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Notes and comments

Chris Freeman forging the evolution of evolutionary economics

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Abstract

Every Schumpeterian is an evolutionary economist in his or her own way. Chris Freeman, whose 1995 essay is published in this issue of ICC, favored a rare combination of the Cambridge tradition, a Marxian view of inequalities and Schumpeter's fascination with innovation as the driving force of capitalism. The article summarizes and discusses this combination and how Freeman generated a challenging agenda for contemporary economics, namely in the context of long wave analysis, the theme for his last book.

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The publication by *Industrial and Corporate Change* of Chris Freeman's 1995 paper, "History, Co-Evolution and Economic Growth" (2019), provides a wonderful picture of his way of thinking and promoting the discussion on essential topics for economics. This was work-in-progress, as several sections just sketch the evidence and the argument (namely I and III), whereas others are fully developed (that is the case of section II, "A Theoretical Framework for Reasoned History", and section IV, "Forging Ahead: the British Industrial Revolution"), which, as the author indicates in the first footnote, would soon be "a couple of chapters in a book". That book would be *As Time Goes By: From the Industrial Revolutions to the Information Revolution* (Freeman and Louçã, 2001), written between 1998 and 2000, thoroughly discussed at a seminar organized by the authors in Lisbon in 1999, with a large number of colleagues surveying the draft versions of the chapters, and then first published in 2001.

In the following, I will recollect some memories on the preparation of that work and comment on passages on this article, which constitutes both a summary of much of Freeman's previous writings and the first formulation of the (co-authored) book, which would be his last one.

1. Chris Freeman at work

A great scholar, an innovative researcher on innovation and micro and macro change, a passionate academic with broad interests, and an impressive teacher, Freeman's contribution to economics suggests the reconstitution of economics as science of real life, focused on understanding major changes, dynamics, and institutions, as well as people, social groups, ideas, and motivations. In this and other pieces, Freeman combined historical research on industrial and technological revolutions with a radically novel theory of mutations in the economic process.

In this, he synthesized three theoretical approaches: the Cambridge tradition that considered economies as organic totalities; the Marxist and classical vision of the economy as the expression of social relations; and foremost the Schumpeterian view on capitalism as an adaptive and innovative system moved by profit accumulation. For him,

evolutionary economics provided this synthesis and expressed his view on living dynamics, studying social forces and organizations in complex institutional systems, understood as the articulation of conventions, laws, traditions, cultural traits, and conflict and class relations. For that purpose, Freeman emphasized the role of endogenous change generated in techno-economic paradigms that organize the system of production and accumulation. In this, he was part of a brilliant generation of promoters of modern evolutionary economics but also stood as one of those rare economists able to combine empirical work on the factors of change and a theoretical approach to the social contradictions as expressed in economic history.

2. Some building blocks of evolutionary theory

A brief survey of evolutionary economics may be helpful to situate Freeman's particular contribution to the field. His view, as expressed under different forms, was that, in spite of advances in sophisticated technical tools and new ways of modeling, we still lack an evolutionary macroeconomics, and that its construction is a fundamental task in order to establish economics as a realistic social science.

Although its genesis refers to an ensemble of diverse contributions through time, the revival of evolutionary economics is particularly due to the seminal book by Nelson and Winter, *An Evolutionary Theory of Economic Change* (1982), which provided both a theory and a practical demonstration of a new approach to modeling. Other building blocks have been the previous Chris Freeman's *The Economics of Industrial Innovation* (1974, new edition by Freeman and Soete, 1997), then the Dosi *et al.*, *Technical change and Economic theory* (1988) opening new avenues for research, then Bengt Ake Lundvall's *National Systems of Innovation* (1992), and Stan Metcalfe's *Evolutionary Economics and Creative Destruction* (1998). After *As Time Goes By*, Carlota Perez's *Technological Revolutions and Financial Capital* (2002), Kurt Dopfer's *The Evolutionary Foundation of Economics* (2005), and Alan Kirman's *Complex Economics* (2010) provide theories, research methods, empirical approaches, dynamic models, and the historical view suggested by evolutionary theory. These books established new agendas for industrial and innovation studies, for management and organizational surveys, for disequilibria and coordination theories, and for the discussion of economic and social conflict and change.

