Micro Foundations of a National System of Competitive and Technology Intelligence

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Abstract

This article deepens the analysis of previous works concerning the building of national systems of competitive and technology intelligence. In it we suggest a theoretical systemic framework to constitute the foundations of such national systems. An adaptation of the so called viable system model is used as a means to understand the functioning and to design transformations in diverse types of organizations. We believe that the use of the suggested model is a good starting point for the structuring of innovation and competitive and technology intelligence systems at different levels of aggregation.

Keywords

Systems approach, competitive and technology intelligence, innovation.

1. Introduction

In previous works(Rodríguez-Salvador, 2005; Rodríguez-Salvador & Lopez-Martinez, 2007), the structuring of a national system of competitive and technology intelligence (CTI) has been suggested. This is defined as the set of agents and their interactions, participating at the national level in the process of transforming information into strategic knowledge through the operation of a virtuous cycle of intelligence. Among these agents we can mention governmental organizations, research and higher education institutions, support organizations, firms and professional and entrepreneurial associations. In the present work we will deepen our analysis to suggest some ideas for the micro–foundations of such a system, with special emphasis on the functional organization of the subsystems or agents which constitute it.

Our proposal should not be considered to have a prescriptive character, but only as an attempt to provide some orientation concerning the understanding of the basic functions of organizations. Additionally, since we shall be using elements of the systems approach it is worthwhile noticing that we will not attempt to provide a model as a faithful representation of reality, but only as a methodological approach to understand the real world and be able to modify it. For this reason we shall use in our analysis relatively simple, but not inaccurate, systems models, recognizing the fact that the use of complex systems could provide more accurate but operatively useless representations of reality. Given its influence on diverse areas of innovation studies we shall start our analysis with a brief account of the use of systems concepts in this sphere.

1.1. The notion of systems in the literature of innovation

Systems concepts have been broadly used in innovation studies, particularly since the publication of diverse and heterogeneous works using the concept of national system of innovation (Freeman, 1987; Lundvall, Bengt-Åke, 1992; Nelson, 1993). These have stressed the need to use a holistic approach to address the study of the production and diffusion of economically useful knowledge and suggest a general framework consisting in the decomposition of the economic system into the elements and interactions that constitute innovation processes.

Despite having some theoretical problems, such as theoretical diffuseness (Edquist, 1997; 2005), the framework has had a surprising diffusion and some of its aspects have been either adopted by innumerable scholars, policy analysts politicians and international organisations, or adapted as departing point for similar approaches such as sectoral and regional systems of innovation and technological systems (Carlsson, 1994; Breschi & Malerba, 1997; Cooke, Gomez Uranga & Etxebarria, 1997). However, given the theoretical ambiguity of the notion this diffusion has implied different interpretations. In what follows we will briefly discuss the origin of the concept of innovation systems and the main subsequent interpretations.

The origin of the use of the notion of systems associated with innovation studies can be found in the evolution of the concept of innovation. Particularly, when interactive models of this process were developed in opposition to the dominant linear view and which implied also the participation of a broad group of agents. Andersen (1994) suggests that this association can be found in the works of several scholars related with Christopher Freeman and SPRU[1].

These interpretations of the innovation process are perhaps more related with notions such as social networks than with systems, since this latter have particular, more complex connotations than the interaction between components, which will be explained in section 2. Nevertheless, what is clear is that these early associations between systems and innovation implied the conceptualization of this phenomenon as a non–linear process involving the coordinated participation of a wide range of actors.

The subsequent use of the notion of systems of innovation, in the late 1980s and early 1990s, involved an extension of the network conceptualisation of the innovation process to include the role of institutions and to a certain extent some aspects of evolutionary economics. It has been extensively discussed that there is not a unified notion of systems of innovation[2], since the main proponents corresponded to different research traditions, where probably the common denominator was Schumpeter. However, apart from the similarities between approaches suggested by Edquist (1997, 2005), it seems that the 'basic original interpretation' was aimed at explaining national patterns of growth and economic development through the analysis of the interactions between the actors and institutions participating in innovation networks.

