COMPLEXITY, SOCIO-TECHNICAL SYSTEMS AND DEVELOPING, A RESEARCH PROGRAM FOR LATIN AMERICA

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Abstract

This paper explains the advancement achieved in a theoretical analytical work, developed to create a convergent framework between social studies of science and technology and the economics of innovation and technological change. It is shown here the ontological, epistemological and theoretical possibilities of convergence between both trajectories, on the basis of a special selection of contributions related to social studies of technology (Actor Network Theory, social construction of technology and socio-technical analysis) and neo-Schumpeterian evolutionary economics oriented to complex systems. These include theoretical advances made by Latin American scholars that seek to interpret and explain problems of innovation, technological change and structural change taking into account the peculiarities of the region.
The different analytical moments carried out are explained, as well as their implications: ontological (non deterministic dynamic conceptions), epistemological (inter-ontology crossover), theoretical ("good theory") and general and specific approach dimensions under assumptions of midrange theories. As a result it is provided the basis of convergence and their assumptions that will allow the construction of a hybrid research program oriented to innovation problems, technological change and structural change in Latin America. It is explained their relevant hybrid research agenda: studies about socio- technical dynamics, studies about socio-technical trajectory and studies about socio-technical configurations and articulations. Finally, in line with the Latin American traditional thought on science, technology and society, the program proposes the creation of an emergent space of articulating policies to promote multidimensional development (economic growth, social inclusion and sustainability)

Key words: social studies of technology, complex system, neo-Schumpeterian evolutionary economics, hybrid research, articulating policies.

Introduction

In recent decades, the relationship between innovation, technological change and development in contemporary capitalism has become critical in various fields of social sciences[1]. Despite the proliferation of contributions, there have been no theoretical or methodological approaches between the different disciplines involved in these issues, nor extensive adhesions in the mainstream of each of them. (Kreimer and Thomas, 2004).
Beyond the differences, these disciplinary contributions have in Latin America certain meeting points in the identification of problems such as the dependent nature of productive and innovative patterns in Latin America

[1]In this sense, there have been different contributions in Latin America, going from foundational work on Latin American thought on science, technology and society, (Varsasky, 1969, 1974**;** Sábato and Botana, 1970**;** Herrera, 1970; Urquidi, 1970,Sagasti and Araoz, 1975; Schwartzman, 1979), the classic but renewed developent theory (Katz and Kosacoff, 1989; Fajnzylber, 1990; Katz and Bercovich, 1993; Hounie et al, 1999; Amsdem, 2004; Ocampo, 2005; French, 2005; Ocampo, 2006; Hausmann and Rodrick, 2006;Katz, 2008;Cimoli and Rovira, 2008), knowledge-based economy and society (Dabat and Ordoñez, 2009; Casas, 2006**;** Stezano and Cuartas, 2008); to the **social studies in science and technology** (Dagnino, Thomas and Davyt, 1996; Thomas, 2008;Vessuri, 2007; Kreimer and Thomas, 2004)and the **economics of innovation and technological change** (Yoguel and Boscherini, 1996; Cassiolato and Lastres, 1999; 2008;Arocena and Sutz, 2003; Kupfer and Avellar, 2008; Fuck and Bonacelli, 2009; Silveira Luz et al, 2011; Dutrénit, 2004), in its "extended" variety (Rivera Ríos, Robert and Yoguel, 2009) and the complex- system-oriented variety (Erbes, Robert and Yoguel, 2010; Robert and Yoguel, 2011).

with respect to developed countries, the poor and unequal capacities to innovate of people and organizations in the region, their recurrent reaction against technological changes, difficulties in establishing incentives for technological and social innovation, and the predominance of institutional frameworks not prone to structural and technological changes. Certain agreements are also seen in the need to explain these problems from the specificity of the continent, whether in the generation of empirical evidence or from models that guide institutional policies on science and technology (Rivera Rios, Robert and Yoguel, 2009; Arocena and Sutz, 2003; Dagnino and Thomas, 2000). Besides, there is another important meeting point when considering that Latin American limitations in innovation processes and technological change are related to the recurrent problems of low economic development, social exclusion and sustainability deficit (Arocena and Sutz, 2003, Katz and Iizuka, 2011, Albuquerque, 2007; Lastres Cassiolato and Arroio, 2005; Rivera Rios, Robert and Yoguel, 2009, Robert and Yoguel, 2010, Perez, 2010; Dagnino and Thomas, 2000; Figueiredo, 2004; Dutrenit and Katz, 2005; Dabat Rios and Rivera, 2004). This overview of the contributions and trajectories, poses as a key challenge for Latin America to propose alternative ways of political and theoretical dialogue between the different disciplinary efforts of the social sciences, which have gained importance in the academic field since they have been tackling these problems in recent times. From the different paths that have arisen in Latin America we have chosen science technology and society and the economics of innovation and technological change as being those who have made major contributions to the study of the relationships between technology, society and development. Some reflexivity exercises have placed these contributions in the field of science, technology and society (STS). Moreover, it has been said that, despite the deliberate convergence efforts made in this field in developed countries, in Latin America, science, technology and society and the economics of innovation and technological change have operated over relatively parallel ways and with very little discussion[2]. Faced with this starting-point problem we ask the following questions: Is it possible to propose any kind of convergence between the fields of study of the problems of innovation, technological change and development in Latin America?, what are the possibilities of convergence and what ontological, epistemological and theoretical assumptions would they depend on?, How would the possibilities of convergence allow the creation of a research program for Latin America with implications on science, technology and innovation policies?

Based on these central issues, this paper explains the results and progress made in an exploratory study of the possibilities of convergence between both trajectories, understanding them in Latin American tradition of thought in science, technology and society. That is to say, it is recognized as a theoretical and political effort with implications for the resolution of the problems of development in the region. Some contributions were taken from the course of science, technology and society, the actor-network theory, social construction of technology and those from the Latin American socio-technical analysis. As regards the trajectory of the economics of innovation and technological change, there have been used some contributions from the Schumpeterian evolutionary economics, with emphasis on recent approaches to the theory of complex systems.

The main objective of this exploratory exercise was to lay the ontological, epistemological and theoretical foundations of a conceptual-interpretive schema (framework), from certain contributions of social studies of technology (SST) and the neo-Schumpeterian evolutionary economics oriented to complex systems (EEC) [3], that allow to tackle the issues related to the processes of innovation, technological change and development from a Latin American perspective. This goal involved a series of implicit specific outcomes that represent an analytical exercise of five interdependent stages. The first, considered the preliminary international and Latin American convergence in science, technology and society, and the economics of innovation and technological change, making certain general assumptions for the selection of theoretical of those trajectories (i). The second, based on the first one, was to explore the possibilities of ontological convergence between STS and the EEC, analyzing the epistemological and theoretical implications and the general analytical dimensions (ii). In the third stage, taking into account the possibilities of convergence, it was analyzed the generation of a hybrid

[2] To get a more comprehensive development of SCTS in Latin America see Oteiza and Vessuri, 1993; Vessuri, 1987; Dagnino, Thomas and Davyt, 1987; Kreimer and Thomas, 2004.

