can affect each other through a number of different mechanisms: through a system of rules and regulations, through bilateral and multilateral agreements, by coercion, *etc.* As a result of the interaction, the decisions may converge or synchronize (while the interests remain different); in this case the actors act in a consistent way and social system functions as a single organism. However, if no synchronization of solutions takes place, there will be a disagreement among actors and the system becomes unstabe.

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Thus, the aim of the present article is to identify the patterns and intensity of actors' mutual influence which can lead to the emerging consistency of their decisions and actions (not opinions) aimed at supporting a stable functioning of social system.

The information field theory can help to solve this problem (see *e.g.*, Bukharin, Kovalev, and Malkov 2009; Bukharin and Malkov 2010, 2011, 2014), since its conceptual field comprises three quantitative indicators of synchronization or desynchronization of the actors' positions *i* and *j* in the decision-making process on a particular issue (the indices take values in the interval between 0 and 1 while the value of zero means a complete consistency, and the value of one – a complete disagreement). Indicators are the following:

- the index of disagreement of opinions So_{ij} (IDO), which is always above zero;
- the index of disagreement of solutions Ss_{ij} (IDS), which can be above zero;
- the index of disagreement of actions Sa_{ij} (IDA), which should tend to zero in social systems.

Let us give an example. IDO reflects the difference of opinions on various issues between the Communist party and the party 'United Russia' in the Russian State Duma; IDS reflects the results of voting of the Communist party and the 'United Russia' in the State Duma on various laws; IDA characterizes the execution of the adopted laws by the members of both parties.

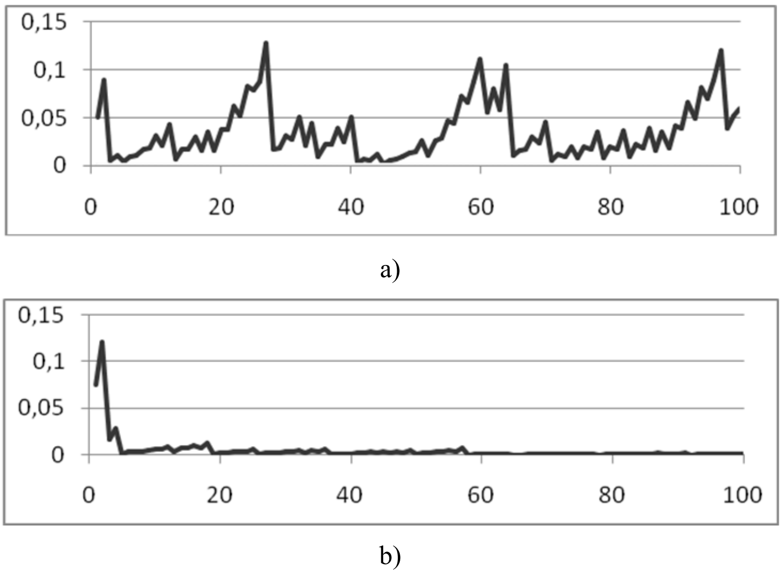

Fig. 1. The typical view of the index disagreement at different moments of time *t*: a) the situation is a significant disagreement, and b) the situation is almost complete consistency (on the horizontal axis – the value of *t*, on the vertical axis – the value of S_{ij})

The method of assessing the indices of disagreement was developed basing on analogies with the assessment of synchronization of related nonlinear dynamical systems with discrete time (see *e.g.* Dmitriev, Starkov and Shirokov 1996; Malkov 1998, 2007, 2009; Malkov and Bilyuga 2015).

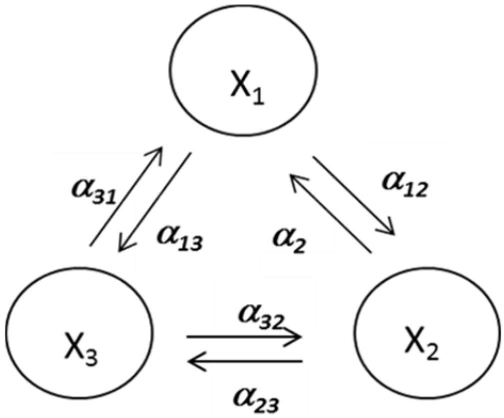

Fig. 2. Synchronization of three connected systems whose dynamics are described by a discrete map *F(x(t))* with the Lyapunov exponent λ >0 (λ characterizes the difference of interests):

$$x_1(t+1)= F((1-a_{21}-a_{31})\cdot x_1(t)+ a_{21}\cdot x_2(t)+ a_{31}\cdot x_1(t)),$$
$$x_2(t+1)= F(a_{12}\cdot x_1(t)+ (1-a_{12}-a_{32})\cdot x_2(t)+ a_{32}\cdot x_1(t)),$$
$$x_3(t+1)= F(a_{13}\cdot x_1(t)+ a_{23}\cdot x_2(t)+ (1-a_{13}-a_{23})\cdot x_1(t)).$$

The findings of investigation of chaotic synchronization systems are the following:

– synchronization can occur only when the intensity exceeds a certain threshold value a' ('synchronization threshold'). Thus, the more chaotic system, the higher the value a' and the stronger must be the connection a_{ij} to prevent a desynchronization of system (a_{ij} – is the link between the systems);

– in general, the increasing number of links reduces the synchronization threshold. However, there may be situations when the introduction of new ties in addition to the existing ones does not improve but worsens the synchronization of system dynamics. The ties are not equal and the result of their interaction depends significantly on the overall structure of ties within the system as well as on the value of λ;

– within a certain structure of relations one can increase their intensity to achieve synchronization at any value of λ. However, there are situations when sufficiently large values of λ prevent synchronization regardless of any intensity of a_{ij}.

At the next stage of the research it was necessary to project this method to the state. It was assumed that a state can be presented as a system of relations between central authorities, local governments, and population. When verifying the assumption on historical data (the case studies were history of France, Germany, Great Britain, the Russian Empire, and Russia) in order to identify the meaningful patterns, we discovered two distinct and sustainable systems of government with high efficiency, namely, the adaptive system (or a democratic republic) and the directory system (or a rigid authoritarian regime). We also suggest that the transition from one system of government to another is rather complicated and accompanied by social instability.

Below we give some examples of highly efficient systems of government.

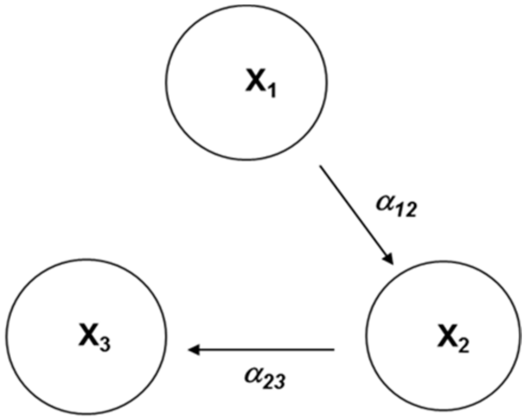

Fig. 3. Option 1. A rigid directive system of governance (X_1 – Central authorities, X_2 – local governments, X_3 – object of management)

Characteristics: a rigid vertical power structure with weak or absent inverse links. The synchronization threshold is high.

Examples: absolute monarchy, oriental despotism, dictatorship, and totalitarian regime.

The synchronization threshold of system is the following:

$$\alpha' = \alpha_{12} + \alpha_{23} = 2 \cdot (1 - exp(-\lambda)),$$

where λ characterizes the difference of interests of main social groups.

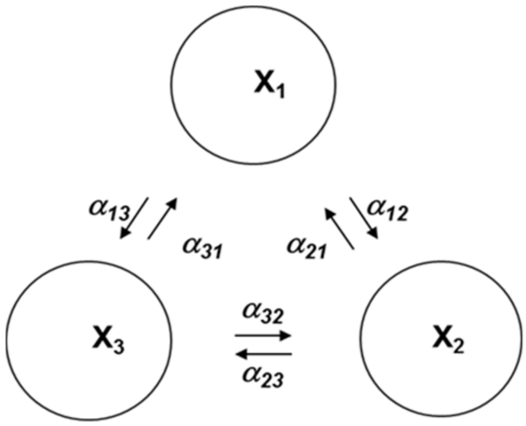

Fig. 4. Option 2: the adaptive control system (X_1 – central authorities, X_2 – local governments, X_3 – object of management)

Characteristics: all ties are involved. The synchronization threshold is low.

Examples: a democratic regime, a parliamentary republic.

The threshold of synchronization system is as follows:

$$\alpha' = \alpha_{12} + \alpha_{13} + \alpha_{21} + \alpha_{23} = 4 \cdot \alpha = 4 \cdot (1 - exp(-\lambda))/3.$$

Now let us pass to alternative systems of government with reduced efficiency.

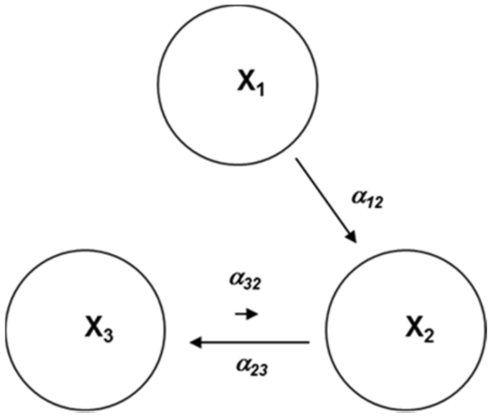

Fig. 5. Option 3: direct system of government with additional inverse links a_{32} (X_1 – central authorities, X_2 – local governments, X_3 – object of management)

Characteristics: in addition to rigid vertical governance there is imposed a partial local economic independence and elements of self-government. The synchronization threshold increases compared to the original system of the directive system:

$$\alpha' = \alpha_{12} + \alpha_{23} = 2 \cdot (1 - \exp(-\lambda)) + 2 \cdot \sqrt{1 - \exp(-\lambda) \times \alpha_{23}}$$

To preserve the governability it is necessary to strengthen control actions.

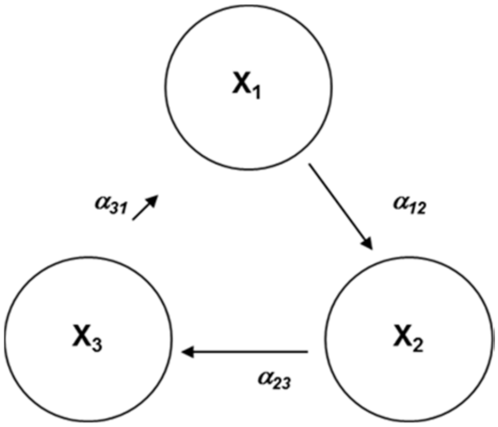

Fig. 6. Option 4: the directive system with additional tie a_{31} (X_1 – the central authorities, X_2 – local governments, X_3 – object of management)

Characteristics: people's direct influence on the central authorities proceeds through elections, demonstrations, *etc*. The synchronization threshold reduces if the chaotic rate is low in system, and increases if chaotic rate is high. In the first case, the controllability increases while in the second case it decreases and it is possible to lose the full of control, regardless the intensity of the control actions a_{12} and a_{23}.

The analysis of the simulation results brings to the following conclusions:

– in authoritarian systems it is necessary to reduce λ (involving ideology and religion as important factors);

– the transition from the authoritarian to adaptive system of government (an imitative democracy) is accompanied by a weakening of the regime;

– this determines the efficiency of 'soft power' (the 'color revolutions', *etc.*).

In Fig. 7 we present a possible rational transition from directive system of government to an adaptive system (through strengthening the ties) without a significant reduction of political stability in a society.

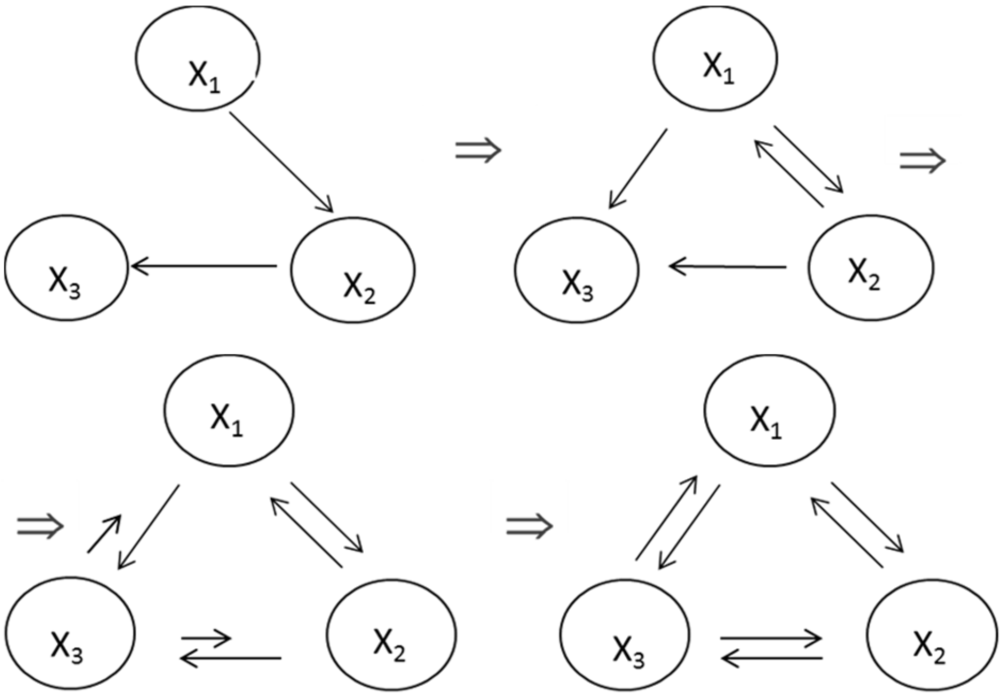

Fig. 7. The rational transition from directive system of government to adaptive system (X_1 – central authorities, X_2 – local governments, X_3 – object of management)

Using the mentioned tool for the analysis of political stability in a society, one can set the task to develop a methodology to forecastthe synchronization/desynchronization of multi-agent social systems.

At the early stages of our research we considered systems consisting of small number of agents in order to compare the simulation results with the actual current events (real events are the events in Ukraine and Novorossia from November 2013 to the present time). The scheme of interaction between the actors in Novorossia conflict is shown in Fig. 8.

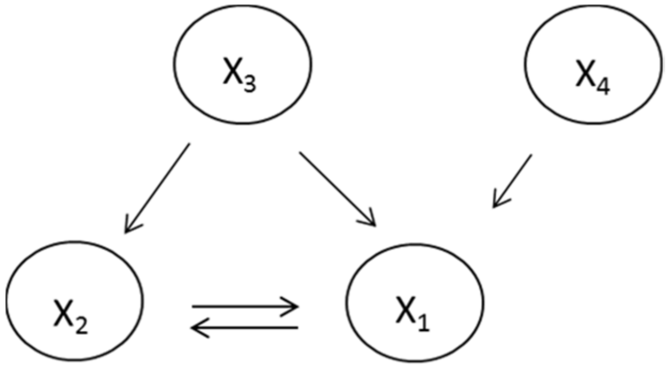

Fig. 8. The scheme of interaction between actors of the conflict in Novorossia: X_1 – Ukraine; X_2 – Novorossia; X_3 – Russia; X_4 – the USA and the EU

Fig. 9 shows the calculated intensity of the USA and the European Union's impact (the values on the y-axis, in relative units) which led to destabilization of the relations between the central Ukrainian authorities and Novorossia with varying intensity of Russia's efforts to stabilize the situation (the values on the x-axis, in relative units) for two cases when initially Ukraine and Novorossia are ready to negotiate (a) and not ready to negotiate (b).

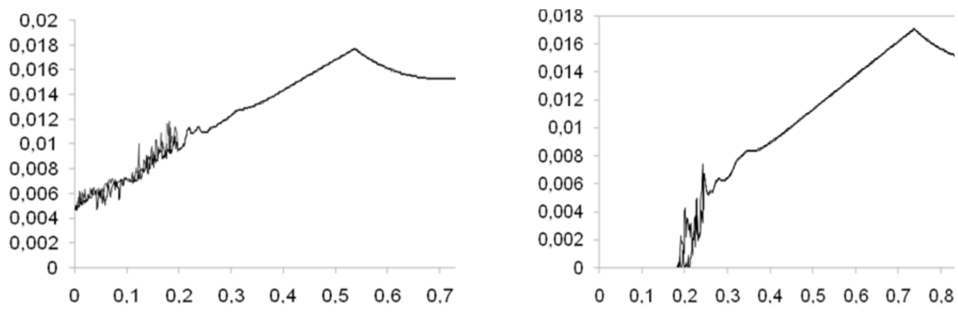

Fig. 9. The results of calculated minimal values of external influences from the USA and the EU (y-axis), which affect the synchronization of the subjects X_1 and X_2 for a given fixed connections between them ((a) – the high level of relationships, (b) – the low level of relations) and various efforts to stabilize the situation from Russia (the x-axis)

Fig. 9 shows that even the Western rather low-intensity desynchronizing impact on Ukraine can bring destabilization (the area above the curve is the area of destabilization). This illustrates the efficiency of soft power tools.

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The 'Age' of Globalization. How Old is the Global World?*

Alexey I. Andreev, Ilya V. Ilyin, and Julia V. Zinkina

The title of the paper poses two interconnected, but yet analytically distinct questions. Let us dwell on each of them.

How Old is the Global World?

The 'age' of global world does not equal to the 'age' of human history. From the perspective of Big History (Universal History, Megahistory), which is one of the most groundbreaking fields in historical research viewing the integrated history of Space, Earth, life and humanity on large-scale time spans using the multidisciplinary approach, as well as the co-evolution of inanimate and animate nature, and social systems, the global world emerged with the Big Bang (see Christian 2004). Focusing specifically on the 'human' global world, its age again is not equal to the age of humankind as a species. Indeed, throughout the early history humans dwelled in a number of separate societies, the vast majority of which hardly interacted with each other. In other words: there is a clear and long period between the global world and the 'human' global world.

In our opinion, the 'human' global world emerged with the establishment of stable relationships and systematic interaction between societies (territories) which comprised the vast majority of the world population.

From this perspective, the definition of the global world is close to that of the World-System, the largest 'suprasocietal system', which originated in the Middle East as a result of the Agrarian revolution and came to comprise the entire world through numerous cycles of expansion and consolidation. In the course of these cycles, the center of the World-System has repeatedly moved; for many centuries China played this role, then it shifted to Europe, and later, in the nineteenth century, to North America (see Grinin and Korotayev 2009: 131–133). Respectively, in order to determine the age of the global world, we can well rely on the following criteria developed in the framework of the world-system approach:

- Generation and diffusion of innovations (Korotayev 2005, 2007);
- Information networks (Chase-Dunn and Hall 1997);
- Trade networks of luxury goods (Frank 1990; Frank and Gills 1993; Chase-Dunn and Hall 1997);
- Military-Political Networks (Frank 1990; Frank and Gills 1993; Chase-Dunn and Hall 1997);
- Trade networks of mass consumption goods (Wallerstein 1974, 1980, 1988, 2004).

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Depending on the chosen criterion, the age of the World System can differ significantly. However, these criteria can also be represented as successive stages of the World System development, reflecting its increasing connectivity, which, after many cycles of expansion and consolidation, allowed the emergence and consolidation of a truly global World-System. If we compare these criteria to the Agricultural (Neolithic), Industrial, and Informational revolutions, and the major economic and technological novelties they brought, it is possible to suggest the following periodization of the global world:

1. The formation of the 'primary' world system in the Middle East approximately between the ninth and seventh centuries BCE is directly connected with the Agrarian revolution. One can hardly call this primary world system 'global' as it covered only the territory of the Fertile Crescent (Palestine, Syria, Northern Iraq and Western Iran). But there were also real (albeit very slow) informational connections, through which the North African and Eurasian region systematically obtained the most important agricultural and craftsmanship innovations from the Middle East, such as domesticated grains, large and small domesticated cattle, horses, ploughs, wheels, copper, bronze and iron products, *etc.* (Grinin and Korotayev 2009: 131–133; 2013; 2014).

2. Considerable consolidation of the world-system and its internal connectivity occurs in the era of agrarian empires. From 1200 BCE to 200 CE, numerous agrarian empires gained power and achieved prosperity, such as the Hellenistic world, the Roman Empire (covering the entire Mediterranean), the Persian Empire, the Achaemenid Empire, the Parthian Empire, the Kushan Empire, the Maurya Empire and the Gupta state in Northern India, the Qin Empire and later the Han Empire in China. The 'circulatory system' of this larger World System was based not only on the network of information exchanges, but also on the network of long-distance trade in luxury goods. The Great Silk Road became the central 'artery' of this system, linking the Roman Empire with the Han Empire since approximately second century BCE, passing through all regions of the Afro-Eurasian World System. Chase-Dunn and Hall even believe that it is the establishment of trade ties between China and Rome through the Silk Road about 2200 thousand years ago that gave birth to the Afro-Eurasian World System (Chase-Dunn and Hall 1997: 149; see also Benjamin in this volume).

3. The emergence of the genuinely global World System dates back to the 'long sixteenth century'.[1] It was born as a result of a series of expansion cycles of the initial World-System, which grew to encompass more and more new societies. The era of Great geographical discoveries played a central role in establishing stable and intense connections between regions hosting the absolute majority of the world's population. In our opinion, this period can be considered as time of the birth of the global world. At the same time, the discovery of new rich resources of the New world – first of all, silver – and their transportation around the world (through the system of historical and newly laid land and sea trade routes) enhanced the world trade and the connectedness of the global networks in general (Flynn and Giradez 1995, 2012; Maddison 2001, 2010).

4. Further development and growth of the World System's global connectivity is directly related to the 'modernization transition', that is to the transition from traditional to modern societies. Often the beginning of modernization and the birth of modern societies in this period is associated with the British industrial revolution and its subsequent spread first to Europe and the USA, and then worldwide. However, with all the significance of the

[1] The term introduced by Fernand Braudel (1973) to denote the period from 1453 to about 1640, later caught up and got widespread in macrohistorical research.

industrial revolution, such an interpretation would unacceptably narrow the scope and downplay the significance of many other aspects of modernization transition, affecting all spheres of human life. Among its main components (in different countries they emerged and gained peaks at different times, with different speed and intensity, proceeding unevenly among the population) include the following:

• Energy revolution – an explosive increase in human energy consumption; the transition from muscular energy of humans and animals and natural-organic (water, wind, wood) energy sources to fossil fuels (coal, and later oil and natural gas);

• Scientific revolution – the radical changes in the knowledge about the world, society, and human beings as a result of fundamental discoveries in mathematics, physics, astronomy, biology, anatomy and chemistry; the emergence of modern science, its principles, methods and institutions;

• Industrial revolution – the transition from an agrarian to an industrial mode of production, from manual labor to machines, from manufactory to factory, accompanied by a rapid growth of productivity and specialization;

• Agricultural revolution – the growth of labor productivity in agriculture, thanks to which, on the one hand, there arose the ability to feed a large population that is not employed in the agricultural sector, and, on the other hand – to free many workers from agricultural labor for industrial production;

• Educational revolution – the spread of mass public education and compulsory primary education;

• Global demographic transition – transition from traditional type of reproduction, characterized by high mortality and fertility rates, to its modern type, characterized by low mortality and low fertility; medical revolution (as well as new norms of hygiene in urban infrastructure) should be particularly highlighted as they made enormous contribution to reducing mortality and changing its structure by establishing efficient control over communicable diseases;

• Political modernization – this comprehensive notion implies the emergence of centralized nation-states; the emergence of bureaucracy (hierarchy of professional state managers); formalization of decision-making procedures; the spread of representative forms of government; the emergence of modern legal traditions, *etc.*;

• Urbanization – significant increase in the proportion of urban residents among the population (compared to traditional societies, where the majority of the population lives in rural areas); urbanization is dynamically linked with the concentration of population in certain places necessary for the modern industrialized production of goods and services, to changes in the employment structure (the rapid growth in the share of urban residents has been accompanied by rapid employment growth in the modern sectors) and dramatic changes in the lifestyle of the majority of population;

• Revolutionary development in transportation (steamboats, railroads, automobiles) and communications (the telegraph) which increased the World System connectedness and its informational penetrability.

• Financial modernization – the emergence of international credit and foreign direct investments on a truly global scale (formerly limited by the European region); the classic Gold standard; dematerialization of money.

• Cultural modernization – general modernization of lifestyle, the unification of time and space measurement, the emergence of mass culture, the transition from folk culture to professional one.

As a famous Russian historian, Nikolay Kradin stated, there are several waves of modernization:

> The primary modernization affected mainly the societies of Western Europe between the sixteenth and the nineteenth centuries. The second stage of modernization encompassed the states in Eastern and Southern Europe, as well as Russia, Japan and Turkey. Modern Asia, Africa and Latin America constitute the third echelon of modernization. Most of them are still in the periphery of the modern World System. Some of them managed to make success in the course of modernization (*e.g.*, India, the majority of Latin American states). Finally, some countries ('Asian tigers') have made considerable achievements (Kradin 2008: 172).

In our view, the varying pace and scope of modernization transition, the uneven spread of its effects and technologies in the seventeenth and eighteenth centuries laid foundations for the nineteenth-century phenomenon called 'the Great Divergence' – the rapidly widening gap in per capita income and living standards between the developed countries and the rest of the world throughout the nineteenth century. It began as a widening gap between the affluent countries of the North and the increasingly backward South; then the gap became evident among the countries of the global North, as the fast-paced West overtook the East.

5. New stage in the history of the global World System – and also of globalization, according to many researchers, – the world's transition to a new level of connectivity and 'globality', comes after the Second World War. This stage can be divided into two periods, corresponding to the fourth and fifth technological modes ('Kondratieff waves'). Moreover, the turning point between the two occurs to be a bifurcation point for a range of important global demographic and economic trends as well.

The first sub-period, from the late 1940s to the early 1970s, sees the mode of analog electronics, the revolution in air transport, household appliances, *etc*. The 1960s and 1970s are marked by the peak of the Great Divergence (the maximum gap in per capita income and living standards between the developed countries and the rest of the world), the peak of pollution in the first world, as well as the peak rate of global population growth due to the explosive population growth in the Third World countries.

However, after two critical decades (the 1970s and 80s) many secular trends changed to the opposite. Since the late 1980s, the world population growth rate has been declining, and the gap in per capita income between the countries of first and third world begins to narrow. At the same time we can observe in the developed world a growing implementation of energy-saving technologies, environmentally friendly production facilities, which reduced damage to environment but also made a significant contribution to the economic slowdown.

In the late 1980s and early 1990s, there is also a great 'leap' in the degree of openness in the global world due to the fall of the Berlin wall and the collapse of the Second World (the USSR and the Soviet bloc). The most important 'engines' of the new wave of integration are the innovations associated with digital electronics, information and communication technologies, primarily the proliferation of computers and the Internet. Google, according to the words of his 'father' Sergey Brin, is 'the great equalizer'. Amid growing openness the rise of China and other developing countries occurs, which narrows the gap between the developed and the developing countries. This phenomenon is called the 'Great Convergence'.

How Old is Globalization?

Let us now switch to the question of the 'age' of globalization. Obviously, the answer to this question will largely depend on our basic definition of globalization. If we take a very particular definition, selecting only certain traits of the phenomenon – such as, for example, the emergence and spread of the Internet – globalization will turn only a few decades old, dating its existence back to the 1970s (when ARPAnet was created) or even the 1990s (when the Internet truly started its global march).

If we look at more general definitions, the age of globalization will increase. Let us take, for example, the definition of Nayef R. F. al-Rodhan and Gérard Stoudmann: 'globalization is a process that encompasses the causes, course, and consequences of transnational and transcultural integration of human and non-human activities' (al-Rodhan and Stoudmann 2006: 36). In this case we can speak of about ten thousand years of history of globalization because, as shown above, transnational and transcultural integration occurred within the primary World-System from nine to eleven thousand years ago. Some researchers assume that globalization is even much older than that. For example, Nayan Chanda believes that globalization began with the exodus of the first humans from Africa, and its most important agents were at a later stage traders, preachers, adventurers, and warriors (Chanda 2007).

In general, there are three to four basic approaches to determine the age of globalization (see, *e.g.*, Bayly 2004: 41–48; Hopkins 2002; Robinson 2007: 125–127; Hopper 2007: 14–25; Holton 2011: 37–39; see also the special issue of the *Journal of Globalization Studies*. Volume 5, number 1: Globalization in Historical Retrospective and World-System Analysis, Guest Editor Thomas D. Hall). All researchers listed introduce somewhat different chronological frameworks, but the common logic behind these frameworks allows us to identify the following four stages of the history of globalization, which are consistent with periodization of World-System's history and the 'birth' of the global world:

1. 'Archaic' globalization started around 5–10 thousand years ago. According to Paul Hopper, it can be assumed that the history of globalization as circulation of ideas, people (media culture), goods and artifacts around the world is measured in thousands of years and has its roots in the emergence of first civilizations. Hopper sees as indication of 'archaic' globalization in the migration of people, emergence and spread of world religions, empires and transregional trade networks (Hopper 2007: 14).

2. Pre-modern (proto-modern) globalization began with the integration of the global world in the 'long sixteenth century', that is about 500 years ago. This period is sometimes referred to as 'protoglobalization'. Thanks to the Great geographical discoveries the most important regions of the world got linked into one global network, which transported flows of goods, capital, migration, cultural symbols and artifacts, ideas, knowledge and technologies, pathogens and epidemics, *etc.*

3. Modern globalization covers the period from the seventeenth to early twentieth century (up until the First World War) and is closely connected with the spread of all modernization transition effects listed above. This period of globalization influences all spheres of social life – political (global diffusion of the modern state model, its management structures and institutions), economic (global diffusion of industrial production, fundamental industrial technologies and new technological modes, global movement of financial capital), social and cultural (intensified global migration, diffusion of ideas and standards, *etc.*). To the end of the stated period, it actively affects not only individual social groups, but populations as a whole (although, again, the effects of globalization are tangible for different societies and states at different speeds and with different intensity).

Globalization reached its culmination by the end of the nineteenth century (the period from 1870 to 1913 is sometimes even called the '"Golden Age" of globalization'), when international trade, international migration flows and international mobility of financial capital reached their historical peaks (for that time). Breakthrough technologies in transportation (steamboats, railroads) and communication (telegraph) laid the basis for the 'Golden age'. The effectiveness of new transport technologies and their shrinking costs led to tremendous scope of international trade (not only in luxury goods but also in cheap and affordable mass consumption goods, including food products) and international migration. Unprecedented speed of communication through the telegraph rapidly accelerated the development of global financial markets and global capital flows.

4. The age of 'newest' globalization equals to several decades; its origin is closely connected with technological revolution and new opportunities for global integration created by information technologies.

The Age of Globalization and its Influence on the Research Discourse

There are diametrically different opinions about the stance of the 'newest' period of globalization among researchers. 'Skeptics' believe that the 'newest' globalization is only a logical resumption and continuation of the processes of global integration which intensively manifested themselves in the late nineteenth and early twentieth centuries (but were interrupted by two world wars), so there is not too much novelty to the phenomenon (see, *e.g.,* Hirst and Thompson 1996, 1999; Hirst, Thompson and Bromley 2009; Wade 1996; Held *et al*. 1999). On the contrary, 'hyperglobalists' consider the 'newest' globalization as the transition of humanity to a fundamentally different stage of development (Gates 1995; Cairncross 2001; Ohmae 1999, 2005; Friedman 2007). It seems to us that like in most discussions, the truth is in the middle and both sides are right to some extent.

A number of aspects of the 'newest' globalization, especially economic ones, such as increase in international (cross-border) economic activity, economic growth of the interrelatedness and interdependence of national economies, growth of global markets, growing international mobility of goods can be regarded as a continuation of the 'Golden Age' of globalization, although each of these areas experienced tremendous changes under the influence of the new technologies.

Moreover, some other aspects of globalization, which were only emerging during the 'Golden Age', reached unprecedented magnitude in the second half of twentieth and early twenty-first centuries, and their role in the global world has changed essentially. For example, we can mention the rapid expansion and growing influence of transnational corporations, the emergence of the international division of labour and global production chains, *etc*.

However, along with this, the 'newest' globalization includes a set of fundamentally new phenomena, which are not connected with previous waves of integration in the global world. This is especially evident in the political and socio-cultural spheres – expansion of global governance institutions, voluntary limitation of national sovereignty in a range of issues; global market of short-term investments and currency speculation; radical change of the mass culture because of increasing access of the majority of population to information; formation of a single global information space, *etc*.

Another point is that both the 'hyperglobalist' and the 'skeptic' views of globalization see it as a sort of end-state of the World System (with the ideally globalized world being somewhat analogous to the 'ideal markets' from the textbooks on Economics), towards which it is either moving swiftly ('hyperglobalists'), or moving extremely unevenly, slowly, or hardly at all ('skeptics'). However, this leads to mixing the notions of 'ideal' and 'global'. Moreover, such a multi-faceted and multidimensional process, encompassing all spheres of human life, can hardly be expected to have a single end-point. As Perraton points out, single equilibrium models are inapplicable to studying globalization (Perraton 2011: 62–63).

However, if we stop viewing globalization as a path to one single result (a 'fully globalized' world, whatever this notion could imply, from the fall of all national borders to full unification and homogenization of global culture – very frequently implying its hegemonisation as well, that is a cultural unification according to values, meanings, ideas etc. of one particular hegemonic culture), then we can assess it not only quanitatively, but also qualitatively – as a macrotransformation of the organization of the ways of life of the humanity, where global processes and institutions can cause local repercussions, and growing interconnectedness leads the specifics of development of one locality to influence ways of life and development trajectories in other, even remote localities.

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Part III. BIG HISTORY PERSPECTIVE

The Evolution of Big History: A Short Introduction

David Christian

Big history represents a modern scientific form of an ancient project: that of constructing unified, coherent and universal accounts of reality. Such projects can be found within the origin stories of most human societies. But in the late nineteenth century, the universalistic project vanished within both the humanities and the sciences, as scholars in field after field coped with the modern tsunami of information by narrowing the scope of their research. The sciences began to return to larger and more universalistic perspectives from the middle of the twentieth century as new unifying paradigms emerged in field after field, and physicists even began talking of 'Grand Unified Theories' of everything. New information and new dating techniques made it more reasonable than ever before to attempt scientifically grounded universal histories and such attempts began to reappear in the 1980s. But not until the first decade of the twenty-first century has that project really begun to take off.

Keywords: *Big history, universe, Darwinism, Big Bang, grand narrative.*

The website of the International Big History Association defines Big History as 'the attempt to understand, in a unified, interdisciplinary way, the history of Cosmos, Earth, Life, and Humanity' (http://www.ibhanet.org/). It seems likely that most human societies have tried to construct unified histories that embrace all areas of knowledge. We often refer to these as creation myths or origin stories. Such stories, or cycles of stories, can be found within all religious traditions. They could even be found within the more secular intellectual traditions of Europe as late as the 19th century, within attempts such as those of Hegel or Marx to construct unified and coherent accounts of how the world had evolved to be as it was.

Origin stories are powerful precisely because they aim at a sort of completeness. They attempt to link all areas of knowledge into a more or less complete account of how things came to be as they are. The result of such projects is the creation of a sort of a map within which individuals and societies can identify their place in time and space, and to which they can tether their deepest intuitions and convictions about existence, meaning and ethics. Without origin stories, we are fated to live within a fragmented, endlessly shifting intellectual universe, deprived of the philosophical and ethical anchors of a more unified vision of how things came to be. We can think of Big History as a modern form of this ancient project. Big History returns in a sense to the old tradition of 'universal histories'.[1] What gives the idea such salience right now is the fact that universalist accounts of the

[1] I have developed this argument more carefully in *The Return of Universal History* (Christian 2010).

past vanished from serious historical scholarship in the late nineteenth century. They have been absent from serious scholarship and teaching for over a century.

Instead, historical scholarship and teaching have been contained within more fragmented intellectual and institutional structures that divided the histories of humanity from those of the natural world, and divided the histories of humanity itself into multiple regional or national histories. Because these were normally based on written evidence, modern histories were also fractured by the presence or absence of literacy, so that they excluded large areas of human history for which no written evidence existed. Sharply focused scholarship of this kind appeared in field after field, in both the humanities and the natural sciences, and its achievements have been immense. Furthermore, there can be no doubt that scholars had good reasons to eschew the more grandiose visions of the nineteenth century universal histories, because in most fields of study, particularly in the humanities, the available information was too thin to discipline large speculative theories, so that all too often ideology overwhelmed hard fact. Social Darwinism was merely the most obvious expression of the dangers of attempting overly grandiose accounts of the past in an era of limited information and nationalist or imperialist ideologies.

But a lot has changed since then. Careful empirical scholarship within many different scholarly disciplines has generated vastly more information than was available late in the nineteenth century. And particularly in the natural sciences, scholars from different disciplines have begun once again to explore unified, inter-disciplinary accounts of the past. These accounts have been associated with the appearance of powerful paradigms within geology (plate tectonics), biology (the idea of natural selection reinforced by a modern understanding of genetic mechanisms), and – perhaps most spectacularly of all – in cosmology. Big Bang cosmology arose from a unification of nuclear physics (the study of the very small) and cosmology (the study of the very large). So powerful was the resulting synergy that cosmologists and physicists began to speculate quite seriously about the possibility of constructing 'grand unified theories', theories that would encapsulate most of physical reality within one grand account of how the Universe works.

The Humanities disciplines remain more fragmented. But the field of Big History is based on the assumption that the time may now have come even for historians to return to large, unifying questions about the past. One reason for saying this is that new dating techniques developed since the 1950s, beginning with C^{14} dating, have made it possible to construct chronologies embracing the whole of time. When H. G. Wells tried to construct a universal history, at a time when such projects were frowned on by professional historians, he had to concede that he had no reliable absolute dates reaching back more than a few thousand years, because absolute dates still relied on the presence of written evidence.

Today, we have a whole range of new techniques for dating events in the remote past, so we can construct reasonably precise absolute chronologies dating back, literally, to the origins of the Universe. Such chronologies allow us to form narratives of the Universe's history that run the gamut from cosmology to geology, to biology and, eventually, to human history. It is possible, as a result, to see human history not as something separate from the history of the Earth and biosphere but rather as a part of that larger history. This, of course, is a narrative that aligns very well with the growing awareness of the ecological embeddedness of human history that has evolved since the middle of the twentieth century.

Another factor that may have encouraged more expansive accounts of the past is the sheer pace of globalization in the late twentieth century, accompanied, as it has been in many fields of scholarship, by the creation of genuinely international communities of scholars. The rise of world history is one expression of a growing awareness among historians that, in a more globally interconnected world, global interconnections need to be taken very seriously indeed. No longer does it make sense to think that the history of each nation can be understood adequately without seeing how it is embedded within a wider world. Increasingly, world history is a project undertaken and shared by historians from many parts of the world; the 2011 conference of the American-based World History Association will meet in Beijing.