Linked with this primary objective, there was also an implicit or explicit policy orientation that is more clearly stated in the Lundvall-Aalborg version in terms of

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[1] See for example the work of Keith Pavitt (OECD, 1971, p. 22), where the concept of innovative system is used referring to the factors and interactions that make possible the innovation process.

[2] The classic reference in this respect is Charles Edquist (1997); another early analysis of these differences was made by Maureen McKelvey (1991). Subsequent works of the main proponents usually make reference to the differences between their frameworks (Freeman, 1995; 2002; Lundvall, B. A., Johnson, Andersen & Dalum, 2002; Nelson & Nelson, 2002).

‘institutional learning’ (Dalum, Johnson & Lundvall, 1992). It could be said that this original interpretation was some sort of ‘appreciative’ evolutionary framework to explain national innovative performance. The main structure of the framework consisted of actors, institutions and relationships involved in innovation activities and from this probably followed the association that it was possible to refer to specific, national innovation systems, i.e. elements and interactions constituting systems at the national level.

Despite the policy orientation, none of the original approaches included an operational version of the systems of innovation approach. This has been mainly developed by the OECD, which adopted the notion since the late 1980s (OECD, 1992; David & Foray, 1994). From this followed what can be called the ‘generalised interpretation’ of the systems of innovation approach which implies that particular systems can be sufficiently described by enumerating the main components involved in innovation processes and analysing some of their relationships. From the analysis of how these interactions shape successful innovation systems it follows that, either missing components and institutions or best institutional practices can be also identified as guides for international institutional learning. This generalised interpretation has been refined in several OECD reports (OECD, 1994; 1999; 2002) as well as in studies carried out by other international organisations such as those of the European Union (Edquist *et al.*, 1998; Soete & STRATA-ETAN Expert Group, 2002) and is usually the one used in the plethora of studies published in the literature that refer to innovation systems.

While the original and the generalised interpretations seem to be very similar, there are subtle theoretical differences that from the point of view of some of the original proponents are of considerable importance. Nevertheless, what these differences emphasise is the orientation of the systems of innovation approach as a theoretical structure to make detailed case studies aimed at identifying features of economic systems that differentiate one national system from another.

The existence of these interpretations suggests therefore, that an in–depth analysis of the systems of innovation framework from the point of view of systems theory could be useful to suggest a unified perspective. This assertion does not deny the beneficial impact that systems of innovation approaches have had in several spheres from innovation studies to policy-making. However, the purpose of this brief introduction was simply to analyse the background and context of the use of systems concepts in innovation related studies and policies. In what follows, we will suggest an alternative approach based on systems thinking, to the use of the notion of systems in the field of innovation and competitive and technology intelligence.

2. Basic background for a systems approach to innovation and competitive and technology intelligence

Our purpose for this section is to suggest a different way to use systems concepts within the functional organization of economic entities; more precisely, we will use the systems approach as a means to understand the decision–making processes that take place within economic entities, such as firms (among other agents or entities). This implies that we will make a distinction between the set of measures intended to modify processes (decision making) and the actual processes themselves. Our approach will consider the models representing the latter, but will emphasise the role and characteristics of the former.

The first thing we need to do when dealing with problems we want to address from the systems perspective is to define the point of view of the observer who perceives and analyses reality. This is important because systems are intellectual constructs to deal with complexity, but we do not have elements to assert that they actually exist. When an observer identifies systemic characteristics of a particular object, situation or phenomenon, those characteristics are determined by his or her point of view, interests and purposes. This means that the aspects that are essential to define systems, such as components, interactions, boundaries, and so on, are dependent on the particular perspective of the observer. It is also important to make explicit, that while dealing with systems we are not determining absolute facts; we are simply establishing a set of conventions more or less useful for our analysis. Thus, the perspective that we shall adopt in this work corresponds to the point of view of an analyst who is observing economic activities and is interested in modifying certain components and processes to achieve specific goals.

