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Creative destruction, knowledge appropriation and structural change: An unresolved dilemma in developing countries

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Abstract

This paper is based on complex system theory applied to social science with the objective of contributing to a larger understanding of economic development. It stresses the relevance given to absorption and connectivity capacities and to the complex system properties of self-organization and adaptation in order to shed light on systems in different levels of aggregation. The present work establishes the relationship between capacities and properties and in turn with the way they interact with the creative destruction processes, knowledge appropriation and structural change. Finally, the paper discusses some policy-related issues derived from the complex system analytical approach.

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Introduction

The present work is aligned with evolutionist and neo-Schumpeterian thought in which innovation is understood as a process of creative destruction, knowledge appropriation and structural change, all of which reinforce the complexity of the economic systems. These economic systems, whether firms, networks, regions or countries, are conceived as complex and defined in terms of their self-organizing and adaptation properties. In this context, the complex system theory applied to social sciences is a valuable tool to analyze the social phenomenon of economic development from the perspective of a set of interactions that determine the complexity of a system

Within this analytical framework, the objective of the paper is to propose an understanding of economic development through the analysis of interactions between different processes and capacities and their effect on the complexity level of the economic system. This work both analyzes sectoral and institutional specificities in the context of the dominant techno-productive paradigm and discusses policy issues arising from the analytical framework used.

The hypothesis of this paper is that the level of development of an economic system, that is, its complexity in terms of properties of self-organization and adaptation, depends on the importance achieved by the process of creative destruction, knowledge appropriation and structural change, on the one hand, and the absorption and

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connectivity capacities, on the other. The present work is founded on the idea that the relevance of these processes and acquired skills is conditioned by the feedbacks among them.

The first section characterizes the processes of competition and creative destruction, knowledge appropriation and structural change. The second section introduces the theoretical approach of complex systems in order to analyze the interactions of processes, absorption and connectivity capacities and the effect on self-organization and adaptation properties. The third section presents the link between the importance achieved by the processes mentioned above on the one hand, and the level of development and productive specialization profile, on the other. Finally, the fourth section has concluding comments and policy topics.

1. The processes of creative destruction, knowledge appropriation and structural change

From a Schumpeterian perspective, competition among agents is understood as a *process of creative destruction* that generates variety and, through the market mechanisms, selection of the most innovative behavior. In this context, innovation is the result of a creative destruction process (Schumpeter, 1912 and 1942) insofar as it changes the routines of the firms and institutions (Nelson and Winter, 1984) through formal and informal learning and the integration of tacit and codified knowledge. In turn, the *process of appropriation of knowledge* depends on the form of technology and knowledge management (Erbes et al, 2006) in firms, territorial systems or networks. This process is essential for an understanding of the dynamyc creation of competitive advantages and appropriation of quasi-rents. The *process of structural change* is primarily conceived as the development of complementarities and reallocation of productive factors towards sectors with increasing returns (Ocampo, 2005, Reinert 2006 and 2001). The paper will show that the three processes are associated with the degree of development of economic systems.

The importance obtained by the process of creative-destruction determines the level of development of a system even if creative destruction and economic development co-evolve. While the mechanisms for selecting market tend to diminish micro-diversity, the process of creative destruction helps to increase it. In this sense, they are opposing forces which are so interdependent that they have an impact on feed competition and development simultaneously (Dosi, 1977; Metcalfe, 2001, Metcalfe et al, 2003, Metcalfe, 2002).

The initial differences in the skills of the actors, the role of the market as a selector of the best behavior and the development of innovations and complementarities among agents are key factors for sustained creative destruction process (Dosi, 1991). The players are trying -through processes of routine differentiation- to appropriate quasi-rents and extraordinary profits derived from competition. From this perspective, when the processes of creative destruction are important and the productive specialization is based on sectors with increasing returns, the prices of goods and services become a dependent variable of innovation. As a result, the market does not impose exogenously but is a product of the process of creative destruction.

In turn, development is conditioned by the opportunities of the players to appropriate knowledge and to avoid leaks in its production, circulation and diffusion. This process is heavily influenced by three factors: the degree of freedom of technology and knowledge management –both, at firm level as productive systems- (Malerba and Orsenigo, 2000 Erbes et al, 2006; Yoguel et al, 2007); the dominant productive specialization profile and finally, the degree of complexity of local systems local, national and sectorial innovation. These factors help explain appropriation forms of knowledge and the ability of agents to have access to quasi-rents.

In this sense, the process of knowledge appropriation acquires specificities at both, micro and macroeconomics analytical levels. At the micro level, it can be conceived as an inverse relationship between appropriation and diffusion of knowledge that derives from the specific form of technology and knowledge management and the predominant market form (Erbes et al, 2006). At that level of analysis, a greater appropriation is associated with increased quasi-rents. However, at the aggregate level (productive network, sector, region or country) the tension between diffusion and appropriation is lost while it is possible to maintain high levels of appropriation with high levels of diffusion. This issue will depend not only on the importance achieved by the diffusion of public goods but mainly on the relevance of networks and interconnections within the productive system. For example, in a system in which the networks are very significant, as in developed countries, appropriation and diffusion will be considerably high because there is a high diffusion of knowledge within the network as club goods. By contrast, in less developed countries, the appropriation is reduced as well as the diffusion because of the low presence of production networks, public goods and club goods.

Lastly, the development process needs to induce structural change processes resulting from "the ability of a system to innovate, the ability of innovation to generate complementarities and the reduction of structural dualism" (Ocampo, 2005). This concept incorporates both the contribution made by Prebish and Hirshman, among others, in the context of theories of development of the decade of the 50's, and those made by the new development theory (Ross 2005, Palma 2005, among others). This idea involves (i) the reallocation of production factors to high-productivity sectors in order to take advantage of the existence of increasing returns, which generate increases in overall productivity and in order to reduce structural dualism; (ii) enhancement of complementariness between agents; (iii) generation of a change in the external insertion pattern into differentiated products with greater elasticity income, and (iv) development of policies to promote the coordination of investment decisions in terms of indivisibility technology (Cimoli et al, 2005). Thus, the process of structural change is not spontaneous but the result of a development strategy that assumes that the actors must define their behavior in a game in which there are complex problems of coordination and information and in which the non-Paretian equilibrium (trap of low growth) can be produced easily (Cimoli et al, 2005. Finally, income distribution is the key factor for explaining the structural change[2] since the highest levels of equity are associated with an increased supply of public goods.