It may be that the extreme fragmentation of scholarship as it evolved since the late 19th century has generated a counter-reaction. There were, after all, good reasons for thinking that an over-rigid breaking up of knowledge into separate disciplines was philosophically incoherent. After all, the very idea of reason seemed to imply an underlying unity between all forms of knowledge. The alternative, after all, was to suppose that reality was itself criss-crossed by arbitrary epistemological chasms that made the knowledge of one discipline incoherent beyond that discipline's borders.

These may be some of the factors that explain why from the 1980s, scholars in a number of different specialist areas began attempting large, unified, and even 'universalist' accounts of the past. Interdisciplinary anthropologist Fred Spier has shown that modern attempts to return to some form of universal history, either in written works or in university courses, appeared from the 1980s within a number of disciplines, and mainly in the USA.[2] Scholars who attempted such syntheses included Preston Cloud, G. Siegfried Kutter and Eric Chaisson, while the first attempt to develop a modern *theory* of Big History was probably Erich Jantsch's *The Self-Organizing Universe*, published in 1980. From the late 1980s, several historians undertook similar projects, including John Mears and myself, both of whom began to teach undergraduate courses in Big History.

Like many other historians who have become interested in Big History, I came out of a traditional scholarly specialization, in my case Russian history. As an admirer of Fernand Braudel, I had always been interested both in the idea of material life as a sort of 'sub-stratum' to conventional historical scholarship and also in the closely related idea of the importance of the *longue durée*. And it was these questions that encouraged me to study Russian material life over long periods. But, over time, I began to wonder about the limits of Braudel's *longue durée*. After all, how *longue* is *longue*? If we learn something of value by surveying trends over many centuries, is it possible that we will learn even more if we stand even further back and attempt to survey the past at scales of millennia? This was, of course, a very slippery slope and once embarked on it, it did not take long to ask similar questions at scales of millions or even billions of years, scales that took me well beyond conventional historical scholarship and into the territory of biologists, geologists and, eventually, cosmologists.

I am not at all sure how typical this path to Big History was. In the early 1990s, the sociologist, Johan Goudsblom, and the biochemist and anthropologist, Fred Spier, began teaching a Big History course at the University of Amsterdam. Goudsblom had always been interested in the sociology of the *longue durée*, particularly as developed in the work of Norbert Elias. And Spier had long been struck by the way that pictures of the Earth from space suggested the importance of a more global and interdisciplinary vision of today's world. In 1996, Fred Spier published a pioneering attempt to theorize Big History in

[2] See 'A Short History of Big History' in Fred Spier's *Big History and the Future of Humanity* (2010).

The Structure of Big History: From the Big Bang until Today (Spier 1996), in which he identified distinct 'regimes' within many different realms, from those studied within astronomy and geology to those studied within biology and the humanities.[3]

In the natural sciences, in an environment increasingly friendly to the idea of grand unified theories, such projects may have seemed ambitious but not unreasonable. However, in the humanities, they were generally treated with deep suspicion. Even world history has had to fight for respectability within the history profession. The conventions that had created modern disciplinary boundaries, with their built-in career structures, criteria for judging success, journals and academies, proved remarkably powerful, and interdisciplinary scholarship remains extremely difficult. As E. O. Wilson pointed out in *Consilience*, a powerful plea for more inter-disciplinary study, the largest of these divides remains today where C. P. Snow found it in the 1950s, between the natural sciences and the humanities (Wilson 1998). Wilson argued that one of the main scholarly projects of the near future had to be the search for unifications that could cross this border, and integrate the human sciences more firmly within modern scientific scholarship as a whole.

Then, somewhat to the surprise of those committed to the project of Big History, in the first decade of the twenty-first century, these barriers began to fall. Barry Rodrigue and Daniel Stasko have tracked the rapid evolution of college level courses in Big History, and they have also compiled a substantial bibliography of published scholarship in the field (Rodrigue and Stasko 2010; Rodrigue and Spier 2010). In April 2011, a formal scholarly association was created to support scholarship and teaching in Big History: the International Big History Association. And just a month earlier, the 'Big History Project' was launched, which will build a free online high school syllabus in big history in order to try to develop Big History education in secondary schools.[4]

And what should the field be called? These various projects have attracted several different names, including 'cosmic evolution', 'the evolutionary epic', 'universal history' and 'Big History'. I first used the phrase, 'Big History' in an essay I wrote just three years after I started teaching a Big History course at Macquarie University in Sydney (Australia) (Christian 1991). I used it because it was simple, catchy, not too solemn, and seemed, by echoing the notion of the 'Big Bang', to capture something of the scale of the course I had begun to teach. The label has acquired broad currency particularly in the humanities, but other labels, such as 'cosmic evolution', may be preferred within the sciences. The labels do not matter too much. What is important is that we seem to find ourselves at a very exciting moment in the evolution of modern scholarship, one in which for the first time in over a century the project of constructing unified, coherent and scientific accounts of the whole of the past is back on the agenda again. Whatever we call the project, it holds the promise of re-creating, now on a firm scientific basis, the unified visions of reality that have been so powerful in most human societies. As E. O. Wilson argued in *Consilience*, there are immense intellectual synergies awaiting those who start bringing together the insights, the information, the methods and the paradigms of today's major scholarly traditions within a more coherent, less fragmented vision of our universe.

[3] In 2010 he published an expanded version of this work in *Big History and the Future of Humanity* (Spier 2010: 9–16).

[4] See the IBHA web site at http://www.ibhanet.org/ and the Big History project web site at http://www.big historyproject.com/.

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From Particles to Politics

Lowell Gustafson

In this paper we investigate the gradual and uneven development in the complexity of polity, or the sustained, structured relationships that incorporate earlier ones and go on to be subsumed by subsequent relationships. This takes us from the very early and long-lasting relationships among two types of quarks to the emergence of human polity, with annihilations, extinctions, and wars as part of the often unpredictable development. Can the study of this process add to the likelihood that it will move more thoroughly through the latest transition toward the greatest known complexity in polity, or will it face the temporary or even permanent effects of entropy?

Keywords: *Big Politics, polity and natural science, Big History and politics, politics and science, Political Science.*

Big Politics is the process of emergent complexity of sustained, structured relations that began with the Big Bang and has continued in stages through today, as it may continue to do in the future. The natural sciences explain how the simplest forms of sustained, structured relationships emerged and how they gradually, unevenly, and increasingly became more complex over time (Christian 2004, 2011; Chaisson 2006; Brown 2007; Spier 2010; Shubin 2013). Relationships have become progressively complex between sub-atomic particles, atoms, molecules, cells, morphology, animals, human families, villages and cities, nations, regions and empires. Each less complex and older set of relationships is incorporated within newer and more complex ones.

From the beginning, each new combination of units exhibits new properties. One significant new property was the emergence of consciousness and self-consciousness. Exactly how matter comes to be able to reflect on itself is still not fully understood, but the ability emerged out of pre-reflective matter. With this new property, conscious beings have played a greater role in choosing among alternative, imagined futures in ways that can create or inhibit further growth in complexity.

Politics among humans are certainly different from, but also emergent from, earlier types that vastly precede the relatively brief human period. Pre-written and pre-human politics are not mere analogies for human politics nor inevitable causes of it, but its necessary antecedents. It is not possible to study the formation of atoms 300,000 years after the Big Bang and predict from that the writing of Plato's *Republic*. It is also a misperception that there is a great divide between human and pre-human politics. Human politics, much less politics before writing, did not emerge fully blown and without antecedents. The field of political science still needs to incorporate the story that the natural sciences permit us to tell, and not to begin its study with the ancient world of a few thousand years ago or even 200,000 years ago in political anthropology. As familiar as ancient political thought is to students of political philosophy and contemporary politics to those who use such methodologies as survey analysis, the study of political science can now vastly predate those periods. The study of light, rocks, bones, and blood as well as written texts, surveys, and electoral results, tell a story of the entire past from which human politics has emerged and remains embedded.

In one way, examining the relationship of politics and nature is nothing new. The famous ancient Greek philosopher, Aristotle, wrote books such as one on *Physics* and another on *Politics*. In the latter, he wrote that humans are by nature political animals. In the European medieval period, Thomas Aquinas developed Aristotelian thought on natural law; he argued that humans were created within a politically constituted community. By the seventeenth and eighteenth centuries, such State of Nature political philosophers as Thomas Hobbes, John Locke, and Jean-Jacques Rousseau postulated human politics before or without such institutions as the state. They wanted to determine how to construct states so that they helped resolve the basic problems of human nature. The authors of the U.S. Constitution saw their political construct as consistent with nature (Kammen 2006). For all of their differences, they all saw human politics as rooted in nature. None of them had the same understanding of nature as has developed since Darwin, Einstein, Hubble, and others in recent centuries.

The emergent complexity of sustained, structured relationships that incorporate earlier ones in new combinations and with new properties is possible due to access within pockets to high quality energy. The second law of thermodynamics would lead us to expect entropy, or transitions from greater to lesser order rather than emergent complexity, which is possible in energy rich pockets. From the origins of polity until today, we can observe in certain places a process of increased complexity due to the existence in certain locations of access to energy. If we can resolve our current energy crisis in a sustainable way, and if we have the imagination, this process may continue. However, there was no uniformity in emergent complexity in the past and there is no guarantee it will continue in the near future. In the distant future, we are virtually certain to face entropy. A narrative of humanity's common origin in Africa, life's origin from LUCA, and the Universe's origin from a singularity, may help foster greater complexity in politics among humans and between humans and our environment.

The major sub-fields of political science are often presented to students with discussions of their origins, structure, and emergent complexity. The origins of these sub-fields occurred centuries or even millennia ago. But our question here is not about the origins and development of American Politics, International Politics, Comparative Politics, or Theoretical Politics; it is about Politics. How has it developed greater complexity and become the human politics that we know today? What instruction might this provide for the future? Politics does not begin with the U.S. Constitution, the Treaty of Westphalia, or Plato's *Republic*. It began long before 1787, 1648, or 2,500 years ago. It cannot be studied only by public opinion polls since it began before any living person. It cannot be studied only by reading primary sources since it began before writing. It is not structured now just by written constitutions or by common law. Politics began long before in ways that continue to make us what we are today. Just as the past did not begin with writing or even with humans, so politics also did not begin with them. Our present and our politics emerge from much earlier antecedents that still includes them. Our well-being in the future may depend on our understanding this and acting on it. In the period since the origin of consciousness and culture, or collective learning, the persuasive narratives we tell ourselves and how we frame our stories become part of the evolution of emergent complexity.

Baryonic Matter

Sustained, structured relationships emerged quickly after the Big Bang, according to the standard view (Carroll 2012). The many complex properties that would characterize human politics were not inevitable from the sustained structure that began to develop 13.82 billion years ago (Planck 2013 Results Papers).

Perhaps, branes bounced or an infinitely hot and dense point without mass began expanding and cooling 13.82 billion years ago. It may be that nothing is always pulsating and is regularly turning into a variety of forms of something. Perhaps, we live in a multiverse with an infinite number of Big Bangs occurring all the time in ways we cannot detect or imagine. Other universes may be sharing our space or off in other locales. Or maybe our own universe has an infinite set of cycles of trillions of years (Singh 2004; Lederman and Teresi 2006; Greene 2011; Lederman and Hill 2011; Steinhardt and Turok 2007). We used to think there was only one galaxy. Then we wondered if there were other inhabitable planets. We now know there are great numbers of both. Why should ours be the only universe? However, for now we will restrict our attention to our own universe and to the development of polity.

At the earliest moment in our universe's known history, there was little discernible structure. If there was a singularity, it is hard to see how there was any structure in a point without mass. Ordered relations among parts did not begin until almost immediately after the Big Bang. If America was one nation formed by 13 former colonies and could adopt the Latin motto, *e pluribus unum* (from many one), the universe might adopt the opposite of from one many (*multa ex uno*). Incredible variation would emerge after the radiation period immediately after the Big Bang. Increasingly complex relationships between a relative few of these varied parts began very quickly.

All but immediately after our own universe's Big Bang, when energy first congealed into normal or baryonic matter, six types of quarks appeared. Four of these quarks led extraordinarily brief lives before returning to energy; they did not go on to form more complex forms of matter. However, two of them – the up and down quarks – did form relationships as they appeared. This will be a pattern. Some things go on to participate in emergent complexity. Many do not.

At least those quarks that survived formed relationships. For a billion and one bits of matter that appeared, a billion bits of anti-matter with opposite spin did as well. When they come into contact, matter and anti-matter annihilate each other. This is a rather good thing from our point of view, since if all the matter that appeared survived, the universe would have been just too crowded to ever have developed into us. Enough matter remained after the great annihilation to eventually make a hundred billion galaxies each with an average of a hundred billion stars all have been formed by the leftovers of the great annihilation. Destruction can be very creative.

The surviving quarks did not exist in isolation; they always exist in threesomes. Their relationship is structured by the strong force that is mediated by the exchange of the charmingly named gluons. Two up quarks and a down one form a positively charged proton; two downs and an up form a neutron. Why is the strong force exactly as strong as it is and not weaker or stronger? Is it different in other universes? It is simply not known. But if it differed at all, we would not be here and neither would anything else that we know of.

Quarks do not merge into one undifferentiated blob. Each proton and neutron is constituted by two different types of quarks. They relate to each other through the strong force, but they keep their distance as well. Relative to their own size, quarks have a rather pronounced need for personal space. Both relationship and distinct identity are part of Big Politics.

The protons and neutrons that were formed quickly after the Big Bang are with us still after almost 14 billion years. In fact, they are us, and everything else that we can see or feel. The structured relationships among individual quarks have been remarkably sustained. As inventive and creative as nature is, it also keeps certain things around for a long time. Something seems to have come from nothing at the Big Bang. That is change. Quarks can maintain their relationships for tens of billions of years. You cannot get much more of a status quo than that. We see in the epic of evolution the combination of long periods of stasis connected by periods of transition to greater levels of complex relationships. Both the status quo and periods of significant development are part of Big Politics.

About three hundred thousand years after the Big Bang, when the universe had expanded enough to cool sufficiently, the electromagnetic force mediated by the exchange of photons could structure a sustained relationship between protons and electrons. Atoms appeared. Hydrogen, with one proton and one electron, appeared in the greatest numbers. If you add up their mass, about three quarters of all atoms in the universe are still hydrogen. If you count atoms by number, they constitute about 90 per cent of all atoms. They also constitute 63 per cent of the number of atoms in your body (ten per cent by mass). As has been said, hydrogen is an odorless, colorless gas which, given enough time, turns into us (Harrison 1981).

Helium, with two protons and two electrons each, formed about a quarter of all atoms' mass that then existed (nine per cent by number). There was also a small amount of deuterium, or heavy hydrogen (one proton, one neutron, and an electron), helium isotopes, and lithium (three protons and electrons). Vast primal clouds of hydrogen and helium atoms, millions of light years across, still majestically float in certain areas of space nearly 14 billion years later. Some have gone on to form greater complexity; many have not.

Once formed, and left on their own, positively charged protons kept their distance from each other. While the strong force bound quarks together and protons and neutrons together within atoms, these atoms did not fuse. They might approach each other as they moved about, but usually swerved off, avoiding connections with each other.

We sometimes hear about an 'atomistic society'. For example, political philosopher Russell Kirk wrote that 'Individualism is social atomism; conservatism is community of spirit' (Kirk 1960). Social atomism refers to a rather asocial condition in which individuals have little to do with each other. The analogy might be a billiard table, with hard billiard balls usually sitting by themselves, but occasionally knocking into each other, sending each other off in various directions. Atoms may be the basic building blocks; in our experience, blocks usually just sit there by themselves. We are each made of about $6.7*10^{27}$ atoms. What are we then like at our most constitutive level? Are we like the individuals discussed by Hobbes in Leviathan? Do we live our lives largely isolated from others? By nature, are we as asocial as the universe's vast majority of unaffiliated atoms? If we seek to form relationships, do we need to find ways to overcome our natural proclivity for individualism? And since we are built from atoms, is that what we are really like, all niceties aside?

But what if the story is one of emergent relationship as well as distinct identity? Recall that even the simplest of atoms – those that have only one or two protons and are still the most abundant in the universe – are each a set of sustained, structured relationships. Quarks which just moments before had not existed, started to be related through the exchange of gluons mediating a strong force. Atoms, which had not existed before the Big Bang plus 300,000 years, added a relationship between protons and electrons. Atoms are sets of sustained, structured relationships. They are the simplest of polities. At our most constitutive core, we are built more from relationships than from building blocks. Quarks and electrons are more fuzzy than blocky. Their 'hardness' comes from forces defining their relationships. What exists between things is as real as the things themselves.

Stars

But what about positively charged protons naturally avoiding each other? Two hydrogen atoms (H_2) might combine on their own by sharing electrons, but they do not fuse into helium as they float in enormous clouds. Helium did not combine with anything. One and two proton atoms by themselves would never on their own have led to us. To form larger, more massive atoms, a new set of relationships was required.

When they did form, atoms were not perfectly distributed, if 'perfect' means absolute equality. They were slightly more densely distributed here, a little less there. This asymmetry, unequal distribution, or imperfection was another very fortunate occurrence. Gravity has no force at the relatively small distances between quarks. However, the space between atoms can be just enough to let it start operating. A clump of atoms here can exert gravitational attraction on a smaller clump there. If all atoms had been equally distributed, their gravitational attraction on each other would have canceled it all out, and they would never have been drawn to each other. However, with the asymmetry, the denser regions could start drawing in the slightly less densely packed atoms. Gravity kept pulling them together, increasing their density and heat. As they were pulled closer together, they began to spin faster like a figure skater drawing in her arms. Once sufficient density and heat developed, with atoms moving about more and more quickly, the atoms overcame their preference to stay away from each other. Hydrogen began fusing. They not only ran into each other, hydrogen nuclei could stick to each other, forming helium, with its two protons and two neutrons, all held together by the strong force.

The newly joined atoms were less than the sum of their parts. Each new helium atom weighed slightly less than the hydrogen atoms which had combined to form it. The missing matter had turned into energy. The fusion caused energy to burst out. Gravity kept trying to draw the atoms in. The equilibrium between these two forces resulted in the formation of stars.

As the helium was formed, gravity drew it in more, until it heated up enough for it to start fusing into heavier elements, such as nitrogen. This released energy and permitted gravity to draw the newly formed elements further in, until they too began to fuse, forming carbon and neon. This was repeated as oxygen, magnesium, silicon, and sulfur were each fused. The largest stars with enough mass to permit gravity to keep drawing the newly fused elements further in developed an onion like structure, with the lighter elements on the periphery; the heavier ones successively formed layers closer to the core. Not only can there be new things under the stars, the stars themselves were something new. The strong force, electromagnetism, gravity, and fusion formed relationships between atoms within the structure of a star.

Gravitational attraction between stars and dark matter formed galaxies or groupings of stars in distinct patterns. Galaxies formed relationships due to gravity in local groups and even larger patterns. The theoretical work of Fr. Georges Lemaître, confirmed by the evidence collected by Edwin Hubble, demonstrated that not only were there more galaxies than our own Milky Way, but that once they got to be further away from each other than those in the local group, they are racing away from each other. It may be that dark energy or anti-gravity is causing the galaxies to keep 'falling out' with space and the universe expanding at ever faster speeds the further from each other they are. In the long run, this may lead to the final disassociation of the universe and the end of polity. The continued development of polity within pockets of available energy is a medium-term possibility. In the long run, we and the universe may both finally succumb to entropy.

When the largest of the stars began to make iron with its 26 protons, energy was consumed rather than released. The equilibrium between gravity and fusion was broken. Almost immediately, the star exploded in a supernova. The sudden increase in temperatures during the explosion permitted the almost instantaneous formation of all the elements with more than 26 protons per atom, all sent streaming into space at incredible speeds, often mixing with pre-existing clouds of hydrogen and helium that had been floating since the Big Bang.

Molecules

Atoms form in such a way that electrons orbit protons in shells. The innermost shell is full with two electrons, the second with eight, the third with 18, the fourth with 32, the fifth with 50. Hydrogen, with its one electron, has a vacancy sign out in its only electron shell. That shell seems to want one more electron to form a full house. Oxygen, with its eight electrons, has two in its first shell and six in its second. This leaves two vacancies in its second shell. This is a match made in the heavens. If two hydrogen atoms hook up with an oxygen atom, each sharing their electrons, each hydrogen atom can have two electrons in its only shell and oxygen can have eight in its second shell. A new relationship between atoms is formed: H_2O – water. This molecule has a new property. At the right temperature, it has the property of wetness, which did not exist before. Water, which is abundant throughout space, is not the only molecule that forms. Dozens of molecules with 2, 3, 4, 5, or more atoms evolve naturally. Many atoms due to the way electron shells work lead to the formation of these new relationships called molecules.

Not all atoms are anxious to form molecules. Helium has two electrons in its only shell and has a No Vacancy sign well lit. It is called a noble gas. Having all they need, nobility does not require additional relationships with the lesser types that are needy. Relationship added to relationship is not much part of helium's story. While hydrogen becomes us, helium often just goes floating off into space. Not everything is social. Not everything forms polity, or sustained, ordered relationships. We saw that same aloofness with four of the six quarks. A subatomic particle formed in nuclear fusion, neutrinos, are much the same. Like photons, they go shooting from stars off into space, but almost never interact with anything. They can sail through twenty miles of lead and never hit anything. It has taken extraordinary measures to detect them at all. History and polity are not built on the backs of two thirds of quarks, neutrinos, helium, or other asocial phenomena. They are indeed the rugged individualists of the universe. The story of emergent complexity in our universe is not uniform and it may not be eternal.

Earth and the Emergence of Life

After a nearby supernova shot its star dust out into neighboring space, disturbing preexisting clouds of hydrogen and helium, gravity again began pulling together the mixture of elements and molecules. A second generation star with mostly hydrogen and helium but also with traces of heavier elements in it – including oxygen, carbon, neon and iron – eventually began shining as our Sun 4.6 billion years ago. It is not big enough to permit gravity to create densities high enough to fuse elements heavier than helium. This is good for us, since huge stars live fast and die young. Our Sun fuses 600 million tons of hydrogen each second, turning it into 596 million tons of helium and more energy than mankind has ever produced in our species' entire history.

The Sun's rate of consuming its stock of hydrogen will permit it to continue shining for a total of about, meaning it is at mid-life now. Its 4.6 billion year history has provided energy and the time for Earth to develop. Although the Sun will likely increase its output of radiation enough within two billion years to kill most or all life on Earth, it will be five billion before it turns into a red giant, evaporates the oceans and engulfs the Earth.

While gravity drew together 99.86 per cent of the total mass of the Solar System to make the Sun, the left over debris went to good use. On the outskirts of the spinning disk that eventually ignited as the Sun, these leftovers from part of the supernova started accreting through the power of gravity. Chunks of iron, nickel, silicon, and bits or gold, silver, uranium and other elements and molecules bumped into each other and stuck together. All this knocking together that created kinetic energy, as well as the radioactive decay of uranium and other such elements, made for a molten, hot planet even on its surface. As its outer layer cooled, Earth formed its own structure from thousands of molecules and the minerals they produced. Heavier iron and nickel sunk into a dense core that is still as hot as the surface of the sun. Silicon and other lighter elements rose to the top. Eventually, a thin layer made of the frothy basalt and granite could cool enough to permit land to form. Lighter and cooler outer layers spinning around denser iron and nickel produced a magnetic shield around the planet that protected it from solar winds that might otherwise blow away Earth's atmosphere.

The process of chemical evolution that had begun in space continued on Earth (Hazen 2005, 2012; Hoffmann 2012; Pross 2012). The most common elements on the surface of the earth continued to combine in many ways. Hydrogen, carbon, nitrogen, oxygen, sodium, magnesium, phosphorus, sulfur, chlorine, potassium, calcium, iron, and other elements on Earth interacted to form over 4,700 minerals. Around black smokers at the bottom of the oceans where tectonic plates separated and mineral rich heated waters bellowed up, or on sun soaked pools of water on rocky beaches, the process of chemical evolution continued. Lipids that created films formed, eventually forming membranes. Carbon, with its four electrons in its second orbit and a total of six overall, was able to combine with many other elements, and was central to the Krebs cycle which spins off amino acids. These molecules continued to combine until they integrated membranes, metabolism or access to energy, and RNA and DNA that permitted reproduction with variation in response to environmental changes. The Last Common Universal Ancestor – LUCA – was combined in the most complex relationship in universal history to date – that we know of.

The first prokaryote cells were earthlings, formed of the commonly available chemicals and elements on earth. They were also children of the universe, with elements forged in stars that had died long before. We can look to the skies where one or more enormous stars exploded billions of years ago – and to the green scum covering the local pond – to see the equivalents of our ancestors. This might bring us a sense of both pride and humility. It also may elicit a sense of intimate relationship with all of nature.

Biological Evolution

It has been said that the dream of every bacteria, the simplest of cells, is to become two bacteria. Reproduction has to be important for any species that plans on surviving, since the death of any given individual is part of the way life works. Sustained relationship is not eternal relationship. The nice thing about being a bacterium is that your dreams can come true about every twenty minutes. Reproduction with variation in response to environmental changes is a skill perfected by prokaryote cells. You just cannot argue with success. They live in virtually any setting, however extreme the condition on earth can be. From deep underground to thermal waters, prokaryotes are there. There are more bacterial cells in and on your body than there are cells that constitute your body. They help you digest food. And when you die, they will digest you. These types of cells have survived for almost four billion years. They will be on earth long after humans have vanished. Many prokaryote cells follow a plan that is not broken and does not need fixing, although they do keep adjusting to new conditions such as antibiotics. They evolve quickly, but as a group, they have not become fundamentally more complex.

However, after a couple billion years of happily reproducing at their same level of complexity, some did become more complex (Dawkins 2004, 2010; Lane 2009). About two billion years ago, eukaryote cells developed with a membrane covered kernel inside the cell in which more complex DNA was kept. It also maintained a relationship with a mitochondrial cell rather than having digested it. This provided an ability to burn carbohydrates and permits us to enjoy eating donuts.

A more complex set of relationships within the cell led to more complex relationships among cells. Films of bacteria on the surface of the ocean or accretions of them in rock like formations of stromatolites in tidal pools were steps towards multicellular life forms. Another step in multicellular cooperation came with creatures like the sponges. These are formed by the same type of cells that could still specialize in serving different functions. Some cells drew in nutrient rich water, others expelled nutrient drained water. Same type of cells; different tasks. Push these cells through a sieve so that they are separated as they fall to the bottom of a tank, and they scoot back together to form another new sponge. These are cooperative cells, not hardy individualists.

Relationships among increasingly complex body structures formed by different types of cells are seen in such examples as cnidarians, or jelly fish, first seen about 800 million years ago. They have little harpoons that can inject prey with poison, have such structures as a mouth / anus, and have two layers of tissue. Their nervous system is pretty uniformly spread out throughout the animal. Jelly fish are still around and doing fine. They have existed 4,000 times longer than *Homo sapiens* have. They see no reason to develop more complexity.

Still, there were additional mutations that worked out in the environment of the time. Flatworms introduced a body plan about 590 million years ago with a right and a left side, an up and down, and a front and a back. Sense organs were put up front, along with ganglia of nerve cells to interpret the incoming data. Chordates like the currently existing hagfish put a cord along its back to protect the flow of information from the ganglia to the rest of the body, as well as putting the mouth up front and an anus in the rear. About 525 million years ago, vertebrates started breaking that cord into bony segments, offering better protection and definition. The first animals to venture out from the seas onto land, such as Tiktalik, had wrists to help scoot on land and a neck to help look around. About 360 million years ago, the first amniotes could recreate the watery world in which reproduction had originally taken place, and start producing eggs with a protective shell and watery interior. About 360 million years ago, mammals first appeared, which had, among other things, a more complex auditory system with more parts that helped them hear better. The story of evolution is in part a story of increasing complexity of body structures, with more complex relationships among greater numbers of parts.

It is worth recalling a few things. First, part of the reason for this development was in response to the bitter competition between and among species. An arms race of those seeking to eat others and those seeking not to be eaten was good to select which individuals would survive to reproduce the next generation. Increasingly complex relationship was spurred in part by sustained relationships that were harshly competition. Conflict, even deadly conflict, can spur greater complexity. Secondly, there was no steady rise from simplicity to complexity. Five major extinction periods between 450 mya and 65 mya caused huge interruptions. This is only part of the reason why over 99 per cent of the species that have ever existed are now extinct. We may be going through a sixth (self-induced) extinction period that we hope does not conclude with our own species' disappearance. However, virtually all species, including the human one, have gone or will go extinct as the evolution of life continues.

Relations among Animals and Plants

Relationships among quarks, protons and electrons, atoms, molecules, cells, and body parts were followed by increasingly complex relations among and between species. Edward O. Wilson's *The Social Conquest of the Earth* offers a brilliant discussion of this phenomenon (Wilson 2012). From quorum sensing of bacteria to schools of fish, bee hives, ant colonies, flocks of birds, herds of bison, troops of chimpanzees, and many other examples, animals often live in groups and groups often form ecosystems.

Not all animals live in groups. Many seem to exist in splendid isolation for most of their lives, coming together just long enough for reproduction without any care for offspring after birth. Mother guppies and sharks would just as soon eat their babies. Sea turtles lay their eggs on the beach, return to the sea, and likely do not think about them after that. Crocodiles help their offspring out of their eggshell and out of the nest; after that, the offspring are usually on their own. Childcare is, of course, more of an issue for various lengths of time for many species. From weeks of care to a couple years is common. Mothers, fathers, and others are involved in different ways, depending on the species.

By the time we get to hominids, our ancestors' survival strategy and increasing sociability went hand in hand (Tattersall 2012). *Australopithecus* and its ancestors were likely more often the hunted than the hunters. They may have scavenged, eating bone marrow of leftover carcasses, but gathering fruits, nuts, tubers, and leaves likely provided a mainstay of their diet. Other than that, they tried to stay out of the way of predators. They had few natural weapons. Their teeth were no match for those of lions. Their speed was no match for cheetahs. They had no shells for defense or wings for flight. No wonder that there do not seem to have been huge numbers of hominids, that most species went extinct, and that our own ancestors came close to extinction (Sarmiento, Sawyer *et al.* 2007). They just did not have that much going for them.

Bipedalism, for whatever reason it was adopted, did permit more use of the arms, hands, and opposable thumbs. A parent could hold a child and pick fruit all at once. But it also altered the skeleton, restricting the birth canal, making child birth that much more dangerous. This became a greater problem once the hominids' greatest weapon did finally start to develop. Brain size from *Australopithecus* to Homo sapiens tripled, with Neanderthals winning the brain size competition. (Brain size for *Australopithecus* averaged between 375 and 550 cm^3, *Homo habilis* from 500 to 800, *Homo erectus* 750 to 1225, *Homo sapiens* 1200–1750, and Neanderthals 900–1880.) It is not just brain size that is important, but how the structure of the brain develops and its size relative to body size. Hominids' enormous cerebral cortex permits the development of memory, attention, perceptual awareness, thought, language, and self-consciousness. With its development, polity emerges into politics. Hominids could not outfight competing species, but they could start to outthink them. Brains rather than brawn would eventually win the day.

But big brains come at a cost. Even with only partial brain development and soft skulls at birth, delivering children had become highly risky. To permit time for the brain to develop to maturity, grow a bony skull, and learn all that they required to survive, childhood for hominids took years. Breastfeeding and childcare-giving mothers developed close relations with offspring over long childhoods.

Child mortality was still likely high. For a handful of children to reach sexual maturity, birth would need to be given to a number more. For a species with relatively few members, the group had a strong interest in reproduction. Especially with life-spans in the 30s or so for adults who got through childhood, this meant that most or all of a female's adult life was involved with pregnancy and childcare. Working mothers were the norm. They likely provided the bulk of the calories through gathering and carried out many other important tasks. Still, they would have needed support as they did the primarily important work of getting children to adulthood so the species and the kinship group could survive. Long term relations between mothers and children and between child care-taking females and males were necessary for the large skulled hominids to survive.

It is one thing to get together briefly to copulate. That is all sharks need to do since childcare is not a problem. It is a wholly other set of problems to stay together for many years to raise children, a problem that hominids did have to figure out if they were to survive. Resolving the issues of food, shelter, and other necessities for a kinship group over years takes problem solving and relationships to a whole different level. The increased demands of a long childhood and the long term adult relations it required selected for an increased ability to figure out how to live together for many years at a time. The gender relations made necessary by being a big brained bipedal species is a root of hominid polity. Sexual politics has changed markedly recently with longer life spans and lower mortality rates. Mothers no longer spend their entire adult lives dealing with pregnancy and childcare, and have the time and energy to do much else.

As Michael Duffy, who writes within the Montessori tradition, notes that as we go through evolution,

> organisms produce fewer and fewer offspring and require longer and longer periods of care, leading to more important and deeper relationships. Fish produce thousands of eggs and rarely care for their young, reptiles produce hundreds of eggs and have only limited contact with their offspring, most mammals produce only a litter of a half dozen young and care for them for a long time through nursing, and humans have one or maybe two babies at a time and produce the most parent dependent creatures on Earth! (Duffy personal communication, May 13, 2013)

Many species have long developed their own ways of developing and maintaining relationships. Baboons groom each other, checking for parasites in the fur. Frans de Waal discusses how bonobos use sex for much the same purposes. Social primates, who were not genetically identical like ants within a colony are, developed a 'theory of mind'; they could understand each other's reactions. They could even sometimes 'feel for each other', or empathize. The law of the jungle, as de Waal argues, includes the social practices and understandings that would later be self-consciously developed into ethics (de Waal 1989, 2005, 2007; de Waal, Macedo *et al*. 2006).

Picking lice out of children's hair and having sexual relations has forever been part of hominid mothers' lives as well (Wade 2006). Hominids' survival strategy led to developed abilities to relate to each other. For their relations to develop, they would need to exchange a lot more than just gluons and photons. If you thought physics was hard to grasp, just try politics.

Memory, Imagination, Symbolic Thinking, and Exchange

Virtually all species remember, although in very different ways. The long childhoods in which each person remembers their period of dependency creates long term memories of caretakers. Hominid adults still remember their own childhoods and their caretakers. They remember how these important experiences were carried out by those who are now old or dead. What was so important is now gone, but remains important in memory. Memories of what is no longer may be pondered while going about present tasks.

Being able to remember what no longer is – and imagine what is not yet – is facilitated by symbolic thinking and language. Vervet monkeys will make one call for threats from above such as an eagle, another for threats in trees such as snakes, or those on the ground such as big cats (Johanson and Edgar 2006; Kenneally 2007; Bickerton 2009). When a monkey makes such a call, others in the troop look in the right direction. A screech signifying eagle causes other monkeys to look up. A sound and an expressed/perceived meaning are linked correctly, helping the group's survival. However, the monkey does not make the sound in the absence of the threat. They do not intellectually manipulate or exchange symbols.

The development of syntax or grammar and vocabulary went along with that of symbolic thought. Being able to consider words and meaning in the absence of immediately present referents, adjust them, move them around and think of alternative arrangements, was facilitated by language. Being able to communicate these ideas in novel yet understandable ways meant that new meanings could be created. With language, communication could nurture more complex forms of politics. Remembering and imagining in the absence of the referent is a source of symbolic thinking, planning, and realizing possibilities.

An important step in the road from the communication of monkeys to the symbolic thinking of hominids may have been tool-making. By over two and a half million years ago at the Gona River in Ethiopia, *Australopithecus* or *Homo habilis* was making stone tools. Other species use tools as well. Crows, wolves, chimps and others will use stones and sticks to achieve various purposes. However, the Gona River chipped tools were fashioned by toolmakers. Tool-making was added to older tool-using skills when symbolic thinking and imagination was possible due to eye-hand and brain development (Nowell and Davidson 2010; Shea 2013). Those who had emerged from nature now began to adjust what they found in nature. Hominids could begin to select what helped them survive and live better. Evolution could begin to be not only in response to environment, but determinative of it. Nature became partially self-selecting in hominids.

By the Oldowan period from about 2.6 to 1.7 million years ago, *Australopithecus* and/or *Homo habilis* had developed more sophisticated tools. By the Acheulean period about 1,650,000 to 100,000 years ago, tools had become bifacial, larger, and more varied. The oval or pear shaped tools were not only functional, they also have shapes that are pleasing to us and, perhaps, to their makers. Natural emergence had become hominids' creativity.

Adjusting nature was done in various ways. Eating meat and tough tubers was hard on the digestive track of early hominids. Cooking them made them easier to digest and taste better. Exactly when this began is not certain, although it seems to have started between 1,500,000 and 790,000 years ago with the fire altered stones at Gesherbenot-Ya'aqov in Israel. The transition from scavenging to hunting had been made at least by a half million years ago, as indicated by spear points and skeletal wounds in prey found at Boxgrove, England and Kathu Pan 1 in South Africa.

Burials indicate a new level of relationship. Other species such as elephants will clearly mourn dead members of the group. But the careful burial of the dead is a human activity. Again, exactly when this began is not clear, but there are burials from 80,000 to 120,000 years ago in Qafzeh, Israel. Here, we have living members of the group remembering the people who had died and imagining they have an obligation to them even after they die. Burial is a relationship with the dead, requiring memory of what is no longer. What is real in the present is only part of what matters. Memories of the past – kept in the electrical/chemical relationships among neurons – can be more important than the hard stuff that one can touch now in the present.

Hunters had long understood the difference between life and death. Causing an animal to bleed from wounds transformed the beast from one running through the woods to one lying on the ground. Did the hunters begin to think symbolically about the 'life' being in the blood that sank into the ground? Does the life of the body go into the earth looking for a new form to inhabit? Is the spirit of the dead animal believed to be angry at the hunter, planning to return to the surface world to make trouble if proper steps of propitiation are not taken by the hunter?

Once grave goods become included in the burials, we seem to also have imagination of the future added to memory of the past. Burial goods suggest that people thought they could indeed take it with them. Everything had a spirit: people, mountains, rivers, pots, weapons, *etc.* The life or spirit of the dead person will need the spirits of various tools or weapons in the next life. Members of the group were socially close to those now dead. They remembered them and valued these memories. They wanted to imagine that their beloved would live on, and that proper actions by the living could help the dead live well.

Ancestor worship may be one origin of religion. This seems to indicate the powerful social attachments our ancestors had with each other.

