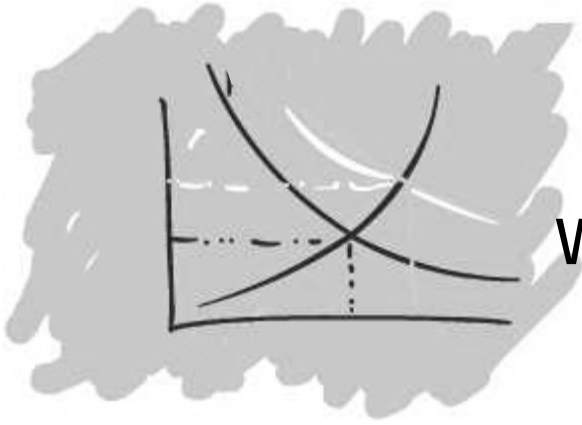


I.S.S.N: 1885-6888



ECONOMIC ANALYSIS WORKING PAPER SERIES

Agents intentionality, capabilities and the performance
of systems of innovation

•

Félix-Fernando Muñoz and María-Isabel Encinar

Working Paper 3/2011



DEPARTAMENTO DE ANÁLISIS ECONÓMICO:
TEORÍA ECONÓMICA E HISTORIA ECONÓMICA

Agents intentionality, capabilities and the performance of Systems of Innovation

Félix-Fernando Muñoz ⁽¹⁾ & María-Isabel Encinar ⁽²⁾

Abstract: We are interested on why and how an economic system evolves and, in particular, on the causes of the differences across systems of innovation (SI). SI's performance differs substantially because there are specific causes at work, apart from the differences in the underlying technologies, institutions, etc. In particular, we refer to the intentionality of the agents interacting within a system *for* innovation to find out the relationship between agents' goals, SI's performance and its policy implications. The underlying thesis in this paper is that agent intentionality is a necessary condition for a substantive explanation of the dynamism of any socio-economic system. The paper departs from an abstract definition of a system as a set of constitutive elements and the connections among them serving a common purpose. And explores how intentionality shapes 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

JEL: O10, B41, D01, E11

(1) and (2) Universidad Autónoma de Madrid (UAM), Madrid, SPAIN

Corresponding author: Félix Muñoz (felix.munoz@uam.es)

Agents intentionality, capabilities and the performance of Systems of Innovation

1. Introduction

The historical emergence of the so-called knowledge-based economies (Cooke, 2001) has favored the emergence of analytical frameworks that classify and analyze the empirical evidence linked to the conceptual elements of the said knowledge economies. A starting point for this kind of theoretical 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. One very important issue is the role these processes play in relation to the elements, processes and dynamical links that configure the innovation processes.

It is apparent that different patterns of innovation exist across nations, regions, sectors and technologies. This is why some authors consider that the relevant level of analysis for innovation processes is the national (Freeman, 1987, 2002, Nelson, 1993, Lundvall, 1992), the sectoral (Malerba, 2002, 2004), or regional level (Cooke et al., 1997). In any case, comparisons among agents, sources of novelty, institutions, and innovation policies in different nations, sectors or technologies reveal significant differences, which suggests that the sources of novelties and their role of dynamical transformation across the economy is much more diverse and thus requires a specific explanation (Mowery and Nelson, 1999). However, these kinds of approaches are not free from criticism; one of such criticisms assesses that the innovation systems approach is at best heuristic, rather than theory (Edquist, 2005, p. 186).¹

This paper departs from an abstract definition of a system as a set of constitutive elements (objects as knowledge, agents, institutions, beliefs, goals, etc.) and the connections among them serving a common purpose. This structure and its evolution should support the analytical description of dynamic phenomena such as innovation processes.

¹ Edquist (2005) points out that the main weakness of the systems of innovation approach is that, despite its usefulness for describing sector performance, it is 'over-theorized' or 'sub-theorized' and is thus not sufficiently clear on its theoretical basis and epistemological status.

We are interested on how and why an economic system evolves, which are the causes of such evolution and, therefore, of the differences across systems. We find out 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 great importance for *explaining* a system’s performance. In particular, we refer to the goal dynamics and intentionality of the agents interacting within a system.