Secondly, it is necessary, at least, to specify the type of system we are dealing with, which in turn implies some taxonomic considerations; and, subsequently it is necessary to adopt a suitable definition of system consistent with and useful for the type of system under study.

Our first assumption is that firms' decision–making activities, in which we are interested, constitute a subset of reality that interacts with another subset consisting of economic phenomena. It is important to mention that these activities involve actions to observe and to modify the processes that take place within the economic subset. To do this, these activities resort to simplified representations or models of what is happening in the subset it observes, as means to reduce the complexity of the observed reality, as well as several types of mechanisms or tools of observation and transformation, which are inextricably linked to the former.

At first sight it seems that the type of situation we are describing could be treated from the systems perspective, firstly, because it resembles conditions that seem to coincide with a commonsensical notion of systems. Secondly, because this same notion makes us believe that the systems perspective is useful to deal with complex problems, and this one, though simply stated, appears to involve high levels of complexity. Thus, our second assumption is that we can analyse decision-making problems from the systems approach. However, this is in fact a broad transdisciplinary area that involves the participation of several disciplines from philosophy and natural sciences to engineering and social sciences. Therefore, it will be also important to specify from which area of the systems approach we are going to analyse policy–making activities.

Since the systems approach is based on the hypothesis that it is insightful to consider the apparently chaotic real world not as a set of unarticulated phenomena but rather as a complex of interacting entities, it is natural that a number of general attempts to describe and classify the possible types of systems have been made. These range from the simple and general polar distinctions such as concrete and abstract, living and non–living, open and closed systems, to more ambitious and detailed ones. However, there is yet no generally accepted classification and many of the suggested proposals reflect a particular outlook, interest or purpose that might invalidate any general systems description of the world. For example, we can find in the literature system's classifications based only on behavioural characteristics (Ackoff, 1971), and several attempts to define taxonomic principles or general classifications of all possible systems (Boulding, 1956; Jordan, 1968; von Bertalanffy, 1968; Checkland, 1981; Mingers, 1997).

For our purposes, we think that from the above literature, Checkland’s classification is sufficient and useful. This is based on the origin of the entities that can be observed in the real world and suggests that any entity which an observer perceives may be described as a system or as a combination of systems selected from the following five classes: natural, designed physical, designed abstract, human activity and transcendental systems. It is worth noting that according to this classification, social systems, defined very generally as groupings of people who are aware of and acknowledge their membership of the group, are considered as an intersection between natural systems and human activity systems.

Additionally, and most importantly, human activity systems include an account of the observer and the point of view from which his or her observations are made. From this follows that human activity systems *do not actually exist*, they are perceptions of sets of self–conscious activities made by specific observers from particular perspectives. Thus, the crucial difference which distinguishes this from some other systems approaches rests on the use of the term system and its implications, i.e. what is systemic is not the complex real world, but the process of inquiry that is used to explore reality. Consequently, the models derived from this perspective are not attempts to model the world, but epistemological devices used to understand reality and to contribute to the debate about possible change[3]. From the above discussion it follows that our third assumption is that firms’ decision–making activities as well as the parts of the economic system with which they interact are human activity systems.

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[3] We can find a similar approach in systems analysis, particularly in the works of C.W. Churchman (1968; 1971; 1979). Another implication previously perceived by Churchman is that in the process of inquiry the observer becomes part of the complexity he is studying; this issue has also been addressed from the perspective of self–referential systems (Luhmann, 1995).

The next aspect to analyse concerns how to characterise and define human activity systems. In this case it seems more appropriate to concentrate on a subclass of them, and assume that that these types of systems are examples of purposeful or teleological entities, i.e. “things some of whose properties are functional” (Churchman 1971, pp.42). We are suggesting then, that firms’ decision-making and its interactions with part of the economic system can be interpreted as constituting a purposeful system.