The discoveries at Blombos cave in South Africa from about 75,000 years ago include an etched, rectangular rock. A net or diamond-like design is scratched, with diagonal and parallel sets of lines. This is not just aimless doodling. This is done by a person interested in perceiving and creating patterns. What other patterns were being perceived and analyzed? Seasons? Plant growth? Movements of animals? Behaviors of fellow members of the group? Did the patterned lines have symbolic meaning of some sort in a way that etched crosses, six pointed stars, or crescents often have for us?

Shells with drilled holes were also found at Blombos. The cave is near the coast, and a diet of sea food sustained them. Did they wear the shells as a way to offer the spirits of the dead animals a place to live after their bodies had been ingested? Did they wear necklaces of shells out of a sense of beauty made possible by using or improving on what nature offers? What do these artifacts indicate about their symbolic thinking?

By perhaps 48,000 years ago, at the El Castillo Cave in Spain, an artist painted animals and designs from dots and lines on the walls. This was the case later as well at Chauvet, Lascaux, and elsewhere. The animals that were painted were not modeling for them. The artists worked from memory. What purposes did they have in painting these animals and designs underground? What were the artists thinking about the animals and designs they painted? It is hard not to speculate. Was the cave where the spirits of dead animals went to live after their blood drained from their bodies? Were these spirits looking for new bodies to inhabit? What was the meaning of the paintings for those who drew or first viewed them?

The importance of reproduction and fertility is made explicit by the so-called Venus figures found at Hohle Fels in Germany from the Upper Paleolithic period, the Woman of Willendorf from about 24,000 years ago, the Woman of Laussel from about 20,000 years ago and many others. These palm size statuettes of women with exaggerated breasts and hips may have offered comfort to mothers going through pregnancy or delivery, or had any number of other possible meanings. Whoever made the statues did so while thinking about fertility and sexuality rather than engaging in sex. These statues demonstrate symbolic thinking about sex in the immediate absence of sexual behavior (Bahn 1998; Lewis-Williams 2002; Clottes 2003, 2008; White 2003; Curtis 2007; Whitley 2009).

The evolution of music is noteworthy. The hardware necessary to transforming the waves through a medium such as air into perceived sounds in the brain began with early land dwellers feeling vibrations in their bones. Sight is great, but you cannot see around the bend or over the hill. Sound provides crucially important information. The patterns and tones of sound provide important information about the environment. Many species produce sounds as well as perceive them. Some birds will sing to announce territorial claims or attract mates. Whales and others too will sing to communicate over long distances. Sounds can convey information to others.

With the malleus, incus, and stapes as part of their auditory system, mammals became able to hear in ways that reptiles cannot. Listening to the sound waves caused by ocean waves, lion roars, chirping crickets, and howling winds all had important meanings for hominids. Hearing and responding to a dependent babies cry, parting the lips and calling ‘Ma’ with various inflections of tone elicited powerful responses among caretakers (Bernstein n.d.). Different sounds would have elicited other profound emotional responses, such as fear or sexual desire. Rhythmic music and drumming would have enhanced group identity during kinship groups' dances. Eventually, fife and drums communicated information and bolstered courage during battle. Campaign theme songs would identify candidates. National anthems would stir patriotism. Perceiving and making music has a long history of the relationships between animals and their environments, and animals such as humans with each other.

Symbolic thinking and imagination made combination beyond natural referents possible. A wonderful example of this is the Löwenmesch or Lion Man from Germany from about 30,000 years ago. A bipedal man's body with a lion's head was not something the artist had ever seen. This was work not from memory alone but from imagination and combination. This indicates the ability to manipulate symbols separate from natural perception. It also indicates a crucially important political ability of combining what had not yet been combined in nature.

Nature had combined much in the past through increasingly complex relationships. Quarks, atoms, molecules, minerals, cells, body parts, animal groups, and ecosystems all kept putting things together in larger and novel combinations. Now, humans could do this at a faster pace and self-consciously.

Placing value on symbols for their own sake was exhibited by early artists as well. For example, there is a beautiful ivory horse sculpture from Vogelherd, Germany from about 32,000 years ago. The artist did not try to include all the musculature of a real horse. Instead, it is an idealized shape with a series of flowing curves. This is not so much a representation of a physical horse as an ideal one expressing a sense of beauty. The artist took delight in abstraction.

Relationships through the exchange of words, music, and symbols developed human relationships. Exchange of goods did too. This also has a long history, going back to sharing food to enhance group relations. Specialized tool production *Homo habilis* sites relatively far from sources of rock that were used indicate trade as much as two million years ago. Trading routes become increasingly extensive and established, until by 14,000 years ago the obsidian trade in the Near East and then the famous Silk Road established what some see as a central core political system.

Political Development

Kinship

The growth of symbolic thinking and exchange of goods, words, glances, gestures, musical sounds, and artistic images facilitated political development. We have discussed the importance of kinship groups. Long term bonding of childcare givers required sophisticated relationships demanding lots of exchanges. Kinship groups within a scavenger-gatherer and then hunter-gatherer economy likely became complex, but were still limited in size to perhaps fifty or a hundred persons. Larger trading routes would have permitted development of complexity of relationship. Family groups needed to exchange offspring for mating in the next generation. This led over generations to complex sets of inter-kinship relations.

In kinship relationships, lineage is important. Loyalties are to caretakers and common ancestors. Family and kinship remains important in our own day. The powerful resonances are indicated by larger groups attempting to appropriate kinship relations. Nationalists sometimes have referred to their country as a Motherland. In the United States, George

Washington is referred to as the 'Father of the Country'. Larger, non-lineage groups often seek to call upon the powerful forces of kinship. One of the values of Big Politics is its scientific story of the real lineage of all persons, going back to a small group in Africa about 200,000 years ago; of all life to LUCA, and the Universe to a single point. It turns out that we really do all have a common background. Big Politics is the scientific story for a period of Human Politics.

Agriculture and Villages

One of the major thresholds of Big History is the Agricultural Revolution. The transition from hunting and gathering to growing crops and raising certain animals is of crucial importance. It also entails a stage of political development (Wenke and Olszewski 2007). Hunting-gathering went along with kinship polities. With agriculture came the emergence of chiefdoms and settled villages of increasing size, beginning to include different kinship lines. This presented the village with an enormous political problem: how to establish a sustained, structured set of relationships beyond kinship.

One way to do this was to create dynasties; village lineages that all could be persuaded or forced to adopt. Lineage now became a symbolic political category rather than a biological one. In many regions of the world, mounds and other monumental burial sites enshrined the lineage of the village. Those within one lineage might still have the right to rule, but all needed to exchange the symbols that helped nurture loyalty to it.

The political leaders of these settlements or villages during the early agricultural era were sometimes those who had access and control over the best growing areas. We start to see increased social stratification and inequalities in wealth as the agricultural era proceeded. Some residences and some graves are noticeably grander than others. Hierarchy in the hunter-gatherer era was more likely based on strength, size, or cunning. In each period, leadership could also be exercised by those whom we call shamans, or those who could impress their fellows with their special insights and relationships. When some went through fasting, whether by choice or necessity, carried out rhythmic dancing while listening to repetitive rhythmic music, added various hallucinogens, and perhaps inflicted self-flagellation, they likely could report any number of special insights and experiences. Shapes would have shifted, experienced as traveling in other realms. These were similar to dream-like states. Dreams while sleeping and trances while awake offered symbolic connections with what was beyond normal referents. Imagined relationships with abstract designs, ancestors, and the supernormal by some could have impressed others and established a claim to leadership.

Village identity could be developed and expressed through styles of clothing, certain verbal expressions, or other identifiers. Stories about the village could be told at gatherings. It took enormous effort and creativity to incorporate loyalty to the family within loyalty to the village.

Cities and Empires

Monumental, ceremonial architecture reinforced the claim by some of symbolic leadership that legitimized claims to leadership. Leaders may have preferred subjects to stand in awe not directly of the universe, but of the leaders' special connections with it. From Watson Brake in Ouachita Parish in Louisiana from about 5,400 years ago to Imhotep's Saqarra in Egypt about 4,700 years ago, grand burial sites began to announce the emergence of full time leading families. Large, stylized burial mounds called attention if not of the gods, at least of the humbled onlookers who stood before them during ceremonies. Equivalents in modern America are the tall, stiff obelisk in honor to the Father of the Country, or the Jefferson or Lincoln Memorials in which political pilgrims can stand reverently in front of larger than life leaders who have mythical meaning and personify the presidential succession that leads to the current national leader.

Large, monumental architecture also announces the emergence of new political units of cities with larger populations and relations of cities within regional associations and nations or empires. The great ancient cities represent a transition to larger, more complex political units. Sometimes these became the hubs of empires; sometimes they were combined with other cities within empires. The modern European empires were transformative through their incorporation of the Industrial Revolution. The British, French, Dutch, German, and Japanese empires were built from steel, oil powered ships, railroads, and gasoline powered vehicles. The Russian and American empires combined these in the Information Age with nuclear power and nuclear weapons.

Empires have survived for various lengths of time, sometimes lasting for a number of centuries. Imperial overstretch often exhausted them. This happened most recently with the Soviet empire, which broke up as many of its satellite states gained independence. It may be happening now with the American empire, with a state that is quickly becoming hopelessly indebted. Hundreds of US military bases add to a military budget that is equivalent to those of the next twenty states combined – and to US budget deficits that, along with entitlements and the interest on previous borrowing, add to the skyrocketing of American borrowing.

The struggles for power within empires and between some of them are the stuff of traditional history. The endless lists of battles and army flanks can make for a depressing account of the human past. Homer's account of the Trojan War is heroic enough, but it is also just another deadly battle scene. And things do not seem to have improved much. We started the twentieth century with a war to end all wars, followed by a horrific Second World War twenty years later. Since the end of WWII, there have been about 250 wars with over 50 million people killed, tens of millions more wounded, and countless made homeless.

Big Politics?

What will replace America's unipolar moment after the end of its empire? Will it be replaced by another empire? A return to a multipolar world such as existed in Europe in the nineteenth century? Are we within a transition to a new level of complexity which incorporates relationships among quarks, atoms, molecules, cells, body structures, families, villages, cities, nations within a more closely related humanity within our common environment?

Some find hopeful evidence for such a transition occurring. The research into missiles starting in the Second World War and continuing through the Cold War is responsible for much of the technology that produced the Earth Rise photo, a banner for globalism ever since it was first taken by astronaut William Anders in 1968 during the Apollo 8 mission. Steven Pinker argues in *Our Better Angels* that we have experienced a promising trend of decreasing use of force. Humans are indeed capable, he argues, of exercising their self-control, empathy, morality, and reason. We have seen the emergence of government claiming a monopoly on force and violence. Many regions of the world have robust trading and financial relations. We have seen increased literacy, urbanization, mobility, and access to mass media. These have led to greater familiarity among cultures. There has been some increase in the rule of various forms of democracy. As bad as the many wars since 1945 have been, there has been no civilizational ending nuclear war. Twenty years separated WWI and WWII; we have gone 68 years since WWII without any WWIII. There is no reason for complacency yet, of course. It was a century between the Napoleonic Wars and WWI; so we have yet to equal the successes of the nineteenth century. Still, there maybe come collective learning about how to keep the peace.

The threat of environmental degradation, pollution, and climate change may have become more pressing that the threat of war. Decreasing reserves of fossil fuels and the carbon emissions from the use of those we have combine in an energy crisis. If this crisis cannot be solved in a sustainable way, the consequences could be negatively transformative. On the other hand, within the past generation, environmental concerns have gone from marginal to central for great numbers of people.

The hopes of those who established the United Nations frequently seem illusory, given that body's actual performance since the Second World War. Yet, the nations of the world continue to belong to it and even make productive use of it at times. We are very long way from a world government, but also a long way from international anarchy.

Where are We Going?

What can we conclude from our 13.82 billion year journey so far in this Universe? The access to high quality energy in certain pockets has permitted increased complexity in relationships between quarks, atoms, molecules, cells, animals, and humans within families, cities, nations, empires, and the world. Each of the earlier relationships continues to be part of our current ones, although often in transformed ways. You and I are the beneficiaries of the relationships that have been developed. We are made from the relationships among quarks, atoms, molecules, cells, and many intricately related body parts. We live within kinship groups, nations, and empires. Many of us are connected with others around the world through the almost instantaneous exchange of digital information. We have evidence for a common origin of all of us and indeed everything in the universe. All of us on earth have a common origin and we may perish together in a species wide extinction; all of life on earth will quite certainly come to an end together as the Sun becomes a Red Giant.

Will we continue to have access to high quality energy and remain as the pockets which continue to develop the most complex relationships of which we are aware in the universe? Can we use this energy without polluting our world and making it uninhabitable? Even if the energy crisis is resolved in a sustainable way, do we have the imagination to combine national, ethnic, and other types of groups within new and meaningful relationships? Can we be as creative as nature was earlier when it first combined protons and electrons, atoms in molecules, molecules in cells, cells in plants and animals, and animals in various groupings? Can we be as imaginative as the artist who carved the Löwenmesch, imagining the combination of lions and people? Or the shaman who imagined how to combine kinship groups in the village? Can the study of Big History be formative enough to teach us how to combine families, ethnic groups, cities, nations, empires, humans, and our environment in ways that protect all of them? Can this be done even while there are many in less complex relationships who show little or no interest in participating in Big Politics, who are satisfied with staying at their level of complexity? Can enough people make the transition to the next level of complexity? Can we fashion a more complex sustainable, structured set of relationships? A new Big Politics?

Or will entropy overtake us before it needs to?

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The Star-Galaxy Era of Big History in the Light of Universal Evolutionary Principles

Leonid E. Grinin

Big History provides a unique opportunity to consider the development of the Universe as a single process. Within Big History studies one can distinguish some common evolutionary laws and principles. However, it is very important to recognize that there are many more such integrating principles, laws, mechanisms and patterns of evolution at all its levels than it is usually supposed. In the meantime, we can find the common traits in development, functioning, and interaction of apparently rather different processes and phenomena of Big History. Of special importance is the point that many principles, patterns, regularities, and rules of evolution, which we tend to find relevant only for the biological and social levels of evolution, may be also applied to the cosmic phase of evolution. The present article attempts (within such a framework for the first time in the Big History framework) at combining Big History potential with the potential of Evolutionary Studies. It does not only analyze the history of the Cosmos. It studies similarities between evolutionary laws, principles, and mechanisms at various levels and phases of Big History. Such an approach opens up some new perspectives for our understanding of evolution and Big History, their driving forces, vectors, and trends; it creates a consolidated field for interdisciplinary research.

Keywords: *Star-Galaxy Era, cosmic phase of Big History, laws of evolution, universal evolutionary principles, Universe, preadaptations, Evolutionary Studies, evolutionary selection, additive and substitutive models of evolution, large-scale structures of Universe, gas-dust clouds, non-uniformity concentration of matter, circulation of matter in the Universe, dark and light matter.*

Introduction

Big History provides unique opportunities to consider the development of the Universe as a single process, to detect vectors of changes of certain important characteristics of the Universe (such as complexity and energy) at various phases of this development. However, one should note that the Big History studies tend to pay little attention to such an important aspect as the unity of principles, laws, and mechanisms of evolution at all its levels.[1] I believe that combining the Big History potential with evolutionary approaches can

[1] Of course, some authors analyze important general evolutionary mechanisms and patterns, which can be seen at all phases of Big History (see, *e.g.*, David Christian's 'Swimming Upstream' and the conclusion of David Baker's 'Shoulders of Giants' in this volume). One can also mention Fred Spier (2010) and David Baker's '10^{500}. The Darwinian Algorithm and a Possible Candidate for a "Unifying Theme" of Big History' (2013). However, we should state our position on Baker's general idea in that interesting paper. While also dealing with universal evolutionary principles like ours, Baker innovates by starting his article with analyzing the selection of universes within which

open wider horizons in this respect (see Grinin *et al.* 2011). Indeed, common traits in development, functioning, and interaction can be found in apparently quite different processes and phenomena of Big History. In this respect the universality of evolution is expressed in those real similarities that are detected in many manifestations at all its levels.

This article is an attempt to combine Big History potential with the potential of Evolutionary Studies in order to achieve the following goals: 1) to apply the historical narrative principle to the description of the star-galaxy era of the cosmic phase of Big History; 2) to analyze both the cosmic history and similarities and differences between evolutionary laws, principles, and mechanisms at various levels and phases of Big History. As far as I know, nobody has approached this task in systemic way yet. It appears especially important to demonstrate that many evolutionary principles, patterns, regularities, and rules, which we tend to find relevant only for higher levels and main lines of evolution, can be also applied to cosmic evolution. Moreover, almost everything that we know about evolution may be detected in the cosmic history, whereas many of the evolutionary characteristics are already manifested here in a rather clear and salient way. One should also bear in mind that the origin of galaxies, stars, and other 'celestial objects' is the lengthiest evolutionary process among all evolutionary processes in the Universe. Such an approach opens new perspectives for our understanding of evolution and Big History, of their driving forces, vectors, and trends, creating a consolidated field for the multidisciplinary research.

Our world is immensely diverse and unlimited in its manifestations. However, fundamentally it is a single world – that is why it is so important to study those fundamentals.

I. THE FORMATION OF THE LARGE-SCALE STRUCTURE OF THE UNIVERSE

Preconditions. After the Big Bang, our Universe 'lived' for quite a long period of time without any stars, galaxies, clusters, and superclusters of galaxies (Khvan 2008: 302). The formation of modern structure of the Universe lasted for billions of years. However, the first stars and galaxies turn out to have emerged not later than 200–400 million years after the Big Bang. And what was the matter from which they had emerged?

Approximately 270,000 years after the Big Bang, a large phase transition occurred resulting in the emergence of matter in the form of atoms of hydrogen and helium. Later, they started to consolidate in new structures (see below). The main mass of this matter concentrated in gas-dust clouds that could have tremendous sizes (dozens parsecs, or even more).[2] For the first time we observe Nature in the role of a constructor. Before that, it had formed just the basic elements. Now one could observe the emergence of enormous structures from tiny particles and 'specks of dust'. After that one could observe this constantly: *large-scale structures are composed of myriads of minute particles and grains*.

there could appear some physical laws and parameters allowing the universes to evolve. Baker explores the selection mechanism among an enormous number (potentially 10^{500}– a fabulous number even for modern cosmology) of universes in the 'multiverse'. We suppose that his algorithm with respect to the selection of universes could hardly be called properly Darwinian. He rather speaks about the evolutionary selection in general – that is not the selection of the fittest, but rather the selection of those capable to evolve – which is much wider than the Darwinian selection. The idea that such selection is not Darwinian is confirmed if one employs Christian's (this volume) and Smolin's (2008: 34, which Christian refers to) definitions of the Universal Darwinian mechanism. Such mechanism should obviously include a mechanism of reproduction. It is clear that there is not any mechanism of reproduction in the case of isolated universes. However, for a theory of the presence of Darwinian reproduction in the evolution of multiple universes see Smolin's earlier book *The Life of the Cosmos* (1997).

[2] 1 parsec ≈ 31 trillion km.

The formation of clouds (and later stars and galaxies) meant a concentration of matter on enormous scale, which could have been caused only by gravity. However, this only force is insufficient for structuring, because in 'an absolutely homogenous universe the emergence of large-scale structures (galaxies and their clusters) is impossible' (Dolgov *et al.* 1998: 12–13). Thus, certain seed grains are necessary – this is comparable with formation of rain drops that emerge around particles of dust or soot; or with formation of a pearl around grit. *Small fluctuations are often needed for the powerful forces to start working.* Actually, minor fluctuations (minute deviations from homogeneity) occurred in the Universe early on. Then the larger fluctuations happened. They could act as seed grains for the formation of galaxies and the matter concentrated around them on a much larger scale until the quantity started to transform into a new quality. This is a perfect example of the point that *the non-uniformity (in particular with respect to the distribution of matter, energy, etc.) is a universal characteristic*. Any major evolutionary shift in biological and social systems is preceded by the concentration of certain forms, resources and conditions in certain niches and places. Thus, in the major system the common processes may proceed in their usual way, whereas in the concentration zone some peculiar processes start (this is what takes place in star formation zones).

Dark and light matter. Nowadays it is generally accepted that dark matter plays an important role in the formation of the first galaxies, as it appeared capable of consolidating into clusters much earlier than the light (baryon) matter. The latter could not contract until the end of the hydrogen recombination (atom formation) due to radiation (270,000 years after the Big Bang). Only when hydrogen nuclei and electrons were able to merge and form atoms, whereas photons separated from the matter and flew away, the pressure of the radiation dramatically dropped. As a result, the light matter would fall in potential holes prepared for it by the dark matter. Though the dark matter was initially more capable to structuring than the light matter, the progress toward structuring turned out to be very short and leading to almost a dead-lock.[3] Meanwhile, the evolutionary potential of the light matter was based on the 'achievements of the dark matter'. Such a model of development is rather typical for evolution. For example, long before the transition to agriculture some gatherers of cereal plants invented many things (sickles, granaries, and grinding stones) that later turned to be rather useful for agriculturalists, whereas specialized hunter-gatherers turned out to be an evolutionary dead end.

The epoch of formation of the large-scale structure of the Universe. First galaxies and stars. There are rather diverse opinions on timing, process characteristics and sequence of formation of stars, galaxies, galaxy clusters and superclusters. There is a hypothesis that galaxy protoclusters were first to originate. However, a more commonly held hypothesis suggests that protogalaxies (in the form of giant condensed gas clouds) were the first to emerge within the structure of the Universe, and later they became the birthplace for separate stars and other structural elements (see, *e.g.*, Gorbunov and Rubakov 2011).

However, in recent years new evidence has come to hand to support the idea that those were the stars that appeared first. This discovery somehow modified the previous theories. At present, it is widely accepted that the stars were first to emerge, but those were the giant stars, much more massive than most of the later-formed ones (May *et al.* 2008). Because of the absence of carbon, oxygen and other elements that absorb the energy from

[3] However, as with any evolutionary dead end, this does not mean an absolute stagnation. At present, in galaxy halos the dark matter is structured in certain smaller structures (see, *e.g.*, Diemand *et al.* 2008).

condensing clouds, the process proceeded more slowly in that epoch; thus, only giant clouds could condense producing massive stars hundreds times larger than the Sun (*Ibid*.). Such giant stars lived only a few million years (the larger is star, the shorter is its life). In addition, the first stars contained a small amount of heavy elements. Thus, more than one generation of stars could change, until the quantity of heavy elements gradually increased. The emergence of 'heavy elements' from the 'dead star stellar remnants' resembles the formation of fertile soil from the remnants of dead plants. The circulation of matter in the Universe is always observed everywhere and at all levels.

In recent years we have witnessed the discovery of a few galaxies that are claimed to be the oldest in the Universe. Meanwhile, the dates of formation of the first galaxies are shifted closer and closer to the Big Bang. The emergence of the first galaxies is dated to less than 400 million years after the Big Bang; and there are even claims that some more ancient galaxies have been discovered. They are claimed to have emerged only 200 million years after the Big Bang (see European Commission 2011). The evidence on the first stars refers to *c.* 150–200 million years after the Big Bang – hence, stars and galaxies appear to have emerged almost simultaneously.

II. THE ERA OF THE STAR-GALAXY STRUCTURE OF THE UNIVERSE

The whole history of the star-galaxy phase of cosmic evolution is basically the history of formation of various structures of different size, as well as their merging into larger structures (but it is a history of their disintegration as well).

1. The structure of the Universe

1.1. Some principles describing the basic structure of the Universe may be applied to different levels of evolution (below we will consider just two of them).

1) *The combination of antagonistic qualities.* For example, in the structure of the Universe one can find the combination of uniformity and non-uniformity. The uniformity is already manifested at the inflation phase, when the Universe started inflating evenly in all dimensions. The uniformity has preserved till present, but only at the largest scale (of an order of magnitude of 100 megaparsecs[3]). For reference, the size of the largest galaxy clusters (such as our Local Group with the center in the Virgo constellation) is 40 megaparsecs at most (Gorbunov and Rubakov 2011). The non-uniformity of the Universe is manifested at scales smaller than 100 megaparsecs; and the smaller is the scale, the more salient is the unevenness. The combination of antagonistic qualities is a phenomenon that is rather characteristic for many other evolutionary levels.

2) *Density and sparsity can be traced everywhere,* starting from the atomic structure, where the mass is concentrated in a tiny nucleus, while most of the atom is an empty space. There is a huge non-uniformity between the scale of the Universe and the space that the main mass of the light matter occupies within it. It is concentrated, first of all, in stars which actually occupy only a 10^{-25} part of the total volume of the Universe (not taking into account the galaxy nuclei [Pavlov 2011: 43]). Not only the hard matter is distributed very unevenly throughout the Universe; the same is true of the gas. Much of this gas is concentrated in giant molecular clouds which are of many thousands of solar masses (Lipunov 2008: 37). The principles of uneven distribution of the matter mass at different evolutionary levels are rather similar. For example, at present the main mass of the Earth's

population is concentrated in a rather small territory in comparison with the total territory where life on the Earth is possible.

1.2. The structure of the contemporary Universe

The main structural elements of the Universe are galaxies, their clusters, and superclusters. All the structural elements are rather stable in terms of gravitation, though they can split, merge, and collide. Galaxies are integral structural entities with a rather complex structure which includes, in addition to regions and arms, a nucleus (core), semi-periphery (so called ‘disc’), and periphery (so called ‘halo’) (Baade 2002: 255). The halo consists of both single stars and various stellar clusters. The halo's radius (a few hundred thousand light years) is much larger than the radius of the galaxy's disc.[4]

According to Hubble, the galaxies are classified into spiral, elliptical, and irregular with various subtypes (*Ibid*.: 18–32); yet, by now one more galaxy type has been identified – the lenticular galaxies.

A galaxy contains around 100 to 200 billion stars. There are small (dwarf) galaxies with a few million stars, there are also giant galaxies consisting of up to a trillion stars. Our galaxy with its mass of about 10^{11} solar masses is one of the largest ones. It contains 200–300 or even more billions of stars. However, the mass of our neighbor – the Great Andromeda Nebula – is about three times larger.

Stars are distributed rather unevenly throughout galaxies, stars are parts of various groups and clusters; some of them consist of just a few stars, but some clusters can contain a few million stars. For example, within our Galaxy more than 1,500 star clusters have been identified (Surdin 2001). There are many globular clusters – spherical clusters tightly bound by gravity and consisting of hundreds of thousands, as a rule, rather old stars.

Galaxies are complex and (to a considerable extent) self-regulating systems, within which some stars disintegrate, whereas new stars form from cosmic gas and dust. The circulation (which results in processes of renovation of matter and its mixing) takes place at all levels of the Universe – both spatially and at different levels of evolutional complexity.

An average galaxy cluster consists of 500–1000 galaxies. Galaxy clusters have a rather regular structure which is likely to include a massive nucleus in the center. Galaxy superclusters are entities consisting of 2–20 galaxy clusters and galaxy groups as well as of isolated galaxies. In general, there are known more than 20 superclusters, including our Local Group.

1.3. Generations of galaxies and stars

There are rather diverse opinions on the number of generations throughout the evolution of the Universe. In addition, there is no consensus on which galaxies should be regarded as old, and which galaxies should be considered young. The point is that within a single galaxy one can find stars and their aggregates that considerably differ in their type, age, and other parameters. For example, the age of our Milky Way galaxy is more than 12 billion years, but that is the age of just its halo while many stars in its branches are only two-five billion years or less. Yet, it appears possible to single out a few widely accepted basic ideas.

1) In the evolution of the Universe, there have been three (or at least two) generations of galaxies and stars. In general, old galaxies are smaller and dimmer. Their stars contain dozens of times smaller quantities of heavy elements than the Sun. The astronomers can hardly

[4] There might be an invisible halo consisting of dark matter behind the visible halo. It may be found in many (if not all) galaxies, whereby the diameter of the dark halo might exceed the diameter of the visible halo by an order of magnitude (see Ryabov *et al.* 2008: 1131).

observe any star formation processes within such galaxies. There is also a hypothesis that more dark mass is concentrated in old galaxies in comparison with younger ones. The same way, older and younger stars differ from each other in their size, luminosity, and chemical composition.

2) It is difficult to speak about a clear periodization of generations of galaxies, because of the ongoing process of formation of galaxies and stars. Galaxies need to constantly renew their composition in order to retain their identity. As Joseph Shklovsky maintains, in this respect galaxies are very similar to primary forests with its mix of tree ages (whereas the age of trees is much less than the age of the forest itself [Shklovsky 1984: 45]). The motility and variability of the celestial landscape resembles very much the motility of geological landscapes.

3) The formation of galaxies can proceed in different ways, for example, through the absorption of smaller galaxies by the larger ones. Another way is merging. Galaxies of younger generations can sometimes form through the accretion of a few small, weak and compact galaxies into a single galaxy. In this case they became 'building blocks' for galaxies. Finally, it may happen that two large galaxies collide. Such a collision may take billions of years and be accompanied with active star formation and emergence of very large and bright stars. Finally, galaxies may diverge again, but in this case they turn out to be very different from what they used to be before the collision, whereas one more galaxy may emerge out of the matter estranged from the both galaxies (see May *et al.* 2008: 142).

There are numerous analogies to those models of galaxy formation in biological, geological, and, especially, social evolution. As stars and galaxies are composed of more or less homogenous matter (that can be divided or united rather easily), they somehow paradoxically resemble societies that consist of people who can be included into other societies through integration or capture. On the other hand, captures are also attested among social animals (*e.g.*, among ants see Genet 2007).

4) Galaxies are collections of different types of stars. However, there are certain peculiarities as regards the position of old and young stars within galaxies. Thus, within our galaxy the younger stars (such as the Sun which is a few billion years old) are generally larger, hotter and brighter. They are located toward the disc plane, and, especially, within the galaxy arms; whereas in the galaxy periphery (in its halo) one would find older stars more than 12 billion years old (which suggests the overall age of our galaxy). Yet, older and younger stars may be also located rather close to each other. Thus, one may find many old stars near the galaxy center (bulge), but there are also young stars that emerged from the matter produced by the disintegration of older stars. The highest stellar density is found in the galaxy center where it reaches a few stars per cubic parsec.

On the one hand, the preservation of generations of stars and galaxies demonstrates an additive character of the evolution of abiotic systems, whereas we can see elements of substitutive model of evolution at biological phase and its full system at social phase of Big History. However, the capture of stars and galaxies with their subsequent integration and prolonged processes of collision of galaxies demonstrates that in abiotic natural systems one may still find some other models of evolution – connected with 'wars' and 'submission of outsiders'.

The type of development through the emergence of different generations of individuals and species (preserving certain generic features, on the one hand, and accumulating important changes in their structure and characteristics, on the other) is rather widespread at all phases and levels of universal evolution. Within any biological class or order (*e.g.,* perissodactyls) we can see how important characteristics vary and gradually change from one species to another, whereas due to those characteristics some species press out others and occupy better niches (see, *e.g.*, Grinin, Markov, and Korotayev 2008). Various types of states and civilizations also rather vividly illustrate the progress: for example, more organized and developed states emerge through the absorption of the achievements of less developed generations of states, which one can illustrate using examples from the history of Ancient Rome, Byzantium, some Medieval European states and so on. The coexistence of different generations sometimes leads to the situation when younger and more advanced entities either transform the older ones or form a symbiosis with them (though in some places one may find 'restrictions' for older types and generations).

1.4. Change of the chemical composition of the Universe

Hydrogen has always been the most abundant element in the Universe chemical composition; yet, its share constantly decreased. This occurred (and occurs) because hydrogen is the main fuel for the nuclear fusion reactions that support life and luminosity of stars. Increasing temperatures inside the core of some stars were needed for the formation of new elements that were absent in the era of recombination. However, all of the fusion reactions that occur to produce elements larger than iron no longer release energy. Reactions of another type are needed for the formation of elements heavier than iron – those reactions consume more energy than release. That is why there are such relatively small amounts of heavy elements in the Universe. Yet, such peculiar reactions do take place – for example, in neutron stars and during explosions of supernovas. When supernovae explode, heavy elements are expelled through the Universe with stellar winds and through the fall of the dispersed matter on the surface of cosmic bodies (so-called accretion). As stars turn to be the main centers of the synthesis of chemical elements, the distribution of heavy elements in the Universe is very inhomogeneous.

The emergence of heavy elements and their concentration in certain bodies and compositions are extremely important processes, which lead to an enormous increase in the number of matter combinations, and consequently have an evolutionary potential; in particular, they lead to the start of the full-scale chemical, biochemical, and biological processes. In certain respects, such a slow and uneven accumulation of new structural elements (heavy elements) resembles the process of an accumulation of valuable mutations in biological evolution, or the accumulation of valuable innovations in social evolution (all of them bring the expansion of the evolutionary potential and increase the rates of evolutionary changes).

2. The Evolution of Galaxies and Stars

2.1. Processes of the formation of galaxies and stars

Until quite recently, the processes of star formation were entirely concealed from an external observer; however, at present due to the technological progress one can observe some aspects of those processes in many parts of our galaxy. Those observations confirm the theory of stellar formation from cold clusters that are heated by gravitation and pressure.

Briefly, this process may be described as follows. Within giant hydrogen and helium clouds, some heterogeneities emerge, which launch (under certain conditions) the gravitation processes that start to collect that mass into spherical forms. Sometimes a direct formation of a giant mass of gas clouds takes place, from which a galaxy or a star cluster later emerges. In this case the cloud fragmentation may occur and thus, more and more gas-cloud spheres (there could be hundreds of millions, or even hundreds of billions of them) emerge, which can gradually transform into protostars. This process continues up to the point when the gas density becomes so high that each new fragment already has a mass of a star (Surkova 2005: 49). Then the gravity starts impeding further fragmentation. This process is denoted as 'cascade fragmentation'. It is remarkable that it resembles certain processes in social evolution – for example, the fragmentation of large early states into separate parts that decentralize up to the point when further division becomes unreasonable (*e.g.*, in certain periods there were dozens and hundreds of independent states in the territories of Germany or France).

As enormous gas/dust clouds appear unstable, they disintegrate into large bundles, so the formation of stars proceeds in groups. This phenomenon is of interest not only with respect to stellar evolution. The group formation is rather typical for evolution in general (in this way populations and sometimes new species emerge; chiefdoms, city-states, and sometimes political parties emerge in groups, and so on).

The further process of the star formation is connected with the point that the initial compression heated the gas to a rather high temperature that, on the one hand, prevents the further compression of the gas, and, on the other hand, eventually contributes to the onset of the nuclear fusion reaction (Hawking 2001: 63–64).

2.2. Diversity of stars and galaxies

Diversity is an absolutely required condition of evolutionary development. And this condition is fully realized within cosmic evolution. As has been mentioned above, galaxies differ in their types, age, size, and structure. In particular, a galactic structure is to a large degree determined by the initial conditions of its formation (*e.g.*, by the character of rotation of the original gas clump from which a galaxy is formed). Stars differ in mass, temperature, chemical composition, luminosity, age, and other characteristics. Those differences may vary greatly. For example, with respect to masses, stars range in mass from about 0.1 to 100 or more solar masses. It is rather natural that the number of smaller entities is orders of magnitude larger;[5] actually, the same phenomenon may be observed, for example, in Zoology or Political Geography where the number of small animals or countries is much larger than that of large ones.

2.3. The life-cycle of a star: Stages of stellar birth, aging, and death

Protostars. As mentioned above, stars emerge through the condensation and compression of gas clouds under the influence of gravitational forces. This is a protostar phase. In comparison with the subsequent life of a star, the period of its slow contraction seems rather short; however, actually this is not a quick process as it continues sometimes up to 50 million years (Surkova 2005: 50). During this period of time, there is a tremendous rise in the temperature at the core of the protostar, the temperature may grow up to 8–10 million Kelvin, and, as a result, thermonuclear reactions become possible. The protostar becomes a young star. However, an external observer will only be able to see it in a few hundred thousand (or even a few million) years when the cocoon of gas and dust surrounding the protostar dissipates.

[5] Thus, for every ten million red dwarfs we find only 1,000 giants and one supergiant (Surkova 2005: 26).

Actually, we deal with a sort of miracle – a giant shining incandescent body, which is capable of living for billions of years, emerges from an absolutely amorphous, lacking any structure, opaque, and cold mass of gas mist. In other words, we deal here with a vivid example of self-organization that takes place under the influence of gravitation and thermodynamic laws. In particular, an intensive contraction leads to heating, which increases the internal pressure, which, eventually, stops the compression process.

One may also note that the emergence of stars and galaxies must have a certain trigger that creates turbulence and heterogeneity. Those triggers and catalyzers are the inherent components of evolutionary mechanisms that may be found in many processes: in chemical and geological processes, within biological evolution with respect to fast formation of species, or within social evolution with respect to state formation (see Grinin 2011 for more details). The supernova shock wave, the collision of a molecular cloud with spiral arms of a galaxy and other events can become such a trigger of the star formation (Surkova 2005: 50).

Another (the longest) macrophase is the main sequence star. During this phase of the stellar lifetime, nuclear-fusion reactions that burn hydrogen to helium in the core, keep the star shining. That is why the duration of the main sequence phase depends mainly on the stellar mass. The more massive is the star, the shorter its lifespan on the main sequence (as with a larger mass the 'fuel combustion' processes run more intensively). A star preserves its size and form due to the mutual struggle of two forces: the gravity that tries to compress the star and the gas pressure produced as a result of nuclear reactions and powerful heating. There is a dynamic equilibrium between temperature and gas pressure. With growing temperature, the gas expands and works against the gravitation forces, which results in cooling of the star; this way the thermal balance is kept. In the lifetime of stars and galaxies, as well as at all other levels of evolution, we find numerous cases and different forms of the interaction between two opposite processes which make it possible for 'individuals' to live. The processes of assimilation and dissimilation support vital activities within biological organisms; the processes of animal reproduction and their extermination by predators support the population balance; interaction between processes of production and consumption is the basis of the reproduction of social systems, and so on.

Red giants. The new phase of stellar evolution is connected with the exhaustion of hydrogen supplies. The gas pressure (that maintained the star balance when necessary fuel was available) decreases and the stellar core compresses. This leads to a new increase in temperature. A star starts to burn heavier elements and thus, the stellar composition significantly changes. Simultaneously with the compression of the core, the star's outer layers expand. In general, the star inflates and expands a few hundred times, and it transforms into a red giant. This phase lasts for about one tenth of the 'active lifetime' of a star, when the processes of nuclear fusion go on in its depths.

