Handbook of Innovation Systems and Developing Countries

Building Domestic Capabilities in a Global Setting

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13 Designing innovation policies for development: towards a systemic experimentation-based approach

Cristina Chaminade, Bengt-Åke Lundvall, Jan Vang and K.J. Joseph

13.1 Introduction

This chapter 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. We take as our point of departure the findings and contributions of the previous chapters in this *Handbook*.

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; 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., 2009; Intarakumnerd and Chaminade, 2007). Policy makers often lack tools for identifying problems in the system and for selecting policies supporting innovation and competence-building to tackle them.

Identifying innovation policies that could be applied to all developing countries is impossible. The heterogeneity in the configuration of their specific innovation systems is too large. Each developing country is embedded in a specific socio-economic institutional context. Nonetheless it is useful to consider how 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 suggest that just imitating innovation policies practised in developed countries is unlikely to deliver the expected results. Scholars and policy makers face a great challenge when it comes to identifying the required innovation policy measures.

There are different analytical frameworks for the identification of problems that require policy intervention. As opposed to the market failure model proposed by 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 chapter we investigate how far this framework is useful for the design of innovation policies in developing countries.

The reminder of the chapter 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.

BOX 13.1 POLICIES IN DEVELOPING COUNTRIES: MAIN CONCEPTS USED IN THIS CHAPTER

Systemic failure: the inability of a system of innovation to support the creation, absorption, retention, use and dissemination of economically useful knowledge through interactive learning or in-house R&D investments.

Emerging innovation system: a system where only some of its building blocks are in place and where the interactions between the elements are still in information.

Policy experimentation: equivalent to some extent to policy learning. It refers to the act of trying different and novel alternatives in the design of policies that might support innovation in very specific contexts, as opposed to the mere imitation of policies.

13.2 Innovation policy and developing countries

13.2.1 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, and so on). 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.

First, 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 Chapter 1 in this volume). As discussed in Chapter 1, learning is the basis of innovation, competitiveness and growth. Innovation understood in a broad way embraces two forms of learning, the STI (Science, Technology and Innovation) and the DUI mode (Doing, Using and Interacting). STI refers mainly to learning through laboratory experimentation, codified knowledge and formal processes of learning. The narrow approach to innovation policy 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.

As we argued in the introductory chapter, much of the current debate on 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. 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 and so on). Innovation policy may be designed to target social pathologies (that is, hunger, poor housing conditions, inadequate health care provision), tight economic conditions (innovation in the financing industry with the introduction of micro credits is a good example) or particular economic activities (agriculture) that dominate the economic structure of many developing countries. Crucial for justifying 'indigenous' efforts on innovation 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[1] 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 developing novel knowledge in specific areas; as a consequence, innovation policy becomes a cornerstone of development strategies (not just science and technology policies, as we emphasized in Chapter 1 in this volume).

13.2.2 Rationales for innovation policy and systemic problems[2]

Different theoretical approaches take a different stand on when and how governments should intervene in the economy. 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 (Nelson, 1959; Arrow, 1962). Within the neoclassical paradigm, innovation is about the creation of new knowledge, and knowledge is seen as equal to information, that is, it is codified, generic, and it is accessible and easily adaptable to the firm's specific conditions (Lipsey and Carlaw, 1998). 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 who should create incentives for the investment in R&D. The neoclassical approach leads to an overemphasis on R&D as the main innovative activity and on the issues of appropriability and economic incentives for innovation. While some of the initial axioms have been relaxed in subsequent developments of the theory such as the 'New Economics of Science and Technology' by Stoneman and Dasgupta 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 theory continues to have great limitations (Bach and Mats, 2005). The new growth theory continues to assume 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 feedback from users of knowledge (Lundvall, 1992).

While appealing as a formal theory the concept of market failure is very abstract in practice and thus fails to deliver practical recommendations for policy makers when it comes to delimiting scale, scope and timing of interventions. As discussed in the chapter by Cimoli et al. in this volume, it may be argued that the modern economy is a giant example of market failure.

Innovation system research emerged as a response to dominant neoclassical paradigms in policy making (Mytelka 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 highlight 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; Borrás et al., 2009; Chaminade and Edquist, 2006), governments are supposed to design innovation policies addressing specific systemic *problems* within the national innovation systems. 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 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.

Problems related to the components of the system: This stream of literature alludes to different problems related to the competences and capabilities of the organizations of the system, to weak institutional frameworks, as well as to their interactions. 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: These are mainly 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 path shifts or radical innovations not foreseen and requiring capabilities that the firms and other organizations of the system lack.

The (fairly limited) literature on rationales for innovation systems can be criticized in many different respects.