2.1. Purposeful and sustainable systems

The necessary conditions that something *S* be conceived as a purposeful system include according to Churchman (1971, pp. 42-43) that:

1. *S* is teleological.
2. *S* has a measure of performance.
3. There exists a social entity whose interests are served by *S*.
4. *S* has teleological components which co–produce the measure of performance of *S*.
5. *S* has an environment which also co–produces the measure of performance of *S*.
6. There exists a decision maker who can produce changes in the measures of performance of *S*’s components and in the measures of performance of *S*.
7. There exists a designer who conceptualises the nature of *S* in such a manner that the designer’s concepts potentially produce actions in the decision maker, and hence changes in the measures of performance of *S*’s components and in the measures of performance of *S*.

8. The designers intention is to change *S* so as to optimise *S*'s value to the social entity.

9. *S* is "stable" with respect to the designer in the sense that his or her intention is ultimately realisable.

This characterisation gives an account of the necessary minimum elements to design a purposeful system, i.e. one designed to transform reality, in this case a set of decisions to modify firms' internal and external processes. However, we still need a systemic representation of the part of reality within which it operates, that is, the firm itself; to accomplish this, we suggest adopting some elements of the 'viable system model' (Beer, 1972; 1979; 1985). This is based on the application of concepts from neurophysiology and cybernetics to the understanding of the functional structure of systems. It is a general recursive model containing the sufficient functional elements and structure that any system needs to be viable, i.e. able to maintain a separate existence. The recursiveness of the model implies that one of the functional elements contains a copy of the whole system, generating a series of nested subsystems, all with the same structure. Therefore, the basic structure of the model is able to map and represent any complex system. For example, in our area of interest, we can start the analysis at the level of a firm —a viable system itself, which is part of an industry, which in turn belongs to the private sector, within a national economy. All the levels of recursion are nested and have the same structure that makes them viable.

Any system that is capable of maintaining its identity independently of other systems within a shared environment performs two fundamental functions: current and long–term stabilisation. These are carried out by two composite subsystems —the system and the metasystem, that operate in different dimensions of recursion and perform five sub–

functions: (1) production of the whole system itself; (2) regulation or coordination of the diverse productive components; (3) self–awareness of the system's identity and control; (4) intelligence, foresight, innovation and planning; and, (5) establishing policies to guarantee the cohesion of the whole (see table 1 and figure 1). Given their nature, production and intelligence include an additional function of perception or link with the environment.

[INSERT TABLE 1 ABOUT HERE]

The next important characteristic is the network of interactions that connect the functional components. The nature of the relationships is partly defined by the function of the elements and partly by the characteristics imposed by the purpose of the whole system. These interactions imply the flow of information containing encoded variety[4]. In fact, the whole system is an entity whose main task is to deal with complexity by variety engineering. This means that the system faces an environment which presents a vast number of possible states and thus, it must be capable of generating an equal number of internal states to absorb the variety of the environment. Consequently, its internal network of interactions corresponds to the flow of different types of resources as well as regulations and coordination rules that allow the production components to respond to the variety of the environment. This entire network is structured and regulated by the law of requisite variety (Ashby, 1956; 1958), which in a simplified form states that only variety absorbs variety.

[INSERT FIGURE 1 ABOUT HERE]

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[4] In this context, variety is defined as the number of possible states of a system.

3. Economic entities as a sustainable or viable systems

We have chosen the conceptualisation and structure of the viable system model, because it helps to solve a problem of the current applications of systems notions to innovation studies. In these, there is a frequent confusion between phenomena occurring in different dimensions. They usually refer to activities that correspond to the interpretation of the actual production system and at the same time to activities that correspond to normative aspects (institutions) related to that production system. Consequently, these interpretations establish a boundary for these components — regions, industrial sectors or nations, but assume that these elements and institutions constitute a system and subsist at the same hierarchical dimension. From this follows an unsolved debate concerning the appropriate location of those boundaries.

