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The implications of the concept of exaptation for a theory of economic change¹

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Abstract

The term exaptation, coined by Gould and Vrba, refers to those characters that are useful for survival but that were not selected for this purpose. In this paper I will focus on the notion of exaptation in socio-economic systems and on its implications for a theory of economic change. In socio-economic systems, an exaptation is the result of a process through which the initial attribution of new functionalities to existing socio-economic entities (agents, artifacts, social institutions) leads to new entities and new relationships between entities. The notion of exaptation forces to examine the processes of change in socio-economic systems in terms of an interaction-based ontology that I will provide, following the complexity theory of innovation. I will use this ontology to highlight how processes of economic change can be analysed in terms of emergent phenomena and in particular in terms of the emergence of new specific functionalities and qualitatively new entities and relationships. I will refer these processes to the relationships between agent and artifacts, and to the organization of the economy and society. This second type of process of emergence will be examined with reference to the changing characteristics and functions of the division of labour emerging from the historical processes of interaction between quantitative and qualitative changes of production relations. I will conclude that economic change cannot be analysed in terms of a mere recombination of existing things or in terms of selection-variation mechanisms. It must be analysed through the dynamic historical process by which “a new thing leads to another”. In these processes of transformation the causality links are themselves the results of processes in which ex ante potential causality links can be transformed into different (and new) effective (or actual) causality links.

Keywords: exaptation; adaptation; quantitative and qualitative changes; complexity; division of labour

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1. Introduction

For a long time, the idea that the origin of what exists can be deduced from its actual functionality (or utility) has been dominant. This idea conditioned evolutionary thinking and found its expression in the notion of adaptation through selection. It is only with the contributions of Gould, Lewontin, and Vrba that an interpretative perspective different from the adaptive theory has emerged and a word to identify such a perspective has been coined: the term *exaptation*. In particular, Gould and Vrba coined the term exaptation to refer to those characters that are useful for survival but that were not selected for this purpose.

In this paper I will focus on the notion of exaptation *in socio economic systems* and on its implications for a theory of economic change. In socio-economic systems, an exaptation is the result of a process through which the initial attribution of new functionalities to existing socio-economic entities (agents, artifacts, social institutions) leads to new entities and new relationships between entities. I will argue that exaptations are the expression of the general phenomenon of the emergence of new specific functionalities and new entities. The main implication of the exaptation-based perspective highlighted in the following pages is that it leads us to analyse economic change in terms of processes through which relationships defining entities involved in economic processes change as a result of the human action embedded in such relationships, giving rise to new outcomes (in terms of new entities). Exaptations are induced by and induce qualitative changes resulting from interacting social processes. Exaptation processes do not have a purpose known in advance: they produce effects to the extent that they give rise to new agents, new artifacts, new social institutions.

In order to grasp the implications of the concept of exaptation, the paper is organized as follow. First of all, in section 2, the concept of exaptation will be highlighted by comparing the adaptation-based and the exaptation-based perspectives. In section 3, I will provide an essential interaction-based ontology defining concepts and entities for the analysis of exaptation processes as emergent phenomena in socio-economic systems. In sections 4 and 5, this ontology will be used to discuss how the emergence of new functionalities, new entities, and new relationships can be analysed at a theoretical level. In particular, in section 4 I will consider the emergence of new functionalities, new artifacts and new markets, and in section 5 the emergence of new functionalities at the level of the organization of production and society. This second type of process of emergence is examined with reference to what can be considered an essential character of all forms of society: the

division of labour which, as history teaches us, came into being along with the first forms of societies. Section 6 contains some concluding remarks on the implications of the notion of exaptation for a theory of economic change.

2. Adaptation and exaptation: two paradigms compared

In evolutionary biology the term adaptation is used to indicate a mechanism of selection of what has become adapted to a certain pre-existent functionality. In general, the “concept of adaptation implies that there is a pre-existent form, problem, or ideal to which organisms are fitted by a dynamical process” (Levins and Lewontin, 1985, p. 67). According to this perspective, through selection organisms adapt themselves to a pre-existent environment and must evolve in order to maintain their state of adaptation as the external environment changes. Once the idea that evolution is the result of a process of adaptation through selection is accepted, each element of an organism – whether it is part of a living organism or of an artifact or of society – has its origin in the function that it currently performs. The feathered wings of birds, for example, should have originated in flight because they are adapted to flight just as the human eye, an organ of extreme perfection, should have been formed by natural selection.

Darwin was perfectly aware that such a theory of evolution could not be applied to the cases in which organs or characters originally designed for a function are co-opted for another function. In chapter six of the Sixth edition (1872) of the *Origin of the Species* entitled “Difficulties of the theory”, for example, Darwin argues that the case of the swim bladder in fish shows that an organ originally designed for the hydrostatic function can be transformed for another entirely different function, the respiratory function. Another case considered by Darwin is related to the cranial sutures of mammals, which are useful and even indispensable for birth, but are not selected for this purpose, for they are also present in the cranium of birds and reptiles. Thus, a characteristic that emerged for some other reason — whether connected or not with the process of natural selection — was co-opted for a different use. Darwin did not think that cases like the swim bladder in fish or the cranial sutures of mammals could question his theory. For a long time, after Darwin, “anomalous cases” of organs originally designed for a function and subsequently co-opted for another function were considered as “pre-adaptations” to the new function.

It is only with the contribution of Gould and Lewontin (1979), Gould and Vrba (1982) and Gould (2002) that an interpretative perspective different from the adaptive

theory has emerged and a word by which to identify such a perspective has been coined. In particular, Gould and Vrba (1982) used the term *exaptation* to refer to those characters that contribute to survival but that were developed for other reasons. Feathers, for example, originally selected for thermoregulation, later were co-opted by birds for flying (Gould, 2002 p. 1232). In other words, feathers are *apt* for flying in virtue of their *ex* form: they are *ex-apt*.

Gould's insight about the importance of changes of functionalities attributed to existing entities has an interesting antecedent. As Gould (2002, pp. 1214-1218) recognized, the principle according to which historical origin and current utility cannot be related to each other as if the origin derived from the utility, was illustrated in 1887 by Nietzsche in an essay entitled *On the Genealogy of Morals*. In section 12 of the second dissertation in this essay, Nietzsche discusses the origin and the purpose of a legal institution, punishment. He argues that origin and purpose of punishment should be dissociated inasmuch as a legal institution is an example of how an already existing thing is "always reinterpreted" and "adapted to new utilities". Nietzsche seems to attribute to these continuous re-interpretations and adaptations to new purposes a general value as a important aspect in human activities. It follows that, according to Nietzsche, even if "you have understood perfectly the usefulness of any physiological organ (or legal institution, social custom, political usage, art form or religious rite) you have not yet thereby grasped how it emerged" for "every purpose and use is just a sign that the will to power has achieved mastery over something less powerful". In the following passage, Nietzsche denies that the development of a thing, an organ, a tradition is a continuous progress towards a goal and admits that, in the process of ongoing new interpretations and adaptations to new secondary purposes, contingent elements are present. "The whole history of a 'thing', an organ, a tradition can to this extent be a continuous chain of signs, continually revealing new interpretations and adaptations, the causes of which need not to be connected even among themselves, but rather sometimes just follow and replace one another at random. The 'development' of a thing, a tradition, an organ is therefore certainly not its *progressus* toward a goal, still less is it a logical *progressus*, ... instead it is a succession of more or less profound, more or less mutually independent processes of subjugation exacted on a thing".

2.1 A comparison between the adaptation-based and the exaptation-based perspective

To synthesize the main differences between adaptation and exaptation, we can compare these two perspectives according to three elements: (a) the types of

processes in action; (b) the relationships between process, structure and function; (c) the relationship between current functionality and the origin of an entity. In very general terms, but I will return to this in a more accurate way in section 3, the *structure* of an entity² is the description of its parts (its different components) and the way in which they interact. The *functionality* of an entity depends on the properties attributed to it in relation to some specific use.

	Processes	Relationship between process, structure and function	Relationship between current functionality and the origin of an entity
ADAPTATION	Natural selection shapes the structure of entities for a current function	Adaptation through selection leads to a given relationship between structure and a pre-existent function	The origin of an entity can be deduced from its current functionality inasmuch as functionality is considered as an end, known in advance, toward which natural selection is directed
EXAPTATION	Entities with a given current functionality are coopted for a new use	From an initial attribution of a new functionality to an existing entity, an exaptation changes the relationship between structure and function	The origin of an entity cannot be deduced from its current functionality. To trace the origin of an entity it is necessary to examine the changes in functionality that have occurred in time

Tab. 1 Adaptation vs exaptation

According to the adaptation-based paradigm (see tab. 1), the process of natural selection shapes the structure of entities for a current function. It follows that adaptation through selection leads to a given relationship between structure and a pre-existent function. If the functionality of an entity is considered as an end, known in advance, toward which natural selection is directed, the origin of an entity can be deduced from its current functionality. By contrast, in terms of the three elements mentioned above, we can characterize exaptation as follows (see tab. 1): an initial process through which entities, with a given current functionality, are coopted for a new use (a new functionality), leads to new entities with a new relationship between structure and function. An exaptation changes the relationships between structure and

² I refer to entities in very general terms. Entities are organisms (or individual characters of an organism), artifacts, agents, organizations, social institutions. Following the complexity-based theory of innovation, I define an entity in term of three interacting elements: its structure, its functionality and its processes of transformation (see Lane et al, 2009). For a more accurate definition of agents, artifacts and social institutions in socio-economic systems see section 3 below.

function. It follows that the origin of an entity cannot be deduced from its current functionality; to trace the origin of an entity it is necessary to examine the changes in functionality that have occurred over time.

2.2 *Defining exaptation in socio-economic systems*

Since the publication of the essay by Gould and Vrba, the notion of exaptation has received a wide audience not only in biology but also in other fields of research³. Defining the notion of exaptation in socio-economic systems, Mokyr refers to the idea that “a technique that was originally selected for one trait owes its later success and survival to another trait which it happens to possess” (Mokyr 2000, p. 57). Dew, Sarasvathy and Venkataraman (2004) do not go beyond this definition. According to Lane (2011), exaptation plays a key role in the dynamic of innovation. An exaptation happens when new patterns of interaction emerge around artifacts already in use, giving rise to new attributions of functionalities⁴. “The idea here is that artifacts gain their meaning through use, and not all the possible meanings that can arise when agents begin to incorporate new artifacts in patterns of use could have been anticipated by the designers and producers of those artifacts” (Lane, 2011, p. 69). In more general terms, I define⁵ an exaptation in socio-economic systems “as a result of a set of interacting processes through which an initial attribution of a new functionality to existing outcomes of human activity – whether they are artifacts, organizations, scientific achievements or cultural models – leads to new outcomes.” (Bonifati and Villani, 2013, pp. 172).

According to this definition of exaptation, it is not sufficient to attribute a new functionality to an existing entity in order to obtain a new entity as exaptation of a pre-existing one. A successful exaptation requires a set of processes of development of new entities and new relationship between entities. It is worth mentioning another aspect of the definition of exaptation just given, namely the meaning to be attributed to the adjective “new” qualifying the word “functionality”. We can identify two different meanings. The first one is related to an existing functionality attributed, for example, to an existing artifact designed to meet a different purpose. In this case, an

³ For references see Gould (2002), pp. 1234-1246. For research in linguistics, see Lass (1990) and Traugott (2004).

⁴ Since new functionalities give rise to new artifacts and to new patterns of interaction that, in turn, give rise to attributions, Lane refers to this process as “a *bootstrapping* dynamic that can produce cascades of changes in agent-artifact space” (Lane, 2011, p. 69).

⁵ See Bonifati (2010), Bonifati and Villani (2013) and Bonifati (2013).

existing functionality is “new” in relation to an existing artifact to which previously such a functionality was not attributed. A second different meaning is related to cases in which a transformation in the context in which an entity is embedded gives rise to functionalities that did not previously exist. In section 4 I will argue that in exaptation processes both types of new functionalities are present.

Existing artifact	Original specific functionalities	New specific functionalities	New artifacts
phonograph	dictating machine	automatic playing of popular music	jukebox
laser	no specific purpose	precision measurement to cause scarring reading barcodes cutting, drilling and welding	laser rangefinder micro-surgical laser barcode laser scanner new cutting instruments and new processes
Hertz laboratory instrument	to accurately measure electromagnetic waves	ship-to-ship and ship-to-shore communication	wireless telegraph
wireless telegraph	to communicate at a distance	transmission of sound	wireless telephone (radiotelephone) and broadcast radio

Tab. 2 Some typical examples of new artifacts with new functionalities that emerged as exaptations from already existing artifacts designed for different functionalities. Sources: Basalla (1988), Rosenberg (1996), Dew, Sarasvathy, and Venkataraman, S. (2004).

Tab. 2 summarizes some typical examples of new artifacts with functionalities that emerged as exaptations from already existing artifacts designed for different functionalities. The phonograph, invented by Edison as a dictating machine in 1877, was successfully co-opted for a different use: a tool for automatically playing popular music in the first jukebox, which became the first major use of the new technology (see Basalla, 1988).

After its invention, the laser was implemented with no specific purpose. In fact, Bell’s patent lawyers thought that it would find no commercial application in telecommunication. The laser technology gave rise to many new products only when new functionalities were attributed to it and many complementary technologies were invented and jointly implemented with already existing technologies. From these processes, the laser rangefinder, new micro-surgical laser instruments, the barcode laser scanner and new cutting instruments and new processes emerged (see Rosenberg, 1996).

The last two examples in the table concern the development of wireless communication technology (see Basalla, 1988). This technology started as a laboratory tool designed by Hertz to test Maxwell's theories on electromagnetic waves. Its initial designed functionality was to accurately measure the electromagnetic waves. By applying Hertz's laboratory tool to a new and different purpose, Marconi developed a new artifact – the wireless telegraph – with a new functionality, that of ship-to-ship and ship-to-shore one-to-one communication. A new system of relationships around the wireless telegraphy activated a new functionality of distance communication: the transmission of sound. This new functionality was activated in connection with the emergence of new knowledge and new capabilities in wireless telegraphy. New technologies were developed and new artifacts emerged, in particular wireless telephone and broadcast radio, a new artifact allowing one-to-many voice communication.

3. An essential interaction-based ontology

To grasp the implications of the notion of exaptation for the theory of economic change, it is first of all worth defining a socio-economic system in terms of the following characteristics:

- (a) *Interactivity*. Agents (individuals or organizations) are embedded in a system of relationships involving a set of socio-economic entities: other agents, artifacts, social institutions.
- (b) *Distributed knowledge*. Knowledge and capabilities generated in a socio-economic system are distributed among many entities: agents, artifacts able to store the results of human learning, social institutions.
- (c) *Intentionality*. Agents act in accordance with a purpose taking into account entities and systems of relationships between entities.
- (d) *Endogenous change*. Since agents' actions generate new knowledge, new entities and new relationships, socio-economic systems change as an endogenous result of a series of interacting processes.

The peculiar characteristic of the exaptation perspective in socio-economic systems is to focus attention on a series of ongoing changes, *in primis* in functionalities attributed to existing entities and from this to the emergence of new entities and new relationships among entities. The analysis of changes in socio-economic systems requires an appropriate essential interaction-based ontology that I

will give in this section by defining three types of entities: agents, artifacts and social institutions. In order to provide these definitions, I will use the notions of interaction, process, functionality, and uncertainty, the meanings of which it is worth clarifying first.

An *interaction* is anything that gives rise to a reciprocal action (influence) between the entities involved. In human social activities, interactions take place, for example, in dialogues or negotiations (in which agents act reciprocally with each other) and in consumption and production activities (in which agents, as defined below, act reciprocally with others agents, with artifacts and with the environment).

Interactions are basic elements for processes. In very general terms, I define *processes* as ongoing systems of interactions whose peculiar characteristic is to produce patterns of changes. It follows that processes are sets of changes triggered by systems of interactions. Any aspect of human activity can give rise to specific processes of change, but all processes in human activity require and give rise to learning processes. It follows that an essential and general characteristic of human processes is that they are cognition processes emerging from dynamic interactions among humans and/or between humans and nature⁶.

The notion of *functionality* is defined in terms of specific modalities of use of an entity. In this definition, a functionality is not a substitute for the purpose known in advance toward which processes of change are directed, as in the adaptation through selection paradigm. Instead, I consider functionalities as emergent specific uses.

Agents, as defined below, act in conditions of uncertainty in which the emergence of new artifacts, new patterns of interaction and new functionalities generates perpetual novelty that makes prediction impossible. This is the notion of *ontological uncertainty*⁷ put forward by Lane and Maxfield (2005).

It is worth clarifying that the definition of functionality given above (that implies the absence of a goal known in advance) and the presence of ontological uncertainty do not imply that agents have a blind behaviour, but simply that, *a priori*,

⁶ See Vygotskij (1978), cap. 5. Vygotsky expressly acknowledges his debt to Engels's dialectical method. See Engels (1883).

⁷ Ontological uncertainty derives from conditions of perpetual novelty in which not only are agents unable to decide *which* consequences will happen as a result of actions they contemplate taking, but also the very criteria of value with which these consequences would have to be expressed simply *do not exist* at the historical moment in which agents must act. Ontological uncertainty, as defined by Lane and Maxfield, has relevant points of contact with the Keynesian notion of uncertainty. See in particular the meaning in which Keynes uses the term 'uncertain' knowledge to refer to everything for which "there is no scientific basis on which to form any calculable probability whatever" (Keynes 1937, p. 113). For the difference between the notion of ontological uncertainty and Knight's notion of uncertainty, see Lane and Maxfield (2005, pp. 9-10).

when taking a direction agents have no guarantees to arrive where they had prefigured to arrive. This is a fundamental ingredient of emergent phenomena that characterize the exaptation perspective.

3.1 Agents

In socio economic systems, agents' actions can be defined only with respect to the system of relationships in which agents are embedded. This must be understood in a non-simplistic sense. For example, when Marconi attributed a new functionality to Hertz's instrument, considered until then as an instrument for measuring electromagnetic waves, he used in a new way the distributed knowledge common to other agents. This generated new social knowledge, new artifacts, new entities and new relationships. Similar considerations apply for the behaviour of a firm that opens a new path of innovations. Note that the use of distributed knowledge requires the interaction with other entities. These examples suggest that in socio economic systems actions are social actions and that agents, even when we refer to individuals, must be defined in terms of entities organizing actions for a certain purpose. It follows that in socio-economic systems, as defined above, agents have to be thought of as organizations. Following Lane (Lane et al. 2009; Lane 2011), an organization is defined in terms of the interaction between structure, function and processes. The *structure* of an organization describes its parts (energetic, material and informational), the interaction modalities among its parts, and the modalities through which the organization interacts with other organizations. The *processes* associated with an organization describe the transformations (within the organization) in which the organization may participate. The *function* of an organization gives directedness to its actions. Organizations, so defined, are the subject of action in socio-economic systems. It follows that we can define an agent as "an organization of human beings and artifacts in the name of which social action is initiated and executed" (Lane et al. 2009, p. 26).

In order to function, socio-economic systems require a continuous flow of actions by agents. Among these, actions that change a particular system of relationships in which agents are embedded can be defined as innovative actions. Note that, because of ontological uncertainty, innovative actions require agents' capability to act by prefiguring entities and relationships between entities that do not exist at the time when agents take such an action. The examples mentioned above are of this type.

3.2 Artifacts

Like agents, artifacts – both tangible (consumer goods, capital goods) and intangible (know-how, services or legislation) – can be defined in terms of three interacting elements: structure, functionalities and processes of transformation (Bonifati, 2010, p. 749). The *structure* of an artifact is determined by its material characteristics, by the processes of transformation that the matter has undergone as a result of human labour oriented by a project, and by the way in which its different components, which are themselves artifacts, interact. The *functionalities* of an artifact depend on the properties attributed to it in relation to its usefulness for some specific use. The interaction between structure and functionalities is governed by the *processes* through which the functionalities are attributed and the matter is transformed. It follows that artifacts emerge from a social process.

3.3 Socio-economic institutions (with particular reference to markets)

A socio-economic institution can be defined, in very general terms, as a set of rules and conventions governing a particular system of relationships functioning in socio-economic systems. In order to grasp the meaning and the role of institutions in socio-economic systems, it is worth starting by considering Polanyi's analysis of three forms of integration between economic and social relationships: reciprocity, redistribution and exchange (Polanyi, 1957). The significant element of Polanyi's analysis is that he identifies institutions that allow reciprocity, redistribution and exchange – which in themselves are only three different types of interactions – to give unity and stability to the integration between economy and society. In particular, he argues that the institution which allows reciprocity to integrate economic and social relations within a community that practises the exchange of gifts is, for example, a symmetrical system of kinship groups. Similarly the presence of an allocative center with the power to redistribute resources, such as the state or other less durable entities, it is a form of integration. Finally, the system of price-making markets is, according to Polanyi, the institution that gives unity and stability to exchange relationships, making the exchange a form of integration.

Following Max Weber, Polanyi identifies market economy as characterized by rational choices under scarcity. He accepts the idea, typical of marginalist economic theory, that market prices, balancing demand and supply on all markets, are able to coordinate individual choices of production and consumption. To carry out this coordination function, however, demand and supply functions of the traditional

theory of prices must be derived from individual rational choices by consumers and firms. In this way, the market is transformed into an abstract model of optimal allocation of resources, which axiomatically assumes that the individual choices are the result of constrained maximization of profit and utility in conditions of perfect competition. In the pure neoclassical economic theory, the market rules out the presence of relationships between agents. As noted by Hirschman: “Under perfect competition there is no room for bargaining, negotiation, remonstrance or mutual adjustment and the various operators that contract together need not enter into recurrent or continuing relationships as a result of which they would get to know each other well” (1982, p. 1473)⁸.

In what follows, to define markets as social institutions I will refer, by contrast, to a price theory of classical inspiration, according to which prices emerge from social conventions and power relationships governing the distribution of income between wages and profits. I consider this concept of price formation as the first of two essential theoretical premises of the definition of markets in terms of recurring patterns of interaction between agents and artifacts⁹. The second premise of such a definition is that markets are governed by a set of social institutions. These are, for example: the system of explicit and implicit contracts on legal markets, the system of agreements and constraints on illegal markets (Hodgson, 1989), the unwritten rules that govern interactions between producers and between producers and consumers (Brusco, 1999). While different social institutions contribute to formulate different systems of incentives that guide agents’ behavior in market systems, markets as social institutions cannot be regarded in any way as a self-regulating mechanism.

3.4 *Markets in context*

The entities defined above are embedded in wider sets of social relationships. To indicate these wider sets of relationships, I use the word *context* in its etymological meaning¹⁰ according to which context can be defined as the set of circumstances interwoven with a phenomenon (and its development). The peculiar characteristic of a context is that, once it emerges, it helps to give meaning to what is embedded in it by making the interpretation of a phenomenon less ambiguous.

⁸ See also Stigler (1946) and Hayek (1949) who explicitly exclude from perfect competition all personal relationships of any kind between the economic units.

⁹ Lane and Maxfield (2005, p. 36) define a market system as “a set of *agents* that engage with one another in recurring patterns of interaction, organized around an evolving family of *artifacts*”.

¹⁰ From Latin *contextus*, derived from *contexere*, that means to weave together, to interweave.

To make less ambiguous the definitions of agents, artifacts and markets we need to define a context for such entities. It is worth focusing our attention on the definition of a context for markets as *loci* of interaction between agents and artifacts. Markets as places of exchange of surplus produced by individuals and communities are ancient institutions. The first industrial revolution brought about a profound change in the function of markets in social organization, transforming them into a means to realize private industrial profits. After the first industrial revolution, production for a potential demand, a demand whose quantitative and qualitative dimension was not known in advance, forced producers to adjust production capacity to expected demand and to sell at a price not lower than that at which a normal profit could be achieved. But to realize profit entails selling and reaching new potential consumers. This imposes new relations between production and consumption. These transformations, in turn, interacted with the change of meanings and functions of other preexisting institutions of social organizations, such as for example the division of labour¹¹.

Against this historical and institutional background – which represents a wide context in which agents, artifacts and markets are embedded – I will attempt to give an example of how *specific dimensions* of the market context can be considered in terms of how competition works. Economists refer to two different types of competition: price competition and product competition. In the basic formulation, for homogenous products and atomistic production, price competition prevails. Although this representation of competition is present in economics textbooks, it probably does not exist in reality. In fact, for the generality of manufactured products, innovations and differentiations are the norm and, for commodities, monopolies prevail. It follows that we must concentrate our attention on imperfect competition, and product competition in particular, as the prevailing form of competition. Product competition is the result of firms' strategies and product characteristics and requires the capacity to innovate and differentiate products and services. Product competition emerges with different specific characteristics for each market by shaping market relationships, for example, in terms of different types of organization of production and sales, different types of global localization of production and different (and new) market institutions. It is a specific dimension of market context created by firms that changes over time. The example just discussed suggests that market context helps to make more accurate (and less ambiguous) the notions of agents, artifacts and markets by considering how that context emerges. In a similar way, the emergence of other specific dimensions of

¹¹ I will return to this in section 5.

market context could be examined, such as, for example, different forms of globalization and financialization.

4. The emergence of new functionalities, new artifacts and new markets: how we can analyze this process of emergence

The exaptation perspective discussed in the previous pages leads us to focus attention on the processes of transformation triggered by initial attributions of new functionalities to existing entities. It is worth returning for a moment to the case of feathers, whose original function was that of thermoregulation. Feathers do not lose this function, but they acquire another completely new functionality of being useful to flight. This new functionality, however, did not exist before living beings with feathers soared through the air. In other words, the new functionality of feathers emerged along with their transformation in order to become apt to a new emergent functionality that did not exist before.

With regard to artifacts, at least in a first approximation, we might be led to believe that the new functionalities attributed to existing artifacts designed for other purposes already exist¹². However, the analysis of the exaptation processes allows us to understand the ways in which the emergence of new specific functionalities takes place. In fact, by exploring the exaptation process we can analyze how new artifacts such as the wireless telegraph, the jukebox or surgical laser instruments are able to provide functionalities that presumably did not exist before: wireless telegraph allows us voice communication at a distance from sea to land, the jukebox reproduces sound but automatically and surgical laser instruments allow *micro*-surgery. These new functionalities emerged along with the new artifacts developed to provide the new functionalities initially attributed to them. In other words, the initial attribution of a new functionality changes the context in which an artifact is used giving rise to new artifacts able to provide new functionalities that did not exist before. Significant aspects of these processes of change can be analysed in terms of a theoretical framework essentially based on processes that activate processes (Lane, 2011; Bonifati, 2013). This framework can be illustrated by distinguishing three different levels of analysis focusing on: (a) attribution of functionalities; (b) development of artifacts; (c) production-consumption networks (see fig. 3).

¹² The functionality to communicate at a distance, for example, already existed when Marconi attributed it to Hertz's laboratory tool designed to measure electromagnetic waves (the wired telegraph provided this functionality). The same can be said for the new functionalities attributed to Edison's dictating machine or to laser technology.

At the attribution of functionalities level, the analysis focuses on the actions of individuals (or groups of individuals) which attribute functionalities by using (or producing) existing artifacts and communicate the new information to the potential producers (or to potential users). At the development of artifacts level, the analysis focuses on the attempts by producers to produce, by interacting with users, artifacts with appropriate structures to provide functionalities attributed to them. Complementary technologies can be developed and functionalities can be better defined by users and/or by producers. As a consequence, functionalities can co-evolve with the development of technologies and products. The production-consumption networks level considers that, in order to be produced and sold, new artifacts must be placed in a wider network of interactions involving new relationships between firms and between producers and customers. At this level of analysis the creation of new markets must be considered.

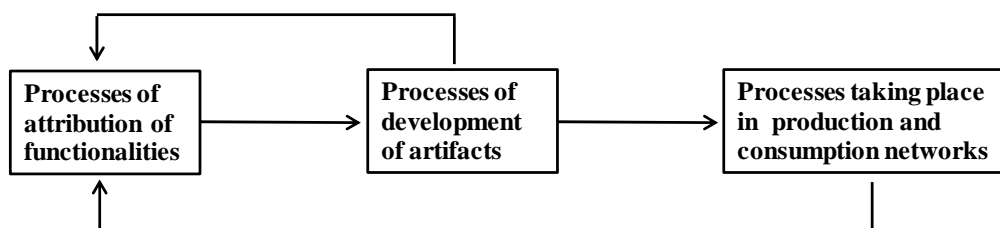


Fig. 3 Processes that activate processes in the analysis of the emergence of new functionalities, new artifacts and new relationships

A crucial aspect of this theoretical framework concerns two feedbacks acting as mechanisms of activation of the processes of attribution of functionalities (see fig. 3). Functionalities can emerge both from producers in the process of developing a product and from users and producers who in new production-consumption networks (new markets) interact with many others agents and artifacts. To return to the example of the wireless telegraph, when, in 1897, Marconi founded the Wireless Telegraph and Signal Company it was not clear what markets the new artifact would serve. From the initial first customers – the British Army and Navy – a new and broader market was built. The new organized system of relationships around the wireless telegraphy activated a new functionality for wireless communication technology – the transmission of sound – giving rise to the emergence of new artifacts (Basalla, 1988, pp. 97-101).

5. The emergence of new functionalities at the level of the organization of the economy and society

The main implication of the exaptation-based perspective highlighted above is that it leads to an analysis of economic change in terms of emergent phenomena and in particular in terms of the emergence of new specific functionalities deriving from intersecting processes giving rise to qualitatively new entities and relationships. In the previous section, I discussed these processes with reference to the relationships between agents and artifacts. Economic change has been discussed with reference to innovation processes in agent-artifact space. In the present section, I will try to discuss briefly the main implication of the exaptation-based perspective from the point of view of the organization of the economy and society. In particular, I will refer to what can be considered an essential character of all forms of society: the division of labour which, as history teaches us, came into being along with the first forms of societies.

As is well known, Adam Smith sees the division of labour as the source of the growth of wealth. The interaction between specialization, within and among productive activities, market expansion and productivity growth gives rise to dynamic economies of scale and to income and wealth growth. Smith considered the division of labour as a natural element of human behavior. According to him, the division of labour “from which so many advantages are derived, is not originally the effect of any human wisdom, which foresees and intends that general opulence to which it gives occasion. It is the necessary, though very slow and gradual, consequence of a certain propensity of human nature which has in view no such extensive utility; the propensity to truck, barter, and exchange one thing for another” (Smith, 1776 [1976], p. 17).

This conception of the division of labour does not give us a full understanding of the historical origins of the division of labour and of the transformation of its characteristics and its functions. To achieve such a comprehension we need a different perspective, important elements of which we can find in Marx’s analysis of the division of labour. Marx sees the division of labour as the organizational form of the relations of production both in the production units and in society. By considering how the division of labour changes with changes both in the relations between means of production and human labour and in the relationship between production and consumption (demand), Marx offers us a rich example of the analysis of changes in the functions of the division of labour from early tribal societies to modern capitalist

society¹³. As an example, I will refer here briefly to Marx's analysis of change in characteristics and functions of division of labour from manufacture to capitalist mode of production.

5.1 The changing characteristics and functions of the division of labour emerging from the historical processes of interaction between quantitative and qualitative changes of production relations

According to Marx, manufacture, defined as a production system in which most craftsmen work at the same time under the same roof, is a response to the expansion of markets triggered by the separation between production and trade and by the development of long-distance trade. Manufacture represents the production base of the mercantile system (in which trade dominates production). If we focus only on the production of the same sort of commodity by a large number of craftsmen working at the same time and in the same place, manufacture, Marx argues, "can hardly be distinguished, in its earliest stages, from the handicraft trades [*Handwerksindustrie*] of the guilds, except by the greater number of workers simultaneously employed by the same individual capital. It is merely an enlargement of the workshop of the master craftsman of the guilds. At first, then, the difference is purely quantitative" (Marx, 1867 [1990], p. 439). Marx, however, was interested primarily in the *qualitative changes* of the division of labour triggered by quantitative changes. At two different but *coexistent* levels of analysis, Marx analyses how a growth in the scale of production (a quantitative change) leads to two types of qualitative changes between the handicraft trades of the guilds and capitalist manufacture. The first type of qualitative difference is that in manufacture the capitalist, in order to start production on a large scale, must anticipate, at the very least, a sum far greater than the maximum amount of money advanced by the craftsman: "... the possessor of money or commodities actually turns into a capitalist only where the minimum advanced for production greatly exceeds the known medieval maximum" (*ibid*, p. 423)¹⁴.

This, at a certain point, changes the qualitative relationship between labour, the means of production and the labour process: "If we consider the process of production from the point of view of the simple labour-process, the worker is related to the means of production, not in their quality of capital, but as being the mere

¹³ See Marx and Engels (1845-46) and Marx (1867 [1990]), in particular chapters 13-15.

¹⁴ Marx adds: "Here, as in natural science, is shown the correctness of the law discovered by Hegel, in his *Logic*, that at a certain point merely quantitative differences pass over by a dialectical inversion into qualitative distinctions" (*ibid*, p. 423).

means and material of his own purposeful productive activity. ... But it is different as soon as we view the production process as a process of valorization. The means of production are at once changed into means for the absorption of the labour of others. It is no longer the worker who employs the means of production, but the means of production which employ the worker.” (*ibid*, p. 425).

Marx connects, as a component of the analysis of a *one and only* process, the analysis of this first qualitative change to a second type of qualitative change, that concerning the labour process under manufacture mode of production. “Even without an alteration in the method of production of work, the simultaneous employment of a large number of workers produces a revolution in the objective conditions of the labour process” (*ibid*, p. 441). The sources of this revolution are numerous and of different types. Here, I summarize them schematically¹⁵:

- (i) Economies in the use of means of production by the mere fact that these means of production are used together by many workers.
- (ii) In general, the potential of many workers working together is greater than the sum of the individual working potential. Some indivisible operations can be made only with the combined work of many workers.
- (iii) In working together, “mere social contact begets in the most productive workers a rivalry and a stimulation of ‘animal spirits’, which heightens the efficiency of each individual worker” (*ibid*, p. 443).
- (iv) The division of labour between different operations of the production process leads to a reduction of the production time through the simultaneous realization of different sequential stages in the production process.

As each craftsman carries out his job in the production of a single commodity, he loses the ability to exercise the ancient craft in its entirety and ends up becoming a “partial worker”, exercising his job in a single operation. Cooperation, which initially appeared as the work of many craftsmen at the same time under the same roof, thus becomes a new form of division of labour based on the division of tasks. This process of change presents different (and in some way opposite) characteristics for different types of artifacts. “A carriage, for example, was formerly the product of a great number of independent craftsmen, such as wheelwrights, harness-maker, glaziers, painters, polishers, gilders ... At first, the manufacture of carriages appeared as a combination of various independent handcrafts. But it gradually began to signify the splitting-up of carriage production into its various detailed operations, and each single

¹⁵ See in particular Marx (1867 [1990]), pp. 442-451.

operation crystallized into the exclusive function of a particular worker, the manufacture as a whole being performed by these partial workers in conjunction” (*ibid*, pp. 455-456).

In the production of other types of artifacts, the capitalist employs many craftsmen, each producing the same, or similar, goods, as happens for example in the production of paper, types or needles. At first, the craftsman performs all the tasks of the production process until, with the increase of the scale of production, the work is divided into individual tasks and each craftsman specializes in the execution of a single task or in a few operations. At first it is just an accidental division of labour which, however, since it brings advantages, is repeated in a recurrent way until it becomes a systematic division of labour (see *ibid*, p. 456).

Between the division of labour in manufacture and the division of labour in society there is a two-way link. On the one hand, manufacture requires a certain minimum level of development of division of labour in society, necessary for capitalist production and the circulation of commodities. On the other hand, however, “the division of labour in manufacture reacts back upon the society, developing and multiplying it further” (*ibid*, p. 473). In fact, the division of labour in manufacture differentiates at the same time both jobs and instruments of labour. “With the differentiation of the instruments of labour, the trades which produce these instruments themselves become more and more differentiated” (*ibid*, p. 473).

Another aspect of the link between quantitative and qualitative changes in the analysis of the division of labour by Marx concerns the transition from manufacture to large-scale industry, which I will only discuss briefly here¹⁶. In manufacture, the cooperation and the division of labour in all their forms are based on the handicraft trades of the guilds. The relationship between workers and instruments of labour continues to be that typical of the handicraft trades of the guilds in which the worker is both the driving force and true creator of the product with the aid of the instruments of labour. A typical example, Marx argues, is the spinning-wheel in which “the foot is merely the prime mover ..., while the hand, working with the spindle, and drawing and twisting, performs the real operation of spinning” (*ibid*, pp. 495-496). The expansion of the potential markets and the introduction of new machines in the mid-eighteenth century change the relationship between the worker and the instruments of labour and the very nature of the division of labor. The machines introduced in the Industrial Revolution are, in fact, new machines that replace the worker in the

¹⁶ See Marx (1867 [1990]), chapter 15 (Machinery and Large-Scale Industry), in particular pp. 492-508, 544-553, 588-610.

realization of the product, as is the case of the machines that allow spinners to spin without the intervention of the human hand. The human driving force becomes no longer sufficient and is replaced by steam engines, already invented in the late 17th century. The new operating machines revolutionize the steam engine which becomes the new driving force capable of simultaneously providing energy to many machines. Manufacture is replaced by modern large-scale industry in which the role of the workers is to supervise one or, more frequently, several machines. Even the character of the division of labour changes. “Along with the tool, the skill of the worker in handling it passes over the machine. The capabilities of the tool are emancipated from the restraints inseparable from human labour-power. This destroys the technical foundation on which the division of labour in manufacture was based. Hence, in place of the hierarchy of specialized workers that characterizes manufacture, there appears, in the automatic factory, a tendency to equalize and reduce to an identical level every kind of work that has to be done by the minders of the machine” (*ibid*, p. 545).

The division of labour in large-scale industry becomes purely technical. It “takes the form primarily of a distribution of workers among the specialized machines, and of quantities of workers, who do not however form organized groups, among the various departments of the factory ... The organized group peculiar of the manufacture is replaced by the connection between the head worker and his few assistants. The essential division is that between workers who are actually employed on the machine (among whom are included a few who look after the engine) and those who merely attend them (almost exclusively children). ... This division of labour is purely technical” (*ibid*, pp. 545-546).

To conclude, the division of labour, in manufacture first and in large scale industry later, becomes a form of organization of social production whose origin and function cannot be attributed to any spontaneous inclination of human nature to barter, as was thought by Smith, and cannot be deduced from its actual utility. The new social function of the division of labour emerges along with a qualitative transformation of the mode of production. It follows that the capitalist division of labour – which separates individual activities and makes them independent, both in factory and in society – is new in quality. It assumes the new function, that did not exist before, of making possible the production of commodities for expanding potential markets. Along with this new function, the capitalist division of labour requires a new function of coordination through which it makes possible the re-composition of labour in commodities production. In the factory, Marx argues, such a function – which, likewise, did not exist before – is provided by the capitalist power of authority over workers. In society, instead, the capitalist division of labour gives

rise to “a motley pattern of distribution of the producers and their means of production among the various branches of social labour ... Division of labour within the workshop implies the undisputed authority of the capitalist over men, who are merely the numbers of a total mechanism which belongs to him. The division of labour within society brings into contact independent producers, who acknowledge no authority other than that of competition ...“ (*ibid*, pp. 476-477).

In his analysis, Marx devotes much attention to the effects of the new characteristics of the division of labour on working conditions, examining, for example, the working hours and the working day. He attaches great importance to the outcome of the struggle for a normal working day and a compulsory limitation of working hours. In particular, Marx considers the “factory legislation ... just as much the necessary product of large-scale industry as cotton yarn, self-actors and the electric telegraph” (*ibid*. p. 610). It is worth emphasizing that Marx considers the extension of factory legislation, which did not exist before, as a characteristic feature of the new mode of production. Where such legislation does not exist or is less extensive, capitalist development could be very different from England, where factory legislation originated and spread across the country¹⁷. As noted by Hirschman, in this consideration Marx shows “a very acute sense of small and critical differences” (Hirschman, 1977, p. 89-90). It seems to me that this “acute sense of small and critical differences” could be attributed to Marx’s awareness that in emergent phenomena small differences can generate significant different outcomes and that, as a consequence, economic and social processes may not follow fixed paths¹⁸.

In Marx's analysis, changes in the characteristics and functions of the division of labour are closely related to the historical changes of production relations. This analysis allows him to bring to light new functions of the division of labour that never existed before. At the same time, it protects firmly from the error of believing that the origin of the division of labour can be deduced from its current utility. Marx's critique of Smith's ideas about the origin of the division of labour is a demonstration of his

¹⁷ See Marx’s considerations in the Preface to the first *Capital* edition (Marx, 1867 [1990], p. 91).

¹⁸ In Marx, broad generalizations, that seem to have a deterministic flavour, and careful analysis of processes, that tend to discriminate and to produce specific results not deducible from broad generalizations, coexist. The relationship between these two aspects of Marx's thought goes beyond the scope of this paper.

awareness that the current function of the division of labour must be separated from its historical origin¹⁹.

5.2 A critical view of Spencer's and Durkheim's functionalist analysis of the division of labour

In re-reading Marx's analysis of the division of labour in the light of the general phenomenon of emergence of new functionalities, new entities and new relationships, we can find a valuable clue to analyzing how changes in functionalities occur at the level of the organization of the economy and society. In fact, Marx's analysis suggests that changes in the characteristics and functions of the division of labour are closely related to the historical processes of interaction between *quantitative and qualitative changes* of production relations²⁰. This re-reading of Marx analysis of the division of labour contains arguments against Marx's alleged technological determinism²¹. In what remains of the present section, I will argue that Marx's analysis of changing characteristics of the division of labour contains an *ante litteram* critique of the functionalist analysis of the division of labour by Spencer and Durkheim.

The idea that evolution is the result of a natural selection process that leads to a given relationship between structure and function has been the basis of one of the currents of social analysis. In particular, according to Spencer (1876-1896), in agreement with what happens in the case of biological organisms, the differentiation of the social structures and functions are the result of population growth. New structures and new features are developed in order to ensure the society's survival in the face of changes in its size and/or in the external environment. According to this vision, which uses the biological analogy in order to explain society's structures and functions, each function provides a specific purpose and thus helps to ensure the survival of the social organism. It follows that, as each organ is selected by the

¹⁹ See for example the following statement in Marx's *A Contribution to the Critique of Political Economy* (1859): "though it is correct to say that individual exchange presupposes division of labour, it is wrong to maintain that division of labour presupposes individual exchange. For example, division of labour had reached an exceptionally high degree of development among the Peruvians, although no individual exchange, no exchange of products in the form of commodities, took place". For a similar statement, see Marx (1867 [1990]), p. 132.

²⁰ The role of the interaction between quantitative and qualitative changes in the relations of production in Marx's analysis of the division of labor, is neglected by Leijonhufvud (1986 and 1995) who examines the division of labor in purely technological terms and establishes a close relationship of continuity between Smith and Marx.

²¹ For arguments against Marx's alleged technological determinism see Rosenberg (1976), in particular pp. 36-39, and Mac Kenzie (1984), in particular pp. 473-480.

process of natural selection to ensure a given function, then each component of society, and each structure is connected to a function through a process of social selection²². Of particular interest for our purposes are Spencer's ideas about the natural tendency to specialization and division of labour. With population growth and with the diffusion and development of cities, individuals tend to differentiate and specialize their activities according to the differences arising from the natural environmental circumstances in which they find themselves. According to Spencer, this tendency is a sufficient condition to explain the division of labour. In fact, he assumes that men act according to a utilitarian conduct searching for the minimum pain and maximum profit. Since the division of labour, by increasing the productive power of labour, achieves this objective, Spencer implicitly assumes that, if the growth of the population leads to specialization, the division of labour necessarily will occur.

Durkheim (1893) accepts the Spencerian biological metaphor, and the underlying vision of evolution, but provides a more rigorous adaptationist analysis of the division of labour. According to Durkheim (1893), with the growth of social relations competition among individuals increases. The division of labour is the answer to a dose of competition unbearable for individuals, who, in order not to be destroyed, differentiate their activities looking for niches for survival. In this view, it follows that the division of labour is the result of an *adaptation to a purpose*, the reduction of competition in favor of forms of "organic solidarity". As highlighted by Gould (2002, p. 1239), Catton refers to the concept of exaptation to criticize this adaptationist thesis by Durkheim. Indeed, Catton argues, Durkheim's thesis implies that mutual relationships have developed in order to reduce competition. However, biologists have shown that in many cases mutualism develops from pre-existing forms of antagonism and exploitation. "Durkheim – Catton argues – would have been astonished to learn that most mutualistic relationships have probably evolved from