[3] From now onwards, the use of the denomination *social studies of technology (SST)* and *neo-Schumpeterian evolutionary economics oriented to complex systems* (EEC) must be understood as theoretical and conceptual approaches operated from the findings and assumptions of the analytical exercise; the denominations *science, technology and society* (STS) and *economics of innovation and technological change (EITC)* are respectively used to identify the wider disciplinary trajectories from where the EST and EEC come and are streamlined.

research program that relates elements from the complexity-oriented evolutionist economics with socio-technical approaches, setting specific analytical dimensions to be the research agenda (iii). The fourth stage was oriented to outline an interpretive-conceptual schema (framework), to be able to generate empirical based studies around the hybrid unit of analysis of the socio-technical systems of production and innovation (iv). And the fifth, proposes science, technology and innovation articulating policies, capable of being oriented to Latin American development in a multidimensional sense (v). In the present article, based on the main objective, the three initial analytical stages are tackled and preliminary proposals are made to create articulating science, technology and innovation policies.

There have been very few international research programs and theoretical constructs linking social science, technology and society with the economics of innovation and technological change in a convergent sense, especially in Latin America. In addition, there are the critical reviews that each trajectory receives on its particular way of theorization and analysis to understand innovative phenomena and technological change. Regarding social studies of science and technology, it is recognized that despite its strong academic growth, it has little impact on policies and interaction with other disciplines. The critical arguments are based on the use of concepts that are difficult to grasp by outsiders, the emphasis on complex and contingent issues that prevents generalizations, and an aversion to instrumental contributions, considering them as technocratic (Geels, 2007; Edge, 2003; Molina, 1995). To this critical perspective emerged from developed countries, it is added the reflective ones originated in Latin America: although the growth that this experience has had in the region is recognized, it is noted that there are difficulties in building their own interpretive frameworks to select topics and problems that are not set by agendas of developed countries. It is also criticized their limited initiative to recover the political sense of the foundational contributions to the thought on Science, Technology and Society in Latin America, and finally, the difficulty to increase their legitimacy within the social sciences themselves (Kreimer and Zabala, 2007; Vacarezza, 2004). Regarding the criticism on approaches to economics of innovation and technological change, the principal is one that demands further empirically based studies (Dopfer, 2008) and seeking input from other social science disciplines such as sociology, psychology, hermeneutics and history (Hodgson, 2007), with the increasing development of the work focused on the "obsession with modeling" (Silva and Teixeira, 2009). Authors like Dopfer, criticize the positions of this kind, even in the context of the economics of innovation and technological change, denominating it as algebraicism. The algebraicism is a scientific and philosophical attitude towards the economy, and eventually, a profound way of thinking social functioning in general, under the contemplative attitude of mathematical logic itself. It works juxtaposing static assumptions of microeconomics to the macroeconomic consequences. From this, there arises type of analysis where the micro represents the space of individual choice and the macro is derived aggregation of these decisions (the sum of the micro becomes the macro). This creates a simplifying holism which is translated into economy core concepts, even evolutionary economy ones, such as structure, population, processes. Hence, to overcome the problem of algebraicism, it is necessary to incorporate contributions from studies on complex-system networks, the theory of self-organization of open systems and universal or generalized Darwinism, replacing the idea of biological evolution by a knowledge processing one. This recognizes as a key issue the generation of systemic explanations that relate micro - meso – macro phenomena (Dopfer and Potts, 2008), primarily, the historical approach of the coordination processes and changing economy. So, possibilities of historicity of economics (histonomic) are raised, operating under generalization criteria in terms of irreversibility, non-ergodicity, non-regularity and path dependence (Dopfer, 2011). Finally, these criticisms lead to the idea that the economy (evolutionary) should be considered as a science of culture (Dopfer and Potts, 2008), away from simplistic explanations based on models from Physics and Biology. Despite some recognition of this lack of convergence and criticism to each of the paths, there exists some recent history where partial approaches arise. In an effort to reconstruct the state of art of "innovation studies" in developed countries, Rossi (2002) took the different points of connection between economic, sociological and historical approaches oriented to the analysis of innovation processes. The author concludes that beyond the conceptual specificities, there are general aspects among the different approaches, such as: (i) opposition to linear models, (ii) the analysis of the cognitive dimension of organizations, (iii) the importance of learning processes and tacit knowledge and (iv) developments in network analysis. One of the most significant convergence efforts at international level has been the work by Bruun and Hukkinen (2003) that triangulates the actor-network theory, social construction of technology and evolutionary economics, considering the possibilities of building a framework through a selection of common elements of analytical nature. We will deal

with these analytical dimensions in the next section. Another significant contribution is the one by Geels (2007, 2009 and 2010) that seeks to link evolutionary economics and the social studies of technology and management of technological innovation to the concept of socio-technical systems. The analytical and empirical contributions developed by this author, explicitly show the possibilities of convergence via multi-dimensional models and inter-ontology crossover type analysis. In a line preceding the aforementioned authors, from the quasi-evolutionary School of Twente, it is asserted that evolutionary economics and constructivism (Social Construction of Technology), convergent contributions within the framework of constructive evaluation of technologies could be established (Van's Belt and Rip, 1987; Schot and Rip, 1997). Members of this school use multidimensional perspective to make it more sociological the understanding of evolutionary processes of variation, selection and retention of evolutionary economic tradition. Other authors have also explored possibilities of convergence between the two fields, applying their frames of reference to specific problems or issues. Mackenzie (1992) notes that, while the sociology of technology and evolutionary economics have different approaches, they can achieve convergence in the study of stabilized networks. Others, like Windrum (1999), use contributions of convergence between both of them to study technological transitions and problems over lock-in effect rupture in socio-technical systems.

In Latin America, some approaches have been proposed. These range from studies analyzing knowledge networks (Casas, De Gortari and Santos, 2000; Villavicencio, 2000), inspired by the contributions by Callon (1989) on socio-technical networks and Freeman (1991) on information and communication networks, which is related to the contributions of innovation systems and innovation processes within interactive terms (Von Hippel, 1988). This approach is applied to case studies to understand interactive processes of networking between government, university and productive sectors, aimed at the emergence of social capital at the regional level (Casas et al, 2000, Casas, 2006). In this sense there exist sectoral technological change processes analysis that articulates the concepts of sectoral innovation system with socio-technical dynamics (Brieva and Thomas, 2008). In works on the state of the art in the field of new economic sociology in our continent, some authors have incorporated the contributions of evolutionary theories and techno-economic networks by Callon (Villavicencio, 2002; Pozas et al, 2004). Moreover, the approximation work between neo-Schumpeterian evolutionism oriented to complex systems, the neo-institutionalist approaches, the new theories of development and studies on cognitive capitalism have added in their "extended" analytical frameworks elements like power, organizational learning, political alliances, players playing against the rules, the concept of historical bloc of Gramscian tradition, among others (Rivera Rios, 2010; Rivera Rios, Robert, Yoguel, 2009). These last proposals have placed the issue of development back in the centre of economic discussions (heterodox) of the region. This is a relevant issue that arises increasing empirical and theoretical interest in the field of science, technology and society.

In a collaborative way, some authors from both paths have presented analysis of the relationship between science, technology and development (Ocampo, Patlán, Arellano, 2003), although they have not dealt with it in the convergent sense aimed in this article. From the perspective of STS some connections have also been established with the underdevelopment issues in Latin America, but not from a convergent point of view. (Vessuri, 1993, Nuñez, 2007). The theoretical works and the case and policies analysis by Thomas (Thomas, 2008, 2010) and Dagnino (Dagnino and Thomas, 2000; Dagnino, 2010) have considered the possibility of including the contributions from economics of technological change in science, technology and society, though in a broader analytical framework of a socio-technical nature (Fressoli and Thomas, 2010). His recent proposal social technology and technology for social inclusion critically analyzes the capitalist sense of the processes of innovation and technological change, claiming for specificity in the study of these problems in the region, towards a solidarity-oriented economy (Dagnino, 2010; Fressoli and Thomas, 2010).