Thus, a key issue for understanding evolutionary processes is the way dynamic connections are formed. The characteristic evolutionary processes of selection and retention operate on this basis (Foster and Metcalfe, 2001). The question is how and which connections activate within an economic system in general, and in an SI in particular. We argue that self-transformation processes result from changes in agents’ knowledge as a consequence of learning and acquisition of (new) evolving capabilities and that these processes are triggered, among other causes, by the dynamics of generation and the hierarchical change of agents’ goals as linked to agents’ intentionality. To accommodate this idea, we propose the analytical concept of an agent’s action plan that would also allow for examination of the evolutionary efficiency of an SI.

The underlying thesis in this paper is that we assume that agent intentionality is a necessary condition for a substantive explanation of the dynamism of any socio-economic system. The argument is consistent with the role that the categories of intentionality, such as belief, goal, 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 (Grosz and Hunsberger, 2006, Metzinger and Gallese, 2003, Baldwin and Baird, 2001). If we are right, the paper would contribute to the microfoundation of SI on agent action (or agency), which result in individual and organizational evolving capabilities, and their consequences for economic change (Loasby, 2008, Felin and Foss, 2006, 2009).

The paper is organized as follows: section 2 points out a theoretical foundation of system that focuses on the concept of connections and that makes them the prime variables; section 3 poses the microfoundation of dynamism of SI, especially how connections are established among elements within a system and how agents’

capabilities evolve; section 4 explores the implications of agents' capabilities and intentionality for the resulting performance of an SI. In this section, we also refer to the 'products' of innovation processes (the structure of an SI) and propose an evolutionary efficiency criterion for the dynamic performance of a complex process. Section 5 offers some concluding remarks.

2. 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 innovative 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: which the specific elements are and how they are connected is knowledge itself - knowledge may be considered as a structure, a system of connections that is also changing.

A feature of any complex evolving system is modularity (Simon, 1969). Once a system emerges (as a complex entity) it can become an element (or subsystem) of a higher-level system. For instance, an innovative organization or firm is a complex system integrated within an SI which, at the same time, is part of a higher order economic system, etc. Thus, every system is built with elements that may be lower-level systems themselves. 'System' is a ubiquitous concept.

As has been said, knowledge is a system itself; and the structures of the human brain by which it is supported also constitute a system (Fuster, 2003, see also Dopfer, 2005, p. 24). 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 the accumulation of connections between the internal elements of a system, and 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 the 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.²

The connections that configure these frames or structures for action are necessarily incomplete.³³ In a context of true uncertainty, it is impossible for agents to know all the feasible links between the elements (usually means, but also goals of action) that constitute a system in the present and future.

Learning consists of 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

² As Loasby has pointed out, the study of economic processes is also the study of institutions (Loasby, 1999, p. 13).

³ An example of a complete system is that of the Walrasian general equilibrium theory. In this kind of system there is no room for learning or for true dynamics. A 'paradox' underlies this argument: knowledge always implies lack of knowledge (Allen, 2004, p. 85).

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).

To summarize, we may assess that knowledge is connections, structure is connections and dynamics consists of changes in connections. Taking for granted this approach, important questions arise: how does a system evolve towards adjacent states? Why is it able to pass from one state to another? How does knowledge grow? And, how does it coordinate efficiently? The organization of knowledge, its growth/evolution and its eventual efficient coordination are all key issues for understanding the configuration and the pattern of innovation of a SI.

3. Action plans, knowledge and agents' goals

For evolutionary economics, social and economic systems are considered as 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 (Loasby, 2001, Dopfer and Potts, 2008), following the well-known evolutionary three-phase schema: generation-selection/adoption-retention of variety (Foster and 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).

However, what changes? What, if any, is the unit of selection in such selection-retention processes? What about the causal explanation of renewed variety? These are controversial issues. For some authors, the unit of selection is routines (Becker, 2004); for North (2005) and Hodgson (1993), it is institutions; for Boulding (1981), Hayek (1945, Hayek, 1952) and Loasby (1999), it is knowledge which evolves, to the extent that they identify the basic economic problem with that of the social organization of knowledge; for others, it is capabilities (Dosi et al., 2000), etc. Finally, there are those who, like Dopfer and Potts (2008), on a more abstract level, consider that it is rules or it is connections between the elements of a system that change.