Giovanni Dosi was pivotal to this research and, in some cases, inaugurated new avenues, in particular as he extended evolutionary dynamics to the articulation of an empirical approach and a generation of agent-based models embodying the intuitions of Smith, Marx, Keynes, and Schumpeter. In a recent book (Dosi, 2012) that recapitulated this work on economic organization and industrial dynamics, he notes that neoclassical economics distinguishes between dynamics and coordination, following the combined assumptions of stable preferences, maximizing behavior, and equilibrium, with optimal decisions from well-defined choices. In such context, the emergence of coordination problems appears to be ontologically impossible: "Why would a representative agent able to solve sophisticated intertemporal optimization problems from here to infinity display frictions and distortions in the short run?" (Dosi, 2012: xvi). As a consequence, in the orthodox framework, coordination is assumed by construction; that is the case, for instance, of DSGE (dynamic stochastic general equilibrium) or RBC (real business cycle) models, in which endogenous cycles tend to be excluded.

Instead, evolutionary economics looks at non-equilibrium processes in which bounded rationality prevails. Another question is, if this can be accurately established under psychological models of individual behavior, *à la* Kahneman or *à la* Thaler, or if this requires alternative descriptions of collective interaction. In this case, heterogeneous agents learn and adapt both within and outside markets, which suggests a larger institutionally embedded evolutionary process not reducible to markets, as proposed by Marx, Veblen, or Coase. Endogenous preferences and endogenous innovations, knowledge- and capability-based firms and national systems of innovation, and coordination as one possible outcome of a social process of decision making impart a structure far different from the optimization and rational expectations framework pushed by the mainstream since the 1970s. Furthermore, complex evolving systems demonstrate co-evolutionary dynamics and emergent properties, such as fat tails, non-ergodicity, and path dependence or hysteresis (David, 2005). This is why evolutionary economics is concerned with the drivers, patterns of change and mechanisms of coordination, and uses stylized facts from empirical observation, exploring regularities and structures, a view that replaces axioms by factually based conjectures (Dosi, 2012).

This new approach has been successful, providing interesting contributions to empirical research on patterns of change at the firm, industry, and national and international levels, suggesting alternatives for decision making, and building a corpus of insightful models. Yet, evolutionary economics still suffers from two limitations, preventing it

from emerging as a coherent alternative to the neoclassical syntheses. First, as Dosi observes, evolutionary economics requires but lacks a theory of value, interpreting the social classes and different relations and strategies, such as rent-seeking, exploitation and, broadly, power (Dosi, 2012: xlvi). Second, an evolutionary macroeconomics proposing a realistic vision of the historical process, including economic cycles and long waves of development, phases of hegemony, and other social, political and economic forms of determination, has yet to be synthesized. The Freeman paper under discussion in this issue of *ICC* and *As Time Goes By* contributed to the second and only incidentally to the first question.

3. Karl Popper enters the room

Before considering the theoretical framework of the paper, a note on a philosophical question is in order, as the 1995 paper includes several pages discussing Popper's approach to social sciences (Freeman, 2019, section III, "Recurrent Phenomena in the Social and Natural Sciences").

Although that would already be controversial in the nineties, Popper's views on epistemology had been taken for long as a standard summary of the state of the art of good science. These views provided a simple criterion (falsification), a promise of outstanding results (confirmed or refuted predictions), a universal comparison with what was understood as the adequate methods of hard sciences and, therefore, means for tribal recognition in science. The question is that all this is useless for economists.

Freeman's reflections on these criteria are fascinating. Indeed, by the time of the preparation of the paper we thoroughly discussed the matter (Chris putting it in an elegant and nicer formulation that I would be unfit to deliver). He was able to pick the very few elements in which Popper could be read as understanding some of the peculiarities of social sciences, namely their inability to conduct large scale experiments (and even their restriction to local experiments only in specific areas of economic action) and the limits of recurrence of several macroeconomic processes. It was obvious that Chris was addressing the only two features he could find in Popper that contradicted the purpose of applying falsificationism to social phenomena. In a stroke of generosity, Freeman accepted with Popper that "the social sciences have much to learn from the success of the natural sciences" (from the "success", not necessarily from the methods or conclusions). But, he used this innuendo to discuss the meaning of the analogy of evolutionary biology to economics, which was precisely denied by Popper (since Darwinism does not lead to predictions to be tested or refuted, it is not scientific for the strict Popperian standard).

As Popper noticed, since social sciences are embedded in history, only "conditional predictions" may be phrased ("prophecies", he also writes). "But this application of the method of conditional prediction does not take us very far", Popper condescended (as quoted by Freeman). Indeed it does not take us very far. History may exhibit approximate structural regularities and recursive processes but not strict repetitions of events; therefore, all historical knowledge is outside the scope of a typical science obeying Popperian methods. There is no laboratory experimentation, no inductive accountability, and no prediction. Moreover, under Popper's approach some natural sciences are excluded as well, whenever they do not allow for predictions and refutation or impose a specific cadre for limited experimentation, such as biology, geology, seismology or others, not to speak of history itself and the whole of social sciences. In our province, explanation, not prediction, is the core of the scientific method.

Freeman chose to address these issues to conclude on the precise implication of a face value metaphor from evolutionary biology to economics. And that was the end of the story, exit Popper. In *As Time Goes By* Popper is only referred to in a couple of short mentions, and his theory of science is not even considered.

4. The contemporary Methodenstreit

Section I of the Freeman paper introduces a critique of the traditional growth theories (Harrod-Domar, Solow, and then Denison), surveying the new growth models (Romer, etc.) and presenting "a tentative effort to develop a theoretical framework for 'reasoned history' and growth economics", which is the theme for section II. There Freeman argues that "five main streams of history" should be considered as relatively autonomous and yet interdependent: science, technology, economy, politics and culture, and eventually a sixth, ecological constraints. The economist should look at synchronicity or its absence among these streams in order to understand social dynamics.

In this, Freeman differed from other theories of growth, mostly since he discussed social evolution and not just a "Kama Sutra of variables" (the expression is Dosi's, as Chris noted in his paper) for a multiple regression eventually

providing a satisfactory R^2. Explaining, in his framework, requires understanding of causality in a concrete sense and not just a statistical measure of correlation. Instead, as he presented the five sub-systems in order to classify the different autonomous and interconnected processes, Freeman proposed a detailed history of economic change, as he shows with his discussion of the causes and development of the British Industrial Revolution, which constitutes most of the paper. The confrontation between these two ways of theorizing Freeman calls the "modern Methodenstreit" (I discussed these topics in Louçã, 1997, 2019).

In *As Time Goes By*, this is combined with the intuition, previously developed together by Chris and Carlota Perez that these factors should be considered in two dominant combinations: the techno-economic paradigm and the socio-institutional system, whose interaction determines the accumulation regime and is part of a specific international hierarchy. This is how these concepts have been defined: < id="132" data-dummy="list" list-type="number">

The *technological or techno-economic paradigm* describes the relations between the mode of production and available techniques. In each period, a constellation of innovations is available to be diffused in the economy, following a key factor and a dominant branch, such as the automobile in the past or information and communications nowadays. But technical innovation alone does not create a new society, since the process of accumulation may be blocked by the mismatch between the techno-economic paradigm and the regulatory framework.

The *socio-institutional framework* involves the regulations, laws and practices that organize work and social reproduction and determine wages. This concept should be broadened to include social security, public services, and other forms of indirect or social wage. The structure of work is a major component of the social order and source of legitimacy, but during periods of contraction social regulation tends to be out of phase with the requirements of capital accumulation, which asks for major transformations in the production and distribution of surplus.

The *accumulation regime* describes how production and realization of value are combined. From the point of view of production, accumulation depends on productivity and surplus. From the point of view of realization, unequal distribution of wealth may inhibit demand. The accumulation regime also refers to the rules of the game, the "productive order" (as put by Dockès and Rosier) and concerns the structure of the ruling class itself, including relations among industrial, banking and financial capital, firms, shareholders, and managers.

Finally, the *international hierarchy* corresponds to the organization of the world economy and defines the insertion of each social formation in the global market. One dimension is the global division of labor, namely who extracts raw materials, who produces industrial goods and more sophisticated services, who dominates the channels of trade, including the communication and the information technologies. But, the international hierarchy also involves the definition of global reserve currencies, the control of investment and international financial flows, and of essential goods, such as energy and water. Financial, military and political relationships define the hierarchy of power.

/ The last item is perhaps less developed both in this 1995 paper and in *As Time Goes By*. Not because it is secondary; on the contrary, it is the implication of the accumulation regime and the technological and economic capabilities as developed in different economies and agents. Moreover, in practical terms, changes in the accumulation regime and at the international hierarchy can generate political conflicts within and between nations. In Britain, the conflicts over the Corn Laws in the 1830s and 1840s and over Tariff Reform in Britain in the late nineteenth and early twentieth centuries had profound effects on the catch-up countries, USA, Germany, and Japan. Conflict over trade issues can yield broader friction in international relations, as illustrated in the Anglo-German naval armaments race before 1914, or later in the emergence of ordoliberalism as a quasi-constitutional rule in the European Union or in the dominance of Merkel's neomercantilist policy, and eventually in Trump's current crusade to redefine the US trade balance.

Table 1 summarizes this view of the contemporary transformations according to these criteria, as applied to the dominant economies.

Table 1. Fordism and neoliberalism

	Fordist capitalism upswing of the long wave c. 1945–1975	Neoliberal capitalism downswing of the long wave 1975 to present
Techno-economic paradigm	Fordism	Computerization
Accumulation regime	Corporate and managerial capitalism	Financialization
Socio-institutional regulation	Social contract	Flexibility
Organization of the international hierarchy	Internationalization	Globalization

5. The reason against technological determinism

In his analysis, Freeman avoided the recurring over-simplification of technological determinism. Instead of a detailed inspection of the historical data on the economy and society, technological determinism focuses on processes and products and tends to assume the future economic success of scientific discoveries from their mere availability. The economy is represented as a deterministic path and a sketch of each new techno-economic paradigm is adopted as a map of the future waves: after computation and communication, biotech, genetic medicine, and pharmaceuticals are indicated as future drivers of new phases of growth.

For instance, some studies base the periodization of long waves on technological trajectories (Edmonson, 2012; Linstone and Devezas, 2012). Li et al. (2007) identify a fifth wave beginning in 1983, reaching a peak by either 1997 (on the basis of profit rate) or 2004 (on the basis of accumulation) followed by a downswing. Korotayev and Tsirel (2010) use a similar dating for that downswing but locate the subprime crash as the turning point. Grinin and Korotayev (2014) investigate the Juglar cycles in the long wave, detecting a cycle from 1990–1993 to 2001–2002, and from then to 2008–2010. On the very eve of the last general recession, Papenhausen (2008) designated the same crisis as a "temporary depression" between two peaks of an upswing with the maximum to be reached in 2018–2020, 10 years after the prediction. A more radical version of technological determinism appears in the prediction of a fifth or even sixth long wave, to be based on neuro-technology and to last eventually until 2060 (Lynch, 2004; Dator, 2006; Grinin and Grinin, 2016), and some researchers predicted these future waves (Nefiodow and Nefiodow, 2014).

Instead, for Freeman the emergence of a techno-economic paradigm cannot alone generate a new mode of development, as the existence of clusters of radical innovations or new systems of production is not sufficient to launch a long wave of development. He always emphasized, as we pursued in our book, that industrial or technological revolutions are insufficient to explain long periods of structural change in modern societies. He distinguished between the emergence of the technical potentiality of the new key factor of an industrial revolution, for example, electricity itself, and its diffusion, including the radical and process innovations generating further social, organizational, and technological change, for example, the consolidation of Thomas Edison's great corporation or rural electrification during the New Deal. He focused on the landscape of the industrial and economic sectors concentrating or following the gradient of productivity and profitability, on the impact of the major changes in production and distribution, and on the social relations supporting both. Rejecting technological determinism, Freeman argued that the explanation for the long period of readjustment after a crisis of accumulation is the structural mismatch between the capabilities of the emerging techno-economic paradigm, established from the pool of available epoch-making innovations, and the institutional framework required for a specific form of their deployment.

Economies are indeterminate social processes, and no mechanical representation can predict their development (in that sense he was amused to quote Popper: "the fact that we can predict eclipses does not, therefore, provide a valid reason for expecting that we can predict revolutions").

6. Economics is a science of social choices

The article considered these factors in its exercise in explanation (the Industrial Revolution) and then in the final notes on falling behind, after the dominance of British capitalism was challenged by emerging powers. This is a splendid example on how an economist can understand history, model the dynamic forces of inertia and change, and model the process of evolution through innovations, shocks and coordination. As in Nelson and Winter (1977) and

Dosi (1982), he looked at technological trajectories and the paradigm they form in order to understand the processes of industrial revolution, also considering the dimensions of social relations, conflict, and institutional power.

In this framework, *As Time Goes By* presented a larger view of the history of the first industrial revolution and then of the other systemic technological changes until our time. As in Marx, Schumpeter, Kondratiev, and many contemporaries, we argued that these changes can be interpreted according to a general pattern of waves of expansion and contraction, deeply rooted in industrial revolutions (the diffusion of steam power, electricity, internal combustion engines, and microelectronics) that transform the way of producing and living and generate specific physical systems, each related to a concrete form of work, management, and use of capital.

Noting that research on industrial revolutions and even on the very notion of a business cycle faded as the developed economies entered the period of sustained growth after the Second World War and as the neoclassical synthesis dominated economics, we proposed to challenge that view. Indeed, even a sophisticated economist as Paul Samuelson believed at a certain moment that the 30 golden years after the War were the inaugural period of permanent growth, unalterable by perturbations, and the concept of economic cycle had retreated into obscurity. Yet, Samuelson's prediction proved wrong and the facts of life rejected the simplistic view of a frictionless economy. What was announced as the era of permanent growth proved to be merely a long phase of expansion, to be followed by a long phase of stagnation. In that sense, our conjecture posits long historical waves, each divided into a broadly expansionary phase A followed, as contradictions and countercurrents build, by a broadly contractionary phase B, beginning with the major recession of the 1970s, proving that the cycles and crises are indeed the pulsation of modern capitalism.

In the book, we argue that a constellation of innovations forming a new techno-economic paradigm was already available by the turn of the century, and has been there for a long time. Yet, the institutional adaptation takes many years to complete as it is a contradictory and conflictive process. It is based on four demanding elements of the neoliberal program: liberalization of financial flows, privatization of public goods, precarization of the workforce, and globalization of markets. This process changes the pattern of accumulation, imposing a new regime, that of financialization, therefore altering the composition and distribution of surplus among the owners of capital.

In fact, the current long recessive phase has been shaped by structural changes imposed through three processes: the neoliberal reconfiguration of institutions, the financialization of surplus extraction, namely through rentism, and accumulation via intensified inequality. These very changes undermine the conditions of relative stability of the economic and social management prevailing during the previous expansion wave and lead to fragile regimes and to chaotic international relations dominated by the decay of the hegemony of the USA. Both economically and socially, it is a dangerous transition. The implication is that new challenges of the international leadership emerge and, 40 years after the end of Bretton Woods and the end of the Vietnam War, and 30 years after the collapse of the Soviet Union, an international order is still to be settled—and what exists is becoming more difficult to stabilize.

7. The statistical conundrum

Chris rejected both the notion of evolution as a superimposition of random events, as if real history were but a single sample drawn from a large universe of possible realizations of the same process, and the notion of events as exogenous perturbations on a sea of regularities. Instead, he preferred to develop economics based on "reasoned history" and to apply his tools to the understanding of complex processes that escape simplistic descriptions. Given that, he suspected the traditional econometric estimation as a mode of proof in the analysis of times series. This skepticism put him at odds with most of the profession.