In spite of the rapprochement search between the theoretical contributions of both paths, the convergent efforts do not have a homogeneous, sound research agenda in Latin America yet. (Thomas, 2010)[4]. Thus, the analytical

[4]To this situation, it should be added the parallel and scarcely convergent search to understand, explain and tackle the issues of the policies related to innovation and technological change, such as dislocations between institutions, the network role in learning processes and knowledge generation, the deficit in the innovation policies in science, technology and production and its relationship to the development problems whether from the economic, the social or sustainability points of view. On this issue we will go deeper at the end of the article.

stage 1 shows that both paths have advanced in parallel and with little dialogue. However, there have been isolated efforts of preliminary convergences that evidence the likelihood of establishing relationships and possible future convergences. These possibilities involve a number of analytical, theoretical and epistemological efforts:

(i) To identify theoretical contributions that share general assumptions about tackling problems on innovation, technological change and development, such as criticism of linear models, centrality of the cognitive and learning aspects in the analysis of organizations and approaches oriented to study Networks.

(ii) To recognize theorizing progress in and from the Latin American perspective

(iii) To browse theoretical contributions that present approaches from the ontological point of view.

(iv) To define an epistemological strategy that allows the theoretical convergence of these contributions.

(v) To propose a series of converging analytic dimensions from the selected epistemological strategy.

(vi) To set a research agenda to enable the deployment of convergent achievements and exceed the critical limitations of each approach.

(vii) To articulate analytical dimensions with problems on innovation, technological change and development in Latin America (recovering the isolated efforts of both paths).

The finding of preliminary convergences of analytical stage 1 resulted in analytical stages 2 and 3.

Analytical Stage 2.
Contributions to the framework: Neo-Schumpeterian evolutionary economics oriented to complex systems and social studies of technology.

Based on the preliminary convergence possibilities outlined at stage 1 the paths explained in the introduction are selected. That is to say, we tried to identify theoretical contributions in the field of science, technology and society and the economics of innovation and technological change that have a critical position to linear models, deal with organizational issues from cognitive and learning approaches, incorporate networking analysis and present efforts oriented to theorize on Latin American specificity. Following these basic criteria, the field of study was selected from science, technology and society: the Actor-Network Theory (Callon, 1987, 1992, 1998, 2001, 2006; Latour, 1999, 2007, 2008; Law, 1987, 2009), the social construction of technology (SCOT) (Bijker, 1987, 1993 and 1995; Pinch and Bijker, 1984, 1987; Pinch, 1996, 2008), and the Latin American contributions to socio-technical analysis ((Dagnino, 2010; Thomas, 2008). While from the economics of innovation and technological change we considered recent contributions of the complex-system-oriented Neo-Schumpeterian evolutionary economics (Dopfer, 2011; Foster, 2005; Foster y Metcalfe, 2001; 2009; Antonelli, 2011; Bloch and Metcalfe, 2011; Saviotti and Pyka, 2008; Saviotti, 2011; Consoli and Patrucco, 2011), which also raises theorizing efforts in Latin America (Robert and Yoguel, 2011).. Below there is a brief description of each of them, considering their main ontological-theoretical components, and then, the possibilities of convergence between them and their epistemological implications are analyzed. The contributions of Neo-Schumpeterian evolutionary economics oriented to complex systems start from a selection of authors of well known international and Latin American experience. They share a number of basic assumptions of evolutionary economy where innovation and technological change are considered the engines of growth and transformation of capitalist economy[5]. The evolutionary economy has as its main objective to study the determinants and effects of the generation of new technological and organizational knowledge, the introduction of innovations, products, processes, organizations, in the mix of supplies and markets, their selection and possible distribution (Antonelli, 2011) [6]. But unlike other contributions of Neo-Schumpeterian evolutionary economics[7], these

[5] Together with the permanent criticism made to the neoclassic models of general balance of the economy mainstream, supported by Newtonian principles (Dopfer, 2011) .

[6] For Dopfer, the evolutionary scheme would be origin, adoption and retention. This proposal comes from rereading the general ontological principles of Darwinian propositions, established in different sciences: variety, mutation, adaptation, selection and retention.

[7] Those that assume biologicist metaphors like Nelson and Winter, 1982 (see the review by Antonelli, 2011,), or based on Darwinistic population thinking (see Dopfer, 2011 reviews what he calls typological thinking, Metcalfe, 1994 and Antonelli, 2011) who focused their analysis on the selective dissemination of new technologies (with random characteristics in their approaches to the selection) rather than on the analysis of the determinants of the current generation of new technological knowledge and introduction of innovations.

authors assume ontological-theoretical complementarities with approaches to complex systems. The complexity theory regarding the contributions of Neo-Schumpeterian evolutionary economics allows the understanding, in the light of dynamic and systemic approaches, of the behavior of changes and endogenous transformations of the production and innovation systems and the economy in general. Innovation is understood as an emergent property of a complex system that operates under the principles of imbalance in a permanent feedback[8] relationship between its micro-meso-macro dimensions (Antonelli, 2011; Dopfer, 2011). Innovation analysis combines the intentionality of the decisions made by the agents with the holistic approach of the properties of self-organization and adaptation to systems. The economic system under assumptions of complexity is understood as a context where the emergence of innovations and processes of technological and structural change are generated and made possible (or not) (Antonelli, 2011; Dopfer, 2011, Bloch and Metcalfe, 2011) [9]. The interaction between innovation, technological change and structural change in these systems generates non-ergodic dynamical processes. This means that the systems historicity provokes strong influences in their dynamics but does not absolutely condition future events. Hence, small events can change the system trajectory, as in the case of innovations (David, 1994; Antonelli, 2007; Antonelli, 2011). This understanding of the historicity of economic systems from the perspective of complexity makes it possible to break with certain distinctive determinisms of evolutionary approaches that are focused on the effects of irreversibility, biologicist lock-in and path dependence. Although these properties are recognized to be specific to the historical trajectories of the systems, to include the possibilities of creative responses permits the incorporation of the intentionality of the organizations and their cognitive potential[10], via accumulated skills and learning to change these trajectories and create new incremental or radical processes[11]. Operating on this cognitive dimension [12] of complex systems, Dopfer (2011) proposes a process of change of economic systems under complexity premises that relate micro-meso-macro dimensions. So the economy is seen as a system composed of organizations that carry knowledge (carriers) to develop economic operations. But in turn, the proposition considers that knowledge is not only updated in organizations, but also in the cultural artifacts they produce, exchange and consume[13]. Agents and devices as knowledge carriers (which are theoretically dealt with as "generic rules"[14] here), can explain interaction and co-evolution phenomena in the economic systems. In a systemic scheme of micro-meso-macro relationships, Dopfer (2011) outlines the concept of a multilevel systemic dynamics where the micro is the dimension where general rules are originated[15], general rules that are updated in different ways by all the agents; the meso level constitutes a grouping of different updates of a single rule[16]., and the macro is the set of rules with their respective updates[17]. Thus, the micro-meso-macro co-evolutionary dynamics of complex economic systems is driven by the differentiation of the agents' activities and the changes in institutional frameworks that coordinate the division of work between them. There are two types of differentiations: a functional technological one, at the organization level, and the other one in the system architecture. These differentiations transform interactions between agents (networks), and at the same time,

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[8] The feedbacks alter the dynamics of the systems. The negative feedbacks make the changes be attenuated and absorbed by the system, achieving stability, while positive feedbacks intensify the changes and lead the system to instability.