In order to understand the microfoundation of an SI, we should carefully differentiate 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 is 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 and the resulting 'products' (Encinar and Muñoz, 2006). 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 (Rubio de Urquía, 2005). In other words, at each instant of 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 (Metcalf, 2004), etc. Agents constitute their action plans 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.⁴

The agent's set of actions and goals linked projectively by means of an action plan may contain different kinds of elements: material or immaterial elements, localized at different moments in time (obviously not all at the same time); with a monetary price (in official currency) or without a monetary price (a subjective level of satisfaction of a

⁴ It is important to distinguish between this use of projective imagination and the Austrian School's traditional approach to 'entrepreneurship', which is based on the concept of 'discovery' (Kirzner, 1992).

need), etc. Action plans are an analytical open representation of agents' projective action, in which actions and goals are not given, but rather *produced* by the agents themselves. These analytical constructions accommodate any kind of action plan, such as a planned trip, a business plan, a strategic plan (Day, 2008, pp. 264-265), with structures of hierarchical dependence between goals and with as many analytical periods of time as necessary. Moreover, these analytical structures may be used to represent how agents' action plans configure the economic dynamics of a society when they are deployed interactively.

Knowledge stands as cognitive networks in the human brain; routines; habits and patterns of behavior, cognitive, social and technological rules; institutions; organizations, etc. Knowledge is also the foundation of capabilities. 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 remain problematic. However, the goals and intentionality of agents play an essential role in explaining the emergence of novelties and evolving capabilities (Langlois, 2006, Cañibano et al., 2006), institutions (Nelson, 2008b, p. 7) and learning processes (Dosi et al., 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. has been postponed.⁵ 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, that goals reached now (or never) may be removed from or replaced in agents' plans, etc. All these changes

⁵ Even so, "intentionality in learning processes is a key, but relatively unexplored, dimension of capability building in strategic tasks" (Zollo, 2008). 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: "I will define a *technology* ... quite simply as a *means* to fulfil a human purpose. The purpose may be explicit...; or it may be hazy, multiple, and changing... But whether its purpose is well defined or not, a technology is a means to carrying out a purpose." North (2005) also devotes chapter (#4) to these issues.

involve learning processes, as well as the emergence of completely new actions that cannot be explained only 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. 7n. 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 (learning). Aligning, coordinating, reordering and even inventing new goals are activities that generate novelty and are therefore sources of true dynamism in economic processes.⁶ For example, the child’s vague idea of becoming a doctor may allow him to discover an ‘innate capacity’ (or vocation); this would lead him to want to ‘become a professional doctor’ (a new goal), and thus to study medicine at university, which finally enables him to work in the profession.

Goals of action evolve over time, inducing changes in agents’ capabilities, which may result in the formulation of renewed goals and intentions and, therefore, in the development of renewed capabilities. Agents differ in knowledge and capabilities, but also in the goals they pursue and in the way they produce such goals. Agents are heterogeneous because they also conceive different goals and/or different hierarchies of goals and, consequently, they develop different capabilities, deploying interactive learning processes to carry out their plans. The result is that agents introduce a wide variety of changes in their (physical and social) environment by means of their actions, thus altering the spaces of action (and the plans) of other agents. The emergence of new intentions linked to the conception of new goals renews agents’ capabilities. Therefore, evolving capabilities open up new possibilities for action that allow the conception of new goals, generating continuous feedback between capabilities and intentions.

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,

⁶ It is important to point out the social character of intentionality: intentionality exists not only in private mental space, but also in functional space with others. Moreover, intentionality is a functional mechanism for social cognition linked to understanding means and ends in attaining goals. A good survey on these issues is Malle et al. (eds.) (2001).

un-knowledge, 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 (Popper, 1948). Nevertheless, human action, *qua* rational, within human constraints, is intended action: there must be goals (reasons) *for* acting (Mises, 1949).⁷ 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 and not all novelties are a consequence or the pursuit of particular goals, the evolution of agents’ goals and intentions is a key explanatory factor because it triggers processes that establish and renew the connections within a system (Muñoz et al., 2011).

4. Capabilities, intentionality and SI performance

Actions such as producing, consuming, innovating, working and organizing, even choosing are conditioned by the goals designed and pursued by agents, goals and intentions that change continuously. The diversity and intensity of such changes in agents’ intentionality have substantial value as important factors for explaining socio-economic self-transformation processes because they trigger search processes and the establishment of connections with adjacent states of the system, altering its topology and thus giving rise to new features that emerge within the system. Moreover, together with the means 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

⁷ “[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)

as giving rise to new evolving capabilities. Socio-economic reality is configured as a product of the co-evolution of these processes.

4.1 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-layers" analysis: on the one hand, the analysis of the constitutive elements of a system (elements and connections; that is, its structure). On the other hand, the analysis of how evolve the connections between those elements (its dynamics). The evolution of such connections is necessarily associated with the diversity and changes in the goals pursued by the agents that configure the SI.

An economic system is not only a set of given elements and their static links, but also the potential dynamics of its connections via capabilities that emerge as knowledge grows. Thus, the emergence of evolving capabilities makes it possible to weave the network and explain it. Let us assume, for instance, an SI within the so called *life sciences*. Learning processes and scientific knowledge in life science allow for understanding the state and evolution of present research, implemented on the basis of the capabilities and skills of scientists. However, these learning processes and current knowledge also generate new research questions that spur the acquisition of new scientific knowledge. This new scientific knowledge, which would 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 tries to illustrate how and why the connections within a system may be continuously being established. As has been said, the emergence and development of capabilities are induced by intention, by agents' tendency towards the

goals they set up. Goals are imagined realities, expectations, valued as more desirable states and towards 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 give rise to (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, the pursuit of new goals allows the emergence of agents' action plans with a new structure 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 fuelling 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 science, much of 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 a halt 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 and 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' capabilities.

To summarize, renewed or improved capabilities reduce the gap between the goals that the agents intend to achieve and the real outcome of their actions. The capability building process may help reduce this gap. Accordingly, intention activates a capability-development process that, eventually, never comes to a halt. On the other hand, new or improved capabilities open up the possibility of setting new goals. Actions intended for achieving these goals may also imply the appearance of new capabilities or modifications in previously existing ones. It is partly through the development of capabilities that dreams or desires may turn into goals: capabilities can activate intention.

4.2. 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 may assert 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 actualized

(“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 being produced.⁸ 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 (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*.⁹

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 connections, is what makes it an evolving complex system.¹⁰ 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.¹¹

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) to then measure and compare the performance of the system relative to the said external metric. Thus, the criterion proposed here and applied to an SI ‘measures’ by the own development (performance) of the SI because it is relative to the goals, intentions and expectations of the agents involved in that particular SI.

⁸ Agents’ actions are both effective and efficient using Barnard’s (1938) terminology.

⁹ 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 Nelson (2008b) and Hodgson (2004).

¹⁰ Note that a simple harmonic motion is dynamic but does not evolve -there is no room for self-transformation.

¹¹ 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).

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. By contrary, 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 be consequent with this goal. The organization action plan is efficient/inefficient a priori depending on the orderings of means/actions aimed at achieving this goal. At the same time, this depends on the absence/presence of logical contradictions or impossibilities among the actions/means to goals and of the absence/presence of conflicting goals. If these orderings mean that the organization is capable of triggering to reach a sufficient aspirational level of satisfaction regarding its main goal, we could say that the connections between 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 strength its financial position. For doing so the institute provide its researchers with monetary incentives to do 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 and then we can say that the actions are efficient or that certain elements linked to G_2 appear and prevent the fulfillment of the plan in which high quality research papers is the primary goal. What if the researchers do maintain the strict preference of their primary goal G_1 over the new goal G_2 ; and at the same time, do they allocate a growing number of hours in G_2 related activities, in such a way that they could have no time enough to produce high quality research papers? When the 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, they maintain the hierarchy of the main goal G_1 over the new goal G_2 , then they are formulating internally inconsistent plans –giving rise to inefficient action.

Does this mean that all agents have to achieve their goals for the SI to perform well? What if the SI supports the fulfillment of the goals of some agents, but blocks that of other agents' goals? 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 denying the possibility of reaching 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 - generating a worsening of 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.¹²

How can inefficiency be lowered? There are different options for removing the source of action-rationing¹³ 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 introducing innovations. (In our example above by means of promoting sabbatical years, recruiting specialized personnel for fund raising activities, etc.)