Indeed, Chris's approach to the formation of each techno-economic paradigm, or the explanation of its mismatch with the socio-institutional framework, the basis for his understanding of the long processes of change in the developed economies, required an argument based on historical inspection of data, not on the uncovering of statistical evidence of some secret mechanism generating the movement. The price for that strategy was simply avoiding the technical attempts to detect these long-term processes using the traditional estimation procedures. Moreover, this led some of his colleagues to dismiss Freeman's views on the technological revolutions and long waves as quests for the Loch Ness Monster, accepting that it may exist, but you can never find it (Diebolt and Escudier, 2002). Although this is not a topic for this article, if the alternative is considered, the historical approach by Freeman emerges as a solid method, since the standard econometric analyses of cycles depend on the implausible contention that cycles could and should be decomposed as the superimposition of a dissipation mechanism plus exogenous shocks

providing for the source of energy. Thus, causation (the shocks) was insulated from explanation (the mechanical device of equilibration). The current RBC techniques follow the same mantra. Indeed, most standard methods recur to several forms of torturing the data, such as linearization around equilibria, detrending, and other forms of filtering in order to censor path dependence or heteroscedasticity. Still today, decomposition remains the method suggested by real business cycle theory, although this depends on *ad hoc* assumptions to establish the period for moving averages and other computational assumptions and techniques regarding trend deviation. The question is that the distinction between trend and difference stationarity (Nelson and Plosser, 1982) is driven by axiom rather than tested facts. Indeed, the notion that fiscal, monetary, or technological exogenous shocks randomly disturb an otherwise stable and stabilizing mechanism owes more to ideology than to science. This representation was established in the seminal paper by Ragnar Frisch (1933), which would obtain him, several decades later, the first Nobel Prize in Economics, jointly with fellow econometrician Jan Tinbergen.

Freeman's more modest approach does not promise to reveal the secrets of nature but suggests an evolutionary explanation of the real evolution of modern economies. This section briefly discusses some statistical evidence on these alternative methods, since this was an important factor for the impact of the 1995 paper and the subsequent book.

Avoiding the decomposition methods to resolve trend, cycle, and shock, several descriptive methods have been used by several researchers. Still, most statisticians concentrated on time series of prices (e.g. Jerrett and Cuddington, 2008, finding long waves in long series of prices of metal, and Erten and Ocampo, 2013 (finding super-cycles in commodity prices). Using the same approach, Kleinknecht (1987) and Atkinson (2004) discussed measures of the systemic impacts of innovation. Korotayev et al. (2011) identified long waves in the evolution of global—but not USA—patents activity and suggest a fifth long wave beginning in the second half of the 1980s. Yet, the outcome variables were chosen based on data availability rather than causal importance. They are not the most relevant or revealing variables. Prices are neither production nor profit, and patents do not necessarily reveal market evolution.

Furthermore, concerns about the validity of decomposition methods led to improvements and alternatives including log-linear trends, the filter-design approach, correlation analysis, structural time series, best fitting polynomial regression, fractional integrated long memory processes, outlier identification and tests for trend break within stochastic models. For instance, using polynomial regression methods, Jourdon and Tausch (2009: 167–190) found long waves in world industrial production series; Li et al. (2007) measured the profit rate and accumulation for the USA, UK, Japan, and Eurozone, using a weighted average of the profit rate, and detected four long waves, measured from trough to trough.

A problem shared by some of these techniques is their minimal theoretical justification. Eventually given this objection, periodogram, or spectral analysis came to dominate as a data-driven alternative free from conceptual biases. Spectral analysis facilitated detection of periodicities in time series for macro-variables, although it requires stationarity (a detrended series) and regularity assumptions (e.g. no structural change in the data), a significant drawback when structural change is the object of study. In any case, spectral analysis has been frequently applied but has led to no consensus on the conclusions. Applying spectral analysis to prices, Diebolt and Doliger (2007) and Diebolt (2014) detect only Kuznets cycles and no Kondratievs, and Solomou (1990) also used spectral analysis to reject the Kondratiev hypothesis. But other researchers reached opposite conclusions (Korotayev and Tsirel, 2010; Bosserelle, 2012), and Ozouni *et al.* (2015:17) found "obvious" long waves, with Kondratiev cycles explaining half of the total variance of gross domestic product (GDP) after the elimination of a linear trend.