[9]According Dopfer, depending on the theoretical intentionality, the analysis of agents' behavior can be focused on the agents' operational level (assuming that their knowledge is constant) or on their level of knowledge, assuming their structural and evolutionary aspects (Dopfer, 2011)

[10] Foster (2005) affirms that many systems are complex and adaptive, but adaptation implies more than natural selection, it implies *creativity*. This is due to the fact that complex human systems have a distinctive cognitive component.

[11] Antonelli (2011) poses this distinction in the economic systems historicity, complexity in the concepts of path dependence and past dependence.

[12] This issue has already been introduced by Foster (2005) as a differential characteristic of complex systems that relate human beings.

[13] In a recent contribution Dopfer (2011) considers that complex-system-oriented evolutionary economy must be thought of as a culture science.

[14] Rules may be subjective ones, operating in the agents (behavioral rules) and objective rules in the artifacts (social rules, collective behaviors, technological rules. In order not to be accused of Platonism, Dopfer, in his theoretical perspective, considers that rules (that he uses as a concepts, not as ideas) have an empirical counterpart that are the operations that actualize the rules in time and space.

[15] The micro dimension has two phases: the first is the creation of a new idea and the second implies the searching, descovering and recognition processes, it is a selection internal to the organization.

[16] This implies an adoption of rules that also has two phases: the first is the actualization and the second is the selection external to the organization, made by the market, where the path dependence effects are played.

[17] The macro dimension involves an initial phase of selectively retained routines, and a secondary phase that involves an extended regime as a possible "breeding ground" for new ideas and feeds back with the micro dimension.

may transform the structures of the systems according to the type of feedback established between both of them (Consoli and Patrucco, 2011). This co-evolutionary dynamics occurs in competition processes. The evolutionism poses a conception of active competition, different from the neoclassical allocation model, and is based on multiple forms of achieving competitive advantages. From this perspective, the agents operate under principles of imperfect information and radical uncertainty, exploring alternatives and experimenting, and the benefits of this process, which involves learning and knowledge generation, are the reward to economic creativity and a signal of the emergent novelty in the market (Metcalfe, 2010). In this theoretical context, it is central to understand the role played by knowledge and learning at the level of organizations that set up and are set up in complex economic systems, where at the same time, given the progress described above, the importance of the cultural objects or devices as component elements is recognized. (Dopfer, 2011; Antonelli, 2011). Moreover, the possibility of modifying paths and system structures enables the understanding of the role of agents' intentionality and their capabilities to respond, not only in an adaptive way but also in a creative one, as we have already explained. The agents' creative responses (Schumpeter, 1947) are placed and occur in a network of interactions under recursiveness dynamics. They appear as phenomena within a historical process, which involves incentives for change, action contexts and market, social and cognitive interactions (Antonelli, 2011; Arthur, 1990). This raises two key issues of this theoretical approach: the role of networks and learning and knowledge generation. The interactions are a critical component of complex economic dynamics since they occur when a number of heterogeneous agents intentionally[18] decide to change their ways of connecting one another, and move in network structuring with different scopes. Antonelli (2011) notes, however, that the ways of interaction in economic systems do not only occur in markets and trading relationships. These are considered only when they have economic neoclassical assumptions on the conception of the agents. However, if it becomes apparent that agents have abilities to learn and innovate, other forms of relationships beyond the transactions become important, such as cognitive interactions that enable knowledge transactions between agents. The cognitive interactions and transactions[19]are essential to identify the degree of virtuosity in the development of innovations that have the organized complexity of a system, as they define, largely, the context in which the generative relations may arise and lead to creative responses from the agents. The concept of generative relationship[20], assumes that the most important cognitive process in innovation is the generation of new attributes, what may occur in this kind of interactions in spaces of agents-devices within organizations or between organizations. Generative relationships emerge in networks whose potentiality to cause innovations depends on a number of structural features of systems such as: the degree of alignment between their components, common goals, interpretive heterogeneity, mutual directionality, permits to appropriate knowledge and information between them and the opportunity detection (Lane and Maxfield, 2005). However, due to the positive feedback effects, it is possible that the structure of complex economic systems can be determined by the strategic behavior of market agents, by the introduction of innovations or by new networks of interaction. So, system structural change is an endogenous process. Somehow, the authors of this line agree that the meso-economic dimension is the "historical" dimension of the system, where the dynamic trajectory is inscribed. It operates as system memory that determines behavior but at the same time, can be modified by the creative reactions of agents. In recent times, in a dialogue with a renewed literature in the field of economic development (Ocampo, 2005; Amsdem, 2004; Cimoli, Porcile and Rovira, 2010, among others) emerges, in Latin America, the necessity to integrate theoretical elements of micro-complexity proposed by neo-Schumpeterian and evolutionary approaches on innovation and macro-complexity considered by structuralism and post-Keynesian economics. Thus, Robert and Yoguel (2011) have raised theoretical contribution under assumptions of the complex systems theory, which integrates both perspectives. The central objective of this integration is to facilitate the analysis of innovation dynamics and structural change in developing countries, considering the interactions generated at micro, meso and macroeconomic levels. When taking the concepts and assumptions about the operation of production systems and innovation under criteria of complexity, the authors believe that the results of innovation efforts not only depend on the behavior of firms (their endogenous

[18]As Antonelli (2011) states, the agents' intentionality appears as a certain degree of conscience about the possible results of the interactions in terms of opportunity and possible future income.

[19]This dimension of cognitive interaction (knowledge) comes from a tradition in the field of evolutionary economics. (Lundvall, 1988; Von Hippel, 1998). However, as Antonelli (2009) and Dopfer (2011) state, from recent studies focused on complexity, the contributions on generative relationship developed by Lane and Maxfield (1997) would result more relevant.

[20] The concept implies an assumption about the cascade innovation process.

