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Agents intentionality, capabilities and the performance of systems of innovation

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Abstract: *The performances of different Systems of Innovation (SI) vary substantially due to the fact that, apart from the differences in the underlying technologies, institutions, etc., there are specific causes at work. In particular, we refer to the intentionality of the agents interacting within a System of Innovation to find out the relationship between agents' goals, and the SI's performance. The underlying thesis is that agent intentionality is a necessary condition for a substantive explanation of the dynamism of any socio-economic system. This paper departs from an abstract definition of a system as a set of constitutive elements and the connections among them serving a common purpose. It also explores how agents' intentionality and capabilities shape the structure, evolution and performance of an SI. In this context an evolutionary efficiency criterion is proposed.*

Keywords: systems of innovation, intentionality, evolving capabilities, evolutionary efficiency

The System of Innovation (SI) framework is part of the tradition of innovation studies (Martin, 2012) that introduces an integrated and dynamic multidimensional perspective of the transformation of systems. The emergence of the so-called knowledge-based economies (Cooke, 2001) has favored the introduction of these new analytical frameworks. A starting point for this kind of research is the recognition and understanding of the complex processes that underlie the characteristic innovation processes of knowledge-based economies. These include knowledge-creation, diffusion and organization processes.

It is apparent that different patterns of innovation exist across nations, regions, sectors and technologies. Thus, this is the reason why some authors consider the relevant level of analysis for innovation processes to be the national level (NSI) (Freeman, 1987, 2002; Lundvall, 1992; Nelson, 1993), rather than the sectoral (SSI) (Malerba, 2002, 2004) or the regional level (RSI) (Cooke, Urange, & Etxebarria, 1997). More recently, Bergek, Jacobsson, Carlsson, Lindmark, and Rickne (2008) proposed technological innovation systems (TIS) as a valid level of analysis. In any case, comparisons between actors, sources of novelty, institutions, and innovation policies in different nations (Bartels, Voss, Lederer, & Bachtrog, 2012), sectors or technologies show significant disparities; suggesting that the sources of novelties and their role of dynamic transformation across the economy is much more diverse and therefore requires a specific explanation (Mowery & Nelson, 1999).

The SI approach benefits from two convergent traditions: firstly, the emphasis of a systemic approach to innovation processes; and secondly, the adoption of an evolutionary theoretical approach.[1] In general a system of innovation comprises a set of agents that interactively deploy a set of market and extra-market activities (Larsen & von Tunzelmann, 2006) with the purpose of creating, producing and selling new products and services. The firms that operate within a system of innovation share certain common characteristics and, at the same time, are heterogeneous. Thus, an SI is composed of a knowledge base, technologies, inputs and a potential (or existing) demand that characterize it. Furthermore, there is a set of institutions that circumscribe the environment within the agents of the system and interact. Agents interact through processes of communication, change, cooperation, competency and command in markets, but also through extra-market relationships. Finally, the SI approach to institutions allows the establishment of relationships that emerge from interaction to be analyzed.

[1] An interesting example of this is provided by Dodgson, Hughes, Foster, and Metcalfe (2011).

From this perspective, it is possible to show how the same 'common' institutions (for example the patent system) can have so many different effects on innovation across sectors or countries (Nelson, 2008b; Werger, 2003).

The usefulness of the SI framework lies in the fact that it allows innovation processes to be analyzed at two analytical levels. Firstly, due to the fact it is a conceptual framework that provides a multidimensional insight into the dynamic links that are characteristic of innovation processes. Evidence of this is the emphasis on the importance of analyzing the co-evolutionary processes that underlie and configure innovation processes. And secondly, because of the fact that the SI framework allows for the location of the role that knowledge and learning play in innovation processes. However, these kinds of approaches are not free from criticism; one such criticism classes the innovation systems approach as, at best, heuristic rather than theoretical (Edquist, 2005, p. 186), it is over-theorized (Sharif, 2006, p. 757), or needs a change in its theoretical foundations (Lundvall, 2007, p. 97).