Star death: three cases. The next phase is the transformation of a red giant or supergiant. Actually, the new form depends on stellar mass and a number of other characteristics such as the stellar rotation and velocity, the degree of its magnetization, and so on. following three outcomes are considered most typical. They depend on stellar mass (but the limit value estimates vary significantly, and so below I will mention the main alternative values after the slash).[6] Stars with the masses smaller than 1.2–1.4/3 solar masses

[6] According to one of classifications (that might be more correct than the one reproduced below), it appears possible to subdivide all the stars just in two classes: a) massive stars (with a mass exceeding *c.* 10 solar masses), producing neutron stars and black holes, and b) non-massive ones producing white dwarfs (Lipunov 2008: 99).

transform from red giants into the so-called 'white dwarfs', when the star sheds its outer envelope to form a planetary nebula with an extremely contracted core (down to the size of the Earth). The further compression does not occur because of the so-called degenerate electron gas pressure that does not depend on temperature. As a result, the white dwarf is rather stable. However, due to the lack of hydrogen and helium, thermonuclear fusions can no longer proceed within such a star. A white dwarf is very hot when it is formed; yet, afterwards the star cools and transforms into a 'black dwarf', that is, it becomes a cold dead cosmic body.

For stars with an initial mass of more than 1.2–1.4/3, but less than 2.4–3/7–10 solar masses, their slow and gradual aging results in an 'infarct', that is a collapse. After the depletion of hydrogen and the decrease of the internal gas pressure (that used to balance the gravity), under the influence of gravity the core gets extremely compressed (by dozens thousand times – up to the radius of ten kilometers) just in less than a second. Almost simultaneously the external layers of the star are blown away with a huge speed as a result of shock wave. This supernova shines brighter than millions of ordinary stars, but for a very short period of time. This explosion expels the stellar material into interstellar medium and thus, there occurs the formation of considerable quantities of heavy (heavier than iron) elements that afterwards concentrate in various celestial bodies. The remaining core contracts to become a neutron star. In its size, such a star is 5 billion times smaller than the Sun, but it is hundreds of thousands of times brighter because the temperature on its surface is 1000–1500 times higher than on the Sun (Lipunov 2008: 133).

If stellar mass exceeds the limit of 3/7–10 solar masses, after hydrogen is burnt out it will start collapsing and explode (though sometimes it may collapse without an explosion), but the force of compression will be unlimited, as the gravity becomes enormous because of the huge mass and absence of internal forces that can prevent the collapse. The action of the gravitational force which is balanced by nothing leads to the situation when the stellar diameter becomes infinitesimally small. According to theoretical calculations, the star is transformed into a black hole whose gravity fields are strong for light to escape.

III. UNIVERSAL EVOLUTIONARY PRINCIPLES IN THE STAR-GALAXY ERA

1. Life, Death, and Catastrophes in the Evolutionary Aspect

The lifetime of stars in terms of maintaining and breaking the dynamic equilibrium

First of all, there is a thermal equilibrium, when the rate of energy produced in the core (through thermonuclear fusions) balances the loss of energy through the emission of radiation into space. This equilibrium is broken when hydrogen fuel is gone. The reserves are apparently compensated when a star starts using another type of energy. This may occur through the contraction of the star which begins fusing helium into carbon, thus producing many times more energy for every atom; afterwards heavier elements may be used as fuel, and each heavier element will produce more and more energy per atom. Meanwhile, the core of the star begins to increase in temperature. There is equilibrium in terms of pressure of different forces and preservation of a certain form and size of the star. Within the main sequence phase, the balance is maintained as the gravity pulls all the stellar matter inward, toward the core, while gas pressure pushes heat and light away from the center. This pressure exists until the reserves of nuclear fuel are exhausted (Efremov 2003: 97). With respect to red giants one may speak about equilibrium of another kind in two dimensions. In the core the temperature grows due to contraction and thermonuclear reactions of higher levels (described above) start; as a result of those reactions the temperature may grow up to 100 million Kelvin. That is why a stronger gravity is balanced by a stronger (due to temperature) gas pressure. In the meantime, within the shell the equilibrium is achieved through the multifold expansion of the outer layers. In neutron stars and white dwarfs, the subsequent phases of the stellar lifetime, there is their peculiar equilibrium.

The problem of the individual's death. Death as an opportunity for life to go on. Stellar life and death can hardly leave anybody indifferent. Actually, within the Big History framework, this is the first time when we come across the problem of a life cycle of individual objects in such an explicitly expressed form. On the one hand, the star's fate, lifespan, and type of death depend on initial parameters, as if they were 'genetically programmed' (and, hence, they may be forecasted); on the other hand, they may be altered by some contingencies. Thus, the star's fate is not 'fatal', indeed. Binary star systems increase highly the variability of the individual star fates; as Lipunov (2008: 252) puts it, we deal here with a kind of 'quadratic evolution'. What is more, it is actually possible to speak about differences in the 'individual' stellar behavior or 'within a group', because the interaction of two, three, and more stars may lead to very significant differences and unusual results that cannot emerge within the development trajectory of individual stars. In fact, similar patterns are observed at other levels of evolution, when behavior of pairs or groups of individuals produces outcomes radically different from the ones observed with respect to the behavior of an individual not interacting with others.

Finally, the meaning of individual's death for evolution may be different. Up to a certain degree one may observe a direct correlation between the 'strength' of death, the power of the stellar explosion, and the formation of conditions for a new evolutionary search. Stellar explosions affect the dynamics of their environment; consequently, they may help create unusual conditions that contribute to the emergence of certain developmental deviations. Within tens of thousands years the zone of explosion expands to a vast area of interstellar medium (covering the distances of dozens of parsecs); in this area one can see the formation of new physical conditions (in particular, temperature, density of cosmic rays and magnetic fields strength). Such a disturbance enriches the respective zone with cosmic rays and brings changes to chemical composition (Shklovsky 1984: 209). The explosions also contribute to star formation. Thus, a star does not die in vain. One can draw here an interesting analogy with extinctions in biological evolution which contribute to new directions of speciation. The stellar destruction can be also compared with the disintegration of large empires with all the subsequent repercussions. The disintegration of a large empire leads to a cascade of new states forming both in the place of the empire and even beyond its borders. Historical detonation contributes to politogenesis the same way as the cosmic detonation contributes to star formation.

Synthesis of gradualism and catastrophism. With respect to cosmic evolution one may observe a combination of two principles that provoke endless discussions in geology and biology. The subject of those discussions is what principle prevails in evolution. Are we dealing mostly with slow gradual changes, eventually leading to major changes (gradualism)? Or, does the development mostly proceed through sharp revolutionary breakthroughs which in biology are often connected with catastrophes? Within star-galaxy evolution the combination of both principles is more than just evident. Here, as at no other evolutionary level, both modes of evolution are organically combined in individual fates of the stars. The main sequence phase of stellar evolution (when the fusing of hydrogen occurs) demonstrates the gradual character and the importance of slow and prolonged processes. However, catastrophes of various scales can take place within the lifetime of any star. For some stars, such radical changes may manifest in major – but still local – changes (such as shedding the outer layers), whereas for other stars these might be tremendous catastrophes when stars die, figuratively speaking, 'brightly' and 'heroically', illuminating the Universe, leaving a billion-year-long footprint of light. The latter, that is the extraordinary phenomena and events, both among the stars and among humans are less numerous than the former, that is the common ones.

2. Some Evolutionary Ideas in Connection with the Star-Galaxy Phase of Evolution of the Universe

In the evolutionary process of formation of stars, galaxies, nebulae, and cosmic clouds one can distinguish a number of important evolutionary principles and laws that are not evident. Their detection is important for understanding the unity of principles of development of the Universe. Those principles and observations are grouped below into several blocks.

2.1. Evolution proceeds with constant creation and destruction of objects

Nature, when creating, destroying, and renewing various objects, 'tests' many versions, some of which turn out to be more effective and have more chances to succeed in terms of evolution. For such a situation of selection within constant destruction and creation process, it appears possible to apply a rather appropriate notion of creative destruction introduced by Josef Schumpeter (1994).

- **'Evolution is stronger than individual objects'.** Cosmic processes are accompanied by constant emergence, development, change, and death of various objects (stars, galaxies, and so on). Thus, here one can point as relevant the principle that was expressed by Pierre Teilhard de Chardin (1987) with respect to life in the following way: 'life is stronger than organisms', that is, life goes on exactly because organisms are mortal. The same is relevant to stellar evolution. We may say here that the cosmos is stronger than stars and galaxies; and in general, evolution is stronger than individual objects.

- **Rotation and keeping balance** take place due to constant destruction (or transition to new phases in the lifecycle) of some objects and the emergence of others. This keeps balance and creates conditions for development, because development is a result of change of generations and species.

- **In every end there is a beginning. Star-evolutionary 'relay race'.** The material of dead objects becomes building blocks for the formation of new objects. This represents the circulation of matter and energy in nature; on the other hand, this represents a sort of 'relay race'.[7] The latter allows using the results of long-lasting processes (in particular, the accumulation of heavy elements).[8] Thus, we deal here with the above mentioned 'creative destruction' – the creation of new objects due to the destruction of the old ones, which ensures continuity and provides new forms with space for advancement (*e.g.*, the change of generations of biological organisms always results in certain transformations). The change of rulers may

[7] For more details on the 'rule of evolutionary relay race' see Grinin, Markov, and Korotayev 2008.

[8] For example, the Solar System emerged from the remnants of a supernova explosion. It is believed that due to this fact there are so many heavy and super-heavy elements on the Earth and other planets.

not necessarily lead to radical social changes; however, each new ruler is somehow different from his predecessor, as a result the accumulation of historical experience occurs.

- **New generations of organisms and taxa are a mode of qualitative development.** One may also detect generations of taxa, which already have significant evolutionary and systemic differences. Thus, generations of stars differ in terms of their size, chemical composition, and other characteristics. Only through the change of several generations of objects this class of objects acquires some features that, nevertheless, are considered to be typical for the whole class of objects.

2.2. Individuality as a way to increase evolutionary diversity

- **Individual fates within evolution.** It appears possible to maintain that with the formation of stars one observes the emergence of individual objects in nature, 'individuals' that, on the one hand, are rather similar, but have rather different individual fates much depending on circumstances of their birth and various contingencies. For example, stars with small masses (in which nuclear fusion occurs at a slow rate) can use all of their fuel (*i.e.*, remain in the main sequence) for many billions of years. On the other hand, blue giants (in which the rate of fuel consumption is rapid and which lose most part of their mass due to their instability) burn out hundreds of times faster.

The stars can end their lives in a rather different way. Some of them, having lost one or a few outer layers, would cool, slowly transforming into cold bodies; some others may contract a few dozen times, or may end their lives with huge explosions blowing their matter into open space. Finally, a star may become a black hole that does not allow any matter to come out of its immensely compressed depths.

- **Ontogenesis and phylogenesis.** The evolution proceeds at various levels: through the development of its certain branch, a certain class, species and so on (and sometimes even at the level of an individual organism). In addition, applying biological terminology, at every level of evolution we find a combination of processes of *ontogenesis* and *phylogenesis*. Of course, within star-galaxy evolution the phylogenesis is represented much weaker than in the evolution of life. Nevertheless, it still appears possible to speak about the history of transformation of certain types of galaxies and stars, and, hence, up to a certain extent the cosmic phylogenesis does occur (see as above with respect to change of a few generations of stars and galaxies that differ from each other as regards their size, structure, and composition).

- **Required and excessive variation as conditions of a search for new evolutionary trajectories.** Within the processes described above one can observe the formation of the taxonomic diversity of space objects; we may even speak about occupying the evolutionary 'niches'. There emerge different types of stars and galaxies (see above). Such diversity is extremely important. Only the achievement of a necessary level of taxonomic and other diversity allows a search for ways to new evolutionary levels. This is sometimes denoted as the rule of necessary and excessive diversity (see Grinin, Markov, and Korotayev 2008: 68–72; for more details see also Panov 2008).

- **Norm, averages, and deviation from a norm.** Only when we find a sufficient diversity, it appears possible to speak about norm, average level, exceptions, and outliers. Scientists have long known that the breakthroughs to new forms usually happen at the periphery, and in those systems that diverge from the previous mainstream.

• **Continuity,** which actually means the emergence of a continuum of forms, sizes, life spans, and lifecycles, is rather characteristic for space objects. Thus, the stars can be presented as a continuum from heavier to lighter ones (whereas the latter become hardly distinguishable from planets). The types of planetary systems uniformly cover a wide range of parameters. There is also a sequence of phases in the transformation of cosmic clouds into stars: condensation of clouds – formation of protostars – formation of young stars, and up to the death of stars. The continuum of forms and sizes of objects may be observed at geological, biological, and social phases of the evolution.

2.3. Object, environment, competition, development systems, and self-preservation

• **The relations between structure and environment.** Multilevel systems (galaxy – galaxy cluster – galaxy supercluster) act as systems of a higher order for stars, and, simultaneously, they create an environment that produces an enormous influence on those stars. A star directly interacts with its immediate environment (*e.g.*, with neighboring stars because of the strong gravity which affects the movement of both stars), whereas with the distant environment the interaction proceeds at higher levels. Within star-galaxy evolution the role of environment is generally less important than at other evolutionary levels, because single stars are separated by great distances and that is why collide rather infrequently. On the other hand, one should not underestimate the role of the environment. For example, the role of the immediate environment is very important in systems of double, triple, or multiple stars. For a small galaxy the influence of neighboring larger galaxy may turn out to be fatal, if it leads to its absorption. *External factors* play the major role in *changes* (*e.g.*, a large cosmic body can pass by a giant molecular clouds, there can occur a star explosion, and so on) and may trigger the process of formation of stars and galaxies (by launching the gas contraction process). Collisions of cosmic bodies may create new cosmic bodies – for example, there is a hypothesis that the Moon emerged as a result of the collision of some large objects with the Earth.

With the development of a certain form of evolution, its own laws and environment gain a growing influence on the development of its objects and subjects. For example, both abiotic nature and the biotic environment influence biological organisms. However, within a complex ecological environment, it is the intraspecies and interspecies competition that may have larger influence than any other natural factors, whereas within a complex social environment it is just the social surrounding that affects individuals and social systems more than the natural forces do. Thus, with the formation of star-galaxy structure of the Universe there emerged macro-objects which start to interact with environments which are larger by many orders of magnitude.

• **The urge toward self-preservation and origins of the struggle for resources.** Stars, galaxies, and planets (as well as other cosmic bodies) have their definite, quite structured, and preserved form. The 'struggle' for the preservation of those forms, the capacity to live and shine, the use of different layers to minimize energy losses lead to a slow but evident evolutionary development. This way the atomic composition of the Universe changes, whereas the diversity of variations of the existence of matter increases. On the one hand, the emergence of structures that strive for their preservation creates a wide range of interaction between the system and its environment; on the other hand, this creates a basis for the 'evolutionary search' and evolutionary advancement. This evolutionary paradox – *the struggle for the self-preservation is the most important source for development* – can be observed here in its full-fledged form. However, star-galaxy evolution demonstrates the emergence of this driving force which will become very important in biological evolution; and it appears to be the most important driving force in social evolution. This is the struggle for resources that among stars and galaxies may proceed in the form of weakening of another object or its destruction (*e.g.*, through a direct transfer of energy and matter from one body to another), in the form of 'incorporation', 'capturing', that is 'annexation' of stars and star clusters by larger groups. We have already mentioned above galactic coalescences. Thus, some astronomers maintain that throughout a few billions of years our galaxy has 'conquered, robbed, and submitted' hundreds of small galaxies, as there are some evident 'immigrants' within our galaxy, including the second brightest star in the northern sky, Arcturus (Gibson and Ibata 2007: 30). It is widely accepted that emergence and expansion of a black hole may lead to the 'eating' of the matter of the nearby stars and galaxies. However, the 'eating capacity' of the black holes is greatly exaggerated in popular literature. In systems of double stars or in star-planet systems one may also observe such a form of interaction as the exchange of energy and resources.

2.4. Multilinearity

Multilinearity is one of the most important characteristics of evolution. Unfortunately, it does not get sufficient attention, and there is a tendency to reduce evolution to a single line – the one that has produced the highest complexity level, which is often interpreted as the main line of evolution. *However, at every stage of evolutionary development one can find an interaction of a few lines that can have rather different futures*. In other words, in addition to the main evolutionary line one can always identify a number of lateral ones. Firstly, they contribute to the increasing diversity; secondly, they allow expanding the range of search opportunities to move to new levels of development; thirdly, the lateral lines may partly enter the main evolutionary stream, enriching it. We quite often deal with two or more coexisting and comparable lines of development whose convergence may lead to a quantitative breakthrough and synergetic effect. Various lines of development may transform into each other. Elsewhere we have written a lot on the issue of social evolution in this context (see, *e.g.*, Grinin and Korotayev 2009; Grinin and Korotayev 2011; Bondarenko, Grinin, and Korotayev 2011; Grinin 2011).

- **Classical forms and their analogues.** The main and lateral lines of evolution may be considered in two dimensions: 1) horizontal (as regards complexity and functions), 2) vertical (concerning the version that would be realized later at higher evolutionary phases). It appears also possible to speak about classical versions and their analogues. Thus, various forms of aggregation and specialization of unicellulars can be regarded as analogues of multicellulars (see Eskov 2006), whereas various complex stateless polities can be regarded as state analogues (see Grinin and Korotayev 2006; Grinin and Korotayev 2009; Grinin 2011 for more detail). Classical forms and their analogues can transform into each other; however, these are just the analogues that tend to transform into classical forms, rather than the other way round (the latter may be regarded as a forced adaptation to sharply changing conditions, and sometimes even as a direct degeneration).

- **Stars and molecular clouds: two parallel forms of existence of cosmic matter.** In this respect we may consider stars and galaxies as the main line of evolution and the giant clouds as its lateral lines; the former may be denoted as 'classical forms', and the latter may be designated as 'analogues'. On the one hand, those forms actually transform into each other. Galaxies and stars emerge from giant molecular clouds, whereas stars through explosions and shedding their envelopes may transform into gas-dust cloud. On the other hand, giant molecular clouds are able to concentrate; the energy exchange occurs within them, and thus, in terms of gravity and structural complexity they are quite comparable to stars and galaxies. They generally have a rather complex 'Russian nesting doll' structure, whereby smaller and denser condensations are placed within larger and sparser ones (see Surkova 2005: 48). The Russian-doll structure is also typical for higher levels of evolution. Thus, smaller groups of social and gregarious animals constitute larger groups and tend to reproduce their structure. The same refers to social evolution, in particular to the non-centralized entities: for example, the tribal formations, whose constituent parts (lineages, clans, and sub-tribes) often reproduce the structure (and structural principles) of the tribe. That is why tribes can easily split and merge when necessary. The same is true of herds of gregarious animals.

Conclusion: The Formation of Various Evolutionary Lines at the Microworld Level

Astrophysical and astrochemical evolution. Almost from the very beginning of the development of the Universe (when the temperature reached thousands of Kelvin) chemical evolution emerges as accompanying physical and astrophysical evolution. Of course, chemical evolution also occurs within stars with the emergence of heavier elements. However, that was rather the formation of the basis for chemical evolution, because chemical processes involve the reactions which lead to the emergence of new substances. Such processes proceed, first of all, within gas-dust clouds where molecules emerge. Hydrogen molecules are absolutely prevalent quantitatively; however, molecules of water and some other substances also emerged. Chemical evolution goes on also on planets (where it combines with geological, or rather planetary evolution) as well as on small celestial bodies (asteroids and meteorites).

In contrast with biological and social forms which from their very start displayed substantially higher levels of organization of the matter, the chemical form (that emerged a rather short time after the physical form) did not represent a higher form of evolution for a rather long period of time. That is not to say that chemical evolution is not important in the framework of general stellar and galactic evolution; however, before the emergence of the Earth-like planet, the physical and chemical forms of organization of matter should be regarded as equally important; note also that they constantly transform into each other. The development of astrochemical evolution is not limited by the formation of simple nonorganic molecules. The processes of formation of molecules proceed further towards the formation of organic substances. More than hundred types of organic molecules have been detected in space (see Surdin 2001; Surdin and Lamzin 1992; Shklovsky 1984). Naturally, this facilitated the emergence of life in a rather significant way.

The Formation of 'Preadaptations' as Points of Future Evolutionary Growth. Within the star-galaxy era the chemical form of development may be regarded as a 'preadaptation' for new levels of evolution. Let us note that in biology the term 'preadaptation' denotes those adaptations that may turn out to be useful in a different environment and to give significant advantages to those species that have them[9] – and generally – to give an impulse to the formation of new taxa. Within the Big History framework, the principle of 'preadaptation' means that at the level where a preadaptation emerges, it generally plays insignificant

[9] This omnivorous ability of hominids allowed their transition to hunting at a very early phase of the anthropogenesis.

role; however, at a new evolutionary level such 'innovations' generally give evolutionary impulses.[10] Respectively, chemical compounds (as is common for preadaptations) do not mean much for cosmic evolution, they were rather 'in reserve' to reveal all their significance at the level of planetary evolution.

I would like to finish this article with a note on one more peculiarity of preadaptations. Appropriate conditions are necessary for their formation. Within biological evolution, the preadaptations often emerge in peculiar environments. Thus, it is supposed that the transformation of fins of the fleshy-finned fish (from which Amphibia descended) into primitive legs occurred within the environment of shallow waters that often dried out. In a similar way, within star-galaxy evolution the emergence of complex chemical compounds can take place only within certain structures of cosmic clouds that made their existence possible as they protected the molecules from cosmic radiation.

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[10] On preadaptations in megaevolution see also Grinin, Korotayev, and Markov 2011: 159–160.

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Standing on the Shoulders of Giants: Collective Learning as a Key Concept in Big History

David Baker

One of the key concepts for the human part of the grand narrative is known as 'collective learning'. It is a very prominent broad trend that sweeps across all human history. Collective learning to a certain degree distinguishes us as a species; it got us out of Africa and the foraging lifestyle of the Palaeolithic, and underpinned demographic cycles and human progress for over 250,000 years. The present article looks at collective learning as a concept, its evolution within hominine species, as well as its role in human demography and the two great revolutions in human history: agriculture and industry. The paper then goes on to explain the connection of collective learning to Jared Diamond's 'Tasmanian Effect'. Collective learning also played a key role in the two 'Great Divergences' of the past two thousand years. One is industry and the rise of the West, described to great effect by Kenneth Pommeranz, the other is the less well known: the burst of demography and innovation in Song China at the turn of the second millennium AD. Finally, the paper concludes with insights into how collective learning forges a strong connection between human history and cosmology, geology, and biology, through what is widely recognized as one of the 'unifying themes' of Big History – the rise of complexity in the Universe.

Keywords: *complexity, collective learning, demographic cycles, evolution, accumulation.*

When I arrived in Sydney in 2010 to start my PhD in Big History, my original topic was long-term patterns in Malthusian cycles. However, it was only a few weeks before I noticed the strong connection between population dynamics, the rise of complexity that is central to Big History's grand narrative, and a concept known as cultural evolution, which is the transmission of cultural ideas, beliefs, and attitudes through an algorithm of variation and selection very similar to the evolution of genes in biology. Cultural ideas evolve and adapt far faster than genetics and this permits a much more rapid increase in complexity. Cultural evolution is, of course, one of many manifestations of the 'Darwinian algorithm' that is observed in cosmology, geology, biology, and even quantum physics, that seems to play a role in rising complexity (Baker 2011a, 2013, 2014; Christian in this volume). My dissertation has explored the Darwinian connection among these differing physical processes and I have explored them in a few other articles, but in this article I would like to focus on an aspect of cultural evolution that is crucial to human progress and the upper end of the immense complexity the Universe has generated so far.

Collective learning is an ability to accumulate more innovation with each passing generation than is lost by the next. It has allowed humans to exploit our ecological niches with increasing efficiency and allowed us to largely harness the energy flows of the planet and the Sun. Through *foraging, agriculture, and heavy industry collective learning has raised the carrying capacity of the population, allowing for more potential innovators, who in turn raise the carrying capacity, thus creating even more innovation. Gradually, over 250,000 years of humanity, the population has risen and we have generated increasingly complex societies and have developed the capacity to harness an enormous amount of energy. In terms of the wider rise of complexity and in processes of Universal Darwinism, collective learning is the summit of the process, and I say the next two words with emphasis, thus far.*

The historian's view of all human history is no longer vague or boundless with a chaotic tangle of periods and research areas. Collective learning gives a clear and definite shape to the whole picture as well as an underlying theme. This is revolutionary not only for Big History, but for areas of conventional human history as well. The idea has its uses within archaeology, agrarian history, and within the study of the industrial era – not to mention our anxiety-fraught examination of the looming trials of the twenty-first century. For the concept of collective learning we are deeply indebted to David Christian for expounding it in his own works, and also anthropologists like Peter Richerson, Robert Bettinger, Michelle Kline, and Robert Boyd, for developing it mathematically and, in one case of a recent paper to the Royal Society, with a strong degree of empiricism (Christian 2005: 146–148; Richerson, Boyd, and Bettinger 2009: 211–235; Kline and Boyd 2010: 2559–2564).

In natural ecology, all organisms are slaves to some form of *S*-curve that restricts the amount of resources available to an individual and a species, enabling them to survive and reproduce. When the carrying capacity of a biological population is reached, the population undergoes strain, decline, and recovery. While potentially destructive to life-forms, it does have the merit of spurring along evolution by natural selection. Thomas Malthus' *Essay on the Principle of Population* (1798) illustrated how the human population growth always tended to exceed the resources capable of supporting its burgeoning numbers. Darwin read it in 1838 and extrapolated it to other organisms whereby species over-breed, compete, and change over time to possess the traits that are best able to extract resources from their environment and perpetuate their survival. It was an epiphany for him. At last, he said, 'I have finally got a theory with which to work' (Darwin 1887: 82). It also applies to human history. In his recent book, big historian Fred Spier identifies the unifying theme of our long story:

> If we want to prevent our bodily complexity as well as all the complexity that we have created from descending into chaos, we must keep harvesting matter and energy flows on a regular basis. *This is the bottom line of human history*. I will therefore argue that during most, if not all, of human history, the quest for sufficient matter and energy to survive and reproduce... has been the overriding theme (Spier 2010: 116; emphasis added).

Until a few million years ago there was nothing on Earth to indicate that anything else besides the *mêlée* of genetic evolution, with its constant generation and annihilation of diversity, would arise. It appeared the short, ignorant, and terrifying existence of beasts of the field was the highest level of complexity of which the planet was capable. Biology seemed like the finest manifestation of the Darwinian algorithm that gradually produced more and more complexity, with the annihilation of useful DNA mutations and the selection of useful ones. However, like stellar evolution builds on quantum Darwinism, like mineral evolution is an extension of stellar evolution, biological evolution soon spawned another Darwinian process. There emerged the groundswell of collective learning, the concept that a species' learning accumulates in ways over several generations that enhances their ability for survival. If harvesting energy to maintain our complexity is the bottom line of human history, then collective learning and its ability to raise the carrying capacity is without question the shape. That shape looks something like this.

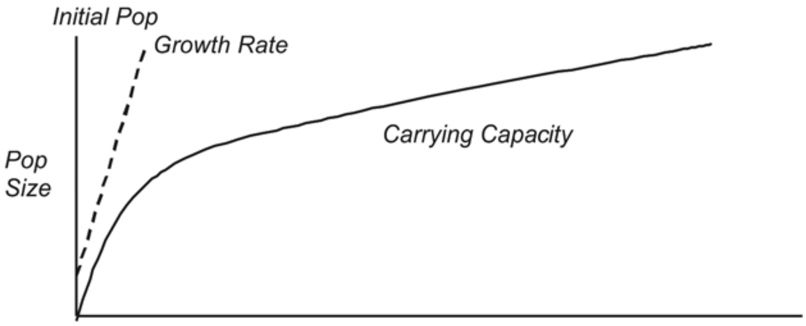

Fig. 1.

Source: Richerson *et al.* 2009: 219.

I. Collective Learning in the Palaeolithic

What precise ability enables collective learning? How did it evolve? What selection pressures made it spring into being? This engages with a much larger and much older debate over the nature of human uniqueness – something to which a refined version of collective learning can contribute. These ideas are universal grammar *à la* Noam Chomsky *vs.* symbolic reference *à la* Terrence Deacon, the emergent thought *vs.* the computational model of the mind, the role of imitation and mimicry in the evolution of language, and the debate over group selection in humans that raged over a recent book by Edward O. Wilson and the counterblast of Steven Pinker (Wilson 2012; Pinker 2012). While the importance of collective learning and technological accumulation to human history has been clearly identified, it is much less clear what trait or a set of traits enabled it in the first place. A number of theories exist and they all seem to revolve around the gradual and the sudden. Chomsky argues against gradualism and considers universal grammar an all or nothing proposition that somehow flickered into being (Chomsky 2002: 80). Pinker argues for a more gradual evolution of a computational model of the mind similar to the evolution of the eyes (Pinker 1997: 21). Deacon argues for the appearance of symbolic reference as a sudden occurrence (Deacon 1997: 328–355). Dunbar claims that enhanced communication abilities and technological accumulation were the gradual result of selection pressures on complex interaction and coordination due to increasing group size and inter-group connectivity (Dunbar 1996: 3–17, 56–58, 62–64, 77; 2004: 28–29, 71–72, 125–126; 2010: 22–33). Finally, Corballis places gesticulation as the fundamental form of social learning with speech being the ultimate form – thus being a change of degree and not of kind (Corballis 2002: 41–65). Whatever the skill that allowed humans to accumulate more innovation with one generation than was lost by the next, it needs to have a clear explanation about how it evolved in real terms without recourse to metaphor and with identifiable selection pressures – whether sudden or gradual.

These questions tie into the next issue: the threshold after which collective learning became possible. Where is it drawn? Is it the result of a gradual evolution over several species or a sudden jump? If we knew what ability, origin, and selection pressures caused collective learning, we might be able to better answer that question. For now it is a big blank spot on the map. Do we draw the line at humans? And if so, how do we treat the nascent elements of collective learning in our evolutionary family? David Christian often gives the example of the Pumphouse Gang baboons, where a skilled hunter dies and information eventually degrades, vanishes, and the range of the species does not expand. He also gives a nod to what he calls the 'sporadic learning' in apes and in *Homo habilis* and *Homo ergaster/erectus* (Christian 2005: 146). But if we place the threshold where more knowledge is accumulated with each generation than is lost by the next, we are confronted with questions about the significance of situations where knowledge neither degrades nor accumulates – it is simply preserved. For example, termite fishing, rock hammers, leaf sponges, branch levers, and banana leaf umbrellas are passed on by social learning, not instinct, and not sporadically, in certain populations of chimpanzees, and are withheld from others outside that cultural network (Pinker 1997: 198–199). They are sustained and passed on, usually from mother to offspring, and are not reinvented every generation. Here is a tremendous ability, however weak, probably possessed by our last common ancestor. This ought to tell us something about the nascent elements of collective learning. But, on the other hand, if this learning does not accumulate, but is only preserved, perhaps, it can conceivably be dismissed, if we wish to maintain a sudden threshold with humanity and not a gradualist account.

Similarly, the stagnant nature of stone tools 2.6–1.8 million years ago may potentially be dismissed as a 'sporadic learning', simply preserving knowledge but not accumulating it. Around 1.8 million years ago, however, the assertion grows more tenuous. Stone tool manufacture is less haphazard, with deliberate shapes being constructed that are passed on culturally. *Homo ergaster/erectus* also migrated into different environments in Asia, no mean feat, and there is evidence of a demographic boom in Africa that may have driven the migration. A demographic boom also indicates an enhanced ability to exploit niches in the ecosystem. There is also evidence of increased brain size and sociality (Stringer 2011: 25–26; Tattersall 2012: 123–124). All of these things are staple arguments for collective learning in *Homo sapiens* and the profound impact they had on the Palaeolithic world. There is no reason why the same arguments could not apply to *Homo ergaster/erectus*, albeit on a lesser scale. But this is a difference of scale, not a difference of kind.

Nevertheless, the jury is still out on whether there was any technological accumulation. When *Homo ergaster/erectus* first arrived on the scene 1.8 million years ago, they were making tools that had not changed significantly since *Homo habilis*. However, 1.78 million years ago we begin to observe rare and crude new forms of teardrop hand-axes in Kenya (Tattersall 2012: 105). But for about 200,000 years we see, for the most part, no major widespread improvements in the stone tools of *Homo ergaster/erectus*. This remained the case in most migratory regions. The tools were functional. The object was to get a flake edge. No aesthetics were involved. But in Africa 1.5 million years ago, where *Homo ergaster* populations were at their densest, the hand-axes first made 1.78 million years ago rapidly became common. What is more, they improve in quality, shaped with a flat edge into multipurpose picks, cleavers, and other kinds of implements (Tattersall 2008: 125–127). This has been considered by some archaeologists as the first clear sign of tinkering, accumulation, and improvement of technology, if only a much weaker form of collective learning among *Homo ergaster/erectus* than *Homo sapiens*, who are the real champions at it.

Still, the assertion that *Homo ergaster*/*erectus* had crossed the threshold into mild collective learning can still be reasonably disputed and dismissed if the case is only based on such limited evidence. This argument is less feasible for the hominines of the last million years. *Homo antecessor*, *Homo heidelbergensis*, and the Neanderthals presided over the systematised and regular use of fire in hearths (790,000 years ago), the earliest wooden spears (400,000 years ago), the earliest use of composite tools (400,000 years ago), the first evidence of intricately constructed shelters (350–400,000 years ago), and the first prepared core tools (300,000 years ago) all before *Homo sapiens* was ever heard of (Goren-Inbar *et al.* 2004: 725–727; Tattersall 2008: 125). *Homo heidelbergensis* became the first pan-Old World hominine (600,000 years ago), showing signs of technological improvement, with the earliest specimens using simpler tools than later ones, and even evidence of pigments at Terra Amata, a site in Europe 350,000 years ago (Oakley 1981: 205–211). The Neanderthals adapted to climes that made clothing and other cultural innovations necessary for insulation and warmth. There is also limited evidence for use of pigments (Stringer 2011: 163–165). They used complex tool manufacture, with prepared stone cores, producing a variety of implements, sharp points, scrapers, teardrop hand-axes, wood handles, with deliberate use of good stone materials, and an endless supply of variations and signs of improvement over time (Tattersall 2012: 166–173; 2008: 150–158).

Now, bearing in mind that *Homo sapiens*, without question, is by far the most talented at collective learning, there is very little doubt that these hominine innovations accumulated over several generations, did not fade away, improved in quality down the chronology, and yielded a certain degree of ecological success and extensification into new environments. Interestingly enough this happened in several hominine species for which there has yet to be found clear evidence of symbolic thought and complex language, two things that are sometimes (and probably incorrectly) attributed as the *cause* of collective learning rather than more efficient vehicles for it. All this raises severe questions about the threshold that must be addressed. It also bleeds into questions about human uniqueness and why it is so important for some people to draw an ironclad boundary between us and our evolutionary family that distinguishes us in essential kind. This sort of essentialism is alien to many forms of evolution. It would be a rash statement indeed to say that if *Homo sapiens* had never existed and had never out-competed other hominines, that these same hominines would not have possessed collective learning or attained some degree of cultural complexity. Much more work, at any rate, would be required before one could make such a statement. As it is, it appears a more gradual evolution of collective learning occurred over several hominine species.

The question of a 'Palaeolithic revolution' is another point of contention. Did *Homo sapiens* undergo a biological change *c.* 50,000 years ago and does this explain the explosion of technological complexity that appears in the fossil record? Or did collective learning and population density achieve a point of saturation allowing for a faster pace of learning? Or did this complexity arrive in Africa prior to 100,000 years ago as McBrearty and Brooks have suggested (McBrearty and Brooks 2000: 453–563)? If the latter, it is probably the result of collective learning maintaining a faster rate of accumulation in denser African populations than disparate migrant ones. Collective learning may have also played a role in the Out-of-Africa migrations themselves. Recent DNA studies have shown exponential human population growth in Africa preceded our most successful migration out of that continent *c.* 60,000 years ago (Atkinson, Gray, and Drummond 2009: 367–373). This coincides with evidence of an increase in the complexity of technology around the same time (Mellars 2006: 9381–9386). It is possible that there is a correlation between migration and population growth that may be explained by the gradual rise of collective learning. If such a connection exists for the ecological success of humans, it might also be applied to the prior migrations of *Homo ergaster/erectus*, *Homo heidelbergensis*, and the Neanderthals. The human correlation is also reinforced by genetic studies by Powell, Thomas, and Shennan that show population density in Africa may have reached a critical mass to allow more consistent technological accumulation without as many periods of loss (Powell, Shennan, and Thomas 2009: 1298–1301).

Decline in population and collective learning can also lead to a Tasmanian Effect, where technology disappears or undergoes simplification. Jared Diamond coined the term for the extreme disappearance of technology in Tasmania (Diamond 1978: 185–186). Kline and Boyd recently established a similar case in Oceania, where technology declined in groups that were isolated or lost density (Kline and Boyd 2010: 2559–2564). My own work has unearthed a similar occurrence of technological disappearance and simplification in the extreme and sustained population decline of isolated parts of post-Roman Western Europe in the fifth and sixth centuries (Baker 2011b: 217–251). Finally, Zenobia Jacobs, Bert Roberts, Hilary Deacon, and Lyn Wadley established two Palaeolithic Tasmanian Effects in Africa, at Still Bay 72,000 years ago and Howieson's Poort 64,000 years ago (Jacobs *et al.* 2008: 733–735; Wadley *et al.* 2009: 9590–9594). All are cases where technology disappears or is simplified in areas that suffered isolation and population decline – a phenomenon deemed more likely in the Palaeolithic due to lower populations and lower connectivity. It might explain why collective learning took tens of thousands of years to get off the ground, relatively speaking, before the explosion of agriculture.

II. Accumulation of Innovations from Foraging to Agriculture

Culture evolves through an accumulation of small variations. Those ideas that are successful or useful, in whatever way, are selected and spread throughout a society. Every invention of technology or breakthrough in practice, like in agriculture, comes from a series of small improvements contributed by a long dynasty of innovators. The single innovation of a genius might be of revolutionary magnitude and repercussions, but would have been impossible without the hundreds of tiny innovations made by the hundreds of generations that came before it. Newton said he stood on the shoulders of giants. It might be fairer to say that every ordinary person stands on the shoulders of other ordinary people – some with more than ordinary perceptiveness and absolutely extraordinary timing. Our technologies, our institutions, our languages are far too elaborate for even the most gifted of geniuses to create from scratch. Human beings have a tremendous capacity for language. We can share information with great precision, accumulating a pool of knowledge that all people may use. The knowledge an individual contributes to that pool can long survive his death. If our populations are large and well-connected enough, more information is acquired by each passing generation than is lost by the next. It can be accessed and improved by countless generations.