capacities and capabilities), but also on macro and meso-economic dynamics in which they are embedded and from which they are part. They propose that these dynamics can be characterized by the type and degree that three processes adopt: the competition process, the process of structural change and the process of cumulative causation. These three processes will assume specific characteristics in productive systems and innovation according to the level of development they have. These processes and the profile of the institutional matrix, either favorable or adverse to innovation (Rivera Rios et al 2009), impact via feedback effects on the innovative behavior of firms. Thus, from interaction and feedback mechanisms between institutional matrix, processes and capabilities of organizations, innovation emerges endogenously as a result of a systemic phenomenon. The fundamental hypothesis of this approach is that in developing countries, such as Latin American ones, profiles of productive specialization based on primary goods and regressive institutional matrix, together with problems and deficit at the level of skills and micro competencies of the firms and their relations to other organizations, have a negative impact on the possibilities of emergence of innovations and processes of structural change. The other path considered relevant in the framework is that of interpretive social studies of technology. These are founded on an ontology based on the metaphor of "seamless web ", which seeks to break with social and technological determinism of science, technology and society problems (Hughes, 1986). They start from the rejection of a priori distinctions about the relationship between technology and society (and also in the political, economic, social or other fields), introducing them from a symmetric perspective relationship between them (Latour, 2007). One of the most relevant contributions considered is the Actor-Network Theory (ART). From a "seamless web" perspective, it understands technology as an generator of processes of irreversibility and reversibility that exceed the dilemma of the micro – macro distinction. A techno-economic network is a coordinated set of heterogeneous actors (human and nonhuman) who collectively participate in the conception, development, production and distribution of methods to produce goods and services, some of which result in market transactions (Callon, 1987). The techno-economic networks can be analyzed in terms of emergence, increasement, enclosure and dismemberment since the actors that compose them have significant degrees of freedom that allow them to develop strategies, innovations, leading to "contingencies" in the network. The ontology of this theory poses a foundational heterogeneity of reality given by a network of human and non-human with variable configurations and its own dynamics. The ontology of ART also becomes an evolutionary temporality raised in convergence and irreversibility processes. The ontology of TAR also becomes an evolutionary temporality raised from convergence and irreversibility processes. Convergence results in the formation of a common area between heterogeneous elements and irreversibility of the permanence in time of this merge of human and nonhuman elements that determine its evolution. Convergence and irreversibility of techno-economic networks open the step analysis of their dynamics. The techno-economic networks are produced around three poles: the scientific one, the technical one and the market, each having its own identity, strategies and procedures. The explanation of how to build a common ground between these poles should be taken from the contributions of Economics and Sociology (Callon, 1987). An actor - network is that one who has the capacity to associate the diversity of elements, give them identity and common history, and describe the relationships between them. The actors and the intermediaries may be hybrid, as well as individual or collective. It is the observer who establishes a "variable geometry" for each actor - network, a hypothesis about its ontology. Any group, actor or intermediary describes a network, under a translation operation and under assumptions of radical symmetry. An actor - network has the capacity to mobilize and translate intermediaries. Network actors make up a techno-economic network, so its change, its dynamics is comprehended by the processes of convergence and irreversibility, intimately related to translation. Convergence leads to the coordination and alignment of actors, opening a micro-political analysis of technological change in terms of mapping of the components of networks, their translations and their modalities of circulation of power. It is also possible to consider trajectories forming and stabilizing networks, conflicts and consensus implicit in relationships between different groups of actors and intermediaries. Another important element is the relationship between irreversibility and learning since stabilization and systemic effects between actors or between actors and intermediaries linked by translation processes, result in predictable normalization between both of them. The new translations and therefore, the related learning, struggle with the robustness and durability of the translations. It is important to say here that Callon considers this evolutionary moment of the convergence network and irreversibility in terms of routines in the same sense as Nelson and Winter. This allows the understanding that various translations that result in different configurations of techno-economic networks can oppose one another. The stronger the coordination and alignment, the more difficult the

emergence or possibilities of articulation of new translations in the network as it operates as a black box when the convergence and irreversibility are high. This means that when it gets to this point the network refers to other network actors as "external" with which intermediaries are exchanged. The punctuation of a network analysis allows considering industrial sectors, a scientific discipline or a particular market. Another relevant contribution of the socio-technical analysis agenda comes from the SCOT (social construction of technology) perspective. Following the tradition of the relativist program's work on Sociology of Knowledge by Collins (1983), the social constructivism of technology by Pinch and Bijker (1987) presents the analysis of objects ranging from appliances to complex socio-technical units. Thus, an ontology supported by the seamless web that intends to surpass micro - macro perspectives, tries to analyze, through reflexivity exercises, the socio - technical relations of the relevant social groups that constitute and generate these artifacts, as carriers of technological change. The analysis from the SCOT perspective ranges from artifacts to technological frameworks, and from these to socio-technical assembly. Through deconstruction of the artifacts, it is sought to consider the different perspectives about them in what is called interpretive flexibility. The interpretive flexibility helps explain the functioning and non-functioning of a device according to the meaning given to it by the relevant social groups. Closure and stabilization are two processes that close the interpretive flexibility and raise the success of an operation modality set by relevant social groups (compared to others in a controversy). On a level higher than artifact analysis, technological frameworks are posed. Technological frames are heterogeneous; they belong neither to purely cognitive or social domain (both); they are not permanent and are held by the interactions between social groups. They grant objectives, thoughts and action tools that establish opportunities to guide future strategies. The technology framework concept is broad enough to include the current theories, goals, strategies, problem solving and use practices regarding a technology (Bijker, 1995). As a concept, it seeks to apply to the interaction between various actors; therefore, it resembles Callon's concept of networks. A technological framework represents how a social environment structures technology and how technology affects the social environment. Thus, it arranges groups related to it, though not fully since there are different degrees of group inclusion, as well as there is always a group that shares different technological frameworks. These are configured (regardless of the actors) through political processes (power appears as the third analytic element). At this level power is exercised and raised in a relational way, and presents two perspectives: a semiotic one and a micro-politic one. The SCOT takes the concept of power from Guiddens (1979). For him power is not possessed but exercised. Therefore it is relational, and it is understood as the capacity to transform "the other's agency" to achieve our own aims. The semiotic dimension of this relational power involves setting certain categories around their order in technological frameworks. On the other hand, the micro-political dimension involves the actors' transformation practices and structuring actions (Bijker, 1995). Technological frameworks can be included in their dynamics within socio-.technical assemblies. Sociotechnical assemblies are the third level of analysis units of constructivism, and can be shaped as long as their behavior is explained by a dominant technological framework, no dominant technology framework, or different interacting technological frameworks (Pinch and Bijker, 1987). Thus the processes of technological change are socially constructed in permanent power tension (micro-political and semiotic), jeopardizing artifacts, technology frameworks and socio-technical assemblies. It is of special interest to our exploration of theoretical convergence possibilities to consider the market approach from the SST perspective. The market, understood from this field, appears as an arrangement or socio-technical assembly that has three central features : (i) markets organize the conception, production and circulation of goods, under some kind of property rights, (ii) a market is an arrangement of heterogeneous agents that streamline various issues (rules and conventions, infrastructure, texts, discussions, scientific and technological knowledge, competence and capacities, etc.), and (iii) the market defines a space of confrontation and power. Recent contributions consider that SST, especially the ones by SCOT and TAR, have generated an interesting line of theorizing and research to continue exploring about materiality in market activities, in the face of increasingly abstract proposals of economic discipline modeling (Swedberg, 2008). Such contributions are enrolled in what Callon has considered as economization processes studies (Callon, Millo and Muniesa, 2007; Fourcade, 2006; Mackenzie, Muniesa and Siu, 2007; Pinch and Swedberg, 2008). They involve processes of formation of behaviors, organizations, institutions and objects that in a particular society are considered as economic, understanding by the adjective "economic" not as something a priori but as a construction. Callón identifies three key agents in the processes of economization: i) the theories of Economics, ii) institutional and technological arrangements that enhance the human agents' cognitive and action capacities, and iii) the artifacts that have been valued and that its