We find that SIs differ substantially because there are specific causes at work – apart from the differences in the underlying technologies, institutions, etc. Several of these 'other causes' appear in a diffuse way throughout the literature, despite their importance for explaining a system's performance. In particular, we refer to the dynamics of the goals (or simply 'goal dynamics') and intentionality of the agents interacting within a system. In this context, our claim is that agents' intentionality is a driver of the dynamics of Systems of Innovation (SI). This claim is based on a general approach in which economic processes unfold through intentional action, although the systemic properties of the system emerge as a result of agent interaction. The importance of the role played by the goals agents pursue according to their beliefs, values and representations, etc. has been recognized (Nelson, 2006, p. 497); however, intentionality seems to be underplayed in the SI literature.

Intentionality – which implies planning of a subjective kind using imagination, beliefs, information, etc. – is important for explaining the changing actual behaviors of the agents within a system; moreover, as action takes place in order to achieve the pursued goals, plans may be altered – modified, updated, removed. For example, Consoli and Ramlogan (2008) show that innovation systems are formed around self-transforming problem sequences posed by agents; firms are characterized by beliefs, expectations, competencies and organizational forms and they deploy learning and knowledge accumulation processes (Nelson & Winter, 1982; Teece & Pisano, 1994; Teece, Pisano, & Shuen, 1997). In fact SIs may be considered a consequence (emerged or spontaneously generated) of the intentional action deployed by the agents (individuals and organizations) that interact within that system. To support this claim we will show how the interactive process – that is triggered by the deployment of agents' actions in real time with the intention of achieving their own goals (Sarewitz & Nelson, 2008) – may be approached.

We depart from an abstract definition that a system is a set of constitutive elements (objects such as knowledge, agents, institutions, beliefs, goals, etc.) and the connections between them serving a common purpose. This structure and its evolution should support the analytical description of dynamic phenomena such as innovation processes. We are interested in how and why an economic system evolves, what the causes of such an evolution are and, lastly, in the differences across systems.

The main thesis is that agent intentionality is a necessary condition for a substantive explanation of the dynamism of economic systems. The argument is consistent with the role that the categories of intentionality, such as belief, goals, intention, collective intentionality, etc., are part of cognitive sciences, artificial intelligence and social philosophy, etc. in the explanation of individual and collective behavior and the emergence of institutions (Baldwin & Baird, 2001; Grosz & Hunsberger, 2006; Metzinger & Gallese, 2003). In this sense, the paper should contribute to the microfoundation of SI on agent action (or agency), which results in individual and organizational evolving capabilities, and their consequences for economic change (Felin & Foss, 2006, 2009; Loasby, 2006).

The paper is organized as follows: Systems, Knowledge and Connections section highlights a theoretical foundation of a system that focuses on the concept of connections and what makes them the prime variables. Action Plans, Knowledge and Agents' Goals section poses the microfoundation of dynamism of SI, especially how connections are established among elements within a system and how agents' capabilities evolve. Capabilities, Intentionality and SI Performance section explores the implications of agents' capabilities and intentionality for the resulting performance of an SI. In this section, an evolutionary efficiency criterion for the dynamic performance of a complex process is proposed. Concluding Remarks section offers some concluding remarks.

Systems, knowledge and connections

Analytically, a system is explained by both its constituent elements and the connections by which they are related in order to accomplish a common purpose, innovation in the case of SIs. In a dynamic analysis, the fundamental issues are that connections are continually changing, which 'makes connections the prime variables' (Potts, 2000, p. 5), and that the recombinant process of connections may generate novelties (Loasby, 2001). Knowledge itself is an example of association among elements: What the specific elements are and how they are connected is knowledge itself – it may be considered a structure; a system of connections that is also changing.

Knowledge is a system; hence the structures of the human brain by which it is supported also constitute a system (see also Dopfer, 2005, p. 24; Fuster, 2003). At the same time, they are parts of a human body, etc. From another point of view, knowledge is embodied in organizations and firms, sectors, etc. that are higher-level systems. The growth of knowledge consists of building connections between the internal elements of a system, and in turn between these elements and others belonging to higher or lower ranks. The economic agent itself is a system. Following Earl (2003), the economic agent is completely reconstructed when all of its internal and external operational connections have been made completely explicit. Moreover, economic agents are continuously establishing (and removing) connections. We refer to such a process as learning.