5. Concluding remarks

No theoretical analysis should be made without a careful observation of reality: it is a matter of fact that agents *plan* their actions. Otherwise, agents' action will be irrational or absolutely erratic (Nelson, 2006). The analysis of the interactive deployment of agents' action and its products provides a useful framework for exploring the nature, properties, dynamics and complexity of connections within economic systems. Thus,

¹² Geels (2004) has explored the origin and consequences of these kinds of tensions and mismatches in goals, interests, etc. in a more specific context.

¹³ These kinds of situations are common in economic theory and have been modelled, for example, in the Keynesian theory of effective demand, the macroeconomic models of rationed equilibria, where agents do not change their plans but rather ration them (see Benassy, 1986), etc.

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 (Mises, 1949) unless as self-referenced explanations -which are not explanations by means of micro-foundations.

In this paper, we have proposed a (micro-)foundation of SI dynamics based on agents' intended action. The goal dynamics of agents within an SI, their intentions, capabilities, and action plans interacting within that system, are key elements to explain 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 reach 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 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 introducing technical or organizational innovations. In any case, policy makers should take into account this variety of circumstances when they try to improve the performance of an SI: which, how and why actors within an SI do have these and no others goals and how do they articulate and deploy their actions in order to reach them and their consequences in terms of capabilities and its dynamic implications are relevant issues for innovation policy.

Of course, further research on these topics is needed, and a research agenda should include not only the integration of the literature on economic systems in general, and of systems of innovation in particular, with an economic theory of action, but

perhaps also with cognitive sciences, management and strategic literature, among others. Otherwise, the risk of the literature on systems of innovation to be considered at best a heuristic, rather than a theory, will remain.

References

- Allen, P.M. (2004) "The complexity of structure, strategy and decision making." In: Metcalfe, J.S. & Foster, J. (eds.) *Evolution and economic complexity*. Cheltenham: Edward Elgar.
- Arthur, W.B. (2007) "The structure of invention." *Research Policy*, 36, 274–287.
- Avnimelech, G. & Teubal, M. (2008) "Evolutionary targeting." *Journal of Evolutionary Economics*, 18: 151-166.
- Baldwin, D.A. & Baird, J.A. (2001) "Discerning intentions in dynamic human action." *Trends in Cognitive Sciences*, 5: 171-178.
- Barnard, C. (1938) *The functions of the executive*, Cambridge, Mass., Harvard University Press.
- Becker, M.C. (2004) "Organizational routines: A review of the literature." *Industrial and Corporate Change*, 13: 643-678.
- Benassy, J.P. (1986) *Macroeconomics: an introduction to the non-walrasian approach*, London, Academic Press.
- Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S. & Rickne, A. (2008) "Analyzing the functional dynamics of technological innovation systems: A scheme of analysis." *Research Policy*, 37: 407-429.
- Boulding, K.E. (1981) *Evolutionary Economics*, Beverly Hills, CA, Sage Publications.
- Cañibano, C., Encinar, M.I. & Muñoz, F.-F. (2006) "Evolving capabilities and innovative intentionality: some reflections on the role of intention within innovation processes." *Innovation: Management, Policy and Practice*, 8: 310-321.
- Consoli, D. & Ramlogan, R. (2008) "Out of sight: problem sequences and epistemic boundaries of medical know-how on glaucoma." *Journal of Evolutionary Economics*, 18: 31-56.