materiality influences the way of valuating them. Studies of economization processes are proposed as a research program where one of the lines is the description, analysis and effort to make intelligible the construction, establishment and dynamics of the markets. This mode of economization is called "marketization". It considers markets as arrangements or socio-technical assemblies (agencements) that have three characteristics: i) organize the design, production and circulation of goods as well as their voluntary transfer under certain property rights, ii) involves heterogeneous components deployed in rules and conventions, technical devices, Metrologic systems, logistics infrastructure, texts, speeches, narratives, scientific and technical knowledge as well as the competences and knowledge implicit in living beings. This span of characterization of the "Marketization" process or market concept from the socio-technical point of view can be applied to capitalist and non-capitalist markets (Caliskan and Callon, 2010; Muniesa and Callon, 2007). A third contribution appears as relevant within the socio-technical analysis. It is the emergent in Latin America, a number of conceptualizations raised in evidence-based work developed in our continent that were oriented to the study of socio-technical co-construction processes analysis based on the analysis of dynamics and trajectories of artifacts, Latin American firms and organizations (Thomas, 2008, Fressoli and Thomas, 2010). Dynamics and trajectory are two central concepts of these conceptualizations. The socio-technical dynamics is a "set of patterns of interaction of technologies, institutions, policies, rationalities and forms of ideological constitution of actors" (Thomas and Fressoli, 2010:229). It is a synchronic concept, which includes techno-economic and socio-political interactions linked to technological change. It can consider either a socio-technical assembly, a large technological system, a techno-economic network or an innovation system as units of analysis (Thomas, 2008). For its part, the socio-technical trajectory is a process of co-construction of products, production processes and organizations, institutions, user-producer relationships, problem-solution relationships, construction processes of a technology "running" and "utility", rationales, policies and strategies of an actor or of a certain technological framework. It is a diachronic concept that makes it possible to establish causal relationships between heterogeneous components in temporal frameworks. The socio-technical dynamics are more comprehensive than the trajectories (Thomas, 2008). The relationship between dynamics and socio-technical trajectories belong to the self-organized type, introducing here the dimension of complexity in socio-technical analysis. The organizational complexity of the relationship between dynamic and trajectories are predominantly endogenous. This would solve micro - macro, or the system – environment analytical problems. Both have an ontological entity in the form of metaphors built by the analyst. Finally, the socio-technical adequacy is established. This is a self-organized, interactive process of integration of knowledge, of an artifact or of a technological system in a socio-technical dynamics or career, and socio-historically situated (Thomas, 2008). These processes integrate different socio-technical phenomena[21], such as operation, transduction processes, re-signification of technologies, problem-solution relations and socio-technical styles. The "functioning" or "non-functioning" of an artifact is the result of a process of socio-technical construction that involves, usually in a self-organized way, heterogeneous elements: material conditions, systems, knowledge (Bijker, 1995; Thomas, 2008; Fressoli and Thomas, 2010), Transduction and problem – solution relations processes turn out to be Interesting for the Latin American case. The former are self-organized processes that generate entity and sense that appear when an item (idea, concept, device, tool, technical system) is transferred from a systemic context to another. The latter are co-construction processes where tacit and codified knowledge are involved. A third important concept to consider in the analysis of particular problems on innovation and technological change in the region is the resignification of technologies. It is a creative reuse operation of previously available technologies. They are not only "mechanic" alterations of a technology, but also a reallocation of sense of this technology and its environment of implementation. To resignify technologies is to re-functionalize knowledge, devices and systems, regulations, financing, benefits, etc (Fressoli and Thomas, 2010).

2.1. The possibilities of ontological convergence and epistemological assumptions.

The theoretical consideration of the SST and the EEC may raise certain chances of convergence from the inter-ontology crossovers perspective (Geels, 2010; Gioia and Pitre, 1990). The inter-ontology crossovers perspective recognizes that although there are problems of incommensurability between theories, approach strategies could be developed either for their general ontological assumptions or their conceptual elements. The

[21] For an extended definition of these concepts see Fressoli and Thomas, 2010; Dagnino, 2010.

approach differs from those positions considering the possibility of full integration. It is also opposed to those which raise the incommensurability of theories and deviates from those eclectic perspectives that use theoretical contributions whose ontology establishes assumptions that are difficult to combine. To be able to operate, the approach requires complementation from the epistemological and methodological points of view. That is, efforts to link ontologies under general shared assumptions require epistemological foundations as a framework for the complementation of theories seeking convergence. Besides, they need a theoretical - methodological strategy to enable the creation of analytical dimensions, realizable concepts and research programs to test that. As regards the contributions of SST and EEC we have considered initially that they share a set of elements of preliminary convergence, and after an analysis of the major theoretical contributions selected, we propose hypothetically that there are dynamic ontological elements that can operate in a convergent way from an inter-ontology crossover perspective. The break of the Neo-Schumpeterian evolutionary approach oriented to complex systems with respect to deterministic assumptions of the classical bioligicist tradition of economics of innovation makes it possible to consider approaches to dynamic elements of the ontology of the contributions of the SST. The distinction between past dependence and path dependence as two ways of interpreting the temporality of economic systems from the complexity point of view, suggests the possibility of introducing the assumptions of uncertainty, randomness and non-ergodicity, issues claimed by ART, SCOT and socio-technical analysis, assuming the ontology of "seamless web" metaphor. A first ontological convergent element can be found in the principle of self-organization, which is a property in the complex economic systems of the EEC and socio-technical analysis approaches, as it is a key the feature of the processes that relate socio-technical trajectories and dynamics. In addition to this element there is the conception of the economic, technological and socio-technical dynamics and trajectories from the endogenous processes perspective. Both issues have the implicit possibilities of understanding reality systemic and complex terms, either as analytical constructs as addressed by interpretive perspectives. This opens up the possibilities to analyze production and innovation systems in terms of networks (which are taken into account in ART, in socio-technical analysis and EEC) as well as the intentionality of the actions of the agents, actors and groups. Finally, there is a significant advancement by certain contributions of EEC, in terms of understanding the dynamic and trajectory of multidimensional space generators and promoters of creativity in relationship to agents and artifacts. Although the proposal does not reach the radicalism of the ART for the symmetry between agents and artifacts, it may well meet points in the understanding of the relationship between groups and SCOT artifacts. Thus, there are possibilities of convergence under the premises of inter-ontology crossover approach between the studies of EEC and SST. This operates as a general epistemological framework for convergent analytical dimensions from the point of view of theory.

2.2. General analytical dimensions. Theoretical issues of the framework.

Having preliminary convergence possibilities been introduced, a dynamic ontology with nearing points and a general epistemological approach based on inter-ontology crossover will be tackled. The result of analytical stage 2 required the exploration of possible general analytical dimensions in order to raise future theoretical and research efforts. These theoretical dimensions will enable analytical connections oriented to research problems that would operate on the basis of theorizing modes considered in the proposed Goodtheory (Di Maggio, 1995). Goodtheory approach proposes to achieve medium-range theoretical approaches where at least two of the following knowledge production criteria can be combined: generality and scope, simplicity and parsimony, accuracy and specificity (Di Maggio, 1995; Geels, 2007). These criteria emerge from the analysis by Di Maggio (1995) who states that social science theories can be grouped into three main types: theories as regularities, critical theories and narrative theories. The theories that pose regularities are strong in terms of generalizations, with great descriptive capacity and are focused on the “what” of problems. The critical ones point to the phenomena complexities but understood in a simple way and clarifying paradoxes. And the narrative type ones put their emphasis on the specificity of the social processes reports in an interpretive sense.
As to theorizing possibilities based on generality and scope, the analysis units of complex systems of innovation and production of EEC and SCOT approaches as regards technological frameworks and assemblies, find convergence potentialities for the identification of regularities and especially, in terms of descriptive capacity. Likewise in situations of descriptive analysis of stabilized networks in ART style. In every case, the units of analysis work as convergence connections with the theory of simplicity and parsimony, where the