The connections that constitute agent knowledge, whatever its content and structure are the basis of their economic and social action. Agents make use of their acquired knowledge to draw up theories (Nelson, 2008a) on how the diverse elements that constitute the physical-natural, technological and social systems within which they deploy their action are causally connected. These theories have a conjectural value (Popper, 1972) and they are not necessarily true in that they have not been scientifically contrasted. These theories are models or frameworks that enable agents to anticipate (or form expectations about) the consequences of their actions in a context of uncertainty, thus defining a set of feasible events and weights ('probability') attached to them by agents. These future courses of action have to be necessarily imagined and deemed possible (Loasby, 1996) since they affect the agents' actions. Models provide frameworks and procedures which, insofar as they are of common use, may be defined as institutions (Loasby, 1999).

Learning consists in testing and (eventually) retaining new connections that prove to be useful for agents to reach their goals; in this sense we may speak of driven learning processes. As a consequence, agents deploy bounded rationality which 'connote the reasoning and learning abilities of an agent who has a goal to achieve and, on the one hand, an at least partially formed theory about how to achieve it (this is the 'rationality' part of the concept), and on the other hand, that the agent's theory is likely somewhat crude and perhaps even a bad guide for action, and that success is far from assured (this is the meaning of the 'bounded' qualification to rationality)' (Nelson, 2008a, p. 78). Both aspects of the concept seem necessary to capture what we know about human and organizational problem-solving in a variety of different arenas. This approach is also compatible with the emergence of novelty and with the growth of knowledge; i.e., with the conditions of possibility of true learning processes (Witt, 2009).

Action plans, knowledge and agents' goals

Evolutionary systems are systems liable to continuous change: Evolution is the result of the self-transformation of systems over time (Witt, 2003b, pp. 12–13). Evolution is seen as the process or set of processes that combine the generation of novelties with the selective retention of some of these novelties (Dopfer & Potts, 2008; Loasby, 2001), following the well-known evolutionary three-phase schema: Generation-selection/adoption-retention of variety (Foster & Metcalfe, 2001). Moreover, evolving systems are characterized by continuous endogenous change induced by the generation of novelties and subject to selection processes that operate on self-organized processes (Kauffman, 1995).

In order to understand the microfoundation of an SI, we should carefully differentiate between the types of connections that are established between the elements in a system. In particular, between the different kinds of elements that are connected: Means/actions and goals/objectives, which determine the *direction* of connections.

Economic dynamics are sustained by agents' activities. And to the extent that these activities are rational, they are planned activities – not certainly in the sense that they obey a central plan, but in the sense that they are planned by agents themselves. Thus economic dynamics may be understood in a complementary way to that previously exposed as the process of generation, adoption and an attempted interactive deployment of the agents' action plans (Encinar & Muñoz, 2006; Muñoz & Encinar, 2014; Muñoz, Encinar, & Canibano, 2011). Agents' action plans are the result of a key operation that consists of agents allocating means/actions projectively in order to reach the goals/ends/objectives they pursue. In other words, at any moment in time, an action plan may be interpreted as a template or 'guide' for action that projectively *connects* elements of a different nature: Something the agent wants to achieve (goals) with the actions and means the agent 'knows' afford him/her success.

Agents choose their goals of action on the basis of a myriad of psychological, social, and cultural factors, motives (Barnard, 1938), beliefs (Metcalfe, 2004), etc. Agents' action plans are constituted using their imagination (Loasby, 2007), taking into account that the goals they pursue are located in an imagined future (Lachmann, 1994/1978). Thus, it could be said without exaggeration that agents 'invent' the future on which they focus their actions. This idea is valid whether we consider objectives in the short, mid or long term. The opportunities for acting in a specific way (entrepreneurial action, for instance) are not hidden somewhere in reality, waiting to be discovered by entrepreneurs or visionaries, but they 'emerge' initially in the mind of agents regardless of the fact that at some time in the future they may be embodied in a written document or an organizational form, etc.