The aspect that is missing from these interpretations is that these elements and institutions constitute a purposeful, sustainable, composite and multidimensional system. In it, the production activities occur in a basic dimension and the policy, intelligence, control and regulation functions take place at a higher level dimension, though control and regulation are trans–dimensional —the system and the metasystem. However, this composite system constitutes a unity with an internal environment and simultaneously, given the recursive nature of the model, its metasystem is an element (a new production unit or system) of another unity subsisting at a higher dimension of recursion (see Figures 1 and 2).

The advantage of this model is that it provides a coherent account of how basic units, which are viable systems themselves, are interlinked and nested to constitute higher levels of aggregation in each recursion. This represents an explanation of how systems differentiate in a self–referential process of distinguishing themselves from the environment and simultaneously organising in subsystems with an internal structure that reproduces the structure of that environment. Such a conceptualisation is much closer to reflect the actual systemic nature of industrial processes. From this perspective, as mentioned above, it is possible to map how individual firms —which are also viable systems composed of nested viable systems, constitute industries. Subsequently, industries constitute the productive sector, which in turn constitutes part of a national economy, which in turn constitutes part of higher–level systems.

[INSERT FIGURE 2 ABOUT HERE]

We are suggesting thus, that any economic entity —a group of nations with shared interests, a nation, a region, a firm, etc., can be represented as a viable system which performs the referred five sub–functions in every dimension of recursion. Naturally, this functional description can adopt quite different organisational structures in each particular case. The detailed mapping of economies as viable systems is out of the scope of this work and we shall refer only to the more general aspects which are related with our purposes[5], nevertheless, Figure 2 depicts a possible general structure for a national system.

For the sake of simplicity, our description of the five functions of the viable system as well as their interactions has been very brief. In particular, we should mention that the subsystem that we have called intelligence is to a certain extent multifunctional, since it includes at the level of a firm for example, foresight, strategic planning and R&D. We have used the term intelligence, since it is closer to represent a teleological perception of the environment and the consequent actions to shape the future of the firm. Others

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5 We remit the reader to the original sources of the viable system model (Beer, 1972; 1979; 1984; 1985).

would prefer to use the term innovation to designate the general function of this subsystem, but we think that the term innovation does not connote the range of activities that this carries out.

In addition, it should be observed that the internal structure of the subsystems that carry out the main functions should comply with the nine requirements of the purposeful systems that we have already mentioned in section 2.1.

At one of the higher levels of aggregation, let us say at the national level, the economic system is composed of several subsystems or production units which are responsible of the reproduction of the whole system itself. From our perspective, these can be understood as producers of knowledge, either codified or embedded in products, processes or services. In a higher recursive dimension, several other organisations constitute the subsystems that are in charge of self–awareness and control, coordination, intelligence and cohesion. We must remember that in each recursion we will find that the same functional structure is repeated, since they are also constituted of sets of viable systems. Therefore, a firm, which could be usually considered the lowest dimension of recursion in an economic system, is also composed of viable systems and has components that perform the functions of production, coordination, control, intelligence and cohesion.

Let us attempt to describe briefly how these subsystems interact in the case of a firm. The best place to start is with the production subsystem, i.e. what we have called ‘the system’. The purpose of this is to generate the products or services that satisfy particular demands of the environment (the market). It also performs diverse operational and managerial activities to achieve its purpose. These are determined on the one hand, by the variety of the market demand, and on the other, by several constraints imposed by the resources and capabilities of the whole firm as well as by a series of regulations established internally, such as procedures, and externally —by systems at higher recursive dimensions, such as standards and norms. There can be several production subsystems within a firm, each one of them attending different market demands. The crucial aspect of this scheme is that each production unit has to cope with a particular level of market variety and be capable of generating the sufficient variety —products or services within specific ranges of qualities (prices, performance characteristics, etc.) to absorb the market demand.