analysis perspective of networks and multidimensional space of EEC would state possible convergence with that of socio-technical dynamics (from socio-technical analysis) and techno-economic networks (ART), from the perspective of SST. This theoretical dimension is founded on the assumption of critically elucidating complex phenomena that are understood in a simple way by the analyst.This theoretical frame makes it possible to set analytical connections with the accuracy and specificity one, being this a relevant narrative dimension, which, when describing and explaining phenomena, seeks to interpret social processes in detail, mainly in case analysis. In this dimension, EEC analysis in terms of generative relationship of agents - artifacts spaces present possibilities of convergence with those of socio-technical trajectory (in socio-technical analysis), analysis of artifacts and relevance groups of SCOT approach and other socio-technical concepts like socio-technical matching, performance analysis and transduction, among others. Possibilities of convergence within each theoretical frame would lead to convergent research between EEC and SST as well as multidimensional analytical connections would allow research between different theoretical frames. From the perspective of EEC, the different theories would understand complexity analysis in terms of macro-meso-micro and feedback effects between each of them. While in the SST approach, analysis linking different theories would operate under the principle of radical symmetry and seamless fabric[22].This generates a proposal for a research agenda that remits researchers to adopt this perspective that deepens hybrid modes of conceptual and methodological instruments. It also remits to recognition of the need for complementation of the EEC and SST prospects in terms of convergent reading of the continental problems innovation and technological change, operating in the sense of what has been considered as complex and complicated by Latour (Strum and Latour, 1987). The analyst's epistemological position, based on inter-ontology crossover perspective, plays on the tension between the principles of "radical symmetry" and "seamless web" of SST (the complex according to Latour, the socio-technical from our perspective), and the dynamic topology of the systemic relationship between EEC macro-meso-micro (the complicated for Latour, complex from our perspective) [23].

Stage 3. Towards a hybrid research agenda between EEC and SST in Latin America.

The inter-ontology epistemological crossover perspective and the assumptions from "Goodtheory" give rise to a research agenda that assumes hybridization as its principle (Dogan, 1996). The scientific disciplines division within specialized sub-fields has led to the development of hybrid specialties. Hybridization process consists of a positive concept feedback, methods, theories and practices, where the contact points are not given by disciplines but by their sectors that are oriented to problems and phenomena shared with other sectors in other disciplinary fields. For this reason, the concept of hybridization is more appropriate than inter-discipline or multidiscipline ones. A research agenda based on hybridization principles between the SST and the EEC can achieve significant contributions from a number of convergences between general theoretical dimensions and multidimensional analytical connections, forming hybrid research nuclei. As mentioned before, the contribution by Bruun and Hukkinen (2003), has been one of the most important attempts to relate SST and EEC. Based on these authors, there can be set a number of specific theoretical dimensions that connect with hybrid research nuclei and can give way to specific lines in the hybrid agenda we are proposing. The dimensions proposed by Bruun and Hukkinen have been taken up and updated in the context of this analytical exercise. These are: (i) explanation of contextual stabilities and network contingencies, (ii) description of the agencies rooted in the social field and heterogeneous networks (iii) analysis of the orientations of the action and divergent interpretations of the convergences, and (iv) explanation of the organizational learning, cognitive and creative processes in instances of social interaction.

The dimension of the contingencies and network stabilization (i) may raise possible research lines linking socio-technical assembly studies and technological frameworks of production and innovation systems in Latin America, with possibilities to perform structural change processes in the region. On the central question of how the structural components of these systems generate feedback effects at other levels (micro and meso) orienting

[22] In this sense, it is still necessary to go deep in the relationship between Gabriel Tarde's thought (well known contribution to SST and ART) and Schumpeter 's (key contribution to evolutionary economic approaches). In order to consider some related approaches see a classical work by A. C. Taymans, 1949 and a more recent one by G. Michaelides and Kostas Theologou, 2009.

[23] *The complex* in Latour, understood a what is not routinary and with diverse behavior. *The complicated* (simple) in Latour, that stablishes behavioral structures and routines (Strum and Latour, 1987).

change processes or resistances from their operating rules? This research nucleus should raise question on the structural components of the traditional productive specialization profiles in Latin America, particularly the role of primary and agribusiness production. Besides, it should analyze the possibilities of structural change that could arise from new sectors or production dynamics, from those related to technology-based activities (ICT, nanotechnology and biotechnology) to those associated with productive and innovative proposals in the field of cultural industries, social economy and social technologies. Moreover, this nucleus should consider what role socio-technical alliances of production and innovation systems ("mature" and stabilized sectors), long-standing on the continent as regards the possibilities of change or resistance to sustainable development models, emphasizing on the analysis of the lock-in effects driven by them. And here, it should open debate in hybrid terms on the meaning of a transition to sustainability, adopting the region's own criteria, not development parameters or horizons taken from developed countries. From this point of view, it becomes relevant to identify the role of certain "players playing against the rules" in the possibilities of structural change towards sustainability in the continent. As well, it turns out to be important to analyze their potential for articulation from their original heterogeneity in spaces of emergence of progressive actions and creative responses.

This dimension must be connected with the principles of generality based theory, being a research nucleus focused on explaining problems macro, regarding the behavior of production and innovation systems and their change alternatives in their dynamics of or in comparison with other modes socio-technical configurations and assemblies. This specific dimension could be so the nucleus of studies on socio-technical configurations and structural change in production and innovation systems in Latin American countries and regions[24].

The dimension of description of agencies rooted in the social and heterogeneous networks (ii), based on theoretical principles of the critical tradition, can focus on the study of phenomena related to the power of relevant social groups in the production and innovation processes, the forward and backward characteristics in Gramscian sense, and how the dynamics of heterogeneous networks are agents-artifacts' multidimensional spaces that allow or block technological change processes in a local-global relational sense. The central issue here will be to critically describe the effects of asymmetries, dependencies and gaps, generated by the dynamics of techno-economic and sociopolitical networks of production and innovation systems that operate on a local-global multi-scale, especially the role of scientific and technological nuclei or poles related to productive poles prevailing in the sector dynamics of the region. It will be also central to focus the critical analysis of the implications of technological change activated by these global networks, from the point of view of social inclusion problems. The past dependence and lock-in effects in the socio-technical dynamics of production and innovation systems in Latin American territory, must be addressed from a techno-economic and socio-political perspective by this nucleus, identifying latent forces (meso-level updates of macro rules) that contribute to long-term historical processes to preserve backlog traps in the region. In accordance with the critical tradition of social science, this nucleus should demonstrate how certain forms of ST & I policies on the continent, customized under cluster style and / or global value chains or other types of micro -technology based clusters, which promote virtuous integration or taking advantage of windows of opportunity opened by the new techno-economic paradigms, take action in a performative way in the production network dynamics in the region to help strengthen these adverse effects to technological change, or that are not conducive to endogenous changes processes in the systems. We called this nucleus of study on the socio-technical dynamics of production and innovation systems and technological change in Latin America. Finally, from the perspective of the assumptions of the interpretative tradition of the social sciences, a nucleus can be built up tackling the study of the orientations of intentional action and divergent interpretations to the convergent ones in production and innovation systems related to aspects of organizational learning and creativity (cognitive dimension). This nucleus could be focused on the analysis of the socio-technical trajectory of agents - artifacts spaces of production and innovation systems in the region, their specificities and specific cognitive phenomena (imitation, transfer, reverse engineering, translation, transduction, problem-solution relationships, functioning –

[24] Implicit in this nuclei there is a criticism to the research work that force descriptions macro on the production and innovation systems behavior, styling links, cooperation modes and construction of institutional identities under models that are inexistent on the continent. It also questions theorizations of the neo-developmental type, that interprets the macro effects in the sense of naive holistic perspectives (over determined one-dimensionally in economic terms- CEPAL- technological- technological paradigm approach- and/ or institutional – neo-institutionalist approaches) that disregards the *meso and micro* components in the complex system dynamics and its scope from the point of view of *cultural (economic) policies* (Dopfer, Manifesto), as well as the diversity of socio-technical phenomena emergent from the *seamless web* perspective.

non-functioning) oriented to the generation of organizational capacity for creative or adaptive responses under heterogeneous networks and socio-technical configurations with distinctive features of the region. The nucleus would be called study of the socio-technical trajectory and innovation processes oriented towards solving the problems of economic growth on the continent.