Evolutionary economics usually describes the evolution of an economy as a consequence of the growth of knowledge. However, the locus of the goals agents pursue (as well as their internal dynamics of evolution, which alter their hierarchical interdependence and contents) and their intentionality as elements that encourage action and knowledge, although recognized in modern neuroscience (Fuster, 2008) is beyond the scope of economics; or at least remains problematic. Nevertheless, the goals and intentionality of agents play an essential role in explaining the emergence of novelties and evolving capabilities (Cañibano, Encinar, & Muñoz, 2006; Langlois, 2006), institutions (Nelson, 2008b, p. 7) and learning processes (Dosi, Nelson, & Winter, 2000, pp. 2–4).

In general, evolutionary economics proceeds in its models and theories as if the goals pursued by agents were given. Action plans should articulate the best way to match (given a set of resources and/or of possible actions) those goals. Until recently the analysis of the role played by agents' intentionality and the goals they pursued in the development of new capabilities, new patterns of behavior, etc. had been postponed.[2] However, a true dynamic theory should consider the real fact that *new* goals of action may emerge, that the hierarchical ordering of goals may change, and that goals reached now (or never) may be removed from or replaced in agents' plans, etc. All these

[2] Even so, intentionality in learning processes is a key, but relatively unexplored, dimension of capability building in strategic tasks. However, the role of purposes is not strange to the literature of technical innovation. For example, Arthur (2007, p. 276) defines technology in terms of human purposes. North (2005) also devotes chapter 4 to these issues.

changes involve learning processes, as well as the emergence of completely new actions that cannot be explained solely by means of knowledge acquisition. They are special connections that are established between new goals and means/actions.

In our approach, intentionality, which can be defined technically as 'that feature of representations by which they are *about* something or *directed at* something' (Searle, 1995, p. 7f. Italics in the original), is linked to goals, and it activates the development of capabilities, the testing of new connections within a system, and, therefore, the generation of new knowledge. Aligning, coordinating, reordering and even inventing new goals are activities that generate novelty and are therefore sources of true dynamism in economic processes.[3]

Of course, not all changes in society are the result of intended actions. In fact, not all actions carried out by agents are intended. Furthermore, not all the consequences of actions are intended or even expected. The consequences of actions may be, and usually are, very different from what agents pursue. Interaction in complex situations, unknowledge, etc. may lead to completely unexpected results. Moreover, it has been said that evolution is a 'blind' process (Vanberg, 2006) because new properties and unintended consequences emerge within it. Nevertheless, human action, *qua* rational, within human constraints, is intended action: There must be goals (reasons) in order to act.[4] From the perspective of action plans, it is possible to analyze how agents' cognitive dynamics might, for example, imply the introduction of new (projected) actions or means in agents' plans and the discovery (invention) of new relationships between actions and goals as a consequence of novelties in the agents' projective space of goals; thus implying a change in the connections between elements within a system. Consequently, although not all actions are intended, nor are all novelties a consequence or the pursuit of particular goals, the evolution of agents' goals and intentions is a key explanatory factor since it triggers processes that establish and renew the connections within a system (Muñoz et al., 2011).

Capabilities, intentionality and SI performance

The diversity and intensity of changes in agents' intentionality have substantial value as important factors for explaining socio-economic self-transformation processes. They trigger search processes and the establishment of connections with adjacent states of the system, thus altering its topology and giving rise to new features that emerge within the system. Moreover, together with the means that agents discover and 'invent' to reach them, these changing goals and intentions constitute the agents' action plans that they (attempt to) deploy interactively. The deployment of driven learning processes is also capable of modulating institutions, configuring agent networks, changing standards, beliefs and agents' habits, etc., as well as giving rise to new evolving capabilities.

Capabilities and intentionality

Our argument enables the identification of the analytical *locus* of agents' goals and intentionality as explanatory factors of the transformation of agents' spaces of action and, therefore, of the systems they configure. The constitution of evolving capabilities by agents within an SI enables a 'two-layered' analysis: on the one hand, the analysis of the constitutive elements of a system (elements and connections; that is, its structure); and on the other, the analysis of how the connections between those elements (its dynamics) evolve. The evolution of such connections is by necessity associated with the diversity and changes in the goals pursued by the agents that configure the SI.

3 Intentionality exists not only in private mental space, but also in functional space with others (Malle, Moses, & Baldwin, 2001).