As mentioned above, the subsystem of regulation constrains the production subsystems according to internal norms, rules, practices, ethos, etc, to help in the coordination between several similar units. Additionally, it also transmits the constraints imposed by higher–level systems in the environment, such as industrial codes of practice, standards, national or international laws and regulations. This regulation subsystem is in close operation with the control subsystem whose functions include the mechanisms to allow awareness of the internal state (of the production units) through audits or evaluations, and the mechanisms to distribute the flow of resources (human, physical, financial and knowledge).

To be able of controlling, this subsystem needs a permanent exchange with the intelligence subsystem responsible of surveying the environment, making the relevant plans and performing the consequent innovation activities. This latter essentially supplies knowledge embedded in the vision of the future of the organisation —which basically is established by determining the necessary adjustments of the variety response of the firm to cope with future demands and the threats of competition, as well as in all the intangible assets that the operational units require to adjust their outputs.

Finally, the system that closes the loop is in charge of establishing general policies that give cohesion to the whole. To do this, its main task consists of monitoring and balancing the forces and the flow of information and variety between the subsystems of control and foresight. It is perhaps unnecessary to remark that the system is in a permanent process of learning and adaptation[6]. What seems somehow paradoxical is that the whole system is a complex entity to destroy variety, in the sense that it compensates the environmental variety; but to do this, it continuously generates variety through its internal processes. From this perspective, a firm is a system to generate variety, and the processes of intelligence–foresight–innovation constitute one among five fundamental processes that interact in the achievement of the ultimate goals of the whole entity.

4. Conclusion

In this paper we have suggested a general systemic framework as a methodological tool to understand activities related to innovation and CTI. With them, thanks to the characteristics of systems, we have been able to recursively describe some aspects of the operation of an economy. From this perspective, it is possible to solve some of the theoretical and operational problems of traditional systems of innovation perspectives. Firstly, we are suggesting a model which is consistent with the systems approach and is based in the identification of processes or functions, which can be generalised to any system within the established boundaries.

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[6] A system is *adaptive*, when there are changes in its environment or internal state that reduce its efficiency in pursuing one or more of the goals which define its function, and consequently it reacts or responds by changing its own state or that of its environment so as to increase its efficiency with respect to that goal. Learning is defined, as the ability of the system to increase its efficiency in the pursuit of a goal under unchanging conditions, thus, in this case it refers to the assessment of the effect of particular actions in helping the system to get closer to its target goal.

Secondly, our proposal does not attempt to explain economic phenomena in holistic terms, but through the detailed analysis of a series of recursive and sustainable subsystems. It is precisely this nature which allows the model to be applied in different levels of aggregation according to the interests of study; sectoral, regional, national, etc. Additionally, these aspects also imply that the system which is used to model reality is not simply constituted by a set of elements and interactions, but by functional subsystems hierarchically organised, that are increasingly more complex according to the level of aggregation of the analysis.

Finally, our viewpoint makes explicit the duality that emerges while approaching this phenomena from the systems perspective, since we are distinguishing between the observed reality, which is perceived as a system to reduce its complexity —what we have called the 'system'; and the observer that designs and implements mechanisms to transform reality —which has been referred as the 'metasystem'. As we have seen, both form part of the same sustainable system, at different levels of recursion.

We would like to stress that the building of a national system of competitive and technology intelligence should start at the level of individual organizations, through the constitution of the minimum units of organization, firms, research centres, public support organizations, as sustainable systems. Only in this way, the emergence of higher hierarchy dimensions will be possible. In the last instance these will constitute industrial and research subsystems as the basis for sustainable productive systems at sectoral, regional or national levels.