First, it is obvious that there are limits to how far one can go in terms of general recommendations for public policy starting from a system of innovation perspective – based on bounded rational agents confronting complex development problems. One of the reasons for this limitation is the fact that the theory hitherto seems to be completely oblivious to the specific characteristics of the system, its evolution, the socio-economic context in which it is embedded and the (global) unbalanced distribution of knowledge (Dolfsma et al., 2008). In practical terms, what might be a problem in one system might not be a problem at all in another system.

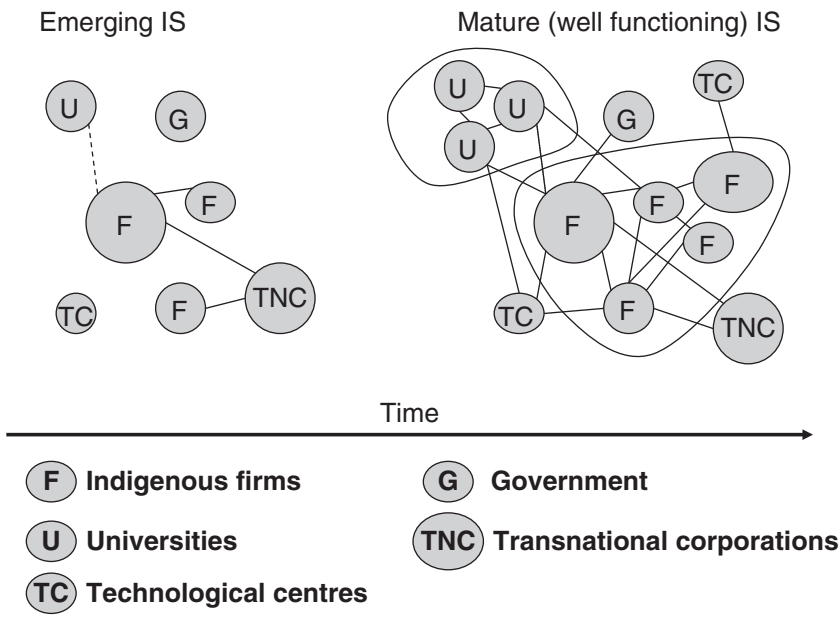
This is especially important when trying to design policies that tackle problems in innovation systems in developing countries. While we acknowledge the diversity of developing countries (and the difficulties in comparing different countries or even identifying general characteristics of developing countries versus developed countries), it is plausible to say that innovation systems in developing countries face different challenges than innovation systems in developed economies. Thus in principle, innovation policies in the South 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 for developing countries requires:

a. a deeper analysis of the specificities of the innovation systems in the South and, as we will argue in this chapter;
b. a great deal of experimentation.

By drawing on some of the findings presented and discussed in this volume, this chapter aims at providing some first steps and *working hypotheses* on how innovation systems in the South[3] differ from the ones in developed countries, and what the implications might be 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.

13.3 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 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



Source: Chaminade and Vang (2008).

Figure 13.1 Stages in the development of an innovation system

ISs will be plagued with systemic problems having to do both with missing or weak components 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 13.1. shows.[4]

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 of 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 (that is by the 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 than in earlier stages (Galli and Teubal, 1997).

Understanding that innovation systems in developing countries tend to be emerging innovation systems 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 a system of policy learning/experimentation should be designed that allows for coming up with new ways of identifying the 'critical elements' and thus creating novel solutions to the problems.

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 analysis presented in the previous chapters of the *Handbook* might serve as a starting point for the discussion of particular problems that innovation systems in developing countries face in terms of capabilities (capability problems), networks (network problems) and transition to a mature innovation system. 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 need further testing.

13.3.1 Capabilities in emergent systems of innovation

As we have argued before, competence-building is central for the creation, absorption and use of knowledge for innovation and thus for upgrading. It is in this way one of the fundamental pillars of growth and competitiveness and also of poverty reduction (Cozzens and Kaplinsky in this volume).

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 and Pavitt, 1995; Lall, 1992). Substantial engineering capabilities make it possible for the firms to experiment with absorption of technology. Technology access cannot be gained through transmission of 'blueprints' but it requires a complicated yet informed process of trial and error.

Only when a certain technical level is achieved, might the indigenous firms start focusing on the acquisition of *managerial competences* (Chaminade and Vang, 2008). In the case of Sasol (Barnard et al. in this volume) it was only after more than a decade from its foundation that the firm started to import management practices like process improvement programmes and management training.

And 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. Nevertheless it is again necessary to underline that this represents a crude approximation to policy only, and needs to be supported by a wide range of experimentation in education institutions, firms and policy makers with the aim of finding the right number and type of engineers (specialists or generalists, formal modellers or problem solvers) demanded by industry and research organizations.

The fact that science and codified knowledge become 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. Neither does it mean that 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, and so on are fundamental for the transition towards mature innovation systems.