4 '[I]n the discourse on prefrontal physiology, *goal* is of the essence. All cognitive functions of the lateral prefrontal cortex are determined, we might say 'caused', by goals. If there is a unique and characteristic feature of that part of the brain, it is its ability to structure the present in order to serve the future, by this apparently inverting the temporal direction of causality. Of course this inversion is not real in physical terms. It is only real in cognitive, thus neural, terms inasmuch as the *representations of the goals for future actions* antecede and cause those actions to occur through the agency of the prefrontal cortex. Teleology thus understood is at the basis of *planning* and *decision-making*, which are two of the major executive functions of the prefrontal cortex.' (Fuster, 2008, p. 4.)

The emergence of evolving capabilities allows us to weave the network and thus explain it. Let us assume, for instance, an SI within the so called *Life Sciences*. Learning processes and scientific knowledge in Life Sciences allow for an understanding of the state and evolution of present research, implemented on the basis of the capabilities and skills of scientists. However, these learning processes and this current knowledge also generate new research questions that spur the acquisition of new scientific knowledge. This new scientific knowledge, which can eventually give rise to new technological knowledge (which might be developed in firms, universities, research councils, etc.), is the starting point for the emergence and development of new capabilities within the scientific community itself and – if the conditions for accessibility and appropriateness so allow – the emergence of firms. The formation of new links between the system of science and firms would follow the implementation of new capabilities of the SI as a whole. Thus, the development process of capabilities as intended (driven) learning processes would configure the connections between several elements that constitute the system.

This example helps to illustrate how and why it is possible that the connections within a system are continuously being established. As aforementioned, the emergence and development of capabilities are induced by intention, by agents' tendency toward the goals they set. Goals are imagined realities, expectations, valued as more desirable states and toward which agents direct their action. Within a system, there is constant feedback between the intention and the evolutionary capabilities and this feedback explains the transformation of the system itself.

The pursuit of a new goal may cause new capabilities and new patterns of behavior to be developed and learning processes to be activated, giving rise to new actions and interactions and new ways of doing things (process innovations) that may ultimately yield (by means of design, or as a result of selection) new institutions and/or modify the existing ones. It also may give rise to entrepreneurial experimentation processes (Bergek et al., 2008, p. 415), political entrepreneurship (Witt, 2003a p. 82), etc.

In other words, pursuing new goals allows for the emergence of agents' action plans with new structures and contents. These new structures of connections between new means/actions and goals introduce a 'renewed genetic material' in the form of new action plans (new conjectures) which, when interacting, transforms the system connections network, giving rise to the emergence of novelties within the system and fueling evolutionary processes. The appearance or hierarchical rearrangement of goals constitutes a source of transformation of the agents' plans and of the subsystems that make up the economic system.

In the example of Life Sciences, much current research is based on skills, routines and capabilities already implemented by scientists and whose origin is linked to past goals they *deliberately* tried to reach. Why then does a system continue to develop new capabilities, as in the case of science, once certain given objectives have been reached? To answer this question, let us assume that the goal pursued by scientists within a specific field may be reached; in other words, it is technically attainable and the scientific community has been able to deploy the actions required (learning, adapting, developing capabilities, etc.) to attain its purpose. If the goal is reached, there would be no apparent reason for continuing the learning process, concluding the capability implementation process. However, experience shows that learning processes never come to an end in a knowledge economy. As already mentioned, the reason lies in the continuous appearance of renewed goals of action.

For instance, in Biomedicine it is not enough to discover a treatment for a serious illness: Scientists are also interested in its mechanisms of propagation, its genetic base, etc. (Consoli & Ramlogan, 2008). The conception of new goals activates behaviors and actions by means of intention and will, aimed at the pursuit of that goal. This process generates new knowledge by transforming agents' evolving capabilities.

The performance of an SI

Based on the endogenous dynamism proposed in this paper (the feedback process between agents' intentionality and their evolving capabilities), the overall function of an SI may be examined from an abstract system perspective. We may examine how the different parts (elements) of the SI are connected (if they are indeed connected), the volume, intensity and character of the interactions, their continuity and the progressive implication of more agents, which agents are more (less) dynamic, the goals they pursue and if they are compatible *a priori*, etc. In this approach, the process of dynamic sequences of connections between the means/actions and goals established by the agents that interact within an SI, which produces new action plans, may be judged in terms of the adequacy of connections.

