

Title

Regional Innovation Systems in Emerging Economies: Evidence of System Failures for Innovation

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Keywords

System Failures; Regional Innovation Systems; Science, Technology and Innovation Policy; System Dynamics; Emerging Economies; Mexico.

Objective

In relation to the analysis of regional innovation systems, scholars agree with the idea that it still remains unexplored some important questions. This is the case, for example, of the relationship between firms' innovative capabilities and the role they play within an overall regional innovation system (Mocciaro, 2012). In this regard, it would be also interesting to investigate the possibility to find some kind of system failures within regional innovation systems. In such cases, system failures may hinder the operation and development of the innovation systems as a whole (Wieczorek et al., 2012), and thus opening up the possibility of a new policy rationale that replaces the neoclassical market failure concept (Edquist, 1997; Wieczorek et al., 2012). In this research, we adopt a definition of system failure as '*systemic imperfections that might slow down or even block interactive learning and innovation in a given system of innovation*' (Woolthuis et al., 2005, p. 610).

The objective of this paper is therefore to contribute to the discussion on the role played by science, technology and innovation policy when system failures appear within a regional innovation system. In particular, we evaluate the possibility of finding system failures in the case of regional innovation systems in emerging economies as a consequence of immature innovation systems characterizing these economies. In so doing, we apply in this research system dynamics methods to develop a model of a regional innovation system in the case of Mexico.

In the literature on regional innovation systems, most of current analyses are characterized by a strong prevalence of conceptual studies and qualitative methods (D'Allura et al., 2012). Accordingly, an important issue in this research is to empirically identify and measure system failures within a regional innovation system to designing an adequate science, technology and innovation policy in order to boost innovation activities within a region. In the analysis of innovation systems, scholars have already identified several system failures (Chaminade and Vang, 2006; Chaminade et al., 2012; Woolthuis et al., 2005): (1) infrastructural failures, (2) transition failures, (3) lock-in/path dependency failures, (4) hard institutional failures, (5) soft institutional failures, (6) strong network failures, (7) weak network failures, and (8) capabilities failures. In this regard, and in opposition to the neoclassical concept of market failure, system failures within innovation systems may negatively influence the speed and direction of technological change and innovation processes (Wieczorek and Hekkert, 2012). However, in the case of emerging economies, the main concern about regional innovation systems is how they emerge and evolve to support regional economic growth through sustaining indigenous firms in the transition to a more innovative and competitive economy (Chaminade and Vang, 2006; Chaminade et al., 2012), as well as how learning interactions with other actors may generate some kind of technological spillovers that contribute to develop innovation capabilities among indigenous firms. Therefore, the design of a regional science, technology and innovation policy in the case of emerging economies should be capable to develop a self-containing regional innovation system that in these countries is characterized by being highly immature (Chaminade and Vang, 2006). Moreover, from this perspective, special attention must be paid to the systemic approach when analyzing regional innovation systems in the case of emerging economies given that it is implied an interactive learning and innovation process that takes place at regional level (Chaminade and Vang, 2006).

The complexity of the process of innovation activity derives from two assumptions: (1) it is a systemic phenomenon (Bergek et al., 2008; Smith, 2000; Woolthuis et al., 2005), and (2) it is pervasive and central to competitiveness among firms (Smith, 2000). From this perspective, innovation cannot be longer seen as a process of discovery, but rather as a non-linear process of learning (Mytelka and Smith, 2002). In fact, the innovation process involves complex interactions between the firm and its environment (Smith, 2000). However, by introducing this approach of innovation as a complex phenomenon, innovation system theory has given way to

identify new rationales for government intervention (Woolthuis et al., 2005). Basically, government intervention is justified when system failures appear. At this point, it is worth saying that there are four innovation-policy-relevant approaches that have been developed in the analysis of innovation systems based on the systemic and evolutionary view of innovation (Wieczorek, 2009): (1) the structural analysis of innovation systems (Nelson, 1993; Freeman, 1988), (2) the functional analysis of innovation systems (Johnson, 2001; Hekkert, 2007; Bergek et al., 2008), (3) the systemic problems approach (Smith, 2000; Jacobson and Johnson, 2000; Woolthuis et al., 2005), and (4) the systemic instruments approach (Smits and Kuhlmann, 2004; Wieczorek et al., 2009). In fact, these approaches should be seen as complementary rather than exclusive.