In emergent innovation systems, capabilities might also be lacking 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. However, when firms start moving towards more advanced activities in the value chain, research capabilities become crucial. This does not imply that universities should not be built at an early stage but it implies that their impact upon innovation might be less than expected if one takes the developed economies as a model.

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 devices for local firms' experimentation with context-specific learning organizational form.

There is a need to diversify both the education system (more technical schools) and the knowledge infrastructure (more technology institutes). As discussed in the chapter by Brundenius et al., too much is now 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.

13.3.2 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). Based on the diverse chapters in this *Handbook* our hypothesis is that some linkages within the system of innovation are more important than others:[5]

a. The interactions between indigenous firms and subsidiaries of multinationals (see chapters by Marin and Arza, Barnard et al., Pietrobelli and Rabellotti, Cozzens and Kaplinsky and Padilla-Pérez et al.).
b. The interactions with domestic users (see introductory chapter by Lundvall et al.).

c. The interactions with domestic universities for the provision of qualified human capital (see chapters by Brundenius et al., Padilla-Pérez et al., Barnard et al.).

a. International user (Transnational Corporation (TNC))–Producer The lack of local knowledge resources in the ISs of developing countries might force indigenous firms to rely much more on TNCs as providers of knowledge and capital (Pietrobelli and Rabellotti, 2006; Schmitz, 2006; Vang and Asheim, 2006 and chapters by Cozzens and Kaplinsky, Pietrobelli and Rabellotti, Marin and Arza, Padilla-Pérez et al. or Barnard et al. in this volume). 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. The 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 (Schmitz, 2006). Typically the TNCs are reluctant to engage in interactive learning (that is 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 and Marin and Arza in this volume for a complete review of the literature).[6] Unless there is substantial indigenous competence-building 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). Pietrobelli and Rabellotti (2006) argue that 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 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 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 (Yun-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 also play 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.[7]

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 emerging innovation systems. Only when firms start moving towards more advanced activities in the value chain, do 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 (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.

13.3.3 Institutions in emerging systems of innovation: linking formal and informal

Despite a high degree of heterogeneity (different history, culture, political system) in the ISs 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, 1994; D'Costa, 2006). Moreover, the links between informal and formal institutions seem in general to be weak.

Chapter 4 in this volume by Fagerberg and Srholec explicitly explores the role of some hard and soft institutions in growth and development. The authors show that there is a strong interdependence between technological capabilities, innovation-friendly governance and deeper social and cultural factors. The existence of an 'innovation-friendly' business regulation is

Table 13.1 Systemic problems in developing countries[a]

Component	Mature innovation systems (developed countries)	Emerging innovation system (developing countries)
Objective of the system	Creation of knowledge	Absorption of existing knowledge
Stage of development of the system	Mature, well developed	Emerging, system in construction
Systemic problems (related to the components of the system)		
Capability problems	Lack of research & technological capabilities (STI) and lack of close interaction with the customer (DUI)	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 large-scale research facilities for advanced basic science	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
Institutional problems	IPR Governance	Linking formal and informal institutions Innovation-friendly business regulation Social inclusion Corruption IPR Provision of trust

Note: [a] 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 also important for development. For example, policies supporting high-tech industries.

crucial for development. This includes the existence of an adequate regulation of the labour market, reliable IPR regimes, and so on (see also Chapter 7 by Joseph on the role of these hard institutions in the development of the sectoral system of innovation of the ICT industry in India). Adequate soft institutional frameworks are also fundamental to the emergence and development of innovation systems. As discussed by Altenburg (Chapter 2) and Fagerberg and Srholec (Chapter 4), high levels of corruption are an important institutional barrier to the development of innovation systems and growth. The level of social inclusion is also crucial for the development of the system. The persistence of inequalities (Chapter 3 by Cozzens and Kaplinsky) or the exclusion of some parts of the population from economic activities (due to poverty, religion, traditions, and so on, see Chapter 4 by Fagerberg and Srholec) 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.

Thus our hypothesis is that in emerging innovation systems, the lack of business regulation, weak or non-existing IPR regimes, high levels of corruption or of social exclusion are important general problems that policy makers should address. An example is corruption. Almost everybody will agree 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.

13.3.4 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, even in this *Handbook*. We might expect that every system evolves in a different (partly path-dependent) manner and following a different pattern. Understanding what the building blocks of a system are and what the main drivers in the transition are 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.

13.4 A step forward – policy experimentation!

As we have argued before, 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 systems in construction. The capabilities, networks and institutions that are needed in early stages of development may be different

from those required for more advanced or mature systems. But we have been careful in highlighting the word 'may', and in presenting our ideas as hypotheses that need further testing.

The systemic failure approach, albeit useful, should not be applied as a mechanical exercise assuming that agents (that is policy makers in this case) are rational, equipped with full information, incorruptible and with unlimited capