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Innovation policies for development: towards a systemic experimentation based approach

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Abstract

This paper sheds light on how to address, conceptualize and design innovation policies taking into account the specific characteristics of innovation systems in developing countries. The main purpose is to reflect on the policy implications of adopting the innovation system perspective to the particularities of developing countries.

Keywords: innovation systems, innovation policies, developing countries.

INNOVATION POLICIES FOR DEVELOPMENT: TOWARDS A SYSTEMIC EXPERIMENTATION-BASED APPROACH

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1. Introduction

This paper sheds light on how to address, conceptualize and design innovation policies taking into account the specific characteristics of innovation systems in developing countries. The main purpose is to reflect on the policy implications of adopting the innovation system perspective to the particularities of developing countries.

It is only recently that the concept of innovation has entered the development discourse and subsequently the agenda of policy-makers in developing countries and international aid organizations (UNCTAD 2007, UNIDO 2007, Farley et al. 2007). Implementing innovation policies in developing countries has proved to be a challenging task. Academics, development practitioners and policy-makers are still struggling with understanding how to conceptualize innovation in developing countries, identifying who are the beneficiaries of innovation processes and more generally conceptualizing innovation system policies in the South (Lundvall et al, 2006; Borras et al, 2008; Intarakumnerd and Chaminade, 2007). Furthermore, in designing innovation policies, policy makers often lack tools for identifying problems in the system and for selecting policies supporting innovation and competence building to tackle them.

Innovation systems in developing countries are very heterogeneous. Each system is embedded in a unique socio-economic institutional context and, in this sense, it is not possible to identify innovation policies that could be applied to *all* developing countries. Neither is this the purpose of this paper. However, the growing literature of innovation systems in developing countries suggests that innovation systems in developing countries differ from the mature innovation systems that we might find in the developed economies. Substantial differences in components and relationships indicate that just imitating innovation policies practiced in developed countries is unlikely to deliver the expected results. The purpose of this paper is to point out to the main differences between (most) innovation systems in developing countries and (most) innovation systems in developed countries and discuss the implications that these differences have for the identification of problems and opportunities.

There are different analytical frameworks for the identification of these problems. As opposed to the market-failure model proposed by the neoclassical analysis (Arrow, 1962) scholars in the system of innovation approach, propose to focus on *systemic failures* (Smith, 2000, Woolthuis et al, 2005, Chaminade and Edquist, 2006). In this paper we investigate how far this framework is useful for designing innovation policies in developing countries.

The reminder of this paper is structured as follows: First, we explain why innovation policy is relevant in developing countries. Then, we introduce what is meant by systemic problems, and apply the concept to developing countries. One of our main conclusions is the need to combine the concept of systemic failures with a pragmatic experimental approach. The main features of such experimental approach are presented in the last section of the paper.

2. Innovation policy and Developing Countries

2.1. Innovation policy in developing countries – why is it relevant?

Why should *innovation* be a policy priority at all in developing countries? This question is crucial when one takes into account the very limited resources that most governments in developing countries have and the acute socio-economic problems that they are facing (extreme poverty, famine, macroeconomic instability, external debt, etc). In this context, innovation policy might be seen as a luxury that most developing countries cannot afford at their current stage of development (UNCTAD, 2007).

In contrast to this view we will argue that innovation in general, and innovation policy in particular are *crucial* for development, at least for two reasons:

Firstly, innovation policy is crucial for developing countries because **innovation and learning, understood in a broad sense are fundamental for growth and industrial competitiveness and thus for catching-up** (Farley et al, 2007, Nelson, 2007 and Lundvall et al, forthcoming). Learning is the basis of innovation, competitiveness and growth. Two forms of learning are fundamental for innovation: the STI (Science, Technology and Innovation) and the DUI (Doing, Using and Interacting) modes of learning (Jensen et al, 2007; Lundvall, 2007).

STI refers mainly to learning through laboratory experimentation, codified knowledge and formal processes of learning. Innovation policy understood in a narrow sense, tends to focus almost exclusively on STI modes of learning and consequently on formal training and R&D as the main instruments for creating innovations. However, as innovation is also based on DUI modes of learning, innovation policy should also be concerned with supporting on-the-job learning and easing the interaction with the users.