[2] As is shown by Cimoli and Rovira (2006), in a cross-section analysis of developed and developing countries, the magnitude of the differences in income between the richest 10% and the poorest 10% of the population is inversely associated with the weight of high-tech products in GDP, with the I&R/GDP ratio and the proportion of the population with secondary education complete.

While each of these processes can be understood transversely to the meso and micro levels of analysis, they occur with varying intensity in each of them. Thus, the process of appropriation takes place mainly in the individual agent or business networks, because the quasi-rent generation occurs at this level of aggregation The processes of creative destruction take place in the meso level (Foster, 2005), but they have a strong impact on the functioning macro and micro ones. This is because this process is strongly associated with the interaction between players that transcends the boundaries of the organization, even though competition is conceived as a forum for generating variety and a different range of behaviors, rather than as an abstract construction of the intersection between supply and demand functions. Finally, the process of structural change refers to a transformation of the economic system as a whole which is influenced by the processes at the micro and meso levels mentioned above.

2. Processes, capacities and properties in complex systems

The analytical framework that provides the theory of complex systems (Antonelli, 2007; Foster, 2000 and 2005; Levin, 2003, Silverberg 1984, among others) enables us to analyze the characteristics of the three processes discussed in the previous section. This is an analytical approach introduced by different authors of evolutionary thought in the last 20 years in order to explain the operation of production systems. (Silverberg, Dosi and Orsenigo, 1988; Dosi, 1991; Dosi and Kaniovski, 1994; Foster, 1993; Dosi and Nelson, 1994; Rizello, 2003; Schenk, 2005; Lazaric and Raybaut, 2005; Foster 2005; Witt, 1997). In particular, this position was clearly spelled out by Silverberg, Dosi and Orsenigo (1988):

> "…in complex interdependent dynamical systems, unfolding in historical, ie irreversible time, economics agents, how have to make decision today the correctness of which will only be revealed considerably later, are confronted with irreducible uncertainty and holistic interaction between each other and with aggregate variables. The *a priori* assumption of an 'equilibrium' solution to these problems to which all agent ex ante can subscribe and which makes his actions consistent and in some sense dynamically stable is a leap of methodological faith."

Complex systems are dissipative (import energy and export entropy) self-organized and adaptive structures defined from its internal components and the interactions between them and the environment (Foster, 2005). These are structures that transform information into knowledge according to the degree of development of their endogenous skills and the linkages established between its components and the environment (Foster, 2005). The density of connections among internal components of a system defines its limits and boundaries.

Complex systems are characterized by (i) the diversity and heterogeneity of skills and routines of components, (ii) the temporary irreversibility produced as a result of dynamics governed by a non ergodic path dependence[3], (iii) the imbalance interactions between components and (iv) the presence of institutional rules, learning, discoveries and selection spaces (in the market or out of it) that operate as mechanisms of coordination and exchange and which play a leading role in the reduction of radical

[3] Small external shocks affect irreversibly the long-term path.

uncertainty (Dosi, 1991; Siverberg, Dosi and Orsenigo, 1988; Nelson and Winter, 1982). According to Antonelli (2007) *"complexity favors the systemic approach in the sense that the outcome of the behavior of each agent and of the system into which each one is embedded can only be understood as the result of the interaction between micro and macro dynamics"*.

From this perspective, the underlying idea of equilibrium is associated with maximum disorder (Mirowski, 1989) and it is therefore a situation with maximal entropy and minimal knowledge. This approach differs from the arguments made by conventional economics -which has its correlative in classical mechanics as in the deterministic Darwinism- where the equilibrium is considered a position of order and, in turn, requires the existence of perfect connections among the components of the system (i.e. information and perfect rationality and the absence of uncertainty). By contrast, the theory of complex systems is a body dedicated to the study of the connections in terms of lack of equilibrium, limited information and radical uncertainty (Foster 2005)[4].

Thus, a complex system is defined as a structure characterized by the properties of self-organization and adaptation.

The property of self-organization implies feedback and self-organization mechanisms which take place in a variable environment without equilibrium (Prigogine and Stengers, 1984). The deterministic and non-ergodic characteristics of the path dependence (Antonelli 2007) explain why complex systems are sensitive to initial conditions and/or disturbances occurring along its path leading to o a multitude of behavior patterns in the long-term that affect the global dynamics of the system (Kaniovski and Dosi, 1994, Antonelli 2007). This property of self-organization can be defined, therefore, as the ability of systems to generate themselves on the basis of their internal structures, i.e. routines and path dependence, and the interconnections among its components. In this approach, this property can be static or dynamic, depending on whether the aim is to reproduce the existing routines, transform them or generate entirely new ones. The property regeneration involves changes in the system that has arisen as a response to internal incentives.

The adaptation property means the system's ability to adapt to changing environments. This involves frequent internal reconfiguration as a result of the need to respond to the changes that are generated in the environment. Thus, property of adaptation produces changes in the system that is primarily a response to external incentives. This property involves static or dynamic reconfiguration according to the specific characteristics of the environment. The more developed the adaptation property in a system is, the greater the chances of taking advantage of new opportunities arising from the changes that occur in the background are, without affecting negatively operation beforehand[5]. This property explains why a system can withstand certain range of variation in its performance, and how it survives on the basis of developing a relationship with the

[4] While Neoclassical economics adopts elements of the physical mechanics for the formalization of his theories, the evolutionary and neoschumpeterian approach resembles thermodynamics. In the first case, the idea of equilibrium implies a state of order and maximum information, but in the second one, implies disorder and maximum entropy.