- Cooke, P. (2001) "New Economy Innovation Systems: Biotechnology in Europe and the USA." *Industry and Innovation*, 8: 267-289.
- Cooke, P., Uranga, M. & Etxebarria, G. (1997) "Regional Innovation Systems: Institutional and Organizational Dimensions." *Research Policy*, 26: 475-491.
- Day, R.H. (2008) "Micro foundations for meso and macro economic theory." *Journal of Evolutionary Economics*, 18: 261-273.
- Dopfer, K. (2005) "Evolutionary economics: a theoretical framework." In: Dopfer, K. (ed.) *The Evolutionary Foundations of Economics*. Cambridge, UK: Cambridge University Press.
- Dopfer, K. & Potts, J. (2008) *The general theory of economic evolution*, New York, Routledge.
- Dosi, G., Nelson, R.R. & Winter, S.G. (eds.) (2000) *The Nature and Dynamics of Organizational Capabilities*, Oxford: Oxford University Press.
- Earl, P.E. (2003) "The Entrepreneur as a Constructor of Connections." In: Koppl, R. (ed.) *Austrian Economics and Entrepreneurial Studies*. Oxford: JAI-Elsevier Science.
- Edquist, C. (2005) "Systems of Innovation: Perspectives and challenges." In: Fagerberg, J.M., David, C.; Nelson, R.R. (ed.) *The Oxford Handbook of innovation*. New York: Oxford University Press.
- Encinar, M.-I. & Muñoz, F.-F. (2006) "On novelty and economics: Schumpeter's paradox." *Journal of Evolutionary Economics*, 16: 255-277.
- Felin, T. & Foss, N.J. (2006) "Individuals and Organizations: Thoughts on a Micro-Foundations Project for Strategic Management and Organizational Analysis." DRUID Winter Conference, 2006 Copenhagen.
- Felin, T. & Foss, N.J. (2009) "Organizational routines and capabilities: Historical drift and a course-correction toward microfoundations." *Scandinavian Journal of Management*, 25: 157-167.
- Foster, J. & Metcalfe, J.S. (2001) "Modern evolutionary economic perspectives: an overview." In: Foster, J. & Metcalfe, J.S. (eds.) *Frontiers of Evolutionary Economics. Competition, Self-Organization and Innovation Policy*. Cheltenham, UK: Edward Elgar.

- Freeman, C. (1987) *Technology Policy and Economic Performance: Lessons from Japan*, London, Printer.
- Freeman, C. (2002) “Continental, national and-subnational innovation systems - Complementarity and economic growth.” *Research Policy*, 31: 191-211.
- Fuster, J.M. (2003) *Cortex and Mind. Unifying cognition*, New York, Oxford University Press.
- Fuster, J.M. (2008) *The Prefrontal Cortex*, Amsterdam, Academic Press.
- Geels, F.W. (2004) “From sectoral systems of innovation to socio-technical systems. Insights about dynamics and change from sociology and institutional theory.” *Research Policy*, 33: 897–920.
- Grosz, B.J. & Hunsberger, L. (2006) “The dynamics of intention in collaborative activity.” *Cognitive Systems Research*, 7: 259-272.
- Hayek, F.A. (1937) “Economics and knowledge.” *Economica*, 33-54.
- Hayek, F.A. (1945) “The use of knowledge in society.” *American Economic Review*, 35: 519-530.
- Hayek, F.A. (1952) *The Sensory Order. An Inquiry into the Foundations of Theoretical Psychology*, Chicago, The University of Chicago Press.
- Hodgson, G. (1993) *Economics and Evolution: Bringing Back Life Into Economics*, Cambridge, UK and Ann Arbor, Polity Press and University of Cambridge Press.
- HODGSON, G. 2004. *The Evolution of Institutional Economics*, London, Routledge.
- Kauffman, S. (1995) *At Home in the Universe. The Search for Laws of self-Organization and Complexity*, New York and Oxford, Oxford University Press.
- Kirzner, I. (1992) *The meaning of the market process*, London, Routledge.
- Lachmann, L. (1994)[1978] “Vicissitudes of Subjectivism and the Dilemma of the theory of Choice.” In: Lavoie, D. (ed.) *Expectations and the meaning of institutions. Essays in economics by Ludwig Lachmann*. London and New York: Routledge.
- Langlois, R.N. (2006) *The Dynamics of Industrial Capitalism. Schumpeter, Chandler, and the New Economy*, London, Routledge.
- Loasby, B.J. (1996) “The Imagined, Deemed Possible.” In: Helmstädter, E. & Perlman, M. (eds.) *Behavioral Norms, Technological Progress, and Economic Dynamics*. Michigan: Michigan University Press.

- Loasby, B.J. (1999) *Knowledge, Institutions and Evolution in Economics*, London, Routledge.
- Loasby, B.J. (2001) “Time, knowledge and evolutionary dynamics: why connections matter.” *Journal of Evolutionary Economics*, 11: 393-412.
- Loasby, B.J. (2007) “Imagination and order.” *DRUID Summer Conference 2007 on Appropriability, Proximity, Routines and Innovation*. Copenhagen.
- Loasby, B.J. (2008) “La microfundamentación de las capacidades organizativas.” In: Cañibano, C., Encinar, M.-I. & Muñoz, F.-F. (eds.) *Economía del conocimiento y la innovación. Nuevas aproximaciones a una relación compleja*. Madrid: Ediciones Pirámide.
- Lundvall, B.A. (ed.) (1992) *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*, London: Printer.
- Malerba, F. (2002) “Sectoral systems of innovation and production.” *Research Policy*, 31: 247-264.
- Malerba, F. (ed.) (2004) *Sectoral Systems of Innovation: Concept, Issues and Analysis of Six Major Sectors in Europe*, Cambridge: Cambridge University Press.
- Malle, B.F., Moses, L.J. & Baldwin, D.A. (eds.) (2001) *Intentions and Intentionality: Foundations of Social Cognition*, Cambridge MA: The MIT Press.
- Metcalfe, J. (2004) The entrepreneur and the style of modern economics. *Journal of Evolutionary Economics*, 14: 157-175.
- Metzinger, T. & Gallese, V. (2003) “The emergence of a shared action ontology: Building blocks for a theory.” *Consciousness and Cognition*, 12: 549-571.
- Mises, L. (1949) *Human action: A Treatise on Economics*, New Haven, Yale University Press.
- Mowery, D.C. & Nelson, R.R. (eds.) (1999) *Sources of Industrial Leadership. Studies of seven Industries*, Cambridge: Cambridge University Press.
- Muñoz, F.-F., Encinar, M.-I. & Cañibano, C. (2008) “On the role of intentionality in evolutionary economic change.” *Structural Change and Economic Dynamics*, 22(3): 193-203.
- Nelson, R.R. (ed.) (1993) *National Systems of Innovation: A Comparative Study*, Oxford: Oxford University Press.

- Nelson, R.R. (2006) "Evolutionary social science and universal Darwinism." *Journal of Evolutionary Economics*, 16: 491-510.
- Nelson, R.R. (2008a) "Bounded rationality, cognitive maps, and trial and error learning." *Journal of Economic Behavior & Organization*, 67: 78-89.
- Nelson, R.R. (2008b) "What enables rapid economic progress: What are the needed institutions?" *Research Policy*, 1-11.
- North, D.C. (2005) *Understanding the process of economic change*, Princeton, Princeton University Press.
- Popper, K. (1948) "Prediction and prophecy and their significance for social sciences." In: Beth, E., Pos, H. & Hollak, H. (eds.) *Library of the Tenth International Congress of Philosophy: Proceedings of the Tenth International Congress of Philosophy*. Amsterdam: North Holland.
- Popper, K. (1972) *Conjectures and Refutations. The growth of scientific knowledge*, London, Routledge & Kegan Paul.
- Potts, J. (2000) *The New Evolutionary Microeconomics. Complexity, Competence and Adaptive Behaviour*, Cheltenham, UK, Edward Elgar.
- Rubio de Urquía, R. (2005) "La naturaleza y estructura fundamental de la teoría económica y las relaciones entre enunciados teórico-económicos y enunciados antropológicos." In: Rubio de Urquía, R., Ureña, E.M. & Muñoz, F.-F. (ed.) *Estudios de Teoría Económica y Antropología*. Madrid: Instituto de Investigaciones Económicas y Sociales Francisco de Vitoria-AEDOS-Unión Editorial.
- Searle, J.R. (1995) *The construction of social reality*, New York, The Free Press.
- Searle, J.R. (2001) *Rationality in action*, Cambridge MA, The MIT Press.
- Simon, H.A. (1969) *The Sciences of the Artificial*, Cambridge MA, The MIT Press.
- Vanberg, V.J. (2006) "Human Intentionality and Design in Cultural Evolution." In: Schubert, C. & Wangenheim, G.V. (eds.) *Evolution and Design of Institutions*. Oxford: Routledge.
- Witt, U. (2003a) "Economic policy making in evolutionary perspective." *Journal of Evolutionary Economics*, 13: 77-94.
- Witt, U. (2003b) *The Evolving Economy*, Cheltenham, UK, Edward Elgar.

- Witt, U. (2009) “Novelty and the bounds of unknowledge in economics.” *Journal of Economic Methodology*, 16: 361-375.
- Zollo, M. (2008) Organizational Learning and Capability Building Research: Past, Present and Future. *Research Seminar at Tilburg University*. Tilburg (Netherlands).