From the origins of collective learning in the Palaeolithic, it is clear that from the rising carrying capacity and increase in cultural variants and innovations, that collective learning has great bearing on the historical narratives. Nowhere is this more relevant than the discussion of population cycles. The inception of the current arc of complexity is easily spotted. Around 74,000 years ago there was a catastrophic eruption at mount Toba, on the island of Sumatra, part of what is now Indonesia. It was worse than anything in recorded history. The eruption drastically lowered temperatures on Earth for several years (Rampino and Self 1992: 50–52). Genetic studies show that the resultant decline in flora and fauna upon which humans could predate had reduced the population to near extinction. It is likely that in the aftermath of a period of starvation, on the entire face of the Earth there were scarcely more than 10,000 (and perhaps as few as 1000) human souls, which, as an aside, is what makes our long history of racism so abhorrent and absurd, particularly those ideological impulses inspired by Darwinism (Williams *et al.* 2009: 295–314; Rampino and Ambrose 2000: 78–80; Ambrose 1998: 623–651). Here is a low watermark for the current trend of human population dynamics. Evidently the starvation did not last long. In approximately the same amount of time that separates us from the dawn of agriculture, the human species had recovered and *c.* 60,000 years ago migrated out of Africa across the world. By 30,000 years ago, the foraging human population had risen to half a million. By 10,000 years ago, the innovation of hunter-gatherer bands had allowed them access to almost every environment on Earth, from Eurasia to Australia to the Americas. We must remember that the carrying capacity for a foraging band is quite low and they need a vast area to supply relatively small numbers. Nevertheless, by the dawn of agriculture the ranks of our species had swelled to six million people, approaching the full capacity for supporting hunter-gatherers of which the entire surface of the Earth is capable (Livi-Bacci 1992: 31). Innovations began to mount up. The earliest recorded evidence for herding goats and sheep in Southwest Asia is from 11–12,000 years ago, and one thousand years later, we have evidence for the farming of wheat, barley, emmer, lentils, and pigs. By 8,000 years ago, East Asia had begun using millets and gourds, and the Americas had domesticated llamas and maize. By 6,000 years ago, Southwest Asia had domesticated dates and the grapevine, while East Asia had domesticated water chestnuts, mulberries, water buffalo, and that mainstay of all Asian crops – rice (Roberts 1998: 136). All of a sudden, much larger numbers could be supported over a much smaller land area. The agrarian civilizations brought about a greater degree of connectivity, faster population growth, and a new rapid pace for innovation. Suddenly there were a lot more minds to generate ideas and a lot less space between those minds in order to conference. Agricultural efficiency gradually improved and practices slowly spread to new regions. From the upper limits of the carrying capacity for foragers, the population increased nearly tenfold by 3000 BC to 50 million people, and it took only another 2000 years to increase this number to 120 million (Biraben 1979: 13–25). But there was a problem. The tinkering of ideas in cultural evolution is random, after all. For nearly 10,000 years, the growth in the carrying capacity of agriculture was sluggish while population growth was exponential, and so there was a series of miniature waves of population collapse and recovery throughout the period of agrarian civilizations. From there came the advent of industry which has raised the carrying capacity and enhanced collective learning by leaps and bounds.

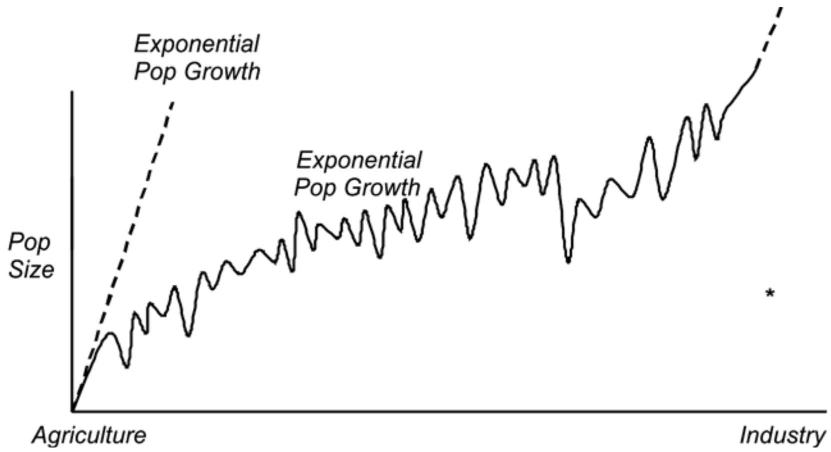

Fig. 2. The asterisk (*) marks a period of severe population decline where learning is lost

Bear in mind that each innocuous-looking downturn on the graph represents a period of intense starvation, suffering, and death. Every few centuries an agrarian civilization overshot its carrying capacity and countless famines, instability, poverty, and plagues ravaging a malnourished landscape, resulted. Each drop of the line represents the death of millions. Sometimes population loss would be so significant that it adversely affected the onward march of collective learning, as the asterisk simulates. If collective learning is lost, the carrying capacity falls, and the smaller group of innovators has to make up lost ground. This reversal of the process is known as the Tasmanian Effect.

III. Collective Learning Undermined and Overthrown

When a catastrophe strikes and a population is reduced and isolated, the accumulation of knowledge slows down and a population's ability to retain information is weakened. The most extreme example of this is from Tasmania, which possessed many technologies shared by their Australian relatives to the north, but whose skills and technologies gradually disappeared after Tasmania was cut off from Australia *c.* 10,000 years ago. Jared Diamond famously observed that when the Europeans first visited Tasmania in the seventeenth century, the native population was small, isolated, and lacked many of the tools and methods that the aboriginal Australians on the mainland possessed. The Tasmanians could not produce fire in hearths, they did not have boomerangs, shields, spears, no bone tools, no specialized stone tools, no compound tools like an axe head mounted on a handle, no woodworking, no sewing of clothes despite Tasmania's cold weather, and even though they lived on the sea coast, they had no technology for catching and eating fish (Diamond 1978: 185–186). Diamond hypothesized that this was caused by the loss of the land bridge between Australia and Tasmania *c.* 10,000 years ago. A subsequent recent study of Tasmania's archaeological and ethno-historical evidence has borne out the same result (Henrich 2004: 197–218). The Tasmanians upon European contact had lost a great deal of technology that was enjoyed not only by their neighbours across the Bass Strait but also by most groups of *Homo sapiens* in the Palaeolithic. Humans probably arrived in Tasmania from Australia 34,000 years ago, across a land bridge, and were indeed cut off 12,000–10,000 years ago by the rising sea (Jones 1995: 423–446). The archaeological evidence shows that at the time of migration, the Tasmanians were producing bone tools, cold-weather clothing, fishhooks, hafted tools, fishing spears, barbed spears, fish/eel traps, nets, and boomerangs, and continued to do so even after the island was cut off by the rising seas. These tools gradually declined in frequency, variety, and quality between 8,000 and 3,000 years ago before completely disappearing from the archaeological record (Henrich 2004: 198). Thereafter, to hunt and fight, the Tasmanians used one-piece spears, rocks, and throwing clubs, and their entire toolkit consisted of 24 items, as opposed to the hundreds of tools possess by the Australians to the north (Ryan 1981). Bone tools are on the Tasmanian record from at least 18,000 years ago, just as they were in Australian records and also enjoyed by Palaeolithic man in Africa from 89,000 years ago (Webb and Allen 1990: 75–78). The archaeological record also shows that from 8,000–5,000 years ago, the Tasmanians relied heavily on fishing, second in their diet only to seal hunting, and much more than hunting wallabies. By 3,800 years ago, fish bones disappear from archaeological sites and it was not part of the Tasmanian diet when Europeans arrived (Henrich 2004: 199). All told, Jared Diamond's hypothesis forty years ago about a loss of knowledge due to connectivity and a shrinking population has been largely borne out by subsequent research.

It is not the only case where such a phenomenon has occurred, though it is undoubtedly one of the most extreme. Other Pacific groups have a history of losing canoe, pottery, and bow technology (Rivers 1926). The Inuit were decimated by a plague and lost knowledge to construct kayaks, bows and arrows, and the leister, until it was reintroduced by migrants from Baffin Island (Rasmussen 1908; Golden 2006). Michelle Kline and Robert Boyd detected a similar trend in Oceania (Kline and Boyd 2010: 2559–2564). The ecological similarity between these environments allowed Kline and Boyd to focus on fishing technology, preventing geographical differences from distorting the results. The groups also had a common cultural descent. The finding was that the number of tools and the complexity of them are higher in larger well-connected populations. Zenobia Jacobs, Bert Roberts, Hilary Deacon, and Lyn Wadley have determined that there was a Tasmanian Effect at Still Bay 72,000 years ago and Howieson's Poort 64,000 years ago (Jacobs *et al.* 2008: 733–735; Wadley *et al.* 2009: 9590–9594). At Still Bay, humans created highly complex flake technology, including finely shaped, bifactually worked spearheads. At Howieson's Poort, humans created composite weapons and stone artifacts, both of which were hafted. These two sites were more innovative than much else in Middle Stone Age Africa, and an increasingly complex social organization is implied by the use of bone tools, symbols, and personal ornaments. The strange thing is that these two industrious cultures are separated by several thousand years of stagnation and total disappearance of their technologies. And the differences between the way the technologies of Still Bay and Howieson's Poort are constructed implies that when Still Bay disappeared, the innovators of Howieson's Poort started from scratch. Both cultures intriguingly fall within the genetic bottleneck that occurred 80–60,000 years ago (Jacobs *et al.* 2008: 733). It would appear a relatively low carrying capacity for hunter-gatherers ranging across a territory, the small size of their groups, and their vulnerability to ecological changes and disasters made the disappearance of knowledge more common in the Palaeolithic. The Tasmanian Effect is not just confined to hunter-gatherer societies, however, though due to the low connectivity and small populations of those societies it may be more common. The Tasmanian Effect can also occur in agrarian civilizations. It occurred in the post-Roman West in the fourth, fifth and sixth centuries AD. We must make clear, however, that this trend was not mirrored in the Roman-Byzantine East, which underwent a different population trend, including growth through the fourth, fifth, and into the sixth centuries AD. The extreme settlement abandonment of the Roman West, started in 350, intensified by the Germanic invasions, and then further exacerbated by the bubonic plague of Justinian, reduced the already sparse and illiterate population to low levels. The loss of technology and expertise is reflected in the decline of various artisanal practices, pottery methods, military equipment and architectural knowledge (Murray-Driel 2001: 56–64; Pugsley 2001: 112–115; Ward-Perkins 1999: 227–232; Arthur 2007: 181; Mannoni 2007: xlv-xlvii; Knight 2007: 100; Rossiter 2007: 115; Bishop and Coulston 1993: 122–149; Coulston 2002: 23; Williams 2002: 45–49; Murray 1986: 31–32; King 2001: 26–28). It remained to subsequent generations to rediscover classical learning and devise new methods to make up for this shortfall and raise the carrying capacity once again. The process of recovery from the Tasmanian Effect took Western Europe more than 700 years.

IV. Song China and Industrial Britain: The Two 'Great Divergences'

In the past two millennia, certain key innovations in Song China and Industrial Britain have prompted an explosion of growth in collective learning, bringing humanity ever closer to industrialization. There were other periods in human history which arguably could be deemed as 'explosions' of collective learning (the Axial Age, the Renaissance, the Enlightenment, the Scientific Revolution, *etc.*) but what is notable about Song China and Industrial Britain is that they were explosions in collective learning that prompted one world zone to tear ahead of their contemporaries in that time period. Hence, scholars often use the phrase 'great divergence' as popularised by Ken Pomeranz (2000). This term has so far applied to the industrial divergence that separated 'West from rest', but taken within the context of collective learning it can also apply to an earlier period.

The first great divergence was in Song China in the ninth and tenth centuries AD which led to something staggeringly similar to the rates of innovation and production seen in the Industrial Revolution. In the sixth century BC, the carrying capacity of China was already ahead of ancient Europe. China was already growing crops in rows, paying attention to weeding, and frequently employing iron ploughs. All of these innovations would not be employed in Europe for centuries. The Chinese also used horse harnesses by the third century BC, avoiding the risk of strangulation by a horse and permitting them to carry ploughs and heavy equipment. The seed drill came into use by the second century BC. In the first-second century BC, the types of mouldboard ploughs that only became available in Europe after Charlemagne were already in use in China (Temple 1986: 15–20). At the time, the majority of the Chinese population concentrated in the north in the Yellow River valley where they farmed millet and wheat – not rice (Ponting 1991: 93). Even before the explosion of wet rice agriculture in China, these innovations served to create a higher agricultural output and carrying capacity compared with Roman Europe centred on the Mediterranean Sea, both in the East and especially the sparsely populated backwater that was the Roman West.

Until the first millennium AD, both world zones had supported themselves mainly on grain products, with the Chinese sustaining a higher carrying capacity than Europe due to better agricultural practices. Even further divergence happened between 500 and 1000 AD with the spread of wet rice production in China, which has a much higher yield than grain. Per hectare, traditional varieties of rice support around 5.63 people compared to 3.67 people on a hectare of wheat (Fernandez-Armesto 2001: 105). Dry rice farming came first. However, it has a carrying capacity that is not much higher than wheat. The problem is that dry rice farming requires constant weeding (Woods and Woods 2000: 50). It was also ill-suited to the climate of northern China. In the north, millet farming in the Yellow River valley began in 6,000 BC (Higman 2012: 23). By 200 BC, the Han north was sustained by the farming of millet and wheat in an inefficient two-crop rotation. The inhospitable soils and temperatures of the Yellow River valley in the north usually permitted only one crop a year. From AD 1, wheat was immediately planted after millet or soy to increase crop frequency. In order to avoid too much loss of nutrients from repeated planting, the crop was often planted in alternating furrows, with new furrows being planted in between the old ones. The Han plough had limited depth of ploughing. Over-seeding was sometimes used to save labour at the expense of the yield (Hsu 1980: 112–114).

Meanwhile, in southern China, rice was domesticated in 7,000 BC along the Yangtze River and by 3,000 BC, a large-scale wet rice farming was present (Chi and Hung 2010: 11–25; Zheng *et al.* 2009: 2609–2616). For several thousand years, the yield was still relatively low because farmers did not employ terracing and paddy systems. Instead, wet rice was grown beside streams and in small irrigated plots (Simmons 1996: 99). This is the reason why northern China held the bulk of the population despite a long history of wet rice farming in the south. Nevertheless, wet rice farming even without terracing and paddies was fairly productive. In the third century BC, the Qin Emperor Shi Huangdi constructed a 20-mile canal to facilitate transport of wet rice from southern China to the populous north (Headrick 2009: 43). Slowly but surely the carrying capacity was being raised. Finally, labour intensive methods of terracing and paddies caught on in southern China in AD 200 (Chang 2003: 16). The employment of a crop with much higher yields than grain and that can sustain higher population densities, might go some way to explaining the higher rate of collective learning and innovation that set these civilizations ahead of other zones in Eurasia in terms of population and cultural complexity.

At the fall of the Han dynasty, the barbarian attacks forced more Chinese south to the Yangtze River basin. The reunification under the Sui in AD 589 made the region more stable, and rice expansion and the migration of the northern population to the south continued in earnest (Ponting 1991: 93). Gradually, migration between AD 500 and 1300 transformed the agricultural output and population distributions of China, particularly intensifying in the Song dynasty (AD 960–1276). The Song government initiated a set of policies to shift agricultural production from the northern millet and wheat regions to the wet rice producing south. In 1012, the Song introduced a strain of rice from Vietnam that allowed for multiple harvests per year, or the alternation of rice in summer and wheat in winter. The government appointed 'master farmers' from local communities, who were to disseminate new farming techniques and knowledge of new tools, fertilizers, and irrigation methods. The Song also introduced tax breaks on newly reclaimed land and low-interest loans for farmers to invest in new agricultural equipment and crops (Bray 1986: 203). The Song encouraged terracing, created fields that were evenly flooded and trapped fertile silts from being washed away. In 1273, the Chinese government distributed 3,000 copies of *Essentials of Agriculture and Sericulture* to landowners in order to improve crop yields. Wet rice farming by this method produced two-three crops a year compared to the meagre one-crop harvest of the millet-producing north (Headrick 2009: 51–52, 85).

The adoption of wet rice farming and the migration of many people to the south had a profound impact on collective learning in Song China. In AD 1, the population of China was around 50–60 million and did not exceed that number level until the tenth century (Faser and Rimas 2010: 118). During the 900s and 1000s under the Song dynasty, migration to the Yangzi river valley to farm rice raised the carrying capacity of China from 50–60 million to 110–120 million, with record high population densities of 5 million people farming an area of 40×50 miles (Korotayev, Malkov, and Khaltourina 2005: 186–188). By 1100, this constituted 30–40 per cent of the population of the globe, compared to all Europe's 10–12 per cent as it just entered its 'Great Leap Forward' (Biraben 1979: 16). The population was raised, so was the density, and so the number and connectivity between potential innovators was increased. This really constitutes the first 'Great Divergence' between East and West, when Chinese collective learning advanced by leaps and bounds by a much higher carrying capacity. It is no coincidence that the Song dynasty was one of the most technologically advanced and industrially prodigious societies in pre-modern history, almost to the point that the late Song dynasty could conceivably have had an Industrial Revolution of their own. For instance, the annual minting and use of coin currency was increased greatly under the Song (Hansen 2000: 264). Farming techniques improved: the use of manure became more frequent, new strains of seed were developed, hydraulic and irrigation techniques improved, and farms shifted to crop specialization (Elvin 1973: 88). Coal was used to manufacture iron and iron production increased from 19,000 metric tons per year under the Tang (AD 618–907) to 113,000 metric tons under the Song (Hansen 2000: 264). The Song dynasty was the first to invent and harness the power of gunpowder. Textile production showed the first ever signs of mechanization (Pacey 1990: 47). Some surprisingly modern innovations in Song China did not arise in conjunction with an increased population, but the eleventh and twelth century innovations followed after the initial rise of the Chinese carrying capacity between AD 500 and 1000. The adoption of wet rice farming and the migration of the Chinese farmers from the northern grain producing region to the Yangzi River valley triggered a rise in the number of potential innovators and a Great Divergence that placed China as one of the largest, densest, and most productive regions of the globe from AD 900 to 1700 – at the very least.

The second explosion of collective learning was the Industrial Revolution itself. It was born out of a collection of small innovations that were selected and spread, combining into a feedback effect that significantly increased the carrying capacity of the human species. In 1709, Abraham Darby used coke to manufacture iron, inefficiently, until tinkering made the practice efficient enough in the 1760s to be selected and spread across Britain. Henry Cort invented a process in 1784 to create bars of iron without use of coke, further increasing efficiency (McClellan and Dorn 1999: 279–281). In seventeenth century France, Denis Papin revived an invention that was known to the Romans, the Chinese, and many other cultures using atmospheric pressure, later worked on by Englishman Thomas Savery, and eventually producing Thomas Newcomen's steam engine in 1712. More tinkering and the harnessing of a steam engine to power a blast furnace for iron production in 1742 also raised production. From there James Watt tinkered with the steam engine in the 1760s making it even more efficient (*Ibid.*: 282). In textiles, the Dutch innovations using waterwheels and the Italian factory plans were brought into England and further innovated into textile production in the 1730s. Three more innovations in the 1780s – the waterframe, the spinning jenny, and the spinning mule, all built on these innovations – transformed cotton to a common commodity rather than a luxury good (Mokyr 1990: 96–98, 111). Once the steam engine was brought into these innovations, the production efficiency advanced even more. From here the steam engine was also brought in to enhance locomotion. The nineteenth century saw this advanced capacity for production and innovation spread into almost every industry and across Europe and the globe. Much of the initial practices that led to the spark of industry were familiar in medieval China, but it was these cultural variations that came together at the right time in the right place to raise the carrying capacity and produce a Cambrian explosion of further innovation (Pacey 1990: 113; Mokyr 1990: 84–85; Needham 1970: 202). In many ways, it was a matter of chance. The occurrence of variation and selection is the key to the advance of collective learning. Conditions have to be just right, there has to be an available niche, and certain cultural variations have to be able to combine to produce material breakthroughs.

V. Collective Learning and the Rise of Complexity

From here collective learning has delivered us to the increased amount of energy, production, and almost instantaneous connectivity that we enjoy today. We have split the atom, revealing for the first time a microcosm of the massive amounts of energy that have radiated for billions of years out from the heart of the sun. We have established highly efficient forms of mass transportation, by sea, land, and air. We have seen the birth and expansion of the Internet, which ties the entire globe of potential innovators together into one community of lightening fast communication. The world's population has just passed seven billion, providing us with an increasing number of potential innovators. Provided we do not exhaust the resources of the planet in the same way that agrarian civilizations occasionally exhausted the resources of the field, we may be facing another explosion of innovation quite soon that shall look as different from the technologies of the industrial and post-industrial eras as factories and assembly lines differ from the implements of early agriculture. Collective learning not only defines our past and present, but our future as well. From this source radiates greater and greater amounts of complexity.

It is important to look at how collective learning ties into the broader Big History themes developed by Eric Chaisson and Fred Spier: the rise of complexity in the Universe and energy flows. It would appear that collective learning plays a direct mechanistic role in increasing the level of free energy rate density and also the number of available cultural variations and technological innovations. This raises the level of complexity in the Universe, just as solar, chemical, and biological evolution do.

Collective learning and rising complexity also ties into Universal Darwinism, an algorithm of random variation and non-random selection, which I have explored in other works (Baker 2011a, 2013, 2014). Variations emerge from collective learning on an unprecedented scale. By comparison, few variations emerge from the chaos of the quantum realm to the Newtonian physical realm, only about a hundred elements emerge from stellar evolution, a few thousand variations emerge from chemical/mineral evolution, millions of variations emerge in the biological realm, and in cultural evolution and collective learning the many variations of innovation are increased further still.

At each stage the free energy rate density increases, as does the magnitude of energy that can be harnessed. And it would appear that the number of possible outcomes is relative to the complexity of the process under discussion. When we arrive at something as complex as culture and modern human society, with a free energy rate density that is many times higher than the average product of genetic evolution and four million times higher than a galaxy, there are a mind-boggling number of cultural and technological combinations. Essentially, if you were to take a human brain and a brain sized chunk of a star, there is no question that the former would have a much higher density of free energy at any given time. The rate of complexity seems to increase with the number of viable selection paths.

Table 1. Amount of free energy running through a gram per second, and the australopithecine and human free energy rate density is determined from the average energy consumption of an individual (Chaisson 2010: 28, 36)

Generic Structure	Average Free Energy Rate Density (erg/s/g)
Galaxies	0.5
Stars	2
Planets	75
Plants	900
Animals (*i.e.* human body)	20,000
Australopithecines	22,000
Hunter-Gatherers (*i.e.* 250,000–10,000 years ago)	40,000
Agriculturalists (*i.e.* 10,000–250 years ago)	100,000
Industrialists (*i.e.* 1800–1950)	500,000
Technologists (*i.e.* present)	2,000,000

It would appear, for the time being, that collective learning and the complexity it bestows is the highest point in this process of which we are yet aware. There are two tiers of human evolution. The first is genetics, which operates in the same way as for other organisms. Those genes gave humans a large capacity for imitation and communication. Those two things enabled the second tier. Culture operates under similar laws, but on a much faster scale. Cultural variations are subject to selection and the most beneficial variations are chosen. Unlike genes, these variations can be transmitted between populations of the same generation and can be modified numerous times *within* that generation. Like a highway overpass looming over older roads, collective learning can blaze along at a much faster rate of speed.

We do not yet know where this tremendous capacity for collective learning will lead. It is likely to reveal even higher levels of complexity in the future, if we do not wipe ourselves out. When it comes to the broader trend in the Universe, it is fairly clear that the next rise of complexity will be down to animate rather than inanimate physical processes. As stars burn down, as planetesimals tumble through cold space, it may be that species like us, with a tremendous ability for collective learning and harnessing energy flows, will reveal even more remarkable phases of cosmic evolution. In that sense, collective learning tells us not only about human history, but about the overwhelming thrust of human destiny in a rising crescendo of complexity. That is, if we do not go extinct beforehand. An asteroid collision, a volcanic super-eruption, or a nuclear war could wipe the slate clean. Eventually the Sun will destroy the Earth. Even in the short term, as the twenty-first century appears to deepen further into crisis, the entire arc of collective learning could come very abruptly to an end. We shall then never know where collective learning might have led us or what we might have achieved as a population of billions of increasingly educated and well connected innovators. Mankind's great task in the twenty-first century is to survive it.

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Mathematical Modeling of Biological and Social Phases of Big History*

Andrey V. Korotayev and Alexander V. Markov

The present article demonstrates that changes in biodiversity through the Phanerozoic correlate with a hyperbolic model (widely used in demography and macrosociology) much more strongly than with exponential and logistic models (traditionally used in population biology and extensively applied to fossil biodiversity as well). The latter models imply that changes in diversity are guided by a first-order positive feedback (more ancestors – more descendants) and/or a negative feedback arising from resource limitation. The hyperbolic model implies a second-order positive feedback. The authors demonstrate that the hyperbolic pattern of the world population growth arises from a second-order positive feedback between the population size and the rate of technological growth (this can also be identified with the collective learning mechanism). The feedback between the diversity and community structure complexity can also contribute to the hyperbolic character of biodiversity. This suggests that some mechanisms vaguely resembling the collective learning might have operated throughout the biological phase of Big History. Our findings suggest that we can trace rather similar macropatterns within both the biological and social phases of Big History which one can describe in a rather accurate way with very simple mathematical models.

Keywords: *biological phase of Big History, social phase of Big History, mathematical modeling, collective learning, positive feedback, biodiversity, demography, sociology, paleontology, geology, hyperbolic growth.*

In 2005, in the town of Dubna, near Moscow, at what seems to have been the first ever international conference devoted specifically to Big History studies, the two authors of the present article – sociologist/anthropologist Andrey Korotayev and biologist/paleontologist Alexander Markov – one after another demonstrated two diagrams.[1] One of those diagrams illustrated the dynamics of the population of China between 700 BCE and 1851 CE, the other illustrated the dynamics of marine Phanerozoic biodiversity during the last 542 million years (see Fig. 1):

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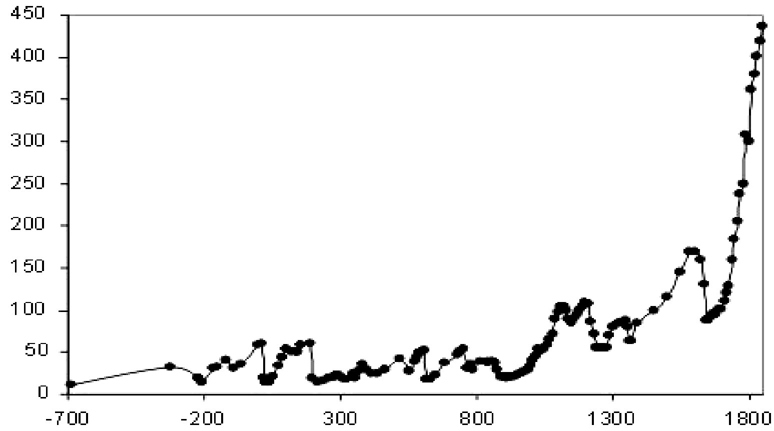
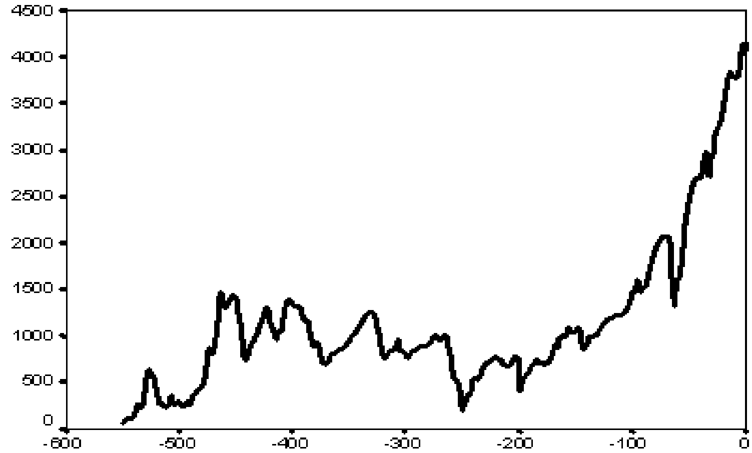
[1] We would like to emphasize that we saw each other at that session for the first time, so we had no chance to arrange in advance the demonstration of those two diagrams.



a)



b)

Fig. 1. Similarity of the dynamics of Phanerozoic marine biodiversity and long-term population dynamics of China: a) – Population dynamics of China (million people, 700 BCE – 1851 CE), based on estimates in Korotayev, Malkov, and Khaltourina (2006b: 47–88); b) – Global change in marine biodiversity (number of genera, *N*) through the Phanerozoic based on empirical data surveyed in Markov and Korotayev (2007a)

Nevertheless, one can hardly ignore the striking similarity between two diagrams depicting the development of rather different systems (human population, on the one hand, and biota, on the other) at different time scales (hundreds of years, on the one hand, and millions of years, on the other) studied by different sciences (Historical Demography, on the one hand, and Paleontology, on the other) using different sources (demographic estimates, on the one hand, and paleontological chronicles, on the other hand). What are the causes of this similarity in the development dynamics of rather different systems?

* * *

In 1960, von Foerster, Mora, and Amiot published a striking discovery in the journal *Science*. They showed that between 1 and 1958 CE the world's population (N) dynamics can be described in an extremely accurate way with an astonishingly simple equation:[2]

$$N_t = \frac{C}{t_0 - t}, \qquad (1)$$

where N_t is the world population at time t, and C and t_0 are constants, with t_0 corresponding to an absolute limit ('singularity' point) at which N would become infinite.

Of course, von Foerster and his colleagues did not imply that one day the world population would actually become infinite. The real implication was that prior to 1960 the world population growth for many centuries had followed a pattern which was about to come to an end and to transform into a radically different pattern. Note that this prediction started to come true only a few years after the 'Doomsday' paper had been published, because *after the early 1970s the World System growth in general (and world population growth in particular) began to diverge more and more from the blow-up regime, and now it is not hyperbolic any more with its pattern being closer to a logistic one* (see, *e.g.*, Korotayev, Malkov, and Khaltourina 2006a, where we present a compact mathematical model that describes both the hyperbolic development of the World System in the period prior to the early 1970s, and its withdrawal from the blow-up regime in the subsequent period; see also Korotayev 2009).

Parameter t_0 was estimated by von Foerster and his colleagues as 2026.87, which corresponded to November 13, 2006; this allowed them to give their article an attractive and remarkable title – 'Doomsday: Friday, 13 November, A.D. 2026'.

The overall correlation between the curve generated by the von Foerster equation and the most detailed series of empirical estimates looks as follows (see Fig. 2).

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[2] To be exact, the equation proposed by von Foerster and his colleagues looked as follows: $N_t = \frac{C}{(t_0 - t)^{0.99}}$. However, as von Hoerner (1975) and Kapitza (1999) showed, it can be simplified as $N_t = \frac{C}{t_0 - t}$.

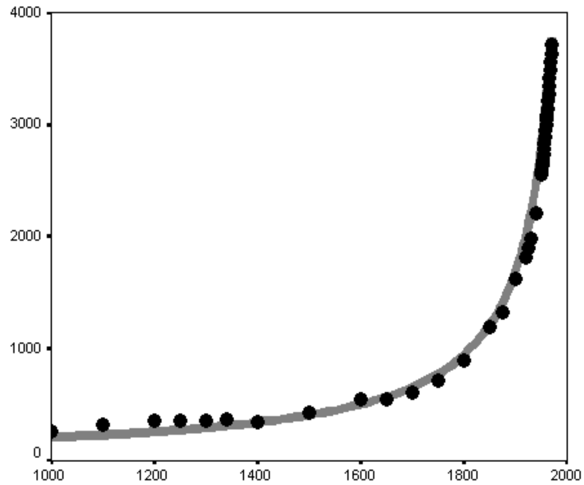

Fig. 2. Correlation between empirical estimates of world population (in millions, AD 1000–1970) and the curve generated by the von Foerster equation

Note: black markers correspond to empirical estimates of the world population by McEvedy and Jones (1978) for the interval between 1000 and 1950 and the U.S. Bureau of the Census (2014) for 1950–1970. The grey curve has been generated by the von Foerster equation (1).

The formal characteristics are as follows: $R = 0.998$; $R^2 = 0.996$; $p = 9.4 \times 10^{-17} \approx 1 \times 10^{-16}$. For readers unfamiliar with mathematical statistics we can explain that R^2 can be regarded as a measure of the fit between the dynamics generated by a mathematical model and the empirically observed situation, and can be interpreted as the proportion of the variation accounted for by the respective equation. Note that 0.996 also can be expressed as 99.6 per cent.[3] Thus, the von Foerster equation accounts for an astonishing 99.6 per cent of all the macrovariation in the world population, from 1000 CE through 1970, as estimated by McEvedy and Jones (1978) and the U.S. Bureau of the Census (2014).[4]

Note also that the empirical estimates of world population align in an extremely accurate way along the hyperbolic curve, which convincingly justifies the designation of the pre-1970s world population growth pattern as 'hyperbolic'.

To start with, the von Foerster equation $N_t = \frac{C}{t_0 - t}$ is just a solution of the following differential equation (see, *e.g.*, Korotayev, Malkov, Khaltourina 2006a: 119–20):

[3] The second characteristic (p, standing for 'probability') is a measure of the correlation's statistical significance. A bit counter-intuitively, the lower the value of p, the higher the statistical significance of the respective correlation. This is because p indicates the probability that the observed correlation could be accounted solely by chance. Thus, $p = 0.99$ indicates an extremely low statistical significance, as it means that there are 99 chances out of 100 that the observed correlation is the result of a coincidence, and, thus, we can be quite confident that there is no systematic relationship (at least, of the kind that we study) between the two respective variables. On the other hand, $p = 1 \times 10^{-16}$ indicates an extremely high statistical significance for the correlation, as it means that there is only one chance out of 10000000000000000 that the observed correlation is the result of pure coincidence (in fact, a correlation is usually considered as statistically significant with $p < 0.05$).

[4] In fact, with slightly different parameters ($C = 164890.45$; $t_0 = 2014$) the fit (R^2) between the dynamics generated by the von Foerster equation and the macrovariation of world population for CE 1000–1970 as estimated by McEvedy and Jones (1978) and the U.S. Bureau of the Census (2014) reaches 0.9992 (99.92 per cent), whereas for 500 BCE – 1970 CE this fit increases to 0.9993 (99.93 per cent) (with the following parameters: $C = 171042.78$; $t_0 = 2016$).

$$\frac{dN}{dt} = \frac{N^2}{C}. \quad (2)$$

This equation can be also written as:

$$\frac{dN}{dt} = aN^2, \quad (3)$$

where $a = \frac{1}{C}$.

What is the meaning of this mathematical expression, $\frac{dN}{dt} = aN^2$? In our case, *dN/dt* denotes an absolute population growth rate at a certain moment of time. Thus, this equation shows that at any moment of time an absolute population growth rate should be proportional to the square of population at this moment.

Note that this significantly demystifies the problem of the world population hyperbolic growth. Now to explain this hyperbolic growth, we should just explain why for many millennia the absolute rate of world population growth tended to be proportional to the square of population.

The main mathematical models of the hyperbolic pattern of the world's population growth (Taagapera 1976, 1979; Kremer 1993; Cohen 1995; Podlazov 2004; Tsirel 2004; Korotayev 2005, 2007, 2008, 2009, 2012; Korotayev, Malkov, and Khaltourina 2006a: 21–36; Khaltourina, Malkov, and Korotayev 2006; Golosovsky 2010; Korotayev and Malkov 2012) are based on the following two assumptions:

1) 'the Malthusian (1978 [1798]) assumption that population is limited by the available technology, so that the growth rate of population is proportional to the growth rate of technology' (Kremer 1993: 681–682).[5] This statement seems rather convincing. Indeed, throughout most of human history the world population was limited by the technologically determined ceiling of land carrying capacity. For example, with foraging subsistence technologies the Earth could hardly support more than 8 million people, because the amount of naturally available useful biomass on the planet is limited, and the world population could overgrow this limit only when people started to apply various means to artificially increase the amount of available biomass, that is with a transition from foraging to food production. However, the extensive agriculture can only support a limited number of people, and world population further growth became possible only with the intensification of agriculture and other technological improvements (see, *e.g.*, Turchin 2003; Korotayev, Malkov, and Khaltourina 2006a, 2006b; Korotayev and Khaltourina 2006).

However, it is well known that the technological level is not a constant, but a variable (see, *e.g.*, Grinin 2007a, 2007b, 2012). And in order to describe its dynamics the second basic assumption is employed:

2) 'High population spurs technological change because it increases the number of potential inventors…[6] In a larger population there will be proportionally more people lucky or smart enough to come up with new ideas' (Kremer 1993: 685), thus, 'the growth rate of

[5] In addition to this, the absolute growth rate is proportional to the population number – with a given relative growth rate a larger population will increase more in absolute numbers than a smaller one.

[6] 'This implication flows naturally from the non-rivalry of technology… The cost of inventing a new technology is independent of the number of people who use it. Thus, holding constant the share of resources devoted to research, an increase in population leads to an increase in the probability of technological change' (Kremer 1993: 681); note that in the framework proposed by David Christian (2005) this corresponds precisely to the pattern of *collective learning*.

technology is proportional to total population'.[7] In fact, here Kremer uses the main assumption of the Endogenous Technological Growth theory (Kuznets 1960; Grossman and Helpman 1991; Aghion and Howitt 1998; Simon 1977, 2000; Komlos and Nefedov 2002; Jones 1995, 2005, *etc.*). To our knowledge, this supposition was first put forward by Simon Kuznets (1960), so we will denote a corresponding type of dynamics as 'Kuznetsian', while the systems in which the 'Kuznetsian' population-technological dynamics combines with the 'Malthusian' demographic one will be denoted as 'Malthusian-Kuznetsian'. In general, we find this assumption rather plausible – in fact, it is quite probable that, ceteris paribus, within a given period of time, a billion people will make approximately a thousand times more inventions than a million people.

This assumption was expressed by Kremer mathematically in the following way:

$$\frac{dT}{dt} = kNT \quad . \qquad (4)$$

Actually, this equation just says that the absolute technological growth rate at a given moment of time (dT/dt) is proportional to the technological level (T) observed at this moment (the wider is the technological base, the more inventions could be made on its basis), and, on the other hand, it is proportional to the population (N) (the larger the population, the larger the number of potential inventors).[8]

The resultant models provide a rather convincing explanation of *why* throughout most of human history the world population followed the hyperbolic pattern with an absolute population growth rate tending to be proportional to N^2. For example, why would the growth of population from, say, 10 million to 100 million, result in the hundredfold growth of dN/dt? The above mentioned models explain this rather convincingly. The point is that the growth of world population from ten to a hundred million implies that human subsistence technologies also grew approximately ten times (given that it will prove, after all, to be able to support a ten times larger population). On the other hand, the tenfold population growth also implies a tenfold growth of the number of potential inventors, and, consequently, a tenfold increase in a relative technological growth rate. Hence, the absolute technological growth rate would grow 10 × 10 = 100 times (as Equation 4 shows that an order of magnitude larger number of people with an order of magnitude broader technological basis would likely make two orders of magnitude more inventions). And as throughout the Malthusian epoch the world population (N) tended to the technologically determined carrying capacity ceiling of the Earth*,* we have good reason to expect that dN/dt will also grow just about 100 times.

In fact, one can demonstrate (see, *e.g.*, Korotayev, Malkov, and Khaltourina 2006a, 2006b; Korotayev and Khaltourina 2006) that the hyperbolic pattern of the world's population growth can be explained by the nonlinear second order positive feedback mechanism that was shown long ago to generate just the hyperbolic growth, known also as the 'blow-up regime'(see, *e.g.*, Kurdyumov 1999). In our case this nonlinear second order positive feedback looks as follows: more people – more potential inventors – a faster technological growth – a faster growth of the Earth's carrying capacity – a faster population growth – with more people you also have more potential inventors – hence, faster technological growth, and so on (see Fig. 3).

[7] Note that 'the growth rate of technology' means here the relative growth rate (*i.e.* the level to which technology will grow in a given unit of time in proportion to the level observed at the beginning of this period).

[8] Kremer did not test this hypothesis empirically in a direct way. Note, however, that our own empirical test of this hypothesis has supported it (see Korotayev, Malkov, Khaltourina 2006b: 141–146).

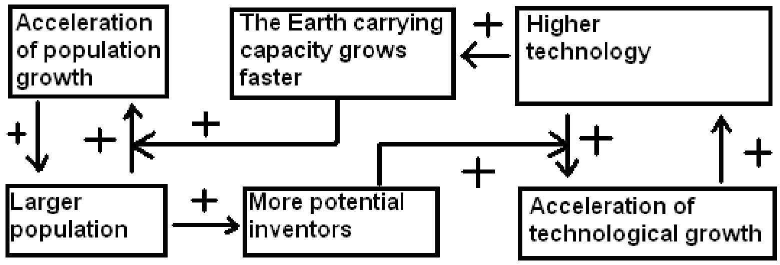

Fig. 3. Cognitive scheme of the nonlinear second order positive feedback between technological development and demographic growth

Note that the relationship between technological development and demographic growth cannot be analyzed through any simple cause-and-effect model, as we observe a true dynamic relationship between these two processes – each of them is both the cause and the effect of the other.

Note also that *the process discussed above should be identified with the process of collective learning* (on the notion of 'collective learning' see first of all Christian 2005: 146–148; see also David Christian's and David Baker's contributions to the present volume). Respectively, the mathematical models of the World System development discussed in this article can be interpreted as mathematical models of the influence of collective learning on the global social evolution. Thus, a rather peculiar hyperbolic shape of the acceleration of the global development observed prior to the early 1970s may be regarded just as a product of the global collective learning. Elsewhere we have also shown (Korotayev, Malkov, and Khaltourina 2006a: 34–66) that for the period prior to the 1970s the World System economic and demographic macrodynamics driven by the above mentioned positive feedback loops can be described mathematically in a rather accurate way with the following extremely simple mathematical model:

$$\frac{dN}{dt} = aSN, \qquad (5)$$

$$\frac{dS}{dt} = bNS, \qquad (6)$$

while the world GDP (G) can be calculated using the following equation:

$$G = mN + SN, \qquad (7)$$

where G is the world GDP, N is population, and S is the produced surplus per capita, over the subsistence amount (m) that is minimally necessary to reproduce the population with a zero growth rate in a Malthusian system (thus, $S = g - m$, where g denotes per capita GDP); a and b are parameters.

Note that the mathematical analysis of the basic model (not presented here) suggests that up to the 1970s the amount of S (per capita surplus produced at the given level of World System development) should be proportional, in the long run, to the World System's population: $S = kN$. Our statistical analysis of the available empirical data has confirmed this theoretical proportionality (Korotayev, Malkov, and Khaltourina 2006a: 49–50). Thus, in the right-hand side of equation (6) S can be replaced with kN, and as a result we arrive at the following equation:

$$\frac{dN}{dt} = kaN^2. \qquad (3)$$

As we remember, the solution of this type of differential equations is

$$N_t = \frac{C}{(t_0 - t)}, \quad (1)$$

and this produces simply a hyperbolic curve.

As, according to our model, S can be approximated as kN, its long-term dynamics can be approximated with the following equation:

$$S = \frac{kC}{t_0 - t}.$$

Thus, the long-term dynamics of the most dynamic component of the world GDP, SN, 'the world surplus product', can be approximated as follows:

$$SN = \frac{kC^2}{(t_0 - t)^2}. \quad (8)$$

Of course, this suggests that the long-term world GDP dynamics up to the early 1970s must be approximated better by a quadratic hyperbola than by a simple one; and, as we could see below (see Fig. 4), this approximation works very effectively indeed:

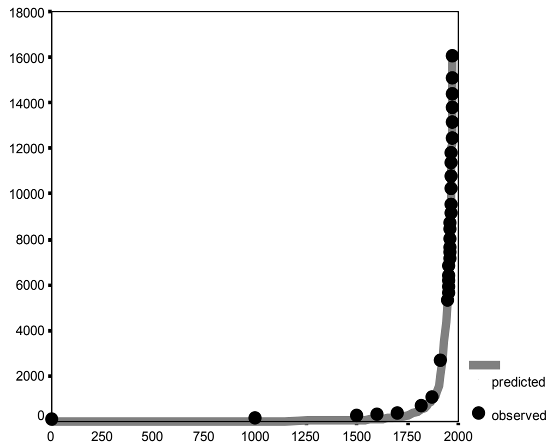

Fig. 4. World GDP Dynamics, 1–1973 CE (in billions of 1990 international dollars, PPP): the fit between predictions of a quadratic-hyperbolic model and the observed data

Note: $R = .9993$, $R^2 = .9986$, $p << .0001$. The black markers correspond to Maddison's (2001) estimates (Maddison's estimates of the world per capita GDP for 1000 CE has been corrected on the basis of [Meliantsev 2004]). The grey solid line has been generated by the following equation:

$$G = \frac{17749573.1}{(2006 - t)^2}.$$

Thus, up to the 1970s the hyperbolic growth of the world population was accompanied by the quadratic-hyperbolic growth of the world GDP, just as our model suggests. Note that the hyperbolic growth of the world population and the quadratic-hyperbolic growth of the world GDP are tightly interconnected processes, actually two sides of the same coin, two dimensions of one process propelled by the nonlinear second order positive feedback loops between the technological development and demographic growth (see Fig. 5).

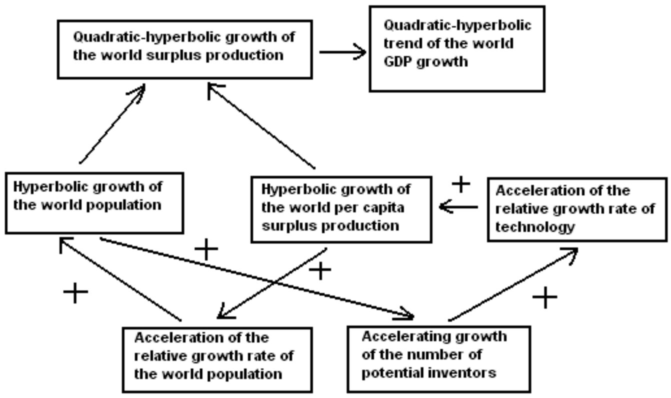

Fig. 5. Cognitive Scheme of the Generation of Quadratic-Hyperbolic Trend of the World Economic Growth by the Nonlinear Second Order Positive Feedback between Technological Development and Demographic Growth

We have also demonstrated (Korotayev, Malkov, and Khaltourina 2006a: 67–80) that the dynamics of the World System population's literacy (l) is rather accurately described by the following differential equation:

$$\frac{dl}{dt} = aSl\,(1-l), \tag{9}$$

where l is the proportion of the population that is literate, S is per capita surplus, and a is a constant. In fact, this is a version of the autocatalytic model. It has the following sense: the increasing literacy is proportional to the fraction of the population that is literate, l (potential teachers), to the fraction of the population that is illiterate, $(1 - l)$ (potential pupils), and to the amount of per capita surplus S, since it can be used to support educational programs (in addition to this, S reflects the technological level T that implies, among other things, the level of development of educational technologies). Note that, from a mathematical point of view, Equation 9 can be regarded logistic where saturation is reached at literacy level $l = 1$, and S is responsible for the speed with which this level is approached.

It is important to emphasize that with low values of l (which correspond to most part of human history except for the recent decades), the increasing rate of the world literacy generated by this model (against the background of hyperbolic growth of S) can be approximated rather accurately as hyperbolic (see Fig. 6).

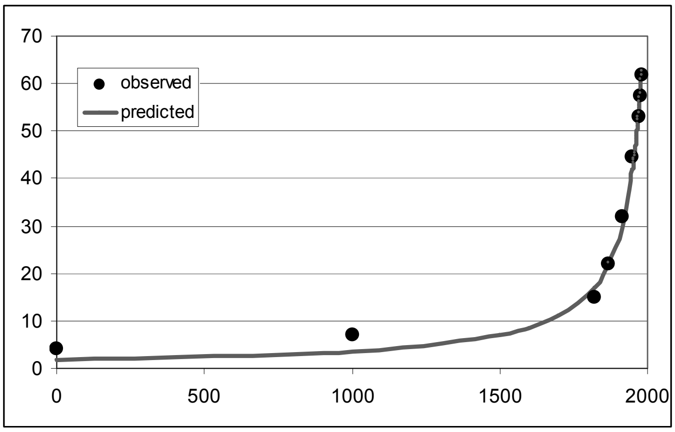

Fig. 6. World Literacy Dynamics, 1 – 1980 CE (%%): the fit between predictions of the hyperbolic model and the observed data

Note: $R = 0.997$, $R^2 = 0.994$, $p << 0.0001$. Black dots correspond to UNESCO/World Bank (2014) estimates for the period after 1970, and to Meliantsev's (2004) estimates for the earlier period. The grey solid line has been generated by the following equation:

$$l_t = \frac{3769.264}{(2040 - t)^2} .$$

The best-fit values of parameters C (3769.264) and t_0 (2040) have been calculated with the least squares method.

The overall number of literate people is proportional both to the literacy level and to the overall population. As both of these variables experienced a hyperbolic growth until the 1960s/1970s, one has sufficient grounds to expect that until recently the overall number of literate people in the world (L)[9] grew not just hyperbolically, but rather in a quadratic-hyperbolic way (as the world GDP did). Our empirical test has confirmed this – the quadratic-hyperbolic model describes the growth of the literate population of the planet with an extremely good fit indeed (see Fig. 7).

[9] Since literacy appeared, almost all of the Earth's literate population has lived within the World System; hence, the literate population of the Earth and the literate population of the World System have been almost perfectly synonymous.

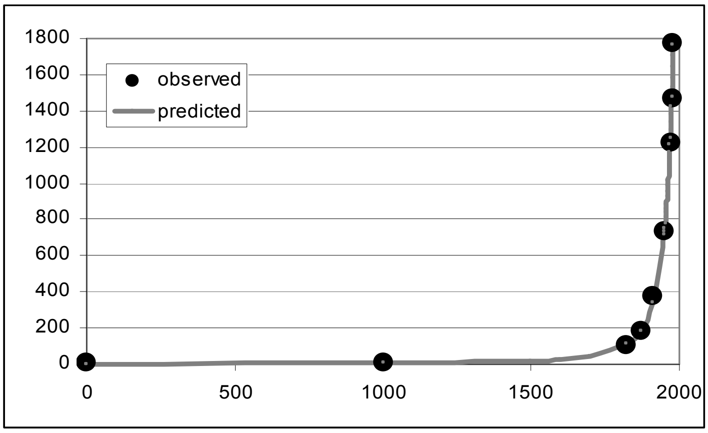

Fig. 7. World Literate Population Dynamics, 1–1980 CE (*L*, millions): the fit between predictions of the quadratic-hyperbolic model and the observed data

Note: $R = 0.9997$, $R^2 = 0.9994$, $p << 0.0001$. The black dots correspond to UNESCO/World Bank (2014) estimates for the period since 1970, and to Meliantsev's (2004) estimates for the earlier period; we have also taken into account the changes of age structure on the basis of UN Population Division (2014) data. The grey solid line has been generated by the following equation:

$$L_t = \frac{4958551}{(2033 - t)^2}.$$

The best-fit values of parameters *C* (4958551) and t_0 (2033) have been calculated with the least squares method.

Similar processes are observed with respect to world urbanization, whose macro dynamics appears to be described by the differential equation:

$$\frac{du}{dt} = bSu\ (u_{\lim} - u)\ ,$$

where *u* is the proportion of the population that is urban, *S* is per capita surplus produced with the given level of the World System's technological development, *b* is a constant, and $u_{\lim}$ is the maximum possible proportion of the urban population. Note that this model implies that during the blow-up regime of the 'Malthusian-Kuznetsian' era, the hyperbolic growth of world urbanization must have been accompanied by a quadratic-hyperbolic growth of the urban population of the world, which is supported by our empirical tests (see Figs 8–9).

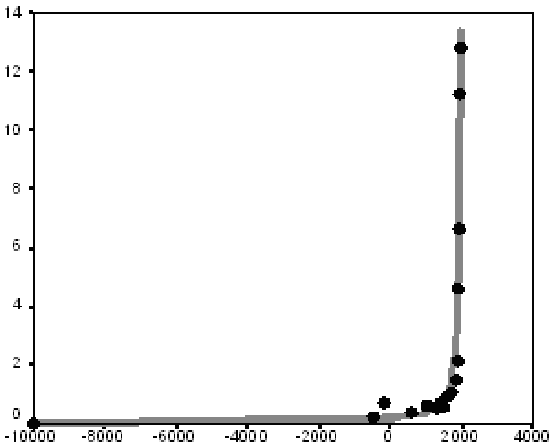

Fig. 8. World Megaurbanization Dynamics (% of the world population living in cities with > 250 thousand inhabitants), 10000 BCE – 1960 CE: the fit between predictions of the hyperbolic model and empirical estimates

Note: $R = 0.987$, $R^2 = 0.974$, $p \ll 0.0001$. The black dots correspond to Chandler's (1987) estimates, UN Population Division (2014), Modelski (2003), and Gruebler (2006). The grey solid line has been generated by the following equation:

$$u_t = \frac{403.012}{(1990 - t)}.$$

The best-fit values of parameters C (403.012) and t_0 (1990) have been calculated with the least squares method. For comparison, the best fit (R^2) obtained here for the exponential model is 0.492.

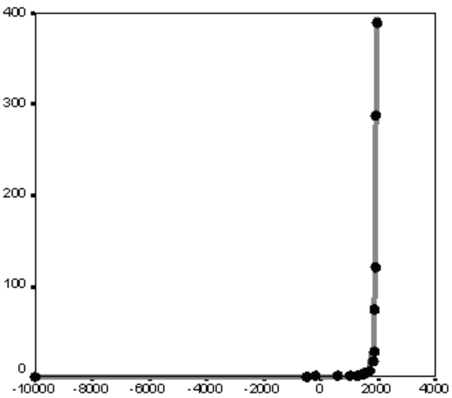

Fig. 9. Dynamics of World Urban Population Living in Cities with more than 250,000 Inhabitants (mlns), 10000 BCE – 1960 CE: the fit between predictions of the quadratic-hyperbolic model and the observed data

Note: $R = 0.998$, $R^2 = 0.996$, $p \ll 0.0001$. The black markers correspond to estimates of Chandler (1987) and UN Population Division (2014). The grey solid line has been generated by the following equation:

$$U_t = \frac{912057.9}{(2008 - t)^2}.$$

The best-fit values of parameters C (912057.9) and t_0 (2008) have been calculated with the least squares method. For comparison, the best fit (R^2) obtained here for the exponential model is 0.637.

Within this context it is hardly surprising that the general macro dynamics of the size of the largest settlement within the World System is also quadratic-hyperbolic (see Fig. 10).

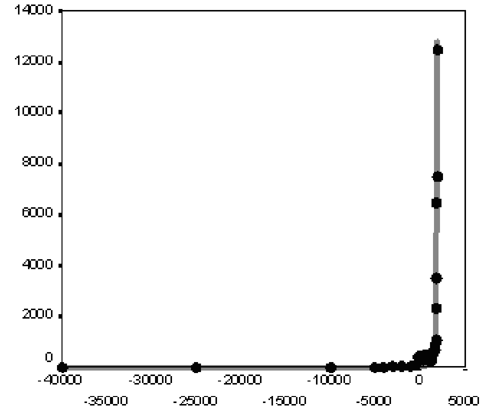

Fig. 10. Dynamics of Size of the Largest Settlement of the World (thousands of inhabitants), 10000 BCE – 1950 CE: the fit between predictions of the quadratic-hyperbolic model and the observed data

Note: $R = 0.992$, $R^2 = 0.984$, $p << 0.0001$. The black markers correspond to estimates of Modelski (2003) and Chandler (1987). The grey solid line has been generated by the following equation:

$$U_{\max t} = \frac{104020618.573}{(2040 - t)^2}.$$

The best-fit values of parameters C (104020618.5) and t_0 (2040) have been calculated with the least squares method. For comparison, the best fit (R^2) obtained here for the exponential model is 0.747.

As has been demonstrated by cross-cultural anthropologists (see, *e.g.*, Naroll and Divale 1976; Levinson and Malone 1980: 34), for pre-agrarian, agrarian, and early industrial cultures the size of the largest settlement is a rather effective indicator of the general sociocultural complexity of a social system. This, of course, suggests that in the 'Malthusian-Kuznetsian' era the World System's general sociocultural complexity also increased, in a generally quadratic-hyperbolic way.

As we have noted in the beginning, the dynamics of marine biodiversity is strikingly similar to the population dynamics in China, the country with the best-known demographic history.

The similarity probably stems from the fact that both curves are produced by the interference of the same three components (general hyperbolic trend, as well as cyclical and stochastic dynamics). In fact, there is a lot of evidence that some aspects of biodiversity dynamics are stochastic (Raup *et al.* 1973; Sepkoski 1994; Markov 2001a; Markov 2001b; Cornette and Lieberman 2004), while others are periodic (Raup and Sepkoski 1984; Rohde and Müller 2005). On cyclical and stochastic components of the long-term population dynamics of China (as well as other complex agrarian societies) see, *e.g.,* Korotayev and Khaltourina 2006; Korotayev, Malkov, and Khaltourina 2006*b*; Chu and Lee 1994; Nefedov 2004; Turchin 2003, 2005*a,* 2005*b*; Turchin and Korotayev 2006; Turchin and Nefedov 2009; Usher 1989; Komlos and Nefedov 2002; Grinin, Korotayev and Malkov 2008; Grinin *et al.* 2009; Grinin 2007c; Korotayev 2006; Korotayev, Khaltourina, and Bozhevolnov 2010; Korotayev *et al.* 2010; van Kessel-Hagesteijn 2009; Abel 1980; Braudel 1973; Goldstone 1991; Grinin, Korotayev 2012 *etc.*).

In fact, similarly to what we have observed with respect to the world population dynamics, even before the start of its intensive modernization, the population dynamics of China was characterized by a pronounced hyperbolic trend – as we can see below (see Figs 11 and 12), the hyperbolic model describes traditional Chinese population dynamics *much* more accurately than either linear or exponential models do:

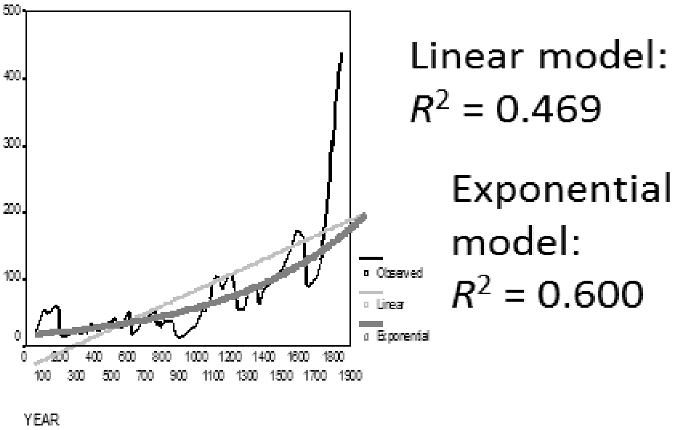

Fig. 11. Population Dynamics of China (million people), 57–1851 CE: fit with linear and exponential models

Note: based on calculations in Korotayev, Malkov, and Khaltourina 2006b: 47–88.

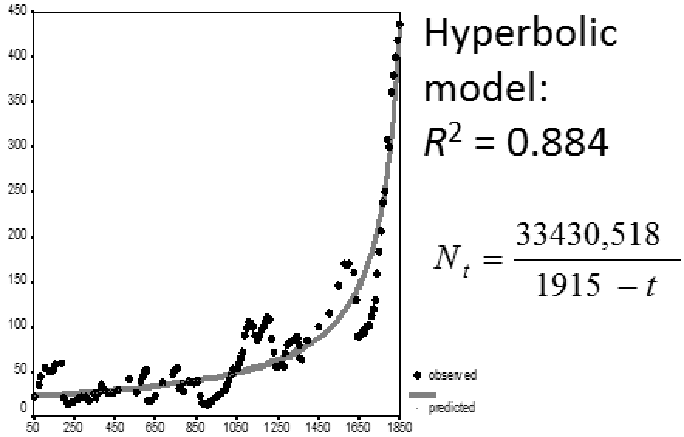

Fig. 12. Population Dynamics of China (million people), 57–1851 CE: fit with a hyperbolic model

The hyperbolic model turns out to describe mathematically the population dynamics of China in an especially accurate way with respect to the modern period (see Fig. 13).

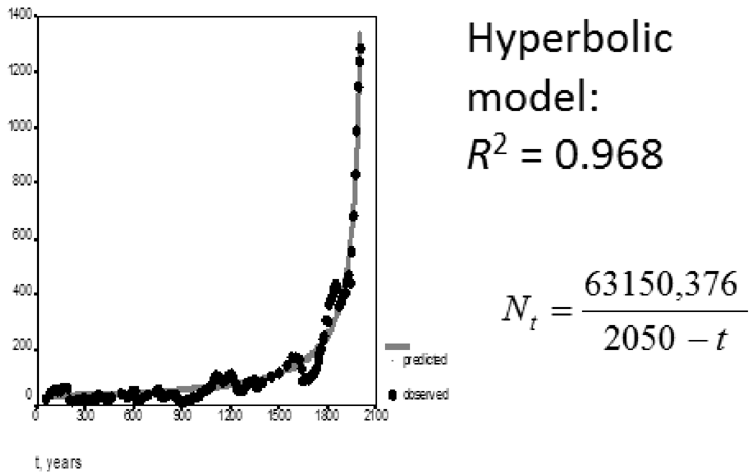

Fig. 13. Population Dynamics of China (million people), 57–2003 CE: fit with a hyperbolic model

Note: based on calculations in Korotayev, Malkov, and Khaltourina 2006b: 47–88.

In a rather similar way the hyperbolic model turns out to describe the marine biodiversity (measured by number of genera) through the Phanerozoic much more accurately than the exponential one (see Fig. 14):

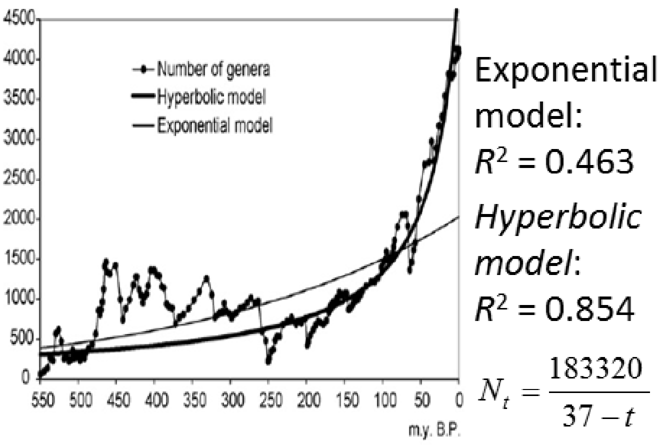

Fig. 14. Global Change in *Marine* Biodiversity (Number of *Genera*, N) through Phanerozoic

Note: based on empirical data surveyed in Markov and Korotayev (2007).

When measured in terms of species number the fit between the empirically observed marine biodiversity dynamics and the hyperbolic model becomes even better (see Fig. 15):

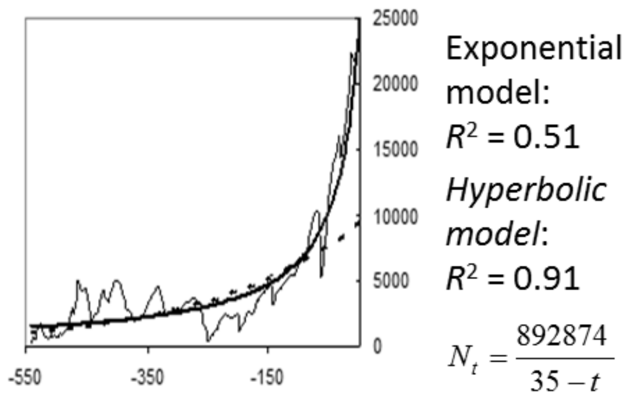

Fig. 15. Global Change in *Marine* Biodiversity (Number of *Specie*s, N) through Phanerozoic

Note: based on empirical data surveyed in Markov and Korotayev 2007b.

The hyperbolic model describes the continental biodiversity in an especially accurate way (see Fig. 16).

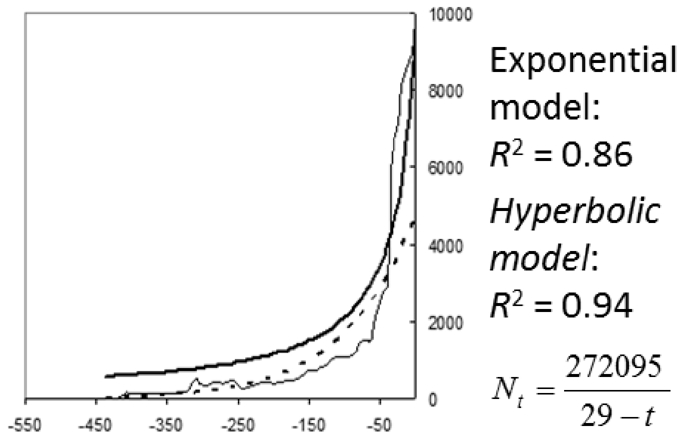

Fig. 16. Global Change in *Continental* Biodiversity (Number of *Genera*, N) through Phanerozoic

Note: based on empirical data surveyed in Markov and Korotayev 2007b.

However, the highest fit between the hyperbolic model and the empirical data is observed when the hyperbolic model is used to describe the dynamics of total (marine and continental) global biodiversity (see Fig. 17).

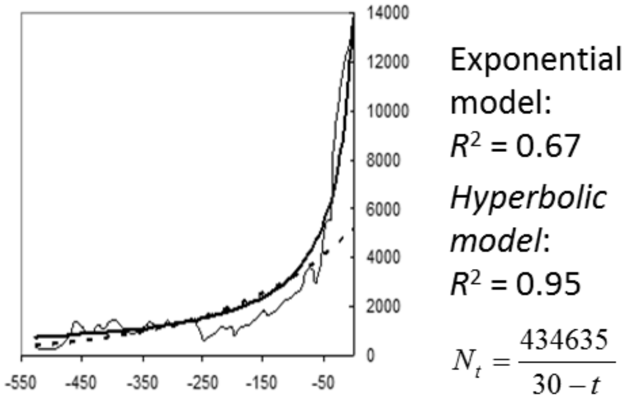

Fig. 17. Global Change in *Total* (Marine + Continental) Biodiversity (Number of Genera, N) through Phanerozoic

Note: based on empirical data surveyed in Markov and Korotayev 2007b.

As we see, the hyperbolic dynamics is most prominent when both marine and continental biotas are considered together. This fact can be interpreted as a proof of the integrated nature of the biosphere.

But why throughout the Phanerozoic did the global biodiversity tend to follow the hyperbolic trend (similarly to what we observed within social World System in general and China in particular)?

As we have noted above, in macrosociological models, the hyperbolic pattern of the world population growth arises from a non-linear second-order positive feedback (more or less identical with the mechanism of collective learning) between the demographic growth and technological development (more people – more potential inventors – faster technological growth – the carrying capacity of the Earth grows faster – faster population growth – more people – more potential inventors, and so on).

Based on the analogy with macrosociological models and diverse paleontological data, we suggest that the hyperbolic character of biodiversity growth can be similarly accounted for by a non-linear second-order positive feedback[10] between the diversity growth and community structure complexity (more genera – higher alpha diversity – the communities become more stable and 'buffered'– average life span of genera grows; extinction rate decreases – faster diversity growth – more genera – higher alpha diversity, and so on).

The growth of genus richness through the Phanerozoic was mainly due to the increase of average longevity of genera and gradual accumulation of long-lived (stable) genera in the biota. This pattern reveals itself in the decrease of extinction rate. Interestingly, in both biota and humanity, growth was facilitated by the decrease in mortality rather than by the increase in birth rate. The longevity of newly arising genera was growing in a stepwise manner. The most short-lived genera appeared during the Cambrian; more long-lived genera appeared in Ordovician to Permian; the next two stages correspond to the Mesozoic and Cenozoic (Markov 2001a, 2002).We suggest that diversity growth can facilitate the increase in genus longevity via the progressive stepwise changes in the structure of communities.

[10] One wonders if it cannot be regarded as a (rather imperfect) analogue of the collective learning mechanism that plays such an important role within the social macroevolution.

Most authors agree that there were three major biotic changes that resulted in fundamental reorganization of community structure during the Phanerozoic: Ordovician radiation, end-Permian extinction, and end-Cretaceous extinction (Bambach 1977; Sepkoski *et al.* 1981; Sepkoski 1988, 1992; Markov 2001a; Bambach *et al.* 2002). Generally, after each major crisis the communities became more complex, diverse and stable. The stepwise increase of alpha diversity (average number of species or genera in a community) through the Phanerozoic was demonstrated by Bambach (1977) and Sepkoski (1988). Although Powell and Kowalewski (2002) argued that the observed increase in alpha diversity might be an artifact caused by several specific biases that influenced the taxonomic richness of different parts of the fossil record, there is evidence that these biases largely compensated each other, so that the observed increase in alpha diversity was probably underestimated rather than overestimated (Bush and Bambach 2004).

Another important symptom of progressive development of communities is the increase in evenness of distribution of species (or genus) abundances. In the primitive, pioneer or suppressed communities, this distribution is strongly uneven (community is overwhelmingly dominated by a few very abundant species). In more advanced, climax or flourishing communities, this distribution is more even (Magurran 1988). The former type of community is generally more vulnerable. Evenness of distribution of species richness in communities increased substantially during the Phanerozoic (Powell and Kowalewski 2002; Bush and Bambach 2004). Most probably there was also an increase in habitat utilization, total biomass and rate of trophic flow in biota through the Phanerozoic (Powell and Kowalewski 2002).

The more complex the community, the more stable it is due to the development of effective interspecies interactions and homeostatic mechanisms based on the negative feedback principle. In a complex community, when the abundance of a species decreases, many factors arise that facilitate its recovery (*e.g.*, there will be more food and fewer predators). Even if a species becomes extinct, its vacant niche may 'recruit' another species, most probably a related one that may acquire morphological similarity with its predecessor and thus, the taxonomists will assign it to the same genus. So a complex community can facilitate the stability (and longevity) of its components, such as niches, taxa and morphotypes. This effect reveals itself in the phenomenon of 'coordinated stasis': the fossil record shows many examples of persistence of particular communities for many million years while the rates of extinction and taxonomic turnover are minimized (Brett *et al.* 1996, 2007).

Selective extinction leads to accumulation of 'extinction-tolerant' taxa in the biota (Sepkoski 1991b). Although there is evidence that mass extinctions can be non-selective in some aspects (Jablonski 2005), they are obviously highly selective with respect to the ability of taxa to endure unpredictable environmental changes. This can be seen, for instance, from the selectivity of the end-Cretaceous mass extinction with respect to the time of the first occurrence of genera. In younger cohorts the extinction level was higher compared to the older cohorts (see Markov and Korotayev 2007a: Fig. 2). The same pattern can be observed during the periods of 'background' extinction as well (Markov 2000). This means that genera differ in their ability to survive the extinction events, and that in the course of time the extinction-tolerant genera accumulate in each cohort. Thus, taxa generally become more stable and long-lived in the course of evolution, apart from the effects of communities. The communities composed of more stable taxa would be, in turn, more stable themselves, thus creating a positive feedback.

The stepwise change of dominant taxa plays a major role in biotic evolution. This pattern is maintained not only by the selectivity of extinction (discussed above), but also by the selectivity of the recovery after crises (Bambach *et al.* 2002). The taxonomic structure of the Phanerozoic biota was changing in a stepwise way, as demonstrated by the concept of three sequential 'evolutionary faunas' (Sepkoski 1992). There were also stepwise changes in the proportion of major groups of animals with different ecological and physiological parameters. There was a stepwise growth in proportion of motile genera compared to non-motile; 'physiologically buffered' genera compared to 'unbuffered', and predators compared to prey (Bambach *et al.* 2002). All these trends should have facilitated the stability of communities (*e.g.*, diversification of predators implies that they become more specialized; a specialized predator regulates its prey's abundance more effectively than a non-specialized predator).

There is also another possible mechanism of the second-order positive feedback between the diversity and its growth rate. Recent research has demonstrated a shift in typical relative-abundance distributions in paleocommunities after the Paleozoic (Wagner *et al.* 2006). One possible interpretation of this shift is that the community structure and the interactions between species in the communities became more complex. In the post-Paleozoic communities, new species probably increase ecological space more efficiently, either by facilitating opportunities for additional species or by niche construction (Wagner *et al.* 2006; Solé *et al.* 2002; Laland *et al.* 1999). This possibility makes the mechanisms underlying the hyperbolic growth of biodiversity and human population even more similar, because the total ecological space of the biota is analogous to the 'carrying capacity of the Earth' in demography. As far as new species can increase ecological space and facilitate opportunities for additional species entering the community, they are analogous to the 'inventors' of the demographic models whose inventions increase the carrying capacity of the Earth.

Exponential and logistic models of biodiversity imply several possible ways in which the rates of origination and extinction may change through time (Sepkoski 1991a). For instance, exponential growth can be derived from constant per-taxon extinction and origination rates the latter being higher than the former. However, actual paleontological data suggest that origination and extinction rates did not follow any distinct trend through the Phanerozoic, and their changes over time look very much like chaotic fluctuations (Cornette and Lieberman 2004). Therefore, it is more difficult to find a simple mathematical approximation for origination and extinction rates than for the total diversity. In fact, the only critical requirement of the exponential model is that the difference between the origination and extinction through time should be proportional to the current diversity level:

$$(N_o - N_e)/\Delta t \approx kN, \qquad (11)$$

where N_o and N_e are the numbers of genera with, respectively, first and last occurrences within the time interval Δt, and N is mean diversity level in the interval. The same is true for the hyperbolic model. It does not predict the exact way in which origination and extinction should change, but it does predict that their difference should be roughly proportional to the square of the current diversity level:

$$(N_o - N_e)/\Delta t \approx kN^2. \qquad (12)$$

In demographic models discussed above, the hyperbolic growth of the world population was not decomposed into separate trends of birth and death rates. The main driving force of this growth is presumably the increase of the Earth's carrying capacity and the way this capacity is realized – either by decreasing death rate, or by increasing birth rate, or both – depends upon many factors and may vary from time to time.

The same is probably true for biodiversity. The overall shape of the diversity curve depends mostly on the differences in the mean rates of diversity growth in the Paleozoic (low), Mesozoic (moderate), and Cenozoic (high). The Mesozoic increase was mainly due to lower extinction rate (compared to the Paleozoic), while the Cenozoic increase was largely due to higher origination rate (compared to the Mesozoic) (see Markov and Korotayev 2007a: 316, Figs 3a, 3b). This probably means that the acceleration of diversity growth during the last two eras was driven by different mechanisms of positive feedback between diversity and its growth rate. Generally, the increment rate $((N_o - N_e)/\Delta t)$ was changing in a more regular way than the origination rate $N_o/\Delta t$ and extinction rate $N_e/\Delta t$. The large-scale changes in the increment rate correlate better with N^2 than with N (*Ibid.*: figs 3c and 3d), thus supporting the hyperbolic rather than the exponential model.

Conclusion

In macrosociological models the hyperbolic pattern of the world population growth arises from a non-linear second-order positive feedback between the demographic growth and technological development (more people – more potential inventors – faster technological growth – the carrying capacity of the Earth grows faster – faster population growth – more people – more potential inventors, and so on, which is more or less identical with the working of the collective learning mechanism). Based on the analogy with macrosociological models and diverse paleontological data, we suggest that the hyperbolic character of biodiversity growth can be similarly accounted for by a non-linear second-order positive feedback between the diversity growth and community structure complexity (which suggests the presence within the biosphere of a certain analogue of the collective learning mechanism). The feedback can work via two parallel mechanisms: 1) decreasing extinction rate (more taxa – higher is the alpha diversity, or mean number of taxa in a community – communities become more complex and stable – extinction rate decreases – more taxa, and so on), and 2) increasing origination rate (new taxa facilitate niche construction; newly formed niches can be occupied by the next 'generation' of taxa). The latter makes the mechanisms underlying the hyperbolic growth of biodiversity and human population even more similar, because the total ecospace of the biota is analogous to the 'carrying capacity of the Earth' in demography. As far as new species can increase ecospace and facilitate opportunities for additional species entering the community, they are analogous to the 'inventors' in the demographic models whose inventions increase the carrying capacity of the Earth. The hyperbolic growth of the Phanerozoic biodiversity suggests that 'cooperative' interactions between taxa can play an important role in evolution, along with generally accepted competitive interactions. Due to this 'cooperation' (~ 'collective learning'?), the evolution of biodiversity acquires some features of a self-accelerating process. The same naturally refers to cooperation/collective learning as regards the global social evolution. The discussed above suggests that we can trace rather similar macropatterns within both the biological and social phases of Big History that produce rather similar curves in diagrams and that can be described in rather accurate way with rather simple mathematical models.

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Galactic-Scale Macro-engineering: Looking for Signs of Other Intelligent Species, as an Exercise in Hope for Our Own

Joseph Voros

If we consider Big History as simply 'our' example of the process of cosmic evolution playing out, then we can seek to broaden our view of our possible fate as a species by asking questions about what paths or trajectories other species' own versions of Big History might take or have taken. This paper explores the broad outlines of possible scenarios for the evolution of long-lived intelligent engineering species – scenarios which might have been part of another species' own Big History story, or which may yet lie ahead in our own distant future. A sufficiently long-lived engineering-oriented species may decide to undertake a program of macro-engineering projects that might eventually lead to a re-engineered galaxy so altered that its artificiality may be detectable from Earth. We consider activities that lead ultimately to a galactic structure consisting of a central inner core surrounded by a more distant ring of stars separated by a relatively sparser 'gap', where star systems and stellar materials may have been removed, 'lifted' or turned into Dyson Spheres. When looking to the sky, one finds that such galaxies do indeed exist – including the beautiful ringed galaxy known as 'Hoag's Object' (PGC 54559) in the constellation Serpens. This leads us to pose the question: Is Hoag's Object an example of galaxy-scale macro-engineering? And this suggests a program of possible observational activities and theoretical explorations, several of which are presented here, that could be carried out in order to begin to investigate this beguiling question.

Keywords: *galactic astrophysics, macro-engineering, search for extra-terrestrial intelligence (SETI), Threshold 9, thinking on cosmological time-scales.*

Introduction – Big History in Context

Big History is a powerful conceptual framework for making sense of the place of humankind in the Universe – a narrative leading from the Big Bang nearly 14 billion years ago to our present information-based technological civilization (*e.g.*, Brown 2008; Christian 2004, 2008; Spier 1996). It synthesizes many different knowledge domains and scholarly disciplines and, in the words of the International Big History Association (IBHA) 'seeks to understand the integrated history of the Cosmos, Earth, Life, and Humanity, using the best available evidence and scholarly methods' (International Big History Association 2012).

Nonetheless, Big History is ultimately concerned with the history of just *one* planet – ours – among the trillion or so that are now thought to exist in the Milky Way Galaxy, not to mention the billions of trillions that can thereby be inferred to exist in the wider observable universe. Thus, it can be considered a single case in the even larger context of the unfolding of the broad scenario of Cosmic Evolution, as that scenario has played out on this particular planet (Chaisson 2001, 2007, 2008; Delsemme 1998; Jantsch 1980). It is easy to imagine other planets where life, and perhaps even intelligence, has arisen, as the Cosmic Evolutionary scenario has unfolded there, possibly giving rise to their own unique variant of Big History. A natural sub-set of the study of Cosmic Evolution is the discipline of Astrobiology (Chyba and Hand 2005; Mix *et al.* 2006), the study of life in the universe, which also includes its own associated sub-set of SETI, the search for extra-terrestrial intelligence (Ekers *et al.* 2002; Harrison 2009; Morrison, Billingham, and Wolfe 1979; Sagan and Shklovskii 1966; Shostak 1995; Tarter 2001). So, one can imagine an expanding set of nested fields of study, beginning with Big History (the history of our own small 'pale blue dot' [Sagan 1995]) enfolded by Astrobiology/SETI (the study of how life may arise in the universe and the search for intelligent forms of it) and encompassed by Cosmic Evolution (the study of how our universe as a whole has changed over the course of deep cosmic time). Whether there is a further enfoldment of our own universe within an even larger 'multiverse' of other universes is a fascinating open question currently receiving some attention among cosmologists.

Our focus here will be on using the step beyond Big History, specifically SETI as a framework for thinking about some of the broad contours that might characterize the unfolding future for intelligent technological civilizations, including possibly our own. Searching for signs of long-lived intelligent extra-terrestrial species, like those that will be sketched here, could provide a way for us to shift our collective thinking to become much more far-reaching and much longer-term – something that increasingly appears to be vitally necessary for the future of our civilization and planet. And if we can actually begin making this collective worldview change – albeit perhaps only minutely at first – then even this small shift of our current mindset could become a rational basis for some measure of hope in our ability to determine both wisely and well what the next stages will be in the long-term Big History view of the potential 'future histories' of our species.

Approaches to the Search for Extra-Terrestrial Intelligence

The modern search for extra-terrestrial intelligence has a history of just over half a century (Dick 2006). It has mainly involved searching for electromagnetic signals, usually at radio frequencies, although, more recently, it has also been undertaken in the optical spectrum (Shostak 2003). Just after the original proposal by Cocconi and Morrison (1959) to search for radio transmissions, Freeman Dyson (1960) suggested looking not for electromagnetic signals but instead for artificial signs of technology, an idea elaborated in further detail a few years later (Dyson 1966). Thus, some recent SETI researchers (Bradbury, Ćirković, and Dvorsky 2011; Ćirković 2006) consider there to be two main approaches to SETI: the '*orthodox*' approach, based on the detection of electromagnetic signals, whether they were deliberately signaled or are simply unintentional 'leakage' from the civilization; and the '*Dysonian*' approach, based on looking for signs of extra-terrestrial technology, without any presumption of deliberate signaling or attention-seeking at all.

The idea of searching for signs of extra-terrestrial technology or artefacts (*e.g.,* Freitas 1983) is an example of an approach that has more recently been called 'interstellar archaeology' (Carrigan 2010, 2012). Such a form of archaeology is hampered, of course, by the enormous distances to other stars, making the more usual pick-axe and soft-brush approach impractical (to say the least!), so any examples of technologies or artefacts we would be able to discover in this way would probably need to be executed on a stupendous scale. Some researchers have suggested, however, that we might possibly find artefacts in our own solar system (Kecskes 1998; Papagiannis 1983). Unfortunately such an enticing 'field trip' is currently beyond our technical ability, although there have been some ideas proposed for the exploration and use of near-Earth objects, including asteroids, in this next half-century (Huntress *et al.* 2006). Along similar lines, Davies and Wagner (2013) have recently suggested taking a closer look at the Moon for any possible traces of extra-terrestrial technology.

The emerging field of 'macro-engineering' is explicitly concerned with thinking about engineering on large scales, so it may be helpful as a framework for informing our thinking in the search for insights regarding examples of extra-terrestrial technology (Badescu, Cathcart, and Schuiling 2006; Cathcart, Badescu, and Friedlander 2012). Macro-engineering can be conceived of at a variety of scales, ranging from sub-regional to planetary, stellar, and galactic in scope (Badescu *et al.* 2006). In what follows below we consider the last of these – galaxy-scale macro-engineering – and how we might go about imagining what forms such almost unimaginable feats of engineering might take, in order to think about how we might detect such artificial activities across intergalactic distances. But first let us examine more closely why this type of approach to SETI may be even more relevant today than it has conventionally been considered to be.

The Drake Equation

One of the pioneers of SETI, Frank Drake, developed an equation which has since become widely used as a conceptual framework for discussion and debate about the various terms which are included in it (Drake 1961). The Drake Equation can be written as:

$$N = R_* \times f_p \times n_e \times f_l \times f_i \times f_c \times L,$$

where N is the number of currently-existing communicating technological civilizations in the Milky Way Galaxy; R_* is the average rate of formation of suitable stars per year in the Galaxy; f_p is the fraction of these stars which have planets; n_e is the average number of planets in each of these star systems with conditions favourable to life; f_l is the fraction of these planets which go on to actually develop life; f_i is the fraction of these inhabited planets which go on to develop intelligent life; f_c is the fraction of planets with intelligent life that develop technological civilizations which are capable of releasing signals into space; and L is the average communicative lifetime of such a civilization. There are several variants to this equation, and there have been many modifications made to it over the ensuing decades as well (Bracewell 1979; Ćirković 2004; Hetesi and Regály 2006; Maccone 2010; Walters, Hoover, and Kotra 1980).

With regard to the parameter L, initially this was often taken to mean the actual lifetime of the civilization. Some early estimates of this parameter tended to be rather gloomy, therefore, given our own case of the unwelcome possibility of hair-trigger nuclear annihilation under which humanity has lived since the mid-twentieth century CE. It was often thought, based on our own example, that many nascent technological civilizations might, therefore, destroy themselves not long after achieving the ability to send signals into space. More recently, as suggested by the above, the meaning of L has shifted subtly from the 'lifetime of the civilization' to the 'length of time such civilizations release detectable signals into space', a shift which changes the character of the term rather significantly.

This newer meaning for *L* has again arisen through reasoning from our own example. The Earth's radio 'signature' has changed over the decades from very high-energy analogue broadcasts from ground-based transmitters aimed towards the horizon (where the suburbs and home viewers are) and which have thereby continued on further out into space, to very low-energy narrow digital beams from orbiting satellites that are targeted at particular regions of the Earth's surface, and therefore do not propagate to any great degree beyond the Earth. This shift from high-power analogue broadcasts to low-power digital 'narrowcasts' (so to speak) has meant that over time the Earth is becoming less and less visible due to 'leakage' from our own terrestrial use of radio waves (Drake 2010).

SETI commentators sometimes use the US TV show *I Love Lucy* as the archetypal example of the sort of broadcast material that is expanding outwards in a 'bubble' from the Earth at the speed of light as a 'cultural leakage' signal from our civilization. One might be moved to observe that, if *those* are the signals that form the basis of an assessment by extra-terrestrials as to whether there is intelligent life on Earth, then perhaps it is *no wonder* that extra-terrestrials have not sought to make contact! Whatever one's opinion about the value of the content it carries, however, over time this leaked electromagnetic energy will die down to a faint whisper, due to the changing pattern of electromagnetic radiation use on Earth. Eventually, once the initial several decades' worth of high-energy broadcasting has passed, the longer-term low-power digital signal emanating from Earth will likely become almost impossible to detect by chance above the normal background radio noise of space. Only some navigational beacons and radar are likely to remain detectable after this time.

This gradual disappearance over time of the Earth as a strong radio source has implications for the wider consideration of the value of *L* in the Drake Equation. It is possible to imagine that other civilizations might also make a similar transition, so that a civilization might indeed be very long-lived, even while having a value of *L* remaining relatively short (Drake 2010). This implies a need to re-think some of the conventional approaches to SETI, or at least some of the assumptions upon which orthodox SETI has been based for so long, if not to expand the thinking beyond conventionality altogether. Indeed, Frank Drake himself has commented that:

> Searching for extra-terrestrial signals is one of the most challenging tasks ever taken on by mankind. …We are challenged to use logic to predict what another civilization, probably much older and more advanced than us, might adopt as a technology we might detect. …To reach an answer, ***we have to become futurists****, reaching far beyond our usual comfortable world of telescope technology to arrive at possible scenarios for the distant future*. This becomes an exercise of intellect reaching far beyond the usual bounds of science theory (Foreword to Shostak 2009; emphases added).

Then, this is the challenge, as posed by one of the founding pioneers of SETI: to imagine how an advanced civilization might develop over the course of perhaps hundreds of thousands or even millions of years, and attempt to conceive of what sort of technology such a civilization might invent or use. We are challenged, in other words, to think on a truly 'cosmological' scale, thinking which will very likely need to include both temporal and spatial dimensions – vast distances and immense timeframes. In order to approach and meet this challenge, we will need some sort of organizing principle for doing so.

'Dysonian' Thinking

Fortunately, Dyson explicitly set out the three 'rules' for his 'game' of thinking about extra-terrestrial technology (Dyson 1966). With very little modification, it is possible to use them from the point of view of our current understanding of technology, and with a view to incorporating ideas coming from the above-mentioned field of macro-engineering. Dyson's three rules can be given as follows (*Ibid*.: 643–644):

1. Think of the biggest possible artificial activities, within limits set only by the laws of physics, and look for those;

2. All engineering projects are carried out with technology which the human species of the *current epoch* can understand; and

3. Ignore questions of economic cost;

and where, in Rule 2, the italicized term 'current epoch' replaces Dyson's original use of 'year 1965 AD'. The given modification allows the rule to be applied at any stage of human history, which will thereby yield different answers depending upon the state of our knowledge in any given epoch. In particular, Dyson stressed with respect to Rule 1 that he was not interested in what an 'average' technological civilization might look like, only in what the most conspicuous of perhaps one in a million might look like, as these would be the easiest to detect over great distances; hence the focus on the 'biggest possible artificial activities' (*Ibid.*: 643–644).

Dyson went on to outline how it would be possible to disassemble planets, build rigid structures in space, and also revisited some of the ideas in his earlier paper (1960) which suggested that attempts to harvest increasing amounts of stellar radiation from the civilization's home star would lead, in the asymptotic limit, to all visible radiation being intercepted by a vast 'swarm' or 'shell' of orbiting collectors completely enveloping the star. While no longer radiating in the visible spectrum, such an object would nonetheless remain visible in the infra-red, owing to the black-body radiation law, whence Dyson's proposal in the initial paper's title to search for artificial sources of infra-red radiation. There have been several searches undertaken since the original proposal in 1960, although at the time of this writing none have been confirmed (see, *e.g.*, Bradbury 2001a; Tilgner and Heinrichsen 1998; Timofeev, Kardashev and Promyslov 2000). The idea of a 'Dyson shell', or 'Dyson sphere', was subsequently taken up and expanded upon by the astrophysicist Nikolai Kardashev (1964), who conceived of technological civilizations as being characterizable on a three-level scale with regard to their ability to use and control energy.

The Kardashev Scale

Kardashev's initial schema has frequently been revised and refined by many others in the five decades since it was first proposed. In brief, it is as follows (Sagan 1973: 233–234):

- **Type I: planetary.** A Type I civilization is the one which makes use of use all of the available energy of its planet, estimated to be on the order of 10^{16} watts (*i.e.* 10,000,000,000,000,000 W), or 10×10^{15} W = 10 PW (petawatts). This would include harnessing, for example, tidal, thermal, atmospheric, nuclear, fossil, internal geothermal and other planetary sources of energy.
- **Type II: stellar.** A Type II civilization is the one which harnesses all of the energy output of its star, something on the order of 10^{26} W = $100 \times \times 10^{24}$ W = 100 YW (yottawatts). This includes collecting all of the radiant energy of the star, and might perhaps even include harnessing the energy contained in its gravitational field.

• **Type III: galactic.** A Type III civilization is the one which has managed to harness the energy of an entire galaxy, something like 10^{36} W, although because galaxies vary considerably in size, this figure is somewhat variable. A civilization capable of using energy at this scale could probably make itself visible, if it chose to, throughout most of the observable universe.

The energy difference between adjacent types is ten orders of magnitude – a factor of 10 billion (*i.e.* 10^{10}). Astronomer Carl Sagan suggested that a decimal interpolation be introduced between the main levels, whereby each factor of 0.1 represents a ten-fold increase on the previous level (Sagan 1973: 234). Thus, a Type I.5 civilization uses ten times more energy than a Type I.4, which uses ten times more than a Type I.3 and so on. In this view, Earth is usually considered to be an approximately Type 0.7 civilization.

It is fairly simple to state the characterization of a civilization as 'using energy on a galactic scale', the definition of Type III, but it is not quite so simple to imagine what that situation might entail in terms of artificial structures we might be able to detect. Does it imply a vast system of beacons, each pulsing out transmissions in the tens of millions of yottawatts range, or would it be something more subtle, such as the ability to move whole star systems around at will, in order to re-configure the wider structure of the galaxy? Is the energy usage expended in a single or small number of artefacts or activities, or is it spread out over innumerable activities whose aggregate total is of the order of magnitude considered galactic in scale?

In the Kardashev scheme, Dyson's idea of re-engineering a star or star system – now usually called 'astroengineering' – is considered to be an example of a Type II civilization. The nature and possible structure of Type III civilizations has received somewhat less attention, although there have been some researchers who have thought along these lines (Annis 1999; Bradbury *et al.* 2011; Carrigan 2012; Ćirković 2006). When this question has been considered in the literature at all – which does not appear to have been often – it has usually looked to expanding the scale of Type II civilizations into the galactic context. For example, Carrigan (2012) wrote of 'Fermi bubbles' or 'voids' as places where there is an apparent dearth of visible stars due to the existence of large numbers of Type II civilizations or Dyson Spheres. Such a void or bubble of reduced optical stellar density could, in principle, be detectable by our instruments, owing to the infra-red blackbody radiation signature it would still emit, combined with the unusual appearance that such a structure would produce. However, Carrigan also noted that detection of such voids in spiral galaxies is somewhat more difficult than in elliptical galaxies, owing to the presence of comparable voids that are naturally found in spiral galaxies. The few efforts made to date do not appear to have found definitive examples of galaxy-scale artificial activity (Annis 1999), but it would be very interesting to search the literature more exhaustively than has been possible for this paper.

What would a Type III Civilization Actually Look Like?

The ideas to be presented here arose in part from asking the question 'I wonder what a Type III civilization would actually look like?' as well as from some related exploratory investigations into the parameter space for possible scenarios of 'contact' – the usual shorthand term for the discovery of extra-terrestrial life, including intelligence. That paper is currently in preparation (where the technique is described in more detail), but, in brief, the 'scenario space' of contact – that is, the range of possible scenarios under which contact might occur – is assumed to be characterized by several parameters, including (among others): the nature of the entity (biological, post-biological, hybrid); the complexity of the entity (simple, complex, intelligent); the form of 'signal' (electromagnetic, artefactual); the intentionality of the signal (deliberate, incidental); and the Kardashev type (0, I, II, III). One can see that the initial form of orthodox SETI (*i.e.*, deliberate or incidental leakage radio signals), later forms of orthodox SETI (*e.g.*, deliberate optical signals), and Dysonian SETI (incidental artefact-producing activities) are all accommodated in the parameters characterizing the form and intentionality of the 'signal'. The meaning of 'artefactual' is deliberately left somewhat open so as to encompass Dyson's own suggestion in his Rule 1 of looking for 'artificial activities', and is taken to mean any objects or artefacts produced by any such 'artificial activities'.

This parameterization can be expanded into a many-dimensional (one dimension for each parameter) combinatorial 'morphological space', following a technique devised by Fritz Zwicky in the early part of the last century, whereby every parameter value is systematically and exhaustively combined with every other parameter value for all parameters (Zwicky 1967, 1969). This results in a very large number of possible 'configurations', numerically equal to the product of the number of parameter values of all parameters. Zwicky used this technique to great effect in his scientific work (Zwicky 1947, 1948). Every distinct configuration of parameter values could, in principle, be examined for its characteristics, although in practice not all configurations necessarily appear as 'solutions' because some parameter value pairs may not be mutually 'consistent' and would thereby be excluded from the total 'solution space' (see Voros 2009 for a more detailed explanation of this method). By way of illustration, our own cultural leakage signals – for example, *I Love Lucy* – can be characterized by the following set of the above parameter values: biological, intelligent (or so *we* might think!), electromagnetic, incidental (*i.e.*, unintentional signalling), Type ~0. More colloquially, this might be rendered as incidental electromagnetic signals (*i.e.*, 'leakage') from an intelligent, biological, Type ~0 civilization.

For our purposes here, it suffices to say that by combining different classes of parameter value it is possible to systematically generate ideas for different potential scenarios for further consideration and investigation. One of these configuration classes (by which is meant that some parameters are left 'free' without being assigned a specific definite value so as to describe a range of related configurations) was as follows: intelligent, artefactual, incidental, Type III, with the nature of the entity left open. This may be characterized more colloquially as a galaxy-scale artefact created by, or perhaps galaxy-scale artificial activities undertaken by, some form of intelligent entity going about its own business; in other words, galaxy-scale macro-engineering.

In what follows, I would like to consider two possibilities for how galactic-scale changes brought about by macro-engineering activities might manifest in terms of structures we might be able to detect over intergalactic distances. The timeframe for this scale of engineering is probably rather long, and might run to many tens of millions, or perhaps even hundreds of millions of years. Dick (2003) has called thinking on these immense timescales 'Stapledonian' and suggests that such a long-term thinking is a necessity when considering the question of intelligence in the universe. In the spirit of Dyson's rules, however, we are only concerned here with artefacts or artificial activities that we could actually detect over intergalactic distances and not with what might be considered an 'average' level of macro-engineering for a 'typical' engineering species. That is, we are concerned only with the biggest, most astonishingly vast engineering projects of which we can possibly conceive – so, we will be thinking along the lines of what Ćirković (2006) has characterized as 'macro-engineering in the galactic context'.

Multi-system Exponentiating Dysonian Astroengineering

Firstly, let us imagine a long-lived Dyson/Type II species branching out from its initial home system, which would likely have been somewhere in the Galactic Habitable Zone (GHZ) (see, *e.g.*, Prantzos 2008) where they most likely first arose as a biological species – although by this stage they may well have moved to a 'post-biological' form (Dick 2003, 2009). Over numerous iterations, new stellar systems are reached by a vanguard group sent from an existing 'Dyson-ified' system and subsequently engineered into new Type II systems, from which new groups are sent out, and so on. This is clearly a geometrically exponentiating process so that, over time, there will end up being a *very* large number of Type II/Dyson civilizations, spreading out in a roughly spherical bubble from the home system. This is similar to the scenario of Fermi voids or bubbles that Carrigan (2012) has imagined. However, we can push this idea a bit further by considering what an initially-spiral galaxy might look like some way further along the exponentiating process. Owing to slight differences in the orbital speed of star systems around the galactic centre due to differences in radial distance from the centre, this expanding bubble is not likely to remain completely spherical, and may end up getting progressively 'smeared out' by differential rotation at the different radii (an admittedly fairly small effect). Over Stapledonian timeframes, however, comparable to several galactic rotations (say $\sim 10^9$ years), this process, which might otherwise have led to a (so to speak) Fermi 'arc' around the centre of the galaxy, could very likely end up filling out into a fully-blown 'gap' that completely separates the galactic core from the rest of the outer stellar disk, through the still-continuing process of diffusion from existing engineered systems into new un-engineered ones.

The radii of this 'gap' in the galactic disk would likely be determined, respectively, by the intensity of the radiative flux from the galactic core or bulge, for the inner, and by the availability of metal-rich stars which contain planetary and other materials suitable for disassembly and re-use for engineering purposes, for the outer. The resulting gap may end up encompassing much of what might have been considered the GHZ of the galaxy, at least to the outer radius in the galactic disk. It is also possible that the inner radius might extend even further inward towards the centre of the galaxy, if the species 'goes post-biological' and no longer has to worry about the effects of what would otherwise be lethal environmental conditions for a biological species. In this case, 'post-biological' is a general term which may be inferred to include machine-based intelligence, or an intelligence based on a technological/artefactual substrate. In SETI, this situation is sometimes referred to colloquially as the question of these intelligences either *having* machines or *being* machines, and the question itself is sometimes regarded as mere hair-splitting.

Galactic-Structural Macro-engineering and Stellar-System Removal

In the second possibility, we imagine a long-lived, most-likely a post-biological species inhabiting a spiral galaxy that either does away altogether with its earlier exponentiating Dysonian astroengineering program in favour of, or perhaps moves directly to, the even grander project of seeking to re-engineer the spiral-galactic structure as a whole. If this species transitions to a post-biological form while still planet-bound, or relatively early into a nascent exponentiating astroengineering phase, then this latter trajectory may perhaps be more probable.

Analogously with Dyson's original astroengineering proposal to harvest stellar energy, although on a much larger scale, this species decides that it wants to directly access and capture all of the luminous energetic flux emanating from the entire galactic core or bulge. Unfortunately, there is usually a considerable amount of intervening material in a typical spiral galaxy which occludes some of this radiant energy from regions further out in the galactic disk by the absorption of some wavelengths – this is why we ourselves do not see the centre of the Milky Way from Earth in visible light. A post-biological species would likely not have need of planets as habitat, and would most probably be able to exist in interstellar space, absorbing the radiant energy directly in a way analogous to our current solar panels, although undoubtedly much more efficiently. Such a species would not be constrained by biological timelines, and – if our own considerations about the implications of the Singularity on Earth are anything to go by (Eden *et al.* 2012; Kurzweil 2006; Smart 2003; Tucker 2006; Vinge 1993) – would effectively become immortal, subject only to accidental destruction, or a conscious decision to power-down.

An effectively-immortal species which wants to gain access to as much of the galactic centre's radiant energy as possible without it being degraded due to absorption and re-emission would likely consider clearing out the intervening material between itself and the galactic core/bulge. This would be macro-engineering on a truly galactic scale. One can imagine a number of possible scenarios for how this might proceed. The asymptotic end-state of these activities on Stapledonian timescales would likely be: a central core of stars, surrounded by a 'gap' in which there are relatively much fewer or perhaps even no stars or other natural material – and which contained uncounted octillions of post-biological entities orbiting the galactic core absorbing the unimpeded radiant flux as they go about their unfathomably post-biological business – with a ring of stars further out remaining from the initial structure of the spiral galaxy. The removal of intervening materials might include combinations of 'lifting' stars entirely for later re-use of their materials (Criswell 1985), or perhaps simply moving entire star systems further out into the stellar ring region, by means of some form of propulsion such as Shkadov thrusters or related 'stellar engines' (Badescu and Cathcart 2000, 2006a, 2006b). Or, it might perhaps be through a combination of lifting stars into Jovian planet – or brown dwarf-sized non-fusioning agglomerations for more convenient storage and then moving these with gravitationally-bound 'solar sails' utilizing the radiation pressure from the galactic centre. In this case, as well, one ends up with a core of stars surrounded by a quasi-toroidal region devoid of stars, ultimately out to a more distant ring of stars, whose inner radius is determined due to the radiant flux from the core being too weak for the post-biological species to utilize, whether directly or for propulsion. This argument is in direct contrast to the 'migration hypothesis' of Ćirković and Bradbury (2006) who have argued for a mass migration of post-biological species to the *outer* regions of a galaxy, for computing-thermodynamic reasons.

Galactic Structure Arising from these Macro-engineering Projects

In both of these cases, the galaxy eventually ends up having a core + 'gap' + ring morphology, reminiscent of the planet Saturn, where the apparently empty 'gap' might merely be comparatively darker due to the presence of a vast number of Dyson spheres, or may actually have been emptied due to the original material having been cleared away – through star lifting, star system re-positioning or similar forms of removal – to make for more open 'living' space for the post-biological entities. We will consider further below some possible empirical observations that could be made of any such candidate galaxy. But for now, of course, the question arises: are there any examples of galaxies that have this morphology? And the answer is: yes, there are.

Hoag's Object – a Lovely Ringed Galaxy

The nature and structural characteristics of the beautiful ringed galaxy known as Hoag's Object, which has the formal designation PGC54559, have long been the subject of debate and speculation (Brosch 1987; Gribbin 1974; Lucas 2002). It was discovered by Arthur Hoag in 1950, who reported it in the scientific literature as a 'peculiar object' (Hoag 1950), hence its common name 'Hoag's Object'. It lies about 600 million light-years away in the constellation Serpens and is something like 100–120,000 light-years across, making it roughly comparable to or slightly bigger than the Milky Way (Brosch 1985; O'Connell, Scargle and Sargent 1974; Schweizer *et al.* 1987). Detailed analysis shows that the galactic plane is almost directly face-on to us, deviating from perfect alignment by only about 20 degrees or so (Schweizer *et al.* 1987). The interested reader can see a high-quality Hubble Space Telescope image of Hoag's Object at the Astronomy Picture of the Day web site for August 22, 2010 (Lucas and NASA Hubble Heritage Team 2010). There are several other such 'Hoag-type' galaxies known (O'Connell *et al.* 1974; Wakamatsu 1990), including the one that is, coincidentally, visible through the gap feature in Hoag's Object itself (Lucas and NASA Hubble Heritage Team 2010).

Hoag initially thought it might be a possible example of gravitational lensing, the ring being an optical effect caused by the bending of light from a more-distant galaxy by an intervening elliptical galaxy located by chance directly in line-of-sight between us and the more distant one. Later spectroscopic work showed this not to be the case (O'Connell *et al.* 1974), and as both the core and the ring appear to have the same redshift, they are almost certainly co-located (Schweizer *et al.* 1987). A variety of other hypotheses have also been proposed for the origin of this lovely galaxy. They include: a 'bulls-eye' type collision between two passing galaxies – however there does not appear to be any sign of the putative 'bullet' galaxy in the vicinity (Schweizer *et al.* 1987); a dynamical instability in what was previously a barred-spiral galaxy, which case can be recovered from adjusting the parameters modelling the galactic dynamics in certain ways (Brosch 1985; Freeman, Howard, and Byrd 2010); an accretion event, wherein the object we see is a late stage in the coalescing process of two colliding galaxies merging into one system (Schweizer *et al.* 1987); and, more recently, that the structure we see can be modelled by a particular type of pressure wave in a self-gravitating gas (Pronko 2006). The last three of these appear to remain viable hypotheses.

However, given our use here of Dysonian thinking over Stapledonian timeframes, and the sometimes finely-tuned adjustments in the parameters that appear to be necessary to recover the structure of Hoag's Object via models of natural processes, what if we instead ask the question that is now almost begging to be asked: Is Hoag's Object actually an example of galaxy-scale macro-engineering? Or, put more simply:

Is Hoag's Object an Artefact?

Having asked this question, of course, the next step is to consider how we might go about answering it. This requires thinking about potential empirical observations that could be undertaken in order to look for 'signatures' that would indicate artificial activities rather than be explicable as due solely to natural processes.

There appear to be at least four empirical observations that could be made with respect to the question of the artificiality or otherwise of Hoag's Object. They range from rather less direct to considerably more direct, and are as follows:

1. *The distances from the centre of the galaxy of the major structural discontinuities* – the outer core/inner gap, and outer gap/inner ring radii – *with regard to what these distances might be expected to be from theoretical considerations arising from different scenarios leading to the core/gap/ring morphology.* If stars or stars systems *are* being moved outward by radiation pressure, for example, then there will be a certain radial distance at which the inward gravitational attraction, set by the core mass, and the outward radiation pressure, set by the core luminosity, are in balance. This would form the boundary of the core and gap. Similarly, the outer gap radius could also be limited by the intensity of radiation pressure for moving material outwards. However, the outer radius of the gap might not be so strongly constrained if the stars are being moved using Shkadov thrusters. If the 'empty gap' appearance is caused by Dyson spheres rather than lack of material, there may perhaps be a different implied radius for the core/gap boundary. Comparisons of different theoretical values, obtained from imagining different scenarios, with the empirical values obtained from direct observation might reveal some interesting correspondences. This may well require more accurate observational data than currently appear to exist.

2. *The spectral profile of the 'gap'.* The difference between a 'gap' consisting of, say, almost empty space containing octillions of post-biological entities as compared to a volume of space filled with billions of Dyson Spheres should, in principle, be discernible, but in reality might be very difficult to determine conclusively. If there are Dyson spheres of the type considered by Dyson himself, these will emit blackbody radiation consistent with a temperature of ~300 K. However, if the engineering is very advanced – and we almost must assume it to be – then the efficiencies possible by use of a structure similar to, say, a 'Matrioshka Brain' (Bradbury 2001b) could produce waste heat with a blackbody radiation profile close to the temperature of the cosmic background radiation of space itself, ~3 K. Similar considerations for thermodynamic efficiency would probably also drive the construction of the substrate for the post-biological entities. This could make it very difficult to distinguish such structures from background empty space. In this instance, possible occlusion or diminution of radiation intensity from beyond the galaxy due to intervening absorptive material might be one way to probe the nature of the 'gap'.

3. *The metallicity profile and chemical composition of the ring*, with respect to anything 'unusual' compared to what is expected of the 'typical' composition of the interstellar medium (ISM) in a galaxy in which the normal processes of stellar evolution are occurring. A species that is converting gap-region star systems into Dyson spheres and not moving materials further outward would not therefore alter the composition of the ring region to any appreciable degree beyond what would be expected from the normal processes of enrichment over time of the ISM in a spiral galaxy. However, if the species *is* moving gap-region materials further outward, then this probably *would* alter the chemical composition and metallicity profile of the ring region and such an 'anomalous' composition might be detectable

via spectroscopic observation. The ring structure in Hoag's Object also shows what Schweizer and co-workers (1987) characterized as an 'osculating braid', a smaller brighter ring within the main ring, touching the inner and outer edges of the main ring at different places; it is clearly visible in the Hubble image mentioned above. The precise nature of this 'braid' is of some interest. It has the appearance of what are in other galaxies considered to be regions of relatively new star formation, although, if so, how so much star formation has managed to be so apparently spatially synchronized raises an intriguing speculation. Is the braid simply a pressure-shock effect caused by multiple and perhaps cascading supernovae events, or could it be due to the deliberate synchronized 'seeding' of new star systems? And to what end? It is possible to imagine that an effectively-immortal post-biological species which is already moving material into the outer ring region might decide as part of this project to undertake a further program of seeding the creation of new stars with the materials so displaced in order to create the potential for the emergence of new biological species. In other words, to perhaps 'cultivate' the sort of conditions conducive for the arising of new biological species (in a region of the galaxy for which they themselves have no direct use) perhaps for subsequent longitudinal observation and study. Or it might simply be to produce an aesthetic effect that changes relative position within the ring over very long timescales, possibly even as a signal to other galaxies. The prospect of effective immortality might require commensurately long-term projects to keep one occupied over the aeons.

4. *The existence of a time-keeping signal beacon* at or near the galactic core. If there are large-scale engineering activities going on which could be up to many tens of thousands of light-years apart and which may require some type of co-ordination, then it would be useful to have a time signal that would act as the standard clock by which these activities could be synchronized – a kind of Galactic Mean Time, as it were (Shostak 1999). A logical place for such a beacon would be at the galactic core, or perhaps immediately nearby, slightly above the plane of the galaxy, as the exact centre may not be feasible due to a black hole or other sources of possible interference with what would need to be a reliable signal. It is most unlikely that such a beacon would be broadcast isotropically – that would be a distinctly inefficient use of energy. An immortal species that is re-engineering a galaxy over Stapledonian timescales is quite likely to be somewhat careful in its use of energy, perhaps even frugal, as it would probably be thinking very much of the long term – and it would certainly have the luxury of time enough to use the most frugally efficient means possible. As such, the signal would most likely be directed mostly along the galactic plane (Shostak 2011: 363) to the regions where it would be needed. Given that Hoag's Object is almost directly face-on to us, this makes the detection of any potential beacon signal of this kind somewhat difficult, although one might hope for some re-emission scattering echoes being deflected in our direction. However, if there were other activities being undertaken further out in the galactic halo, the signal might then be broadcast somewhat more widely, so we might possibly get lucky. Needless to say, a very sensitive receiver would be required for carrying out such an observing program.

Concluding Remarks

This paper has been an attempt to apply 'Dysonian' thinking to the question of what galaxy-scale macro-engineering might look like when undertaken over 'Stapledonian' cosmological timeframes by intelligent species that are long-lived enough to do so, and which have very probably transitioned to an effectively-immortal 'post-biological' form (Bradbury *et al.* 2011; Ćirković 2006; Dick 2003).

By generalizing Dyson's original idea of an engineering species interested in harnessing ever more amounts of radiant energy from a single solar system to an entire galaxy, we arrived at the intriguing notion of a purposely re-engineered galaxy eventually having a core + 'gap' + ring morphology, somewhat reminiscent of the planet Saturn. When we look to the sky, we find that there are indeed several examples of such galaxies, the most well-known 'type specimen' of which is Hoag's Object, PGC54559. The unusual structure of this beautiful galaxy has long been remarked upon, and the attempt to resolve the question of its origin has seen a variety of hypotheses advanced based on the assumption of natural processes. Here a different question was posed concerning its origin – namely, whether it might actually be the result of artificial activities. Thus we asked: Is Hoag's Object an example of galaxy-scale macro-engineering? Several theoretical considerations were discussed and four specific empirical observations were suggested that could be carried out in order to begin to investigate this wonderfully beguiling research question.

Mounting a search for evidence of galaxy-scale macro-engineering, and the thinking required to seriously contemplate the possible forms such projects might take in order to be able to do so, could be one way to help us think much longer-term – something humankind would seem to be in desperate need of right now. If nothing else, simply entertaining the idea that someone somewhere in the Universe might have been able to successfully navigate the dangerous time Carl Sagan called 'technological adolescence' can give us some hope in our own ability to do the same at this critical point in the history of our species. Better yet, finding a definite example of such a success could be the very stimulus we need that prompts us to begin to take our future seriously enough to guide it consciously, responsibly and foresightfully. A search for evidence of this kind would be relatively inexpensive to conduct. But it just might end up being an immeasurably valuable – perhaps even absolutely priceless – piece of information to possess. It could not hurt to have a careful look...

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Post-singular Evolution and Post-singular Civilizations

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It is shown that the ability of the world civilization to overcome a singularity border (a system crisis) determines some important civilization's feature in an intensive post-singular phase of development. A number of features of the post-singular civilization can stimulate its 'strong communicativeness', which is a prerequisite for the formation of 'the galactic cultural field'. Post-singular civilizations – carriers of the cultural field – are considered as potential partners in interstellar communication and as our own potential future.

Keywords: *evolution, civilization, singularity, exo-humanism, contact saturation, SETI.*

1. Introduction. Scale-Invariance and the Singularity of Evolution

Initially, this work was motivated by a question related to the SETI program (Search for Extra-Terrestrial Intelligence): If intelligent life is a normal phenomenon in the Galaxy and if the rate of technological evolution is as high as on Earth, then the Galaxy must be full of highly-developed technological civilizations and we should see them in all directions.[1] So why do not actually we see them? This question is well known and is frequently referred to as the 'Fermi paradox'.

I prefer, however, the following form of the question, which is of much more significance: Assuming intelligent life to be a normal phenomenon in the Galaxy, what would such a highly-developed, technological civilizations look like and why would it be 'invisible' to us? This question is of great practical importance. If we want to find extraterrestrial civilizations, we need to understand what we are trying to find. Our methods should depend on the object of our search. If you go hunting for a duck, you should know that a duck likes water!

In order to find such an answer, one needs to first develop an understanding of what civilization might look like in the future. This is a challenge, of course, but it is rather possible. The idea is to look at technological development in the light of the general laws of evolution.

I outlined such a model of evolution on Earth from the origin of life up to the present, as a sequence of phases with phase transitions between them. It was a model of *global biospheric revolutions*. Each biospheric revolution is the result of some *evolution crisis*, and

[1] The Kepler mission (Borucki *et al.* 2011) has already discovered 68 planetary candidates of approximately Earth-size during its first three months of operation; 54 of these are found in the temperature range appropriate for a habitable zone. Undoubtedly, this is only the first small portion of what will be much larger results, because long-period planets (about one year and more) have not yet been considered, *etc.*

the revolution (the phase transition) overcomes the crisis. The list of these phase transitions includes 19 events, including the Cambrian explosion, mammalian revolution and the Neolithic revolution. The last analyzed event was the information revolution (computers, post-industrialisms – 1950) (Panov 2005).

Each of the phases becomes shorter in duration with the passage of time. Moreover, the sequence of the phase transitions is scale-invariant, which means that the corresponding sequence of time-points is a simple geometrical progression and that various parts of this sequence may be derived from other parts by scale transformation. We call this *the scaling law of evolution*. But such a sequence of points may not be prolonged to infinity in the time. Yet, the duration of phases tends to zero and the frequency of the phase transitions tends to infinity near a point of time t^*. Indeed, the sequence does not exist after the point t^*. This point is called the *singularity of evolution*. By its physical meaning the singularity of evolution is a concentration of evolutionary crises – it is something like 'a crisis of crises'. Of course, the singularity of evolution is only a mathematical artifact, because any real quantity may not become infinite. But the prediction of the Singularity inevitably means that the scaling law of evolution that has held for about 4 billion years must be changed to some other law near the point t^*.

The position of the Singularity point t^* may be estimated by extrapolation of the sequence of the biospheric revolutions. The result is: $t^* = 2004 \pm 15$ (*Ibid.*). Therefore we are now in the time of the Singularity!

My analysis of the sequence of biospheric revolutions is not the only method that leads to a derivation of the Singularity. It has been long known that the hyperbolic growth law of human population also possesses the property of scale-invariance and that extrapolation of it predicted the Singularity for 2026 (Foerster *et al.* 1960). Additional details of this scenario were elaborated by Kapitza (1996). There is also the notion of a 'technological singularity' that was proposed by Vernor Vinge (1993); it is based on arguments like scale-invariance and was predicted to occur in the first half of the twenty-first century. Thus, a variety of arguments, each of which points to almost the same date for t^*, force us to seriously consider the singularity of evolution. But, we must keep in mind that the Singularity is not a single point in time – it is a period of time, approximately the first half of twenty-first century, a time when the laws of evolution and historical trajectories will change dramatically.

Now, suppose that scale-invariance and the existence of the Singularity is a universal property of evolution on all planets where life can produce intelligent civilization. Based on our experience here on Earth, the technological period of our civilization has only been a few decades long and our efforts at cosmic transmission have been low. So the probability of us detecting a similar *pre-singular* civilization in the SETI process would be almost negligible. Therefore, a potential contact partner could only be a *post-singular* civilization. Thus, the problem that we should address is: What would such a post-singular civilization look like? The other side of the question is: What is our own post-singular future? We will argue that these two sides of the question are very closely connected with each other.

2. The 'Exo-humanism' of a Post-singular Civilization

Let us consider the use of the concepts of 'humanism' and 'ethics'. A human being is a creature devoid of natural powerful tools of aggression – claws, fangs, *etc.* When a hominid took a stone tool and became the owner of the first technology, nothing prevented them from crippling or even killing a near relative with it. Perhaps, in many cases this was indeed done, but it might also be a reason why populations of especially aggressive hominids did not leave descendants. Less aggressive populations survived, and the prohibition on murder was fixed – first genetically (by survival), then culturally (by regulation).

As technology developed, the killing power of weapons increased. Correspondingly, cultural restrictions on aggression against both people and nature needed to improve. These restrictions were imprinted in ethics, morals and humanism. They were by no means given to human beings *a priori*, but were developed to limit the destructive action of human technology (Nazaretyan 2004, 2009; Eco 2002). There are also other such mechanisms in human culture, such as criminal legislation and its punitive system of fines, prison, *etc.* Hereafter the term 'humanism' will be considered in this kind of a wide sense: any form of cultural restriction on destructive technology.

It is clear that the survival of a civilization after its Singularity means that a civilization has managed to overcome its deepest technology-related crises. In order to overcome them successfully, a post-singular civilization must have elaborated the corresponding adaptation mechanisms and used them for its homeostasis. *If a civilization does not elaborate such mechanisms, it will not enter the post-singular stage of development* – it degrades and/or perishes. It is not difficult to imagine at least some of the necessary preservation mechanisms.

- First, sufficiently effective mechanisms to deter aggression must be elaborated. Otherwise, a civilization will destroy itself by internal conflicts related to the increasing use of irreplaceable natural resources and the simultaneous increase in the killing power of weapons.
- Second, powerful mechanisms restricting material consumption and effective use of resources must be implemented.
- Third, a civilization must overcome the centrifugal influence of corporate and state self-interest and elaborate planetary concepts, because crises near the Singularity occur on a global scale and can be overcome only by common efforts and continuous compromise.
- Fourth, the preservation of civilization must include an increase of ecological consciousness that matures to the point of becoming a social instinct.

A singularity crisis cannot be overcome without a huge jump in the power and in the depth of the mechanisms developed to constrain the destructive effects of technology. We call this jump, *the post-singularity humanization of civilization*. I emphasize once again that such 'humanization' should not be interpreted simplistically or too literally. It certainly may include ethical principles accepted by the majority of people, for example, humanism in its classical sense. However, 'humanization' can also be implemented as a system of legal and punitive measures. Its focus must be on a holistic system of cultural constraints that curb destructive technology-related effects and which will keep civilization alive as a cosmic-technological entity.

The assumption that elaboration of such constraining mechanisms is possible is not arbitrary. Based on many facts, Akop Nazaretyan has shown (2004, 2009) that cultural constraints of aggression have been increasing throughout the history and pre-history of humankind as technological power was increasing. Moreover, they were increasing at a growing rate, so that in spite of the increase in the killing power of weapons, the level of bloodshed (per capita) decreased. Nazaretyan summarized this conclusion which is *paradoxical* for ordinary consciousness as the 'Law of Techno-Humanitarian Balance' (*Ibid.*).

Recent examples of the Law of Techno-Humanitarian Balance in action are the sweeping-out of the bloodiest political regimes of the twentieth century (Stalin, Hitler, Mao Zedong, and Pol Pot) and their replacement by gentler methods of administration. A sign of the awakening of planetary consciousness and the development of ways of overcoming corporate and state self-interest is the Kyoto Protocol. A lot of other examples of the formation of ecological consciousness can be adduced, from Earth Day to international NGOs. Certainly, the idea that a developed form of humanism should be typical for highly-developed cosmic civilizations is not new. It was expressed by Konstantin E. Tsiolkovsky and Ivan A. Efremov early in the twentieth century, and recently, for example, in the papers by Gindilis (2001, 2003) and the book by Nazaretyan (2004).

It is curious that this humanization of terrestrial civilization finds its most direct expression in attitudes to the Cosmos. For example, it is clear that if there were life on Mars, it would be of a most primitive kind. We would expect that humans would think only about their own safety and ignore such potential life. But actually, all vehicles sent to Mars have been carefully sterilized so as not to harm potential Mars life! Another example is the destruction of the space explorer *Galileo* in the atmosphere of Jupiter in 2003, so as not to allow terrestrial microorganisms to infect the Jupiter satellite Europa, where the existence of life is also possible.

The dispute about the permissibility of the experiment 'Deep Impact', whose aim was to bomb the comet Tempel-1 in order to study the chemical composition of the comet, is also indicative of such concerns. Opinions varied. Many professional astronomers and astrophysicists thought that such 'barbaric' methods should not be allowed. The apotheosis of this dispute was a lawsuit brought by Marina Bai in the Presnensky court of Moscow against NASA for an award of moral damages caused by this experiment. The formulation of the lawsuit was as follows: 'The NASA activity encroaches on the vital cultural wealth and the natural life of the Cosmos, which upsets the balance of natural forces in the Universe'. The case was considered by the court, but the claim was denied. A transfer of ethical norms and ecological thought to the Cosmos lies at the heart of this case.

All this could be considered an amusing incident if not for the sympathetic attitude of many professionals. Any large-scale astro-engineering activity, including transformation of comets and other bodies in the solar system, would cause fierce opposition from the public. Large-scale astro-engineering activity may turn out to be impossible, not due to technical reasons but from a post-singular cosmo-ethics point of view.

These examples show that post-singular humanism could hardly exist in a civilization 'for internal use only'. These properties must also appear in relation to the Cosmos as a whole, whatever these relations might be: cosmic engineering, contact with non-sentient and intelligent forms of life on other planets, *etc.* An intrinsically perfect, highly-humanistic system cannot be primitively aggressive in its external manifestations. *Exo-humanism is a system of cultural constraints that limit destructive potential at the technogenic planetary level.*

It should also be emphasized that it is unknown if the process of humanization of *terrestrial* civilization is fast enough and deep enough to overcome the crisis of the Singularity. Our statement is rather conditional: *If* post-singular, cosmo-technological civilizations exist, *then* the process of their humanization in the period of overcoming the Singularity must be fast and deep, and that is why they must be exo-humanistic.

3. Cosmic Expansion and Intensive Development

There is a widespread belief that the negative consequences of the need for extensive technological development and the related exhaustion of irreplaceable resources on Earth can be overcome by expansion into outer space. In this fantasy scenario, billions of people will live in cosmic towns, we will use resources of other planets, all unsafe industries will be located in outer space, far from Earth. But such visions are quite groundless.

In particular, the time needed for preparation of such large-scale opening-up and settlement of space is insufficient (Gindilis 2001). It is impossible to physically accumulate enough resources for organization of an ecologically safe and inexpensive but intensive traffic to even a near-earth orbit during the few decades of the technological period. Another obstacle to large-scale astro-engineering could be cosmo-ethical or cosmo-ecological reasons related to exo-humanism. As we saw, these factors are already appearing, in spite of the modest nature of the present-day challenges.

Predictions from the 1970s about what would happen with space technology and space exploration by the end of the 20th century turned out to be highly unrealistic. For example, K. Erike, a participant in the U.S. space program, predicted a space station for 25–100 persons that would be put into orbit after 1985 (Levantovsky 1976: 37). Similarly, a solar power station with the capacity to produce 5 million kilowatts was also predicted, one that weighed 9570 tons and had 45 km^2 of batteries in stationary orbit.

These predictions had been based on a linear extrapolation of the rate of space development that had occurred in the middle of the 20th century, which is why they failed to materialize. The tempo of such advances was too much to maintain and many of the proposed plans are still unimplemented. Indeed, a sharp decline in space activities has already occurred. There are other things that need to take place on Earth before such extraterrestrial activity can get back on track.

After overcoming a singularity, a civilization must establish a stable existence for itself without any hope of engaging in rapid cosmic expansion. This period of stabilization must focus on the intensive development of Earth's own resources. Even if large-scale cosmic expansion is possible in principle, it cannot be allowed to occur at the expense of the technological explosion. A considerable period in the post-singular phase must pass before enough necessary resources are accumulated. Since it is difficult to make forecasts about the possibility of cosmic expansion in a distant post-singular phase, and since transition into the intensive phase of development must come first, then let us concentrate on features of behavior of a cosmic civilization in the intensive phase of development.

Proposed models of SETI research during the intensive phase of development would be determined by the overall existing conditions. Since energy resources of a cosmic civilization would be rather restricted, transmitters of signals would be only of pencil-beam diameter, whatever carrier might be used. The most probable receivers also would be of pencil-beam size and would be oriented to monitor separate stars. Powerful omni-directional stationary radiators would be excluded because of their large energy requirements. And it would also be quite probable that they would be rejected because of ethical or ecological imperatives of exo-humanism, because of their destructive effects on outer space.

4. Information Crisis

The issue of 'the end of science' deserves a large paper or even a book of its own, but for our purposes here, this range of study will only be considered in brief.[2] First, let us define what we mean by 'science'. There are several methods of cognition: philosophic, religious, *etc.* Science is one of these forms of cognition. A scientific truth is not a synonym for truth in general, but its results can be reproduced. In science, there are two basic classical methods to verify results: 1) a reproducible experiment in natural sciences, or 2) a deduction or calculation in mathematics (deduction is also a method of reproducible reasoning in natural sciences). We call the methodology based on the combined use of reproducible experiment and deduction: *the classical scientific method.* By definition, science is a method of cognition assisted by classical scientific method.

In the period of technological explosion, science – along with consumption of resources and energy – is in a state of a heavy (exponential) growth. The time of doubling (of different characteristics – the number of scientists, the number of publications, and the number of discoveries) is only 10–15 years (Lem 2002; Idlis 1981). The current rate of the development of science cannot last infinitely or simply for a long time; this follows from elementary arithmetic.

In his famous book, *Summa Technologiae*, Stanisław Lem asserts that we will reach the near 'saturation' of the scientific method (Lem 2002). Apparently, he was among the first to seriously discuss the limitations of science and thought that it would cause a future crisis of civilization, which would demand special measures to overcome it. Lem called it the 'information crisis', and we will use this term here.

In 1963, when this book was written, Lem thought that the exponential growth of science would last 30–70 years and that it would end in the period between 1990 and 2030. Lem wrote: 'Thus, if the current rate of scientific growth will remain, then in some 50 years every inhabitant of Earth will be a scientist'. Apparently, his forecast refers to about 2010 and, as can be easily seen, strongly overestimates the real number of scientists. Indeed, as with the space program discussed above, the growth rate in numbers of scientists has already fallen. It seems that Lem's general forecasts are coming true.

The problem of 'the end of science' still keeps exciting peoples' minds. Currently, there is a lot of literature dedicated to it, such as Krylov (1999) and Horgan (2001). From my point of view, the issue is especially important in the context of the evolution of civilization. Such an approach allows us not only to better understand the essence of the crisis but to also think of possible ways of overcoming it.

The scientific method arose in the evolution of civilization, at a specific stage of development, for the solution of important problems. The first elements of the scientific method appeared in the ancient world; however, they were not a leading factor of development at that stage, *i.e.* they were merely one of the forms of *superfluous diversity* (superfluous diversity is a pool of ideas from which society selects and which then lead to new systems after a phase transition). In the ancient world, the leading methods of cognition were philosophy, religion and art. However, the scientific method played a more important role in overcoming agrarian crisis in the late Middle Ages, and then became one the leading fac-

[2] Much more detailed analysis is presented in our paper (Panov 2009).

tors of the first industrial revolution and the subsequent development of civilization. It was a special case of very general mechanisms of evolution. Superfluous diversity was involved each time in overcoming evolutionary crises (Nazaretyan 2004).

However, sooner or later, effective solutions become exhausted, and the classical scientific method is not an exception. This does not mean that science will disappear. Old forms do not totally disappear when new forms appear; they just remain in a reduced form, yielding leadership to more progressive systems. It should be expected that the classical scientific method will lose its leading role in the development of civilization and will be replaced by other forms of cultural activity. 'The end of science' is not necessarily the end of cognition, and, moreover, it is not the end of evolution. New forms of cognition or other types of cultural activity will arise, ones that might not even be considered cognition in our contemporary meaning. This has happened before: The world of mythology was extracted from a whole primeval worldview, which was then replaced by philosophy on nature, religion, *etc.*

Although we employ inductive logic to consider the future of science, it should be understood that, while induction can be a method of constructing such hypotheses, it cannot be used as proof of anything. As far as questions about the very distant future go, a special caution should be made, since some ideas are extrapolated from the scale-invariant pre-singular stage of evolution to the post-singular stage, where the evolutionary result can turn out to be very different than expected.

It is also important to have a notion of the concrete causes that can lead to 'saturation' of the scientific method. It will allow us to understand the dynamics of the process and to estimate, at least roughly, the time scale involved. At least three basic groups of causes can be identified.

First, sooner or later, science will run into limitations caused by the lack of availability of natural resources. Such tendencies already exist. In the United States, we saw the cancellation of construction on the Superconducting Supercollider in 1993 and the recently pared-down space programs. In prospect, *at best,* science expenses could be stabilized at a constant level, taking into account the intensive character of development of post-singular civilization.[3] This must mean stabilization and a gradual decrease of the flow of *new* scientific results, because the cost of every newly solved scientific problem increases due to the increase of its complexity, in spite of development of new scientific methods (computer simulation, processing of data, *etc.*).

At present, only rare cost-effective studies are carried out by lone scientists, as was done a century ago. For the most part, scientific teams work together today, exploiting giant and very expensive experimental facilities. Many modern scientific problems can be solved only by international collaboration. Decline in the flow of scientific information (more precisely, discoveries) causes a decrease of interest of the society in science, which leads to a decrease of fiscal appropriations for studies and a further decrease in the flow of new results. A positive feedback loop is thereby closed. As a result, scientific investigations are cut back. This is especially dangerous because, due to the high rate of collapse, many participants in these events can have no time to understand what is going on. I have presented a mathematical model of this development (Panov 2009).

Secondly, it is clear that science will also encounter ethical limitations related to post-singular humanization. From examples of recent history, we can remember the strong op-

[3] Please, note that it would not be so under the conditions of the extensive growth of a civilization at the expense of the cosmic expansion.

position to experiments on the cloning of human beings. Other kinds of concern also fall into this category, such as opposition to genetically modified products that impede genetic investigation or concerns about radioactive contamination that hinder the development of nuclear-power research. Even a general distrust of science is quite widespread among uneducated people.

In addition, a third group of limitations exist – a field of research can simply be 'exhausted' for further scientific study (Horgan 1996). L. V. Leskov and V. M. Lipunov wrote about that problem in relation to SETI research (Leskov 1985; Lipunov 1997). Certainly, the potential completeness of studies in fundamental physics would not cancel out a possibility of studying phenomena at higher system levels, but it strongly reduces a probability of scientific discovery which, in fact, coincides with the interests of society.

Please, note that, in my opinion, there are no serious grounds to consider the problem of 'the exhaustion' of science to be real. But the public opinion related to it is quite real. Expectations of the end of fundamental physics (even if based on false premises) can cause public pessimism which, via feedbacks, affects the stability of science on the whole.

We have not yet mentioned the expansion of pseudoscience with its distinctly negative attitude towards real science, as well as other factors that seem to us to be less important. Thus, there is not one, but a number of interacting causes that can impede the development of science. That is why the information crisis is actually, to a great extent a *system crisis of science*. Apparently, sooner or later, post-singular civilization must deal with this phenomenon.

Overall, resource limitations would seem to be the most important issue in the crisis of science, but ethical concerns can grow stronger with time. We do not at all mean that the current state of scientific research soon forebodes the end of science; it just indicates an inevitable falling off of efficiency by the classical scientific method. Apparently, terrestrial civilization is near the first phase of this scientific crisis. Nonetheless, developing processes are so dynamic that it is unlikely that the classical scientific method will be a leader of cognition in the coming centuries. This is an issue that will unroll over the next few decades. This knowledge presents us with an opportunity to seek a solution.

Is the information crisis dangerous for civilization? A positive answer is most obvious, but some qualification is necessary. If the cognitive function of mind can be exhausted, then the end of civilization is inevitable (Lipunov 1997). Though this thesis has not been proven, it seems quite plausible and I accept it as a hypothesis. Although science is now the leading method of cognition, it is not the only one, as mentioned above. The information crisis means the closing of only one channel of cognition.

Can a civilization avoid the crisis by making one of the other existing methods of cognition the leading one? Every method mentioned above is older than science and was once a leader, but evolution does not enter the same river twice. It seems that the information crisis will inevitably lead to a general crisis of civilization. This crisis could first manifest itself in science and technology, but it is easy to imagine that such a crisis of science will lead to a larger crisis in general culture: An all-planet 'longing for something new' and a feeling of being in a blind alley may arise.

The crisis can be overcome, if a new strategy is found that can replace the classical scientific method as the leading function of cognition. Such a new strategy could be related to a considerable modification of ideas about reproducibility or truth. Brand new channels of obtaining information could also appear. The search of possible new directions for future development should be related to analysis of the pool of superfluous diversity, since all known cases of new strategies were taken from these pools. Therefore, a number of different scenarios can be conceived. That is to say, it is quite possible that the information crisis is a point of polyfurcation with different possible exits.

Here, we will not analyze all the possibilities of overcoming the information crisis (there are many of them). But it is important that one of the ways of replacement of the classical scientific method is related to solution of the SETI problem. This variant will be discussed in detail in the next section together with other particularities of post-singular civilizations. It is not difficult to see that we are dealing with the search for possibilities to overcome the information crisis among the factors of superfluous diversity. Keep in mind, though, that while work on the SETI problem is one of the forms of cultural activity of humankind, it does not yet play an essential system-forming role.

Let me make one important concluding remark about this information crisis. Although we see the inevitability of a system crisis in science in the more or less distant future, it does not follow that the support of science should be discarded. On the contrary, science should be supported as much as possible, because scientific knowledge will serve as a basis for overcoming many other crises of the singularity.

5. Communicativeness of Post-singularity Civilizations

It was shown above that, in the post-singular phase of development, a civilization will have to meet two problems: A restriction on space exploration and an information crisis. Besides taking out a civilization to the way of intensive development, the first problem can cause serious internal discomfort, because it will make people feel closed-in, restricted to their stellar system or a planet, as in a shell. The second problem can cause a dangerous destabilization of the overall system. Let us try to imagine the behavior of a civilization in this situation, relying on the above analysis.

A civilization like ours, which has approached the information crisis, must understand that it is necessary to access new ways of obtaining knowledge in order to preserve homeostasis. These new pathways to knowledge must be alternative to the saturated and degraded classical scientific method. If the problem cannot be solved in some other manner, then obtaining of information from other non-terrestrial civilizations could provide such a method, if it is sufficiently rich and connected to as many correspondents as possible.

Moreover, in such a crisis situation, the discovery of at least one extraterrestrial civilization could give powerful moral support for it to overcome its crisis, because it would demonstrate that civilization has prospects for progress. Simultaneously, this would also solve the problem of 'the shell complex': Real cosmic expansion would be replaced by a virtual informational one. Such cosmic transmissions probably contain information about the historical path of millions of other civilizations, which could be used to optimize pathways for our own civilization's development. That is why SETI contact could radically increase the stability of our civilization.

Such information could be obtained only if other civilizations made cosmic transmissions, which is most likely. Being exo-humanistic, a post-singular civilization would have to engage in this form of communication, which would be so important for other civilizations in the Cosmos. Highly-developed civilizations would not spare themselves with transmissions into space but would try to maximize these efforts. It should be expected that transmissions into space would actually be a stabilizing component for a post-singularity civilization that had experienced the information crisis. Perhaps, this is a possible answer to the question raised by Viktor Shvartsman (1986) about the purpose of interstellar transmissions: Since obtaining new knowledge cannot be the purpose of transmissions, consequently, this activity does not belong to science. But what could be their purpose then?

Civilizations should seek to not only send transmissions into space, but to make them as informative as possible. The simplest way to do that is the transmission of not only its own information but also that received from other cosmic civilizations. An exo-humanistic civilization also must think how to share information about vanished civilizations, which is similar to our present attitude about ancient monuments. Thus, one of the actions of a post-singular civilization at the stage of a system crisis and afterwards is active transmission of messages into space and the relaying of everything that has been received.

On the basis of such a model, any civilization that may have not yet found a contact partner and *which is at the stage of the information crisis* must apply all of its efforts to solve the SETI problem. Obtaining a new source of knowledge becomes a vital necessity of the civilization, if only to provide hope for its people. Only in this state of awareness will a civilization becomes *communicative in a strong sense.* The readiness of a civilization to spend significant resources to address the SETI problem should not be expected to take place earlier than when the information crisis becomes evident to the majority of its people. Historical experience shows that the important problems of civilization are solved only on the principle that: 'Without thunder, there is no religion'. It is evident that terrestrial civilization is still far from this communicative phase.

Does it mean that it makes no sense to engage in solving the SETI problem now? – By no means. At the time when such contact will be seriously needed, the theoretical base and methods of search for cosmic civilizations and communication with them must be ready. The on-going research and growing database of exo-planets of the terrestrial type is extremely important. And all that should be done now. As was noted, the work on the SETI problem could be a key factor in overcoming the future information crisis.

6. Galactic Cultural Field and the Character of Information in Cosmic Transmissions

In an earlier paper, I discussed the positive influence that such cosmic contacts might have on stabilizing civilizations. I also showed how a phase transition might be possible in our Galaxy, from the time when the probability of finding a contact partner during the lifetime of a civilization is much less than 1 (*the epoch of silence*) to when it is close to 1 (*the epoch of contact saturation*). Moreover, during the latter state of the Galaxy, it would be very stable (self-sustained). It has been shown that the dynamics of such a transition would be similar to a second order phase transition (Panov 2007).

It was further argued in the previous section that the possibility to overcome the information crisis by engaging in cosmic transmissions would actually have a significant positive influence on the linked civilizations. The expected properties of post-singular civilizations create the possibility for the transition of the Galaxy from the 'epoch of silence' to the 'epoch of contact saturation'. In such a state, the cosmic civilization population of the Galaxy would have rather remarkable properties.

In the epoch of contact saturation, messages sent by a civilization to space during the communication phase will be received and relayed by at least one other civilization with a probability of about 1. That is why information about civilizations that completed the communication phase can be kept in the Galaxy during an indefinitely long time, being transmitted from one civilization to another. Upon establishing the state of contact saturation, the amount of information available to all in the Galaxy increases steadily and turns into a single cultural field. We emphasize that the existence of the cultural field does not mean two-way communications between civilizations.

As information in the cultural field is accumulated, every civilization, proceeding from the imperative of exo-humanism, will process and relay greater and greater amounts of it. When that information begins to flow, the post-singular communication system will become so saturated with data that it will be impossible to relay all of it. Cosmic civilizations will start selecting the most valuable. In its turn, changes of the information content will have a feedback influence on the constitution and properties of civilizations in the Galaxy. The cultural field will turn into a single umbrella-civilization, evolving according to its own laws. Actually, we deal with a qualitatively higher level of organization of matter following the social one. As such, the galactic cultural field has many interesting properties, which I have discussed in detail in a previous paper (Panov 2003).

Establishment of the cultural field is very similar in its essence to the 'big correction' of V. A. Lefebvre (1997). The case in point is the coordinated activity of many intelligent 'cosmic subjects' for improved development of life and intelligence in the Universe. Lefebvre considered the situation in which cosmic subjects do not have the possibility to agree directly with one another upon fulfillment of this work and have to act on the basis of the moral imperative in the hope that the others act in the same manner. Such a scenario of behavior of post-singular civilizations corresponds closely to his idea.

A model of the cultural field suggests that the typical cosmic transmission of one cosmic civilization must contain information of many, maybe millions of other civilizations. It would be a complicated and branched information system. The term 'transmission' is inadequate; one needs to talk about *an exo-bank of data.* Transmission of such a huge amount of information with the help of a modulated laser beam or a wide-band but narrow-beam radio signal would not be an unsolvable problem for a civilization whose energy resources do not exceed those at the planetary stage of development, as expected for an exo-humanistic, post-singular civilization.

It is easy to imagine the possible character of information in exo-banks of knowledge. Obviously, it is mainly meant for post-singular civilizations that have already faced the information crisis (since only such cosmic civilizations could find a contact partner). That is why, such fundamental sciences as physics, mathematics and astronomy would not be the most interested parties in exo-banks, because post-singular civilizations that are close to exhaustion of the scientific method must have a similar level of knowledge in this field. Certainly, some specific information of the fundamental character can be of interest, for instance, parallaxes of quasars and distant galaxies, which was pointed out by V. S. Lebedev (2007).

However, a more fundamental kind of knowledge will become important to facilitate the decoding such exo-bank data. It should be expected that most information will be 'humanitarian' in character, such as biology, history, sociology, literature, art and religion. It would feed the function of cognition instead of cognition in the form of natural sciences. We call a cosmo-technological civilization that has stabilized its existence by processing external information of a humanitarian character as an *exo-humanitarian civilization*.

The conclusions by which we arrive here are close to the idea expressed by Philip Morrison at the Byurakan SETI conference in 1971:

> In my opinion, the most part of this rather complicated signal will mainly refer to what we would call art and history, but not natural sciences and mathematics. For me this is clear from combinatoric considerations, because our society or any other long-living society will solve many natural-scientific and mathematical problems by easier ways than by studying records of interstellar messages (Morrison 1975).

Victor Shvartsman stated similar ideas in 1986: 'An opinion generally accepted among physicists that the extra-terrestrial intelligence must pass fragments of its scientific knowledge to "younger brothers" seems to be very disputable'. He noted that information related to art and games can turn out to be much more important. This opinion is mainly grounded in two considerations. First, scientific information forms a single logical construction. If a part is lost, the whole is lost too. In other words, the scientific information is difficult for decoding and understanding.[4] Whereas information contained in art is much more resistant to the loss of fragments – the kept parts have a definite integrity and value as before. Rules of logical games are very simple and compact. They can be transmitted easily. At the same time, they contain huge amounts of information about an unimaginable number of potentially possible logic sets. Second, art and games say much more about the intellect that created them than impersonal scientific information or even data of neurophysiology.

It should be noted that, in the present paper, the way to similar conclusions differs from arguments of both Morrison and Shvartsman. They consider that the main motive of 'humanization' of a message is that it is difficult to understand interstellar messages of a scientific character. Our idea is that interstellar messages will be accessible for study (or, perhaps, the necessity to study them) only after most of the problems are solved within the framework of the classical scientific paradigm. However, our second motive about the predominant importance of 'humanitarian' information in comparison with scientific has much in common with Shvartsman's ideas though it does not repeat them literally.

But the considerations of Morrison and Shvartsman that it is difficult to extract information from an interstellar message are also very important. How do we decode the exo-banks of knowledge? Certainly, it is difficult to pose such a problem. Only some general considerations about that can be expressed.

It should be expected that an exo-bank of information will contain one or several root messages with a signal attracting attention and instruction for further search for information. This part of the exo-bank must be decoded easily (for instance, on the basis of reduction to natural-scientific or mathematical concepts). But difficulties are certain to be faced in advancement to the 'humanitarian' parts of the exo-bank.

Here the papers of B. N. Panovkin (1981) about the difficulty of mutual understanding of different cosmic civilizations should be remembered. Panovkin considered the process

[4] I do not agree with this reasoning. *Vice versa,* the knowledge in mathematics, physics, chemistry and astronomy (cosmology) are common to all and should be easy to decrypt.

of setting up correspondence between systems of ideas (thesauri) of these civilizations and showed that, generally speaking, this problem is not solvable algorithmically even for a two-way contact. However, in our opinion, such a conclusion does not mean that understanding is impossible. It only means that the process of understanding must be of a substantially non-algorithmic character. But it is the man that is able to an illogical guess or irradiation inaccessible to a finite automaton.

At the initial stage of studying materials of the exo-bank there can be no correspondence between thesauri of different cosmic civilizations at all (except a very narrow field of simple mathematic or natural-scientific concepts). It can be built gradually as the exo-bank is studied in the cycle of a conceptual model or a test. Models of the understanding of some fragments of the exo-bank are suggested, and then these models are tested on other materials of the exo-bank. If the model stands the test, it is accepted and used for construction of newer and finer models, otherwise it is rejected. A non-algorithmic element of this process is the suggestion of new models. Here it is impossible to do without guesses and irradiations. The understanding achieved in this way will never be final, but it will always be of a model-building character.

It is easily noticed that this cyclic process is very similar to the standard cycle of the classical scientific method of a hypothesis – an experiment. That is why the process of understanding the exo-bank can be called 'exo-science'. Thus, after the information crisis the leadership in methods of cognition can pass from science to exo-science.

Exo-science is not simply another version of science. The key-components of exo-science are truth and reproducibility. In exo-science the notion of truth turns out to be of two-levels: 1) How adequate are models of interpretation of information, and 2) How truthful is the interpreted information itself? If it is still possible to achieve something resembling repeatability of results at the first level, then at the second level, in many cases, it will be unachievable in principle. The element of belief becomes inevitable in the obtained knowledge. Besides, the obtained knowledge itself refers not to nature directly, but either to artificially generated information, or to nature, but indirectly through artificial information.

Let us emphasize that the possibility itself of a long process of obtaining knowledge by the method of exo-science is not less important than the content of obtained knowledge. The process of exo-scientific cognition can drag on many thousand years, but this is just what is necessary to support the homeostasis of civilization at the intensive post-singularity phase of development. It is hard to tell how and when this process of exo-scientific cognition will be exhausted (since this must happen eventually).

7. Final Remarks

We proposed the scenario of post-singular evolution in which the leadership system is a post-singular civilization in intensive phase of development. A post-singular civilization is exo-humanistic and exo-humanitarian, one that is part of the galactic cultural field (Section 6). The typical features of an exo-humanitarian civilization must be moral imperatives of exo-humanism (Section 2) and, apparently, a declining state of investigations with the classical scientific method, at least in the field of fundamental sciences (Section 4). Such a civilization is communicative in the strong sense (Section 5). It would not be overstating the case to say that, when establishing contact with such a civilization, we contact the wider cultural field and become an element of it.

We would like to emphasize that the quantitative estimates show (Panov 2007) that even at the epoch of contact saturation of the Galaxy (Section 6) it is a very difficult problem to find the first partner for interstellar communication if pencil-beam channels dominated in the galactic cultural field. Therefore, the Fermi paradox (silence of the Cosmos) may easily coexist with the galactic cultural field: Great efforts from each civilization are needed to establish contact with the cultural field. We cannot see a lot of civilizations in all the directions because the civilizations are in intensive post-singular exo-humanistic stage when the energy resources of the civilizations are not large and they can use only pencil-beam channels for interstellar communication. This is a possible answer to the main question stated at the beginning of this paper.

Though we were trying to avoid arbitrary hypotheses, the approach used in the analysis is the scenario approach. The scenario suggested in this paper can turn out to be more or less plausible or be wrong. The crisis phenomena in science can be softer than it was assumed, but they can occur against the background of other crises, which was not taken into account. The strategy of overcoming crisis phenomena based on the solution of the SETI problem can be combined with the strategy of creation of an artificial intelligence or other global conceptions. Maybe, different strategies are incompatible, so, civilizations can be divided into several types according to their way of overcoming the information crisis: cybernetic, communicative, *etc.* Even if a suggested scenario is correct in general, nevertheless, rare strong deviations from it are possible. So, for instance, at a small distance between two civilizations the contact can be established not at the post-singular phase when the strong communicability is achieved, but much earlier. It easily may take place in a star cluster. Such civilizations can go by the way of creation of super-civilizations with a large-scale astro-engineering activity, as is assumed, for example, in some papers (Kardashev 1981; Kaplan and Karadashev 1981). Maybe, the galactic cultural field created by exo-humanitarian civilizations is only a kind of 'incubator' for super-civilizations and only a phase in development of intelligence. All that means that both the search for beam signals typical for the cultural field and the search for 'cosmic miracles' typical for super-civilizations must be implemented simultaneously.

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flict, Escalation, and Limitations on Two-Level Games (2011, Stanford University Press), *Globalization and Global History* (2006, Routledge), *Strategic Rivalry: Space, Position, and Conflict Escalation in World Politics* (2008, Cambridge University Press), and *Puzzles of the Democratic Peace: Theory, Geopolitics and the Transformation of World Politics* (2005, Palgrave-Macmillan). He has also received the World Society Foundation's Award of Excellence in World Society Research, the International Global Research Association and Moscow State University's V. I. Vernadsky Gold Medal of Honor (for contribution to global studies), and the International N. D. Kondratieff Foundation and Russian Academy of Natural Sciences' Silver Kondratieff Medal (for contribution to the social sciences).

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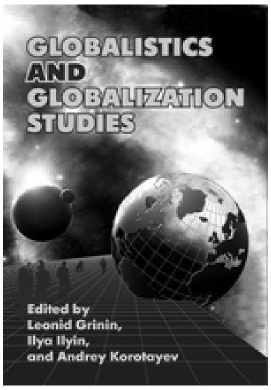

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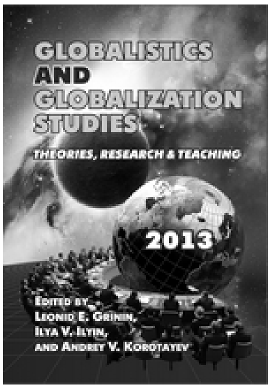

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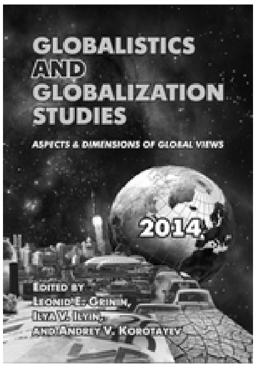
This is the second issue of the new series titled Globalistics and Globalization Studies. Globalistics may be regarded as a sort of systemic and more or less integrated ‘core’ within Global Studies. At present Global Studies function in two main dimensions – in the research of global political, economic, cultural and social processes, on the one hand, and in the realm of teaching – manifesting themselves in the creation of various Global Studies programs and courses for university students who learn to see the world in its entirety and variety. The second dimension is immensely important as the contents of such programs and courses may determine how the world will be comprehended by those people who may decide its fate in a decade or two. This dualistic nature of Global Studies has determined the general direction of our anthology that comprises both the theoretical dimension of Global Studies and their application to the teaching process.

The anthology consists of three parts presenting a wide range of views on the meaning of the contemporary epoch, the past and the future of some important global processes as well as problems and successes in the teaching process of Global Studies. Part 1. Globalization in Historical Retrospective. Part 2. Globalistics, Global Studies, and Global Processes. Part 3. Teaching Global Studies.

In the present anthology one can find perceptions of globalization by a number of famous scholars from different countries of the world (Ervin Laszlo, Christopher Chase-Dunn, and others), but one can also get to know rather peculiar visions of globalization by Russian scientists and educators.

GLOBALISTICS AND GLOBALIZATION STUDIES ASPECTS & DIMENSIONS OF GLOBAL VIEWS



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Edited by Leonid E. Grinin, Ilya V. Ilyin, and Andrey V. Korotayev

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Nowadays globalization processes have become all-embracing. But at the same time, despite the ever-increasing flow of publications on globalization, our understanding and knowledge of it still leaves much to be desired. Especially it concerns the global processes in general, of which globalization is a part. We also need to systematize our ideas about globalization and Global Studies to somehow fit the realities. In particular, this concerns the education process, because the current state of education will determine the way people will perceive reality in the forthcoming decades. This yearbook aims at contributing to the solution of these important tasks. It is the third in the series of yearbooks titled Globalistics and Globalization Studies. This year it has the following subtitle: Aspects & Dimensions of Global Views. Its authors consider globalization and Global Studies in different dimensions and aspects: philosophical, methodological, and pedagogical, in terms of various processes, problems and perspectives. Of course, to some extent this means that this yearbook presents rather diverse materials. But globalization itself is very diverse. And its comprehension may proceed in the framework of different theoretical approaches and points of view.

In the present yearbook one can find perceptions of globalization and Global Studies by a number of scholars from different countries of the world and learn rather peculiar visions of globalization by the Russian scientists and educators. The yearbook will be interesting to a wide range of researchers, teachers, students and all those who pay attention to global issues.