²² This organismic and functionalist vision of society, proposed by Spencer on the basis of its particular interpretation of evolution, taken to its extreme, formed the theoretical and cultural background for social analysis that in the late nineteenth and early twentieth century becomes known as "social Darwinism". La Vergata (1995) pointed out that in Spencer's thought the two metaphors of social organism and 'struggle for life' have a common root. They made their first appearance in the first Spencer's book, *Social Statistics* (1851). "More important – La Vergata argues – they were used for the same basic purpose: a plea for noninterference with the spontaneous development of society, which is gradual, unalterable, and self-adjusting. Although the organic analogy was not developed as much as the idea of competition was, it is evident that they supported each other and were complementary" (p. 197).

host-parasite, predatory-prey, or plant-herbivore interactions rather than ... among formerly competing conspecifics. There are initially antagonistic interactions (e.g. predatory-prey pairs) in which selection pressures, over time, convert them directly into mutualism ... without the conversion passing through to neutral phase” (Catton, 2002, p. 104). In others words, according to Catton, the source of Durkheim’s error is in his disregarding the functional shift principle: “Evolutionary Ecologists now know that mutualism evolves by some adaptation of structure or behavior that *changes* the outcome of an interaction from which the parties can not withdraw” (ibid , p. 105).

It is particularly interesting for our purposes to note that both Spencer and Durkheim consider the effects of quantitative changes in population on the division of labour in terms of adaptations: Spencer considers the division of labour as a spontaneous adaptation to changing external conditions determined by an increased population; Durkheim considers it as a result of a process that, by limiting the disruptive effects of competition, leads to forms of organic solidarity. Neither, however, are able to see what seems to be clear to Marx: namely that quantitative variations trigger processes of qualitative change of the forms of the division of labour already existing, giving rise to new functions and new entities.

An inherent limitation in adaptationist explanations of the relationship between structure and function in social systems, is that they fix this relationship. In the same way as cells and organs have a given structural relationship with an evolved body, so the members of a society have a given structural relationship with the society at a given stage of evolution. In a society that has developed the division of labour, the different individual entities (individuals, enterprises) have a given structural relationship with the society, in the same way as, in the Durkheim’s vision, the function of the division of labour seems to be given and invariant. It follows that it seems difficult to give an account of the changes in the characteristics and functions of the division of labour. Since the forms and the very function of the division of labour have changed historically, the adaptationist and functionalist perspectives seem do not to be adequate for an analysis of these changes. The perspective based on exaptations, instead, by focusing on changes in functionalities and in the related emergence of new entities and new relationships, seems to represent an alternative able to grasp the processes of change. In particular, this perspective can represent a guide to analyze the changing characteristics and functions of the division of labour starting from its current characteristics and functions.

6. Concluding remarks on the implications of the notion of exaptation for a theory of economic change

According to the adaptation-based paradigm, natural selection shapes the structure of entities for a current function. It follows that adaptation through selection leads to a given relationship between structure and a pre-existent function. If the functionality of an entity is considered as an end, known in advance, toward which natural selection is directed, the origin of an entity can be deduced from its current functionality.

The exaptation-based perspective highlighted in this paper focuses instead on *changes* in functionalities as a result of emergent phenomena. According to this perspective, entities, previously shaped or not for a particular function, are coopted for a new use, giving rise to new entities and new relationships among entities. It follows that the origin of an entity cannot be deduced from its current functionality. To trace the origin of an entity it is necessary to examine the historical process of change giving rise new functionalities and new entities. The implications of the notion of exaptation for the analysis of economic change derive from the essential characteristics of the processes of emergence of new entities triggered by an initial attribution of new functionalities. To summarize the implications that have emerged in this paper, I will refer here to two general considerations.

The first concerns the necessity to examine the processes of change in socio-economic systems in terms of an interaction-based ontology. Section 3 contains an attempt to define agents, artifacts and socio-economic institutions – three fundamental entities in socio-economic systems – in terms of such an ontology. I used this ontology to highlight how processes of economic change can be analysed in terms of emergent phenomena and in particular in terms of the emergence of new specific functionalities and qualitatively new entities and relationships. In section 4 I referred these processes to the relationships between agent and artifacts, and in section 5 to the organization of the economy and society.

The second general consideration, on which I will focus here more extensively, is the following. If changes of functionalities are emergent phenomena, economic change cannot be analysed in terms of a mere recombination of existing things or in terms of selection-variation mechanisms²³. It must be analysed through the dynamic

²³ In previous works (see Bonifati, 2010 and 2013; Bonifati and Villani, 2013) I provided a critical discussion of: (1) the Schumpeterian theory of economic change as “creative response in history” (Schumpeter, 1947); (2) the evolutionary theory of economic change by Nelson e Winter (1982); and (3) the theory of technological development based on the notion of speciation (see Adner, R. and

historical process by which “a new thing leads to another”. In these processes of transformation the causality links are themselves the results of processes in which *ex ante* potential causality links can be transformed into different (and new) *effective* (or actual) causality links.

The idea that socio-economic development is the story of how one thing leads to another is proper to Hirschman’s conception of development (Hirschman, 1958 and 1977). One of the great merits of Hirschman’s generalized linkage approach to development is its capacity to orient research towards the analysis of complex inducing mechanisms of economic development, at a specific fine-scale of investigation and in conditions of uncertainty both on the demand and supply side (Hirschman, 1967, chapter 2). This approach is a strong antidote against the temptation to explain development (and underdevelopment) in terms of elements external to the development processes themselves, such as, for example, the presence (or absence) of pre-requisites. However, it seems to be different from the exaptation-based perspective with respect to an important element: the role of the social process of change of functionalities seems to be underestimated and the possibility that the occurrence of changes of functionality may give rise to different (and new) causality links might, as a consequence, be blurred in the linkage approach.

Hirschman's theory of development has a non-deterministic character, and this makes it open to taking into account the exaptation phenomena. Hirschman’s generalized linkage approach and the exaptation-based perspective seem to be complementary, a conclusion strengthened by considering two features of Hirschman’s generalized linkage approach. The first one is that, according to Hirschman, development is essentially a process of mobilization (activation) of potentialities already present, albeit latent, in ongoing activities’ characteristics. This first feature leads to the second one: linkages as “investment-generating forces” are dynamic in nature and they lead to new activities. It follows that the realization of linkages is connected, by its nature, to dynamic phenomena, like innovation and product differentiation²⁴: as highlighted above, it is hard to think of processes of innovation and product differentiation regardless of the social processes of change of functionalities.

Levinthal, 2002 and Levinthal, 1998). For a wider critical discussion of the use of biological metaphors in economics see Ginzburg (2009).

²⁴ See Bonifati (2011) and Ginzburg (2014).

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