The vulnerability of spectral methods to *ad hoc* assumptions encouraged some researchers to adopt wavelet analysis, which can incorporate irregular, non-stationary, and complex signals, including non-homogeneity through time. Applying this approach to USA, UK, and France wholesale prices for 1791–2012, Gallegati *et al.* (2017: 129) found strong evidence of long waves before World War II and some indication of linked movements afterwards, but for the last period the signals from prices and GDP diverged (Bernard *et al.*, 2014). Comparing their wavelet analysis to those obtained with the Christiano-Fitzgerald band-pass filter, the authors claim robust results. Jacks (2013) applied the technique to price series and reached similar conclusions, but Metz (2006, 2011) obtained the opposite conclusion.

Gerald Silverberg (2003), who reviewed the controversies on how to measure and model long waves, discussed these "theory-free econometrics" and, although taking a skeptical view, suggested returning to Schumpeter's hypothesis, following the inspection of clusters of innovations, of conducting sectors and creative destruction leading to waves of infrastructure investment, like the long waves or General-Purpose Technologies diffusion. In that sense, the essential reason for the *lochnessism* of the long waves clearly emerges: concrete historical processes, which form an

epoch, a phase of development, or a long wave, do not repeat and therefore cannot be measured by a statistical test conceived to detect the orderliness of cycles. Furthermore, the asymmetry of the upturns and the downturns (Coccia, 2010), the implications of social and political variables and internationalization of economic relations, all establish the long waves as historically specific, although eventually having the same type of systemic causes. For this reason, a statistical tool tuned on regularity is unable to detect the patterns of structural change represented by these periods.

Empirically oriented and using data for 20 advanced countries since 1848 and the turning points detected by Mandel (1995), Basu checked the growth rate of real per capita GDP and capacity utilization in upswings and downswings and, following the Social Structures of Accumulation argument, finds evidence of the business cycles in expansionary long phases being "reproductive" (endogenously restoring profitability expectations) whereas they are "non-reproductive" in the long stagnation phases (Basu, 2016).

Robert Brenner (2002) suggested the impact of destructive international trade conflicts as an explanation for global turbulence, and attributed the decline of the profit rate to over-accumulation through competition and globalization followed by a fall in the rate of investment, aggregate demand, and productivity growth. The failure of the manufacturing sector, the epicenter of competition with high sunk costs, to replace less productive extension echoes Adam Smith and rejects the Marxian explanation of the declining of the profit rate via rising organic composition, which could be consistent with technical innovation (this is discussed by Duménil *et al.*, 2001; Stockhammer, 2015).

Marx had proposed in volume III of *Capital* the reverse explanation: the declining rate of profit causes intense competition, trade wars and devaluation of capital. In the same sense, Anwar Shaikh, in his massive book on capitalism, interrogated not the specific cycles but the nature of the pattern itself:

> "How can the capitalist system, whose institutions, regulations, and political structures have changed so significantly over the course of its evolution, nonetheless exhibit recurrent economic patterns? The answer lies in the fact that these particular patterns are rooted in the profit motive which remains the central regulator of the system throughout its evolution" (Shaikh, 2016: 726).

In the same sense, Chris and I used the rate of profit and the processes of accumulation, technical change, and social adaptation as the convenient representation of social and economic dynamics under capitalism. Therefore, no theoretical claim on these long-term processes can be established on grounds of a simple statistical demonstration; yet, a theory can be established on the basis of stylized facts, on historical interpretation, descriptive statistics and auxiliary mathematical tools, and on a comprehensive analysis of technological and social change. That is what Freeman demonstrated with the sections of his 1995 paper on the inaugural Industrial Revolution.

8. Epilog

Although clear-eyed about the menaces our societies face, Chris Freeman was an optimist and struggled ceaselessly for the socialization of the benefits of new technologies, in order to democratize information and to enable broad access to common goods. He thought, rightly, that the contemporary information revolution presents an opportunity for full employment and a better life, and he opposed anti-democratic regression. Neoliberalism and the populist authoritarian turn manifest the current structural crisis but represent only one strand among many. In any case, the dice are not all cast.

The question remains: where will this transition based on slow recovery and recurrent financial crises lead? Will it aggravate inequality, conflict, and international disorder? Or can it be challenged and changed? Every Freeman's student knows how he would answer to those questions.

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