Much of the current debate of the use of the term innovation and innovation policy in a developing country context emerges from a misconception of what we understand by innovation. Innovation refers not only to "new to the world" innovations but also to the absorption of innovation and technology existing somewhere else ("new to the firm"). We agree with Viotti (2002), that most innovation taking place in developing countries is related to the absorption of technology and competence building rather than resulting in introductions of new-to-the-world innovations[2]. This broad conception of innovation is crucial for development and catching-up.

Secondly, innovation policy is crucial for development because innovation can be targeted to solving or mitigating particular development problems (food scarcity, tropical diseases, land erosion etc). Innovation policy may be designed to target social pathologies (i.e. hunger, poor housing conditions, inadequate health care provision), tight economic conditions (a good example are the innovations in the financing industry with the introduction of micro credits) or particular economic activities (agriculture) or structures (informal economy) that dominate the economic structure of many developing countries. Crucial for justifying 'indigenous' efforts on innovation

[2] This is not exclusively of developing countries at all. Countries like Sweden, Norway, Denmark or Finland owe their prosperity to the capacity of firms to absorb and use new technology developed elsewhere, rather than to their ability to introduce radical innovations (Freeman and Lundvall, 1987; Lundvall, 1988)

through an adequate innovation policy is that many social pathologies are not on the radar screen of the TNCs or the political elite shaping the configurations of the innovation systems in the developing countries; it might just not be considered profitable to invest in solving these problems[3] or simply not carry sufficient political prestige (as opposed to creating high-tech enclaves as we witness in India and China today).

So, broadly defined, innovation is crucial for a socially inclusive catching-up process and for developing novel knowledge in specific areas. Innovation policy, understood in a broad sense, thus becomes a cornerstone of development strategies.

2.2. Rationales for innovation policy and systemic problems

One of the critical issues for policy-makers is to understand for whom, when, where and how they should intervene in the system. Different theoretical approaches take a different stand on when and how governments should intervene in the economy. As we have argued elsewhere (Chaminade and Edquist, forthcoming), hitherto the intervention-debate has been dominated by neoclassical economists. In their vocabulary policy-makers should intervene when there is market failure, that is, when the market cannot by itself allocate resources efficiently (Arrow 1962). Within the neoclassical paradigm, innovation is about the creation of new knowledge, knowledge is seen as equal to information -i.e., it is codified and accessible - and it is easily adaptable to the firm's specific conditions (Lipsey and Carlaw 1998). The main line of argument of the neo-classicals is that the uncertainty, appropriability and indivisibility that characterize scientific knowledge will lead to an underinvestment in R&D by private actors, thus justifying the intervention by the government creating incentives for the investment in R&D. As a consequence, the neoclassical approach leads to an overemphasis on the issues of appropriability and economic incentives for innovation and on R&D as the main innovative activity. While some of the initial axioms have been relaxed in subsequent developments of the theory like the New Economics of Science and Technology by Dasgupta and Stoneman among others (Dasgupta 1987; Stoneman and Dasgupta 1987) and the New Growth Theory (Romer 1986, 1990; Grossman and Helpman 1991, Aghion and Howitt 1992), the neoclassical axioms for innovation policy making continue to have great limitations (Bach and Mats 2005). There is still an assumption that agents are rational, that the system can achieve equilibrium and that there is a quasi linear relationship between R&D and growth, thus ignoring the fundamental uncertainty associated with the innovation process (Verspagen 2005) as well as the importance of feed-back from users of knowledge (Lundvall 1992).

Innovation system research emerged as a response to dominant neoclassical paradigms in policy making (Mylteka and Smith 2002, Sharif 2006) providing an alternative explanation of how innovation takes place and how DUI in combination with STI trigger innovation beyond R&D. While the neoclassical approach tended to downplay the specific institutional framework in which innovation activities take place, innovation system approaches highlights the role of learning (in firms and policy organizations) as shaped by the institutional setting. According to the literature on innovation system policies (Mytelka and Smith 2002; Borras et al, Forthcoming;

[3] See Arocena and Sutz, 2005 for some examples of drugs that are not considered profitable by large pharmaceutical companies despite the huge impact they will have on the population of poor countries

Chaminade and Edquist, 2006) governments are supposed to design innovation policies addressing specific systemic *problems* within the national innovation systems.[4] A systemic problem is broadly defined as the inability of the system to support the creation, absorption, retention, use and dissemination of economically useful knowledge through interactive learning or in-house R&D investments (Carlsson and Jacobsson, 1997, Norgren and Hauknes, 1999: Smith 2000; Woolthuis, Lankhuizen et al. 2005, Chaminade and Edquist, 2006).

Generally speaking the problems identified in the literature can be classified into problems related to the components of the system and problems related to the functioning of the system. While the market failure approach is about getting the prices right, the systemic approach is about getting the institutions right.

Problems related to the components of the system: This stream of literature alludes to different (and interrelated) problems associated to a) the competences and capabilities of the organizations of the system, b) the institutional frameworks and c) the interactions among organizational actors. First, the system might be deficient in some types of organizations, like research institutions, learning firms or intermediate organizations (infrastructure problems). Second, the organizations might be there, but they might be lacking sufficient *competences* (human, organizational, technological and so forth) reflected in a limited capacity to learn, adopt or produce new technologies over time. The lack of competences might also constrain their ability to engage in interactive learning with other organizations of the system, thus causing *network problems*. The interaction might also be limited by, for example, the absence of trust between the agents (*informal institutional problems)* or for example, a deficient regulation (*formal institutional problems).*

Problems related to the dynamics of the system: The literature on rationales refers mainly to difficulties that might arise when firms and other actors encounter technological problems or face changes in the prevailing technological paradigms that exceed their current capabilities (Chaminade and Edquist, 2006). These may be called *transition problems.* Typically, they appear when firms are confronted with not foreseen path shifts or radical innovations that demand certain capabilities that the firms and other organizations of the system lack at that point in time.

So, under the system of innovation perspective, policy makers should intervene when there is a systemic failure. Systemic failures need to be identified taking into account the specific characteristics of the system, its evolution or the socio-economic context in which it is embedded. In practical terms, what might be a problem in one system might not be a problem at all in another system.

This is especially important when trying to design policies that aim at strengthening innovation systems in developing countries. While we acknowledge the diversity of developing countries, it is plausible to say that innovation systems in developing

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In this paper we link public policy to 'problem solving'. This should be understood in a very broad sense including not only reactive but also proactive policies such as establishing new institutions that enhance the capacity of the system in opening up new sets of opportunities. Also we realise that some such systemic changes cannot be expected to emanate from the state itself but rather from social movements that give government policy a new direction away from clientelism and corruptive practises.

countries face different challenges than innovation systems in developed economies. Innovation policies in the South, in principle should differ from those implemented in the North. However, policy-makers in the South - through the intervention of international organizations such as the World Bank, IMF and UN - may be stimulated to adopt innovation policies from the North, not adequate for their specific systems. Designing adequate innovation policies requires:

a) a deeper analysis of the specificities of the innovation systems in the South and, as we will argue in this paper,

b) A great deal of experimentation.

This paper aims at providing some first steps and **working hypotheses** on how innovation systems in the South[5] differ from the ones in developed countries and what might are implications for the design of innovation policies in the South. In that sense, what follows needs to be seen as a first approximation that needs to be adjusted to national specific circumstances.

3. Understanding systems of innovation (and systemic problems) in developing countries

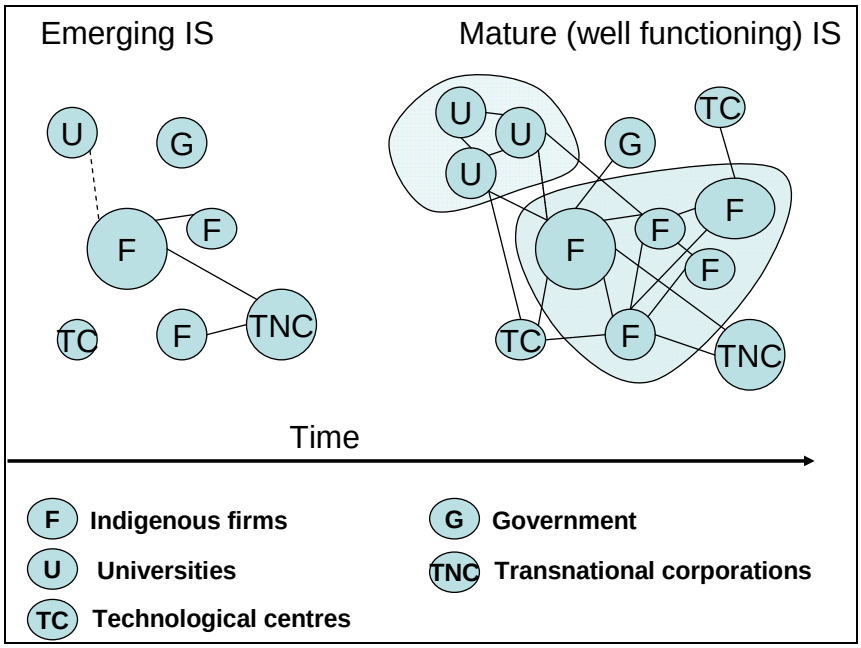
The literature on systemic failures has been developed with the implicit aim of correcting systemic failures in otherwise well-functioning innovation systems. However, well-functioning innovation systems, based on intense interactive learning are seldom found in the developing world. If we consider that an innovation system (IS) exists only when all its systemic aspects are in place, **it would be impossible to trace and identify any IS in developing countries** or the traces of ISs will be plagued with systemic problems having to do both with missing or weak component and with missing or weak links among the components.

In a less developed economy innovation systems can be better conceptualized in an evolutionary perspective, that is, they should be understood as emerging systems where only some of their building blocks are in place and where the interactions among the elements are still in formation and thus the system appears to be fragmented as Figure 1. shows.[6]

[5] As we have argued before, developing countries display a high degree of diversity in terms of systemic problems as well as cultural and institutional specificities. What is a problem that requires government intervention in one system, might not be what is required in another one. While the following discussion attempts to highlight some commonalities, we want to stress again that any analysis of a system has to take into account the specificities of that system, its trajectory and socio-economic and political framework.

[6] We are aware of the limitations of these graphical representations of an innovation system. In this sense, the figure should be considered only as an illustration of the differences between the two ideal phases in an innovation system. The 'interactions' are highly stylized as different sector across time and space will be organized differently.

Figure 13.1. Stages in the development of an innovation system



Source: Chaminade and Vang, 2008

According to the literature, in **emerging innovation systems** we might expect weak inter-sectoral links, the absence of interface units and universities specialized mainly in the supply of manpower (Galli and Teubal, 1997). DUI forms of learning are problematic as the competences of the users are low and the relationships are lacking in terms of trust (Lundvall, 1992, Lundvall, 2007). STI forms of learning can be weak due to the low level or research capabilities in universities and firms. In emerging innovation systems, firms and other building blocks of the system are not yet able to produce radical innovations but they are accumulating the competences and capabilities that are needed to engage in different forms of interactive learning. Innovation enabling policies tend to be constrained by (the lack of or limited) capacity and competence of policy makers partly as a function of internal political cultures and resources and the externally imposed requirements (i.e. by IMF and the World Bank).

The emerging innovation system might gradually evolve into a **mature innovation system**. In the mature innovation system interactions between the building blocks take place through market and non-market mechanisms such as informational links, interactions and other kinds of formal and informal networks. We might expect that firms and other organizations in the system have developed their absorptive capacity and are engaged in continuous interactive learning with other firms, users, universities and other organizations in the system. As said above it thus follows that, at this stage of development, the university-industry linkages become more important for catching up (Galli and Teubal, 1997).

Understanding that innovation systems in developing countries tend to be emerging innovation systems rather than mature ones has important implications for the identification of system constraints. Coming back to our

previous discussions, the question is not whether the elements and relationships within the system are weak but *what* elements *are critical* for the emergence and development of an innovation system into a fully fledged socially inclusive innovation system and how systemic innovation policies might be designed[7]. Identifying what elements and relationships are critical in emergent systems of innovation requires a deeper analysis of the specificities of systems of innovation in developing countries. The evidence on the functioning of innovation systems in developing countries is still rather limited. In this respect, what follows should be taken as hypotheses that will need further testing.

3.1. Capabilities in emergent systems of innovation

Competence building is central for the creation, absorption and use of knowledge for innovation and thus for upgrading. Most of the literature on innovation and developing countries argues that in emerging innovation systems, crucial capabilities are those related to the absorption and adaptation of technology from external sources of knowledge. The importance of *engineering and design capabilities* in early stages of development, when the absorption of technology is fundamental, has been largely highlighted in the literature (Bell, 1984, 2007, Bell and Pavitt, 1995, Lall, 1992, Figuereido, 2000, Lee et al. 1988). Substantial engineering capabilities make possible for the firms to experiment with the absorption of technology. In other words, technology access cannot be gained through transmission of 'blue prints' but it requires a complicated yet informed process of trial and error.

Only when a certain technical level is achieved, the indigenous firms might start focusing on the acquisition of *managerial competences* (Chaminade and Vang, 2008). It is not until later that *research capabilities* become crucial for innovation and growth.

Accordingly, our *hypothesis* is that the lack of STI research capabilities should not be considered the most important development constraint in the early phases in the formation of the system but the lack of engineering, design or even managerial capabilities should. If that holds true, policies supporting competence building and innovation should pay particular attention to training basic and advanced engineering, design and managerial capabilities.

Two important reservations need to be made here. Firstly, policy makers need to experiment with education institutions and firms with the aim of identifying the right type of engineering capabilities needed for the system of innovation (specialists or generalists, formal modellers or problem solvers), the right amount etc. The fact that science and codified knowledge is becoming increasingly important across sectors and firms even in agriculture, fishing and resource-extraction industries predominant in developing countries, does not imply that innovation policy can be reduced to science or technology policy and an exclusive focus on engineering capabilities.

[7] As we will argue later, designing policies requires a high degree of experimentation on new ways of identifying the 'critical elements' and finding creative novel solutions to the identified policy challenges.

Secondly, the former should not be interpreted as if experience-based learning and tacit knowledge have become less important for innovation. To bring innovations, including science-based innovations, to the market organizational learning, open industrial networks as well as employee participation ('shop floor' experimentation and up-scaling) and competence building are more important than ever. That is, a context specific combination of DUI and STI forms of learning is crucial (Lundvall, 2007). Independently of the stage of development, innovation in firms is enhanced when learning through science and technology is combined with on-the job learning and the interactions with users (Jensen et al, 2007). Firms that have introduced knowledge management practices and have flexible organizational structures tend to be more innovative than other firms, independently of the stage of development (Jensen et al, 2007; Freire Garcia-Zarco, 2007). The lack of learning organizations is a serious obstacle for the development of DUI forms of learning. Thus, our suggestion is that policies targeting the adoption of flexible structures in organization, knowledge management practices, etc. are fundamental for the transition towards mature innovation systems.

We believe that innovation and competence building in most developing countries would benefit from upgrading the skills of workers and farmers and from training more skilled workers and technicians. This can be done by formal education and training, but also by diffusing the concept of learning organizations among firms; the diffusion should function as heuristic device for local firms' experimentation with context specific learning organizational form.

The former discussion refers mainly to capabilities at firm level. But in emergent innovation systems, capabilities might be lacking also at university level. At an early stage of economic development our evidence suggests that the lack of advanced research capabilities at the university level is not the most critical weakness for the emergence of the system (Vang et al, forthcoming). However, when firms start moving towards more advanced activities in the value chain research capabilities become crucial (Chaminade and Vang, 2008). This does not imply that universities should not be built at early stage but it implies that their impact upon innovation might be less than expected if one takes the developed economies as a model.

There is a need to diversify both the education system (more technical schools) and the knowledge infrastructure (more technological institutes). As discussed by Brundenius et al (2008) too much is expected from universities and codified knowledge. The predominant idea that competence building is identical to university based knowledge is highly problematic. Diversified and rich knowledge systems where the transition from education to professional work is minimal are crucial for development.

3.2. Networks in emerging systems of innovation

Engaging in interactive learning (both STI and DUI) with other organizations of the system is fundamental for the development of innovations (Lundvall, 1992). Our hypothesis is that some linkages within the system of innovation are more important than others:

a) The interactions between indigenous firms and subsidiaries of multinationals

b) The interactions with domestic users and

c) The interactions with domestic universities for the provision of qualified human capital.

a) International user (TNC)-Producer

As a large amount of literature highlight, the lack of local knowledge resources in the IS of developing countries might force indigenous firms to rely much more on TNCs as providers of knowledge and capital (Pietrobelli and Rabellotti, 2006, 2008, Schmitz, 2006; Vang and Asheim, 2006, Giuliani et al, 2005, Padilla et al, 2008). For many indigenous firms the users tend to be TNCs and the relationship between these users and the indigenous producers is normally highly asymmetrical in terms of power, knowledge and incentives to collaborate. Firms in developing countries are often specialized in lower value-adding activities, which implies in most cases hierarchical or quasi-hierarchical relationships with the TNCs (Gereffi et al., 2005; Schmitz, 2006). Typically TNCs are reluctant to engage in interactive learning (i.e. joint experimentation) with the indigenous firms due to the low absorptive capacity of the latter, the lack of differentiation between firms and the goods that they supply and the fear of losing knowledge (D'Costa, 2006), as the vast literature on direct and indirect spillovers from TNCs to indigenous firms has demonstrated (Dunning, 1993; Dunning and Narula, 2004; Lall and Narula, 2004; Narula and Marin, 2005; Marin and Bell, 2006).[8] Unless there is substantial indigenous competence-base the TNCs will a) mainly locate routine activities in developing countries, b) locate knowledge exploiting activities with almost no direct or indirect spillovers or c) locate subsidiaries with a knowledge augmentation mandate which parasites on the indigenous R&D efforts (but still without substantial spillovers). As Pietrobelli and Rabellotti argued (op. cit.), in emerging systems of innovation interactions based on captive or hierarchical forms of governance tend to dominate. The accumulation of local capabilities might support the move to other forms of governance where interactive learning between the subsidiary of the transnational corporation and the indigenous firms is more likely to occur.

b) Domestic user-producer

While there is a great potential in absorbing knowledge from abroad, building competence on the user side domestically as well as enhancing the quality of non-market interactions (creating the conditions for trust) are crucial elements in a strategy aiming at building mature innovation systems, particularly considering DUI forms of

[8] Nevertheless Schmitz's (2006) recent survey illustrates that the interaction between TNCs and indigenous firms can lead to upgrading for the indigenous firms. Schmitz points to that upgrading and innovation especially happens in relation to product and process improvements but only seldom for functional upgrading. Schmitz however does not pay much attention to the open ended experimentation process the indigenous firms have to under go to move up the value chain. Hence, functional upgrading maintains a function of relation to the TNC not experimental learning.

learning. Our *hypothesis* is that the role of the domestic users might be more relevant in large markets like Brazil (Cassiolato et al, 2003), India or China (Yung-Chung et al, 2008). The development of the "nanocar" in India, the Lilliput computer, the take off of the mobile phone industry in China or the sugar-cane fuels in Brazil are good examples of the role of local users stimulating innovation in these large developing countries. However, one should not neglect the role that the domestic user can play also in smaller countries, particularly targeting local needs.

Policy makers can facilitate DUI forms of learning in developing countries by supporting learning organizations that promote on-the job learning but also by creating the institutional conditions for the emergence and consolidation of trust between users and producers[9].

c) University-industry

Interaction with universities is important in STI modes of learning. With regards to this form of interaction, the literature on rationales for public intervention in the innovation system refers to the lack of advanced research capabilities as an important systemic problem. However, our evidence suggests that the lack of advanced research capabilities at the university level is not the biggest problem in the emergence of the system, as we argued before (Vang et al, forthcoming). Only when firms start moving towards more advanced activities in the value chain, research capabilities become crucial.

The lack of intermediate organizations bridging the differences in technological capabilities between the TNCs, the universities and the indigenous firms is frequently a systemic weakness in emerging systems of innovation. Intermediate organizations such as measurement, standard and testing quality infrastructure, play a fundamental role translating the knowledge from TNCs to indigenous firms, particularly in least developed systems of innovation (Lall and Pietrobelli, 2005; Szogs, 2008; Szogs et al, 2008). One possible policy instrument for the development of linkages between different organizations in the system, is supporting the emergence (and sustained development) of intermediate organizations.

[9] Transnational communities can play a fundamental role supporting the creation of trust among users and producers, particularly across country borders.

Table 1. Systemic problems in developing countries[10]

Component	Mature innovation systems (Developed countries)	Emerging innovation system (developing countries)
Capability problems	Lack of research & technological capabilities (STI) and lack of close interaction with the customer (DUI) Absence of large research scale facilities for advanced basic science	Lack of engineering and design capabilities (STI, absorption of technology) Lack of managerial capabilities (intermediate stage of development of the IS) Lack of learning organizations and not sophisticated customers (DUI) Absence of technical centres
Network problems	Lack of dense inter-firm networks Weak university-industry research networks	Weak linkages TNCs-indigenous firms Weak linkages with customers Links university with rural communities and local needs (developmental universities) Insufficient provision of qualified human capital from universities to firms Lack of bridging organizations

[10] It should be noted that this list is not exhaustive and that it does not imply that other factors, including those listed under the mature industries are not important also for development. For example, policies supporting high-tech industries

Component	**Mature innovation systems (Developed countries)**	**Emerging innovation system (developing countries)**
Institutional problems	IPR Governance	Linking formal and informal institutions Innovation friendly business regulation Social inclusion Corruption IPR Provision of trust

3.3. Institutions in emerging systems of innovation: linking formal and informal

Despite a high degree of heterogeneity (different history, culture, political system) in the IS of developing countries, we will argue that they tend to be characterized by a low degree of institutional thickness and thus weak interactive learning (Amin and Thrift, 1995; D'Costa, 2006). Moreover, the links between informal and formal institutions seem in general to be weak.

Some recent evidence suggests that there is a strong interdependence between technological capabilities, innovation friendly governance and deeper social and cultural factors (Fagerberg and Srholec, 2008). The existence of an "innovation-friendly" business regulation is crucial for development. This includes the existence of an adequate regulation of the labour market, reliable IPR regimes, etc. Adequate soft institutional frameworks are also fundamental to the emergence and development of innovation systems. High levels of corruption, for example, are an important institutional barrier to the development of innovation systems and growth (Altenburg, 2008; Fagerberg and Srholec, 2008). The level of social inclusion is also crucial for the development of the system. The persistence of inequalities or the exclusion of some parts of the population from economic activities (due to poverty, religion, traditions, etc) has a fundamental impact on the capability of a system to emerge and evolve into a fully fledged innovation system as it neglects the potential for competence building of a part of the population (Cozzens, forthcoming).

Thus our hypothesis is that in emerging innovation systems, the lack of business regulation, weak or non-existing IPR regimes, high levels of corruptions or of social exclusion are important general problems that policy-makers should address. An example is corruption. Almost everybody will concur with that corruption hinders development. Yet, political experimentation with how corruption can be reduced is minimal. Instead there is a tendency to fall back on inefficient traditional control mechanisms.

3.4. Transition from an emergent system to a mature system

The transition from an emergent system to innovation to a mature innovation system is a rather unexplored research topic. We might expect that every system evolves in a different (partly path dependent) manner and following a different pattern. Understanding what are the building blocks of a system and what are the main drivers in the transition from an emergent to a mature innovation system requires systematic comparative analysis of systems over time and across countries or regions. This is a major research challenge for innovation system scholars. The problem of lack of data will be discussed in the next section.

4. Is a systemic failure approach enough? A step forward – policy experimentation!

The systemic failure approach might provide a useful framework to start discussing the conditions under which policy makers are expected to intervene. But it is rather abstract and does not consider the specificities of developing countries. In the previous section we have argued that innovation systems in developing countries are in most cases emergent systems or systems in construction (Arocena and Sutz, 2000; Chaminade and Vang, 2008). The capabilities, networks and institutions that are needed in early stages of development might be different from those required for more advanced or matured systems. But we have been careful in highlighting the word "might" and in presenting our ideas as hypotheses that need further testing.

The systemic failure approach, albeit useful, should not be applied as mechanical exercise assuming that agents (i.e. policy makers in this case) are rational, equipped with full information, incorruptible and with unlimited capacity to capture and analyze the information. By doing so, we would not be far from neoclassical assumptions. The lack of information on the functioning of the system is particularly acute in developing countries. This may be illustrated with the fact that

- Many countries, particularly the least developed countries, do not conduct any R&D or innovation surveys.

- For those countries where there are indicators, they mostly capture STI forms of learning (R&D investment, number of researchers, etc) but not DUI forms of learning. Indicators on organizational change or interactions with users (DUI forms of learning) have just recently been incorporated to innovation surveys. But only few (large) developing countries conduct innovation surveys and most have done it very recently (that is, there is not longitudinal data that can allow researchers to monitor the dynamics of the system).

- Finally, the long term data that would be necessary to monitor the transition of a system, is only available for few indicators in an even fewer number of countries.

Policy experimentation becomes then a cornerstone in the development and implementation of innovation policies in developing countries (Rodrik, 2008). This is a line of research that requires much more attention from researchers in the near future. Our tentative suggestions on processes and procedures that underpin such policy experimentation include at least the following:

A) Try to engage all major players in building a common vision for national development. Capitalists, workers, government, knowledge institutions and mass media. This way one creates the conditions for many voices to influence and shape the type of political experimentation.

B) Make efforts to reduce corruption and to train administrators who are loyal to the national development project. Unless people trust in the political project of the nation they are not likely to engage in the creation of the shared vision etc.

C) Build national innovation strategy in interaction with sectoral and regional initiatives. Stimulate the competition among regions and promote initiatives toward building regional innovation systems in laggard regions. Take into account and exploit their domestic and international links as potential sources of capability building.

E) Experiment with industrial, education and trade policy that, in the given context supports a production structure with a growing share of sectors offering cumulative learning, potential backward and forward linkages and high income elasticity. This will lead to a larger base of people who can participate in the different types of industrialization experimentation, hence increasing the skills and experience diversity that is required for policy innovations.

F) Support experimentation also at the level of different organizations in the system, for example, university research involved in experimental research targeting the needs of the poor, facilitating upgrading of traditional industries etc. Designing enterprise policy to create incentives for firms to increase their experimentation with innovations and upgrading (including investing internally in competence building) is also crucial. Programs offering 'appetizers' - free access to some services if the firms share their own experiences with other firms may be one example. Designing networking policy to create incentives for firms and research institutions to collaborate in problem solving - this might change the role of research institutions but it also requires competence and acceptance at the demand side - vouchers and good examples may play a role, is another example of joint experimentation.

5. Concluding remarks

In innovation policy in developing countries there are many challenges ahead, particularly with regards to the interaction between research and experimentation in the context of public policy (Rodrik, 2008).

One of the foremost challenges for policy makers is to conceptualize innovation systems as emerging innovation systems, where most of the elements of the system might be there but where the interactions between the organizations might be still in formation and some capabilities may be lacking and where there are no simple solutions to development. Identifying the problems in the particular system of innovation is a first step in designing adequate innovation policies.

A second challenge is to develop policy learning processes supporting the understanding of the specificities and particularities of the specific region or country under analysis. Developing countries are very heterogeneous and what might work in one country might be counter-productive in another. One cannot (and should not) transplant a specific 'best-practice' from one system to another (Rodrik, 2008). This is one reason why policy learning should take place through experimentation (Heilman, 2008 cf. Rodrik, 2008). Policy makers should dare to implement new measures, new instruments and learn from their impact on the system's ability to innovate. The identification of the problems should then be combined with policy experimentation with potential solutions.

A third challenge for policy makers is to acknowledge that there are different sources of innovation (DUI and STI). Innovation policy needs to address both these sources and acknowledge its differences. DUI will be even more rooted in soft institutions and organizational issues than STI. Active labor market policies and policies aiming at broad based education systems as well as at life-long learning may be seen as indirect ways to stimulate innovation through DUI-learning.

In developing countries much emphasis has been on the interaction between indigenous firms and TNCs as a main vehicle for acquiring the competences needed to upgrade and catch up. But as we have discussed in this paper, the interaction with domestic users is as important to pursue in emerging innovation systems. Often the weakness in a relationship reflects weak competence among users and here policies need to address this problem rather than assume that the weakness is located at the supply side. However, as emphasized through out this paper the specific types of policies for supporting this type of learning requires extensive local experimentation and policies supporting this.

Policy experimentation is crucial in a developing country context. In this paper we have only provided the first steps on the path towards an stimulating and challenging new research agenda.

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