[5] In biological systems there is a similar capacity, called resilience (Scheffer, Westley, Brock, and Holmgren; 2002).

environment which takes into account both its own complexity and that of the environment.

From the perspective of complex systems, the construction of these properties is the result of various types of interactions generated within a specific path defined in terms of the evolutionary history of the system. Thus, it is not a deterministic development path dependence since they can present deviation produced by external attractors and transient random shocks (Antonelli, 2007). In this context, it may be argued that these concepts help to explain the economic coordination without the need of the equilibrium idea, which is present in both conventional and heterodox economics. This approach helps to understand the evolution of organizations subject to conditions of temporary irreversibility, in which change is non-linear and highly uncertain (Metcalfe, 2002).

Both the intensity acquired by the three processes described in the previous section, as well as the complexity of the properties of self-organization and adaptation, are related to the absorption capacity and connectivity of systems (Figure 1).

The absorptive capacity of a system can be defined as "the ability to recognize the value of new external information, assimilate it and apply it" (Cohen and Levinthal, 1989). In this regard, the absorptive capacity of a system is not linked only to the possibility of taking over the existing knowledge on the environment, but it also relates to the identification of useful knowledge and its usefulness in generating new one. As a result, the absorption does not entail the ability to develop automatically or to be equally accessible to all systems, but it requires the development of pre-built capabilities within the evolutionary path taken by the system.

The ability of connectivity is associated with the system potential to establish relationships and to generate interactions with other systems aimed primarily at increasing their knowledge base. Thus, different levels of development in this connectivity capacity define different options of access to knowledge, resources and opportunities. Like the absorption capacity, the connectivity ability exceeds interaction and involves driving interactions and prioritizing relationships that are being established with other systems in terms of what they bring about. Ultimately, this is the ability that defines the degree of opening or closing of a system (Poma, 2000) presented different levels of aggregation.

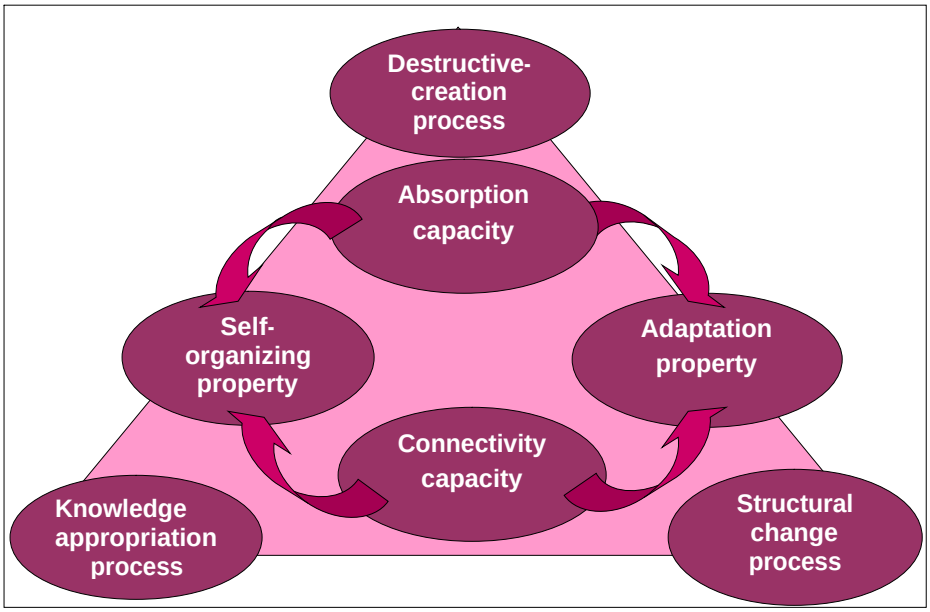
These two capabilities together with the properties of self-organization and adaptation are closely linked and, in some cases, affect one another. The absorption and connectivity capacities of systems influence the degree of development that meet the self-organizing properties and adaptation, the latter of which are strongly associated.

Both properties of self-organization and adaptation are conditioned by the importance achieved by the absorption and connectivity capacities of the system. In operational terms, the property of self-organization can be likened to the endogenous capacity of the system to generate skills and complex routines. The influence of absorption capacity and connectivity on the property of self-organization relates to the fact that for any system to regenerate, it requires knowledge not only produced inside, but also knowledge capable of incorporating the environment. Thus, the development of self-organizing property implies the existence of joints with other systems that are functional

to the construction of this property, and skills associated with identification, absorption and application of useful knowledge.

The property of adaptation is influenced by the size and complexity of the formal and informal links that the agents developed to complement their skills and generate innovations in their routines. Also, this property is conditioned by the absorption capacity as long as it determines the potential of the system for having access to knowledge disseminated within the networks, frames or environments to which they belong (Cimoli and Constantine, 2000; Roitter et al, 2007; Erbes and Yoguel. 2007; Borello, Morhorlang and Silva, 2007). Here, the diffusion of knowledge does not take place randomly among the component of the system but depends on their capacity to absorb and to connect[6].

Figure 1. Properties, capacities and interactions of processes



Two-way relations can occur between the properties of self-organization and adaptation, and between absorption capacity and connectivity. In the first case, it may be argued that the capacity of adaptation of a system is linked to the ability to produce internal space of regeneration that enables to process the environment changes and develops new strategies in order to survive in it. A significant portion of the properties of self-organization of systems stems from mutations in the system, which would not have taken place without strong resilience. In the second case, the absorption capacity and connectivity also show significant areas of complementarity. Thus, it may be argued that the systems with a higher rate of development of their absorptive capacity tend to be more open and with greater density in relationships with other systems. They are also in a better position to exploit the potential of these derivatives interactions. At the same time, the density in relationship and the degree of openness of the system defined by

[6] David and Foray (1994) and Antonelli (1997) propose to replace the concept of diffusion by percolation which reflects heterogeneity of economic agents in terms of their absorption and connectivity capabilities.

connectivity, contributes to the development of the absorptive capacity of the system when it becomes exposed to a significant flow of knowledge that the system must learn to prioritize in order to evaluate and use it for personal gain.

In this sense, when both capacities are present, there appears a semi-autonomous self-organization process with adaptation qualities that are able to exploit the conditions in the environment, including opportunities and risks (Schenk, 2005). However, for this to happen, it requires the presence of channels of communication that allow systems to react to changes both in terms of positive and negative feedbacks. The former are associated with the ability of the system to absorb elements that enhance endogenous powers (introducing energy that decreases entropy). The latter, which are the most frequent, are reactive to external inputs and damage the self organizational dynamics of the system, increasing entropy. In such cases, the system actors resist change rather than adapt to it.

The significance reached by the skills and properties described so far is strongly affected by the processes of competition and creative destruction, structural change and knowledge appropriation. At the same time, the features that assume the capacities and properties impact on or condition the magnitude reached by the processes. Firstly, the self-organizing property is higher when the process of creative destruction and structural change are deeper. Likewise, complex processes of appropriation of knowledge demand greater complexity of the property of self-organization, particularly in the construction of routines that reduce the risks of copying and imitation of knowledge.

In the same vein, both the processes of structural change and creative destruction and appropriation of knowledge induce the development of absorption properties in the systems that make possible to recognize, absorb and apply the new knowledge generated.

Both the process of structural change -especially the development of complementarities- and the competition and creative destruction one, act on the ability to generate greater connectivity, which produce requirements for the opening up the system and interactions to ensure access to resources for the survival in the new context. In turn, processes involving concentration of knowledge in certain systems show the importance of connectivity capability as a tool to have access to the knowledge which would have been otherwise forbidden.

In short, the development of any of the three processes mentioned bears a direct and positive relationship with the complexity required of the capabilities and the properties that define and characterize a system, with special emphasis on the latter. In other words, the degree of development of these two properties determine the possibilities for a system to survive and develop in the presence of the processes of creative destruction, structural change and appropriation of knowledge contexts associated with highly dynamic and strong uncertainty.

3. Creative destruction, structural change and appropriation: development specificities

The complex system described above in terms of capacities and properties has strong sectoral specificities, which impacts on the potential economic development and are dependent of the specialized pattern of a country or a region (Malerba and Orsenigo, 2002; Pavitt, 1984; Reinert, 2007). Within a specific techno-productive paradigm (Dosi 1988, Freeman y Perez, 1988), different activities can be classified according to increasing returns (Dabat, Rivera and Stulwark, 2007, Reinert 2007). When the main characteristics of the specialization pattern are the predominance of decreasing returns, the three processes are very weak. In these cases, the leaking of knowledge is higher than knowledge appropriation. Therefore, competitive processes are not guided by creative destruction but instead competition is based on pricing and predatory practices which accentuate the destructive component of competence. There is not a structural change but structural heterogeneity and a low level of complementarities. In sum, the weaknesses of the specialization pattern are associated with the low probability of economic development.

The relationship between economic development and the three processes discussed above depends strongly on sectorial and technological characteristics, knowledge management and market structure[7]. As is shown in Malerba and Orsenigo (2000) in the management of technology is considered a set of characteristics that refer to the accumulatively, appropriation, opportunity and knowledge base that define a technology. In developed economies, the combination of these characteristics configures a pattern of sectoral behavior under the assumption of intragroup homogeneity.

Related to knowledge management (Erbes et al, 2006), some dimensions can account to explain the reason why the knowledge produced by an organization is an entry barrier and becomes a source of quasi rents. Therefore, the relevance adopted by knowledge as an entry barrier depends on (i) the sources of knowledge, (ii) the source and modality of the learning process, (iii) the integration between tacit and codified knowledge and (iv) the way of appropriation of the economic benefits of knowledge. The knowledge management stresses the idea of complementarities between both types of knowledge, rather than a transformation processes.

Another relevant dimension, associated to the sector and the environment of the company (Pavitt, 1984, Reinert, 1995), refers to the type of market in which the firms compete, considering the extreme cases of oligopoly and free entry.

It is important to consider increasing returns to scale, the magnitude and persistence of barriers to entry and, consequently, the ability of the players to generate and appropriate structural quasi-rents. For this purpose, the firm's size, the firm's concentration and years in the market, the source and stability of the quasi-rents and the way of distributing quasi-rents in different organizational forms should be taken into consideration.
The specificities of the three dimensions help us to explain the degree of development of the processes of creative destruction, appropriation of knowledge and structural change. In complex systems there is a correspondence between technology and knowledge management characterized by high absorption capacity and connectivity, by the construction of barriers to entry and by a oligopolistic market structure, which

[7] In a previous paper all these dimensions have been studied as regimes (Erbes et al, 2006)

makes possible the creation and appropriation of quasi–rents. Such cases are characterized also by high adaptation (positive feedbacks) and self-organizing properties, which reduces the entropy of the complex system (see table 1).

Table 1. Interaction among processes and (i) management of technology, (ii) market structure and (iii) knowledge management .

Processes	Technology management	Market structure	Knowledge management
Structural change	Dynamic advantages derived from interaction	High market concentration	Sources learning internal to production networks and derived from national and international systems of innovation.
Creative destruction	Major incentives for innovation	Club goods, high barriers to entry derived from internal cognitive capacities. High stability of quasi-rents	
Appropriation	High cumulativeness with a specific generic knowledge base and high complementarities	Epistemic communities	Complexes process of knowledge generation and translations. Several ways of appropriation: IPR, secrets, displaced code book, high-speed innovation rate.

A virtuous management of technology is characterized by enterprises and sectors with high levels of appropriation of knowledge that operate in a context of high barriers to entry[8] which limit the participation of new players.

There is a prevalence of decreasing costs resulting from cumulative learning as a result of development of externalities and complementarities among players such as those that characterize the processes of structural change (Cimoli, 2005). In these cases, there is a high cumulativeness of knowledge[9] derived from endogenous efforts to build skills and from the quantity and quality of linkages both within and outside firms. Therefore, appropriation reaches significant levels of development. This strong cumulativeness also leads to the generation of both radical and incremental innovations. In turn, the technological opportunity comes from the exploitation of complex scientific knowledge, resulting from endogenous developments and interactions among agents linked by complex translation mechanisms. They are dynamic opportunities constantly renewed when the processes of creative destruction takes place.

The oligopolistic markets, characterized by high barriers to entry, are the dominant form of concurrency in complex systems. The agents can both benefit from technological linkages and complementarities of knowledge derived from the structural change processes and from increasing economies. In this situation it is possible to expect a high stability of agents competing in concentrated markets on the basis of new radical

[8] Based both in market regulations and development of cognitive capacities

[9] Accumulativeness refers to the existence of a path of knowledge accumulation in a firm belonging to a given sector.

innovations manifested in a combination of accumulation and creative destruction. As a result, the degree of stability of the quasi-rents generated by the integration of knowledge is higher than in systems or networks that compete in free entry local markets. In spite of the fact that they operate in sectors with strong technical progress and instability, the main characteristics of these markets allow these firms to decode environment uncertainties. These production networks are characterized by various forms of distribution of surplus. When these production networks are not hierarchical the surplus distribution derives from the innovative firm's capabilities.

Finally, from the perspective of knowledge management, these complex systems generate high cognitive skills that can reduce the risk of imitation. In these cases, there is a predominance of firms in which learning processes are generated in hypertext organizational structures (Nonaka and Toyama 2002), which raises the level of the absorption capacity. These learning processes are not limited to buying capital goods but are also fuelled by knowledge derived from basic and applied science and firm's linkages with its environment. These agents can reduce R&D costs and can increase the likelihood of successful innovations by decentralizing innovation activity across multiple start-ups. These start-ups increase diversity and produce more efficient mechanisms for selecting behaviour than the market. Therefore dynamic processes of creative destruction and regeneration of diversity is produced.

In this sense, this kind of knowledge management not only develops elevated endogenous competencies from own R&D, but also coordinates and absorbs the developments generated by other companies in their environment. Besides, the development of learning processes is reflected in continuous innovation and the ability to exclude (other firms) through displaced books of codes, which are not easy to de-code for other firms competing in the market. This firm's pattern can be assimilated by an epistemic community which reduces the risks of knowledge leakage. The learning process comes primarily from formal R&D and combines different types of learning, especially those derived form networks. Given the reasons stated above, the creation of advanced capabilities is associated with a risk reduction of the flow of knowledge in the form of "club goods".

All these issues are consistent with an advanced kind of complex system in which the three processes are strongly linked systemically and reach significant high levels. These situations can be found mainly in developed countries. By contrast, developing countries have lower levels of complexity which limits appropriation, changes in specialization with increasing complementarities among agents and actors and on income redistribution. Finally in these countries, competition processes are more focused on prices and distribution struggles than on innovations oriented to increase variety and improve selection processes. Following Foster (2005), it is possible to find complex systems of a different order to differentiate productive structures of developed countries from the developing ones. Thus, while in developing countries there is a predominance of complex adaptive systems of third-order -with an adaptation that goes beyond natural selection and involves creativity-, in developed countries -where the knowledge economy is more relevant- fourth order complex systems characterized by the interplay of knowledge through mental models prevail (Foster, 2005).

All these issues make it possible to describe how these processes are expressed differently in developed and developing countries. So (i) the uneven specialization

pattern and the kind of returns that are generated (increasing or decreasing), (ii) the possibility of implementing protective mechanisms to avoid imitation and declining profits, and (iii) the level of development of the local and national innovation systems, are three limitations of developing countries that affect their possibility of appropriation of knowledge, generation of quasi rents and the way (collusive or classical) of dissemination of benefits of technical progress(Reinert 1995). From this perspective, the specialization pattern is a key factor in order to differentiate appropriation of knowledge processes, structural change and competition via creative destruction in developed and developing countries.

While the activities that characterize the specialization pattern in the developed countries can be labeled Schumpeterian - characterized by increasing returns to scale, dynamic existence of imperfect competition, technical progress and de-incorporated innovation efforts and strong synergies among sectors, a profile derived from static comparative advantages has the opposite traits and leads to the predominance of Malthusian activities (Reinert, 2007). In this sense, the predominant type of productive and service specialization in developing countries is characterized by limited processes of creative destruction and even 'destructive destruction', almost no structural change, and very low appropriation. These patterns are derived from diminishing returns to scale, perfect or close to perfect competition in markets strong volatility of prices, a demand for unskilled labor and use of low quality processes and technical progress mainly incorporated. This uneven production specialization is reflected, in turn, in the mechanisms for the appropriation of knowledge closer to traditional forms of protection and weak spill-over on the productive structure. Therefore, the firm's choice of what kinds of goods and services to produce or offer define a set of dimensions related to the importance of acquiring knowledge, the kind of returns to scale, the generation of competitive advantages and market forms[10] (Rosenberg, 1982; Reinert, 1997 2007; Rodrik, 1999).

As a result of strong differences in productive specialization between developed and developing countries, in developed ones there is a predominance of knowledge production networks integrated to national innovation system, while in developing countries this kind of networks are virtually nonexistent (Reinert 1997) because structural change is not important. Therefore, developing countries are characterized by production networks which pay little attention to the knowledge produced endogenously, although in some cases, there may be dynamic industries within specialization in those regions[11].

As Reinert (1994) has proposed, it is possible to identify uneven development in developing countries from a neo-Schumpeterian approach when: (a) the country does not appropriate any fruits of innovations (a classical spread) and (b) the country may be specializing in an economic activity where there is no innovation. In both cases it is easy to specialize in being poor in the international division of labor. If the

[10] In Reinert (2007) is shown that the Washington Consensus Decalogue is not a sufficient condition when the specialization pattern is not well defined.

[11] The automobile sector is an example of high differences in the way it is structured in developed and developing countries: as a knowledge network in the former and bureaucratic networks in the latter. In such countries, the subsidiaries of multinational companies build weak local production networks characterized by poor technological and organizational capabilities compared to those generated in developed countries (Albornoz. Milesi and Yoguel, 2005; Albornoz and Yoguel, 2004).

specialization pattern is focused on products with exogenous innovation processes, the discussion about appropriation does not make any sense. The growing path of this type of countries will strongly depend on having high international prices in the products belonging to the specialization basket and not in their endogenous capabilities (depending on whether the latter will lead them to innovate and to make a strong appropriation of the knowledge generated). From the perspective of developing countries, appropriation, structural change and creative destruction become key points in the development process. In this sense, the development of all these process from a systemic perspective means taking advantage of windows of opportunity by choosing the right technology, and the appropriate knowledge and competition regimes, which will be associated with the right global production network. But, these windows of opportunity are a moving target (Perez 2004; Reinert 2006), and they depend on the processes, capacities and properties mentioned above.

Finally, it is worth noting that issues related to appropriation of knowledge are not individual processes in the new paradigm. The discussion of the role of knowledge in the development of dynamic competitive advantages and quasi-rents appropriation emphasizes the importance of new network organizational forms upon which economic activity is increasingly organized. These appropriation processes associated with creative destruction are much more collective than individual and are strongly dependent upon both the particular predominant specialization and the passage of competition schemes from individual firms to those in which the competition process is based mainly on production networks.

4. Final remarks and policy questions

In the previous sections we have stressed the fact that developing countries face the challenge of paying more attention to the processes of (i) knowledge appropriation, (ii) structural change and (iii) creative destruction. Yet, this will only happen as a result of the development of the capacities and properties described in the second section. This implies moving towards markets in which the agents are price-formers rather than price-takers, and in which the development of absorption and connective capacities becomes a key factor in the competition process. This issue requires industrial and technological policies since a free market will consolidate the dominant positions in the world market in which developed countries have absolute advantages in the most technologically dynamic sectors

The design of these policies need to move along a path in which there is tension between public and club goods, where knowledge is becoming a good with restricted access derived from the level of development of the absorption and connectivity capacities discussed in this paper. Moreover, in the present tecno-productive paradigm associated with the production of goods based on knowledge, the chances of development are associated with a wide dissemination of knowledge both in the form of public goods and club goods flowing through a high density network. This situation does not imply an inability to capture and generate quasi-rents but it entails more openness in the competitive process (greater variety and better selection) where barriers to entry are generated by the agent's differential competencies derived from a path of competence creation and accumulation.

As we have discussed, from a Schumpeterian perspective, the idea of market equilibrium and development are a contradiction in terms. Moreover, an approximation to competition from the complex systems theory, as this paper assumes, holds the hypothesis and argues that economic development conceived as a creative-destruction process, appropriation of knowledge and structural change involves transit through a disequilibrium path. In this sense, interventions should go beyond the idea of solving market failures in two reasons: because public policy should not aim at market equilibrium and because market failures are the rule rather than the exception of the way the market works (Possas, 1987). For of all these reasons, economic policy can never be a temporary but a permanent intervention. As a result, public policy should aim at generating dynamic market failures making it possible to follow a path of structural change (Castaldi et al. 2004).

The analytical scheme, based on complex systems theory provides an appropriate framework for the discussion of policies from a systemic perspective, especially in developing countries where there are important restrictions for the development of knowledge-intensive activities and great limitations for productive complementariness among agents.

In this sense, policy design should take into account the characteristics of the three processes, the two capacities and the two properties. From this perspective, policies should act on the diffusion of public and club goods, the selection and creation of new sectors and the positioning of the local agents in the global network structure to which -directly or indirectly-, they belong to.

In the first place, the diffusion of public goods is key issue because they constitute basic input for the development of club goods. It is necessary to improve the educative system to avoid the rise of perverse selections mechanisms, and to create equal opportunities to have access to both formal and informal education. Besides, in order to spread knowledge and information inside and among companies it is necessary to create incentives for the development of endogenous competencies centered in (i) the systemic training of workers and employees[12], (ii) the development of processes of continuous improvement and quality assurance (iii) linkages of firms with the national and sectoral innovation systems from the perspective of a non lineal model (Stokes XX), (iv) the infrastructure development of ICT of free access, and (v) the advantage of networks of nationals scientists and technologists living abroad.

Secondly, the selection of sectors with potential for development, which increasingly incorporates knowledge and the promotion of new sectors to increase the weight of the actors knowledge-intensive, requires the application of a vertical policy that raises the level of knowledge in the present productive structure and modifies the specialization profile by taking advantage of steep learning curves related to key sectors in the new paradigm. Therefore, the vertical policy must be centered on (i) the promotion of learning processes and competitions among agents, (ii) the generation of dynamic market failures and processes of technological accumulation with positive externalities, and (iii) the development of entailment processes firm-university within the framework beyond the individual supply and demand conceptions. The latter requires the prioritization of basic research oriented to vacancy areas.

[12] This refers to the fact that it is necessary to plan, organize and evaluate methodologically ex pos training processes training, given the existence of differential competencies of the agents.

Thirdly, to get a major position of local agents in the hierarchy of the global network they belong to, it is necessary to develop a public policy that takes into account private relationship nucleus-supplier-client. In this sense, the policy should enhance the generation, circulation and appropriation of knowledge in order to create dynamic competitive advantages. This implies developing functions of translation among agents in terms of languages and discovery of new contexts.

Therefore, if we considered the factors determining the three processes, policy makers should aim at increasing cumulativeness and appropriation significantly from the development of adoption and connectivity capacities. These dimensions of policy are not independent of the three process analyzed and therefore are horizontal to them. From the perspective of the determinants of appropriation, policies should focus on a significant increase in cumulativeness knowledge incorporated in the production of goods and services. This entails not only harnessing the company's external sources by improving the inter- phases between the company and the scientific system but also improving the internal sources consolidating the basic competitions of the agents and he circulation of information and knowledge inside the companies. Besides, it is necessary to develop institutions that allow the appropriation as a system of intellectual property rights but also to reinforce alternative and endogenous forms of protection, such as high innovation rates.

Table 2. Overall objectives of political by appropriation of knowledge, structural change and competition process

Proceses	Objectives
Appropriation	Increasing cumulativeness knowledge embodied in produced goods
	Increasing appropriation of knowledge and the integration of tacit and codified knowledge. Improving the development and access to public goods such as education, health, etc..
Structural Change	Inducing a complex profile of specialization in goods and services with greater weight of monopolistic sectors generating quasi-rents (sectors located in the higher levels of paradigm's productivity). Favouring the increasingly complex nature of networks and linkages among agents. Favouring increasing returns, technical change and synergies among agents. Increasing complementarities among agents and the activities that reduce structural heterogeneity
Creative-destruction	Creating incentives to generate complex routines in order to protect integrated knowledge and greater appropriation of quasi-rents through barriers and imperfect competition. Development of monopolistic rents by means of emulation behavior (catching-up)

The policy actions oriented to encourage processes of structural change should focus on inducing a complex profile of specialization in goods and services and on increasing the weight of sectors located in the higher levels of productivity. Developing processes of structural change also requires the production of much more complex networks in order to generate increasing returns, technical change and increasing synergies (Reinert 2007). Actions oriented to improve the processes of creative destruction should develop incentives to build complex routines in order to increase the knowledge protection and allow greater appropriation of quasi-rents coming from barriers and imperfect

competition and from development of monopolistic rents from emulation patterns (catching-up).

In turn, because of the synergy generated by the three processes, the policy objectives are strongly linked. The improvement of the management of knowledge by integrating tacit and codify not only has a direct impact on the level of agent's absorption capacities but also on the connectivity capacities. In other words, policy tools acting both from the demand and supply perspective are necessary. However, this also needs significant changes in the organization of firms into more complex structures in order to include projects in competition in a context of top-down and bottom-up relationships simultaneously. Changes in these directions will enable firms to raise the sources of learning significantly focused on de-incorporated technical progress. Therefore, an increasing complexity in firm's knowledge management should produce a greater weight of patents, a greater importance of codifiable but un-coded knowledge (diplaced code books) and a speed of innovation greater than that in rival firms. Finally, this set of policies associated with each of the three processes analyzed also will tend to generate a significant increase in agent's absorptive and connectivity capacity and therefore on the two associated properties: self organization and adaptation.

References

Antonelli C. (1997) *Percolation processes, technological externalities and the evolution of technological clubs*, Empirica, Kluwer Academis Publishers. Netherlands

Albornoz, F., Milesi, D. and Yoguel, G., (2005) Knowledge circulation in vertically integrated production networks: the cases of the Argentine automotive and iron and steel industries, in Dutrenit and Dodgson (Eds) Innovation and Economic Development, Lessons from Latin America, Special issue, Vol 7 Nro 2-3, Sydney

Albornoz, F. and Yoguel, G., (2004) "Competitiveness and production network: the case of the Argentine automotive sector, Industrial and Corporate Change, Vol 13, Nro 4.

Antonelli, C., (1999) "The evolution of industrial organization of the production of knowledge", Cambridge Journal of Economics, Vol 23.

Borello J, Morhorlang H and Silva Failde D (2007) Economías de Aglomeración en Países Semi-Industrializados: el caso de las tramas automotriz y siderúrgica en la Región Metropolitana de Buenos Aires, Argentina, http://pav-tramas.ungs.edu.ar/tramas/Ungs/25_07_07/, Buenos Aires

Brown, J. S.andDuguid, P., (2000) The Social Life of Information, Harvard Business School Press.

Castaldi C., Cimoli M., Correa N. and Dosi G. (2004), Technological Learning, Policy Regimes and Growth in a Globalized Economy: General Patterns and the Latin American Experience, LEM, Working Papers 2004/ 01, Pisa, Italy.

Cimoli M (2005), *Redes, estructuras de mercado y shocks económicos. Cambios estructurales en los sistemas de innovación en América Latina*, in Casalet, Cimoli and Yoguel (Eds) Redes, jerarquías y dinámicas productivas, FLACSO México, OIT México y Miño y Dávila, Buenos Aires.

Cowan R., David P., Foray D., (2000) "The explicit Economics of Knowledge Codification and Taciteness", Industrial and Corporate Change, Vol 9 Nro 2.

Dabat A, Rios M y Sztulwark S (2007), Rentas económicas en el marco de la globalización: desarrollo y aprendizaje. Implicancias para América Latina, XII Seminario Latino Iberoamericano de Gestión Tecnológica, Bs Aires, octubre.

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David, P. A. and Foray, D., (1994), *Percolation Structures, Markov Random Fields and the Economics of EDI Standard Diffusion*, en Global Telecommunications Strategies and Technological Changes Pogorel (Editor). North-Holland, Amsterdam.

Dosi, G., Freeman, C., Nelson, R.R., Silverberg, G., Soete, L.L.G. (Eds.) (1988), Technical Change and Economic Theory. Frances Pinter, London,

Dosi, G., Pavitt, K. and Soete, L. (1990), The Economics of Technical Change and International Trade, London: Harvester Wheatsheaf.