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Figure 1 The viable or sustainable system model

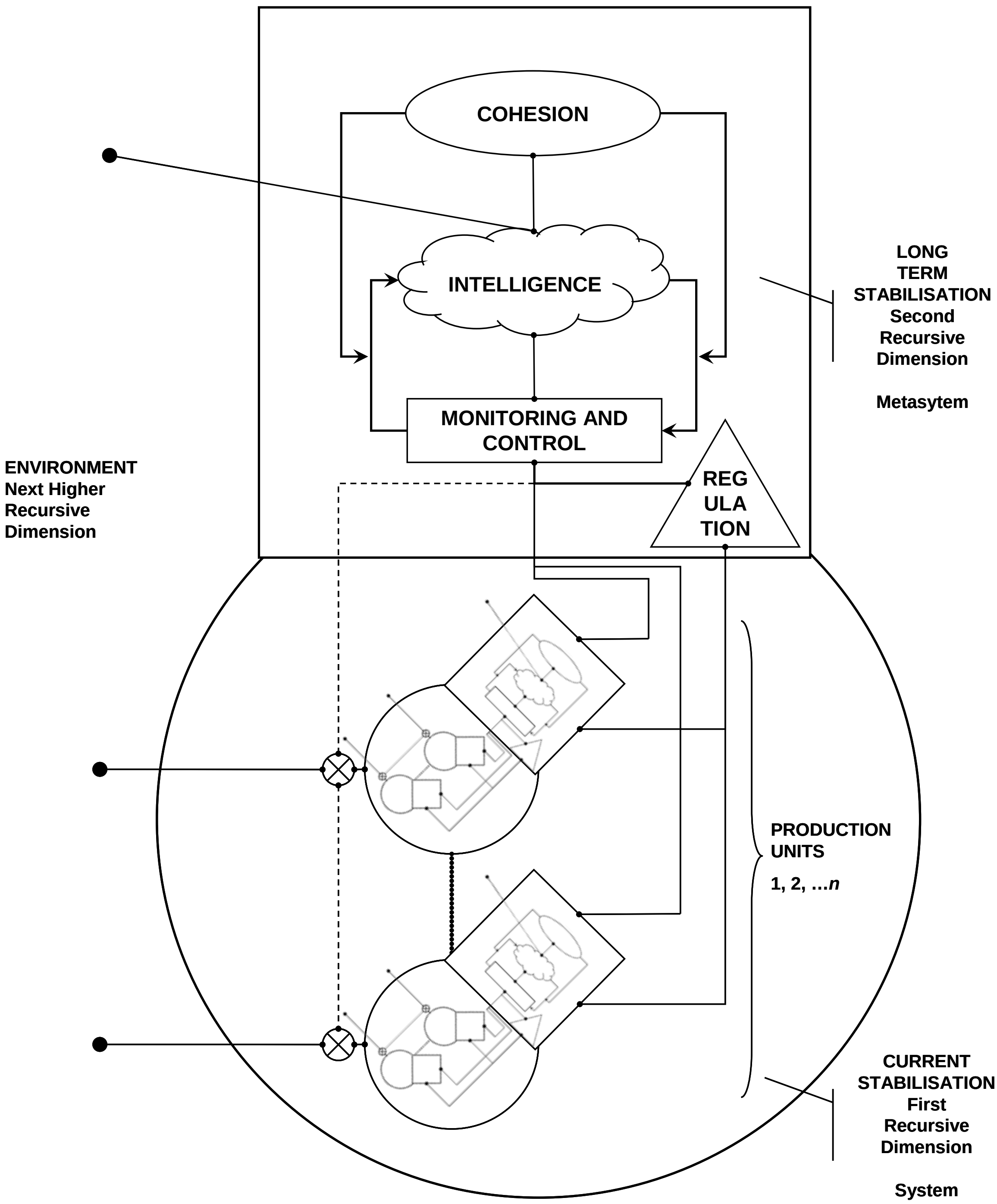

Figure 2 A sustainable national system of production

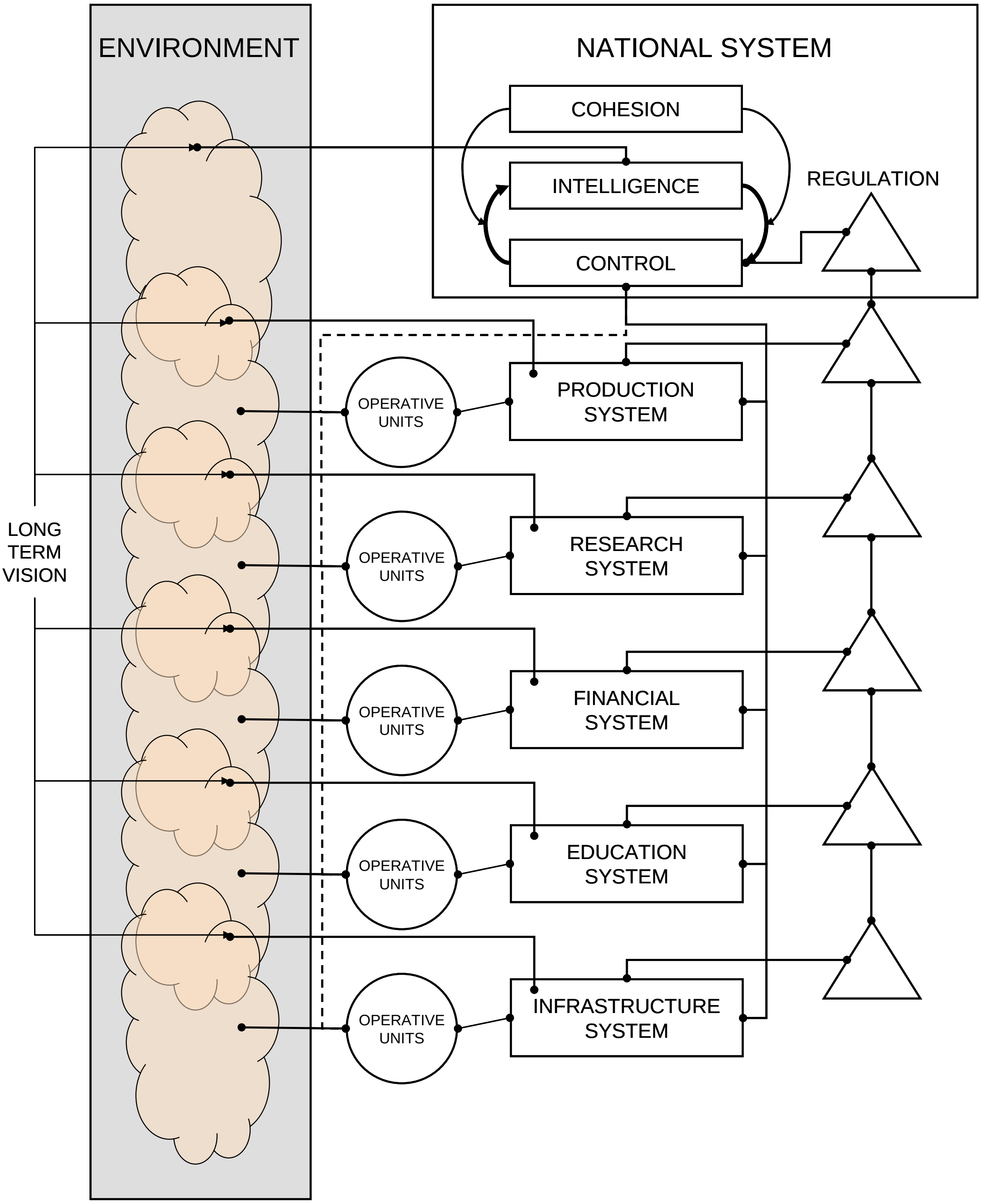

Table 1. Functions and dimensions of viable systems

Fundamental function	Local function	Dimension of recursion
Current stabilisation	Production	*n* (system)
Current and Long–term stabilisation	Regulation	Link between *n* and *n+1*
Current and Long–term stabilisation	Control	Link between *n* and *n+1*
Long–term stabilisation	Intelligence	*n+1* (metasystem)
	Cohesion	*n+1* (metasystem)