Roughly speaking, we can say that connections between means/actions and goals are adequate if they allow the projected actions and the deployment of means to produce the pursued goals. In other words, connections between means/actions and goals are adequate when intentions (which activate and change as new goals are formulated) give rise to actual facts as expected. Thus, there is *evolutionary efficiency* within an economic system when agents' intentionality is being 'materialized' through agents' actions: Because of the efficiency of the connections between means/actions and goals, intentions turn out to be actual facts in which goals are produced.[5] For example, within a given SI, scientists satisfy their aspirations of wisdom and (perhaps) social recognition; 'capitalists' or venture capital firms achieve a reasonable return, which is an incentive for investment; governments that fund (public) scientific research obtain a social (and perhaps political) return; users have better, safer and cheaper products and services at their disposal or a cleaner environment; enterprise and public organizations achieve their social goals, etc. In short, the fulfillment of the different agents' goals and the compatibility (coordination) of their plans and expectations (von Hayek, 1937, p. 37), etc. strengthen the (new) connections within the system: This entire means that the characteristic pattern of innovation of the system is efficient.[6]

The efficiency criterion we propose here is an evolutionary criterion because it is based on the continuous feedback process that goes from intention to actions and vice versa that is at the basis of the self-transformation (evolution) of agents' action spaces. This self-transforming process of a system, of its elements and of its connections, is what makes it an evolving complex system. This intentional pursuit of goals by agents causes new capabilities and new patterns of behavior to be developed and learning processes to be activated, giving rise to new actions (and interactions) and new ways of doing things (process innovations) and so on, in a co-evolutionary process.[7]

The purpose of this criterion is not to fix an external register of the elements, products and functionalities (e.g., determined by an external policy evaluator) so as to then measure and compare the performance of the system relative to the said external metric. Rather, the criterion proposed here and applied to an SI 'measures' through the development (performance) of the SI itself because it is relative to the goals, intentions and expectations of the agents involved in that particular SI.

In terms of this criterion the performance of an SI is high if the connections within that system are adequate insofar as they *cause* the achievement of the pursued goals; if this is the case, we say that the SI is evolutionary efficient. In contrast, low SI performance would be the result of inadequate connections that do not lead to the achievement of the pursued goals; this is the case of an inefficient evolutionary system. Consider the next example. Let us take an action plan of an organization – the publication policy of a research institute of medical sciences, for example – whose main aim is to increase the prestige of that institution by means of reaching a prominent position in international medical publication rankings. Let G_1 be that goal. If G_1 were the main goal pursued, then the remaining means/actions and goals in the research institute's action plan should lead to and

5 Agents' actions are both effective and efficient using Barnard's (1938) terminology.

6 We should also consider the 'institutional return' of an SI: How the institutional environment emerges, adapts and transforms and how this affects the compatibility of the agents' goals ('coordination') within an SI. See Hodgson (2004).

7 An example of the role of designing and implementing policy goals (and targeting) and its consequences in terms of infant industries development and cluster formation is Avnimelech and Teubal (2008).

be consequent with this goal. The organization's action plan is efficient/inefficient *a priori* depending on the ordering of the means/actions required to achieve this goal. At the same time, this depends on the absence/presence of logical contradictions or impossibilities among the actions/means to goals and on the absence/presence of conflicting goals. If this ordering means that the organization is capable of triggering the actions/means needed to reach a sufficient aspirational level of satisfaction regarding its main goal, we could say that the connections between the means/actions to goals and other goals are efficient (from the point of view of the acting agent).

Now let us suppose that the research institute proposes a second goal, which may also operate as a means to increase its prestige: To strengthen its financial position. By doing so the institute provides its researchers with monetary incentives to carry out entrepreneurial activities such as fund raising. Let G_2 be that new goal. This policy tries to give the researchers the possibility of reaching a certain extra level of income and tries to increase the quality of their scientific production. The (new) actions that are carried out may lead to the new proposed goal G_2 being achieved. If so, then we could say that the actions would be efficient or that certain elements linked to G_2 would appear and prevent the fulfillment of the plan in which high quality research papers are the primary goal. What if the researchers were to maintain a strict preference for their primary goal G_1 over the new goal G_2; would they, at the same time, allocate a growing number of hours to G_2 related activities, such that they may not have enough time to produce high quality research papers? When researchers devote a growing number of hours each day to complementary activities (such as meetings with venture capital firms, doing business plans, etc.) and, at the same time, maintain the hierarchy of the main goal G_1 over the new goal G_2, then they are formulating internally inconsistent plans – and thus giving rise to inefficient action.