Dosi, G. (1991) 'Some Thoughts on the Promises, Challenges and Dangers of an "Evolutionary Perspective" in Economics', *Journal of Evolutionary Economics*, 1: 5–7.

Dosi G and Kaniovski, Y. (1994) 'On "Badly Behaved" Dynamics', *Journal of Evolutionary Economic*s, 4: 93-123.

Dosi and Nelson, R., (1994) 'An Introduction to Evolutionary Theories in Economics', *Journal of Evolutionary Economic*s, 4 (3): 153-72.

Erbes A, Robert V, Yoguel G, Borello J and Lebedinsky V (2006), Regímenes tecnológico, de conocimiento y competencia en diferentes formas organizacionales: la dinámica entre difusión y apropiación, Revista Desarrollo Económico Nro 181, Vol 46, Abril-Junio, Buenos Aires

Erbes A and Yoguel G (2007), Technological competition and the development of networks in the argentine automobile case in the post-devaluation period, V Globelics Seminar --The Global Network for Economics of Learning, Innovation, and Competence Building Systems-, October, Saratov-Russia

Foster, J. (1993) 'Economics and the Self-organization Approach: Alfred Marshall Revisited?', *Economic Journa*l, 103, July: 975–991.

Foster J (2000) Competitive selection, self organization and Joseph A Schumpeter, Journal of Evolutionary Economics vol. 10, no. 3, 311–28.

Foster J (2005) Fron simplistic to complex systems in economics, Cambridge Journal of Economics, 29, 873-892

Freeman C 1994, *The economics of technical change*, in Cambridge Journal of Economics, Vol 18 (5), Oxford university Press, UK.

Ernst D and Lundvall B A, 1997 "Information Technology in the Learning Economy. Challenges for Developing Countries", DRUID Woking Paper Nro 97/12, Aalboarg

Langlois, R. 2003. *The vanishing hand: the changing dynamics of industrial capitalism* Industrial and Corporate Change, Vol 12, Nro 2.

Malerba F and Orsenigo L, 2000. "Knowledge, Innovative activities and industrial evolution", Industrial and Corporate Change, Vol 9, Nro 2.

Metcalfe S (2002), "Knowledge of growth and the growth of knowledge"in Evolutionary Economics

Metcalfe et al, 2003, Economic development and the competitive process, First Globelics Seminar, Rio, Brasil.

Nelson R (1962), The rate and direction of technical change, National Bureau of Economic Research, N. York

Nelson, R. R., and Winter, S.G. (1982) An Evolutionary Theory of Economic Change. Cambridge: Harvard University Press.

Nonaka, I. and Toyama, R. (2002) A firm as a dialectical being; towards a dynamic theory of the firm Industrial and Corporate Change Vol 11. nº5.

Ocampo J A (2005), The quest for dynamic efficiency: structural dynamics and economic growth in developing countries, in Ocampo (ed) Beyond Reforms: Structural reforms and macroeconomic vulnerability

Pavitt, K. (1984) *Sectoral patterns of technical change: Towards a taxonomy and theory*, Research Policy Nº 13. Possas M ( )

Prigogine, I. & Stengers, I. (1984). *Order out of Chaos: Man's New Dialogue with Natur*e. New York: Bantam.

Possas, M. (1987) Estructuras de Mercado y Formación de Precios en Condiciones de Oligopolio 1. ed. São Paulo: HUCITEC. 1985

Reinert E. (1995) "Competitiveness and its predecessors--a 500-year cross-national perspective" Structural Change and Economic Dynamics, Volume 6, Nº 1. Elsevier Science

Reinert E (2007) Wow rich countries got rich and why poor countries stay poor, Constanble, London, UK

Rizzello S (2003), Towards a cognitive evolutionary economics, Working paper, Dipartimento di Economia "S. Cognetti de Martiis", Centro di Studi sulla Storia e i Metodi dell'Economia Politica "Claudio Napoleoni" (CESMEP)

Rodrik, D, (1999), *The new global economy and developing countries: making openness work*, Economic Development Policy Essay Nro 24, Overseas Development Council.
Rosenberg, N (1982), Inside the black box: technology and economics, Cambridge University Press, Cambridge.

Roitter S, Erbes A, Yoguel G, Delfini M and Pujol A (2007) Conocimiento, organización del trabajo y empleo en agentes pertenecientes a las tramas productivas automotriz y siderúrgica, http://pav-tramas.ungs.edu.ar/tramas/Ungs/25_07_07/comparacion.pdf, Bs Aires. .

Scheffer, M., F. Westley, W.A. Brock, and M. Holmgren (2002), Dynamic interactions of societies and ecosystems—linking theories from ecology, economy, and sociology, in Gunderson and Holling (Eds), *Panarchy:understanding transformations in human andnatural systems*. Island Press, Washington, D.C.,USA

Schumpeter, J. A. (1934). The Theory of Economic Development. Cambridge: Harvard University Press. (New York: Oxford University Press, 1961.) First published in German, 1912.

Schumpeter, J. A. (1942). Capitalism, Socialism, and Democracy. New York: Harper and Brothers. (Harper Colophon edition, 1976.)

Shin T and Laymb (2006) Paths of commercial knowledge: Forms and consequences of university–enterprise synergy in scientist-sponsored firms, Research Policy 35.

Silverberg G (1984), Embodies technical progress in an economic dynamic model: the self-organizing paradigm, in Goodwin, Kruger and Vercelli (Eds) Norlineal models of fluctuating growth, New York, Springer

Silverberg, G., Dosi, G. and Orsenigo L. (1988) 'Innovation, Diversity and Diffusion. A Self-Organization Model', *Economic Journa*l, 98: 1032-1054.

Yoguel G, Erbes A, Robert A y Borello J (2007) Diffusion and appropriation of knowledge in different organizational structures, Working `papers in Technology Governance Nro 13, The Other Canon Foundation, Norway and Tallin University of Technology, Tallin, Estonia.

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