Finally, it is important to mention that the analysis of innovation systems from a systemic perspective is advantageous given that they involve many actors, structures and interactions (Cook et al., 2004; Niosi, 2010; Stamboulis, 2007; Viale and Pozzali, 2010; Vohora et al., 2004). In this sense, this approach allows analyzing institutions, organizations and policies endogenous to the economic system (Niosi, 2010). Moreover, this perspective should be understood as a way of investigating innovation systems as complex adaptive systems (McCarthy, 2003; Niosi, 2010; Viale and Pozzali, 2010), and as a way of exploring the theoretical and empirical basis of regional innovation systems in terms of the relations established between different actors in the process of technology transfer and innovation developments (McCarthy, 2003; Schwaninger and Grösser, 2008; Viale and Pozzali, 2010).

Research Methods

There are at least two reasons to favor a system perspective in the analysis of regional innovation systems (Viale and Pozzali, 2010): (1) each particular regional innovation system has its own characteristics, and (2) it is necessary to give a dynamic description of the configuration of a system of innovation in order to forecast the possible evolution in the near future. This perspective, along with probable system failures appearing at innovation systems, could be very helpful at the time of designing an adequate science, technology and innovation policy to foster innovation activities within a region. In this sense, it is important to have a suitable tool to modeling innovation systems, given that the majority of past analyses have been conducted according to a subjective and qualitative approach (D'Allura et al., 2012; Doloreux and Parto, 2004, 2005). In this regard, we argue in this paper that system dynamics methods are an adequate tool to address this task. Actually, system dynamics methods allow modeling and simulating regional innovation systems behavior given that this approach contributes to revealing the nature of the relationships established between different stakeholders participating in the process of innovation in a region. Moreover, system dynamics simulation models may contribute to theory development when the theoretical focus involves multiple and interacting processes, time delays and other nonlinear effects, as it provides an analytically precise means of specifying propositions linking constructs, assumptions, and a coherent theoretical logic underlying the theory (Davis et al., 2007). In addition, the construction of models based on system dynamics methods have become a mechanism for developing new theories in social sciences, given that this approach stresses the importance of the structure of the system when determining the behavior and relationships in which the system operates (Davis et al., 2007; Morecroft, 2007; Sterman, 2000; Schwaninger and Grösser, 2008; Wolstenholme, 1999).

Scholars agree with the idea that modeling and simulation in social sciences contributes to understand social phenomena in the real world (Davis et al., 2007; Sawyer, 2004). In this regard, system dynamics models have proved to be an adequate conceptual and methodological framework to model systems of innovation as a more formalized and precise theory as (Niosi, 2010): (1) they contribute to clarify the underlying causal relationships

between variables of the system, (2) they are useful dealing with time, (3) they are useful when data are scarce, (4) they can summarize and simplify the main assumptions and hypothesis of the model, (5) they uncover data to clarify the importance of different variables, and (6) they explore new possibilities when developing theories.

On the other hand, there are four basic elements characterize system dynamics models (Forrester, 1975): (1) feedback loops, (2) flows and stocks structure, (3) time delays, and (4) non-linearities. These characteristics reveal the fact that innovation systems can be seen as complex multi-loop systems interconnected within a structure that reinforces multiple feedback processes with a high degree of uncertainty. Actually, these features characterize innovation systems as constantly evolving systems in a disequilibrium, nonlinear, historically dependent, self-regulating, adaptive, and counterintuitive trajectory, making them to be resistant to policy (Sterman, 2000). Therefore, system dynamics simulation models may contribute to theory development when the theoretical focus involves multiple and interacting processes, time delays and other nonlinear effects as they provide an analytically precise means of specifying propositions linking constructs, assumptions, and a coherent theoretical logic underlying the theory (Davis et al., 2007). In this research, we suggest that regional innovation systems are composed by multiple dimensions (variables), each of which is associated with its own rate and direction of change causally connected to produce patterns of change in the innovation system (McCarthy et al., 2010). In short, models developed under the system dynamics approach are characterized by a series of feedback loops (reinforcing and balancing) and time delays that describe the complexity of the system (Sterman, 2000).

Results

It is important to note that the results to be presented at this conference are part of the results of a larger project still in progress. The total results to be achieved in this research are: (1) a qualitative analysis of system failures within regional innovation systems in the case of emerging economies (even if the main objective is to develop a simulation model, the qualitative analysis is important in that it allows establishing some preliminary explanations on the nature of the system failures in the case of emerging economies), (2) a system dynamics simulation model of a regional innovation system to assessing probable system failures that may appear throughout the innovation process (the results achieved from the simulation model may contribute to design a more accurate science, technology and innovation policy to fostering innovation activities within a region), and (3) a system dynamics simulation model in relation to some specific sectors in emerging economies applying this approach (as part of this research project, we are working now on developing a system dynamics model of the biotechnology innovation system in Mexico). It is important to mention that all these results will be evaluated and applied to the case of a regional innovation system in Mexico.