Each of the hybrid research nuclei work under the principles of the Midrange Theory. The mid-range theory consists of limited groups of assumptions, from which specific hypotheses derive and are taken to the field of empirical research. The contributions of these theories do not remain separate, but aim to meet in a larger network of theories. Despite its proximity to the empirical, they are abstract enough to treat different social spheres (Merton, 1992:87). The use of the mid-range theory involves a number of criteria such as: to focus on a limited number of themes and topics (a), to combine different concepts in an analytical model (b) and to look for patterns and explanatory mechanisms (c). The mid-range theory was proposed by Merton (1949, 1957, 1968) in response to the search, in the field of sociology of totalizing theories. Geels (2007) in the field of studies on issues of innovation and socio-technical systems, recovers Mertonian ideas on mid-range theory, defining it as one that focuses on a definite aspect of social phenomena, contains a limited number of concepts and propositions that are clear, specific and empirically researchable, and whose concepts are related to each other and allow the emergence of a theory (without totally being so). This emergent theory takes the form of analytical models that are not deterministic in nature (Geels, 2007:629) but explain how a concept influences on another.

Hybrid agenda, development and articulatory practices.

So far, we have presented the progress of the results of exploratory analytical exercise stages 1, 2 and 3 and their way of forming a hybrid research agenda based on a convergent framework between the SST and the EEC[25]. This research program, in Latin American context, needs to be integrated into the recurrent problems of underdevelopment in the region: from the point of view of economics, social exclusion and poor sustainability.

Therefore, it implies to understand development in a multidimensional sense, that under the convergent framework, analyzes the specific issues related to the characteristics of the economic development of the region (permanent “primarization” of economy, industrial sectors of low technological intensity, modes of organization of production and services of the social economy, cultural industries, technology-based "islands of knowledge", recovered companies, among others)and its relationship with the permanent problems of inequality, technological and educational gap caused by the technological change dynamics that generate social exclusion. Thus, under a multidimensional conception, the hybrid research program aims at providing empirical evidence, reflections and discussion around the idea of development, understood as a complex process of breaking trends toward techno-economic concentration and socio-political stabilization of socio-technical systems of production and innovation, held under lock-in effects and regressive character articulations that do not allow economic growth[26] drive, social inclusion and sustainable policies for structural change. This problematization implies, from convergent framework, to be approached from multidimensionality: narrative, critical and explanatory, as we have stated in the previous section[27]. But, at the same time, it must regain the impulse of political praxis implicit in the traditional thought of Latin American science, technology and society. In that respect, its research nuclei will have to propose articulation policy actions under heterogeneous identity[28]. Hybrid research efforts must be set by articulation political praxis emergence. These emergence spaces recognize the plurality of theoretical and political positions (identities), based on their chances of

[25] In a future article of a forthcoming publication the results of stages 4 and 5 will be explained. In this article it will be developed further the hybrid analysis unit of *production and innovation socio-technical systems* and the concepts that are elaborated from the convergent framework (socio-technical dynamics, socio-technical trajectories, socio-technical articulations and socio-technical configurations) and questions related to articulatory policies of ST+I.

[26] Economic growth is considered here as economic development.

[27] The convergent approach proposed here, aims to broaden the studies, in terms of complex analysis, using a value chain style, cluster, networks that are made in one-dimensional way and give scarce possibility to interpretive or critical depth ; being in many cases, empirical based foundations for political formulations of ST+I; biased or supportive, either explicitly or implicitly, of regressive socio-technical articulations.

[28] The concept of articulation comes from Laclau. It takes the contributions of socio-technical alliances analysis by Thomas, those from the Gramscian historical blocks, and the technological framework of SCOT. However, eventually, it is defined near the articulation concept by Haraway (1999).

integration (not definitive, in tension or transient) between approaches with potential ontological, epistemological and theoretical preliminary convergences. And that in turn, raise the horizon of action spaces for developing new socio-technical configurations capable of being development-oriented in the sense made explicit before. In the narrative dimension, from the perspective of political praxis, it implies to analyze the possibility of stimulating economic development from these processes in certain enterprises, sectors or regions, mature or new, considering, in turn, the discussion about the capitalist nature of economic growth or alternatives to this, such as the proposals on social economy. The narrative dimension must clarify for policy makers, with higher degrees of specificity, the particular socio-technical adjustments of the spaces of the agents-artifacts, whose socio-technical trajectories have been or could be set in areas of new socio-technical articulations. The identification of players playing against the rules (or that could do so), is crucial here to break the permanent cycle of adaptive responses typical of Latin American countries, and make way for profound change processes in the productive and innovative socio-technical configurations of the region. In relation to the previous dimension and from the political point of view, it is up to the critical perspective to consider new modes of creating techno-economic and socio-political networks and how to break lock-in effects with them, reinforcing concentrator convergences and interpretive stabilizations that pose human-artifact oriented by ideas and rules generated in nodes of global networks that promote lifelong dependency and social exclusion. The challenge here is to explicitly promote from science, technology and innovation policies, a plurality of spaces of emergence of socio-technical new articulations in a progressive sense, democratizing their formulation processes, implementation and monitoring. Where the effect of technological change be discussed under assumptions that problematize the current institutionalized rules and articulations of science and technology, standardized analysis models in cluster style and value chains that operate in a performative way over decision-making in production policies, ignoring inequality, exclusion and concentration situations that occur in the productive and innovative network globally. Finally, on a search of general explanatory elements, it is to establish standard analysis of articulations and socio-technical configurations of our production and innovation systems and their orientation in favor or not of a structural change. In this respect, the problems of defining sustainable policies in scientific, technological and industrial fields are absolutely relevant for Latin America, in terms of ensuring transition processes towards development in multidimensional sense. Transition studies that have become important in developed countries (Van de Poel, 2000; Perez, 2002; Geels, 2002, 2005; Elzen et al., 2004; Rotmans et al., 2001) should be reinterpreted in the context of the region under problematizations about their own sustainability. Unlike transition studies developed countries that focus on issues mainly related to environmental sustainability, in Latin America, transition studies should focus on the possibilities of sustainable structural changes that operate at the level of the socio-technical configurations, raising discussion on socio-technical complexity horizons[29]. These horizons will allow policy makers to map spaces of possible technological innovation emergence, give a heuristic capacity to analyze their implications from the point of view of economic development, social inclusion and sustainability of the change in structural sense. They will grant stable institutionalism what will enable to sustain and monitor progress in the transition processes under metaphors about the possibilities of construction of new heterogeneous networks, and a renewed narrative about the necessary capitals and resources to develop them (Smith and Raven, 2012). Therefore, a convergent framework between SST and EEC will make possible the development of a hybrid research agenda, with articulation policies, whose spaces of emergence of ideas and action programs are oriented to discuss and propose transition possibilities towards development. Considering: How can we achieve a transition towards socio-technical trajectories that enables the generation of agent-artifact spaces that favor creative actions? How can it be achieve the transition from productive and innovation networks of the region towards socio-technical dynamics ensuring progressive social inclusion? And, How can new identities be built as regards the role of science, technology and innovation in Latin America that operate as new horizons of socio-technical configurations fostering sustainable change?

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