Does this mean that all agents have to achieve their goals if the SI is to perform well? What if the SI supports the fulfillment of the goals of some agents, but not of others'? What if one agent's goal is to block the development of the SI? What if some agents' goals are unrealistic? In our example, the researchers pursuing entrepreneurial activities (linked to G_2) are intrinsically preventing the possibility of achieving their main goal G_1 – high quality papers – which is a flagrant paradox. All this results in an internal inconsistency of action plans that produces a rationing of goal satisfaction and which, in turn, worsens the efficiency of the agents' actions. Thus a system (individuals, organization, etc.) as a whole may produce a lower performance in terms of the pursued goals.[8]

How can inefficiency be lowered? There are different options for removing the source of action-rationing[9] within such a system: agents may lower their expectations (reviewing and, eventually, removing some of their goals); adjust their actions/means to the rationing; review the content and/or hierarchy of the goals of their action plans; abandon some of their goals; change the institutional setting; and, perhaps introduce innovations. (In our example above by means of promoting sabbatical years, recruiting specialized personnel for fund raising activities, etc).

Concluding remarks

No theoretical analysis should be made without a careful observation of reality: It is a fact that agents *plan* their actions. Otherwise, agents' actions would be irrational or absolutely erratic (Nelson, 2006). The analysis of the interactive deployment of agents' actions and their products provides a useful framework for exploring the nature, properties, dynamics and complexity of connections within economic systems. Thus, the dynamic action of the agents that interact within a system should be explained under the categories of intentionality (Searle, 2001). Otherwise it is almost impossible to explain the products (commodities, technologies, structures, systems, etc.) and categories (value, prices, causality, etc.) of action unless as self-referenced explanations which are not explanations by means of micro-foundations.

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8 Geels (2004) has explored the origin and consequences of these kinds of tensions and mismatches in goals, interests, etc. in a more specific context.

9 An example is the Keynesian theory of effective demand (see Benassy, 1986).

In this paper, we have proposed a (micro-) foundation of SI dynamics based on agents' intended actions. The goal dynamics of agents within an SI, their intentions, capabilities, and action plans interacting within that system, are key elements to explaining the dynamic performance of such a system. If our argument is accepted, substantial differences in SI's performance – apart from the differences in the underlying technologies, institutions, etc. – are due to the goal dynamics and intentionality deployed by agents interacting within those systems. This is particularly clear when we consider the evolutionary efficiency criterion proposed in this paper. Agents pursuing their goals may or may not reach them. If only some agents achieve their goals, the SI performance would imply that some agents' goals would be blocked or rationed. This result may be a consequence of the activities of a prominent agent (e.g., a monopoly) or coalition (an oligopoly) within the system; of some agents' goals being unrealistic; of deficient connections with other economic subsystems (e.g., with the financial sector); etc. In these cases, how can the inefficiency be of an SI be lowered? There are different options for removing the source of rationing within such a system: agents may lower their expectations (reviewing and, eventually, removing some of their goals); adjust their actions/means to the (perceived) rationing environment; review the content and/or hierarchy of the goals of their action plans; abandon some of their goals; change the institutional setting; and, perhaps introduce technical or organizational innovations. Nevertheless, policy makers should take into account this variety of circumstances when trying to improve the performance of an SI: Which goals actors have within an SI, how and why they are these goals and not others and how they articulate and deploy their actions in order to reach them. Finally they should also consider how their consequences in terms of capabilities and their dynamic implications are relevant issues for innovation policy.

Of course, further research on these topics is needed, and a research agenda should not only include the literature on economic systems in general, and on SI in particular, with an economic theory of action, but perhaps it should also include cognitive science, management and strategic literature, among others. Otherwise, the risk of the literature on SI being considered a non-organic part of a broader theoretical corpus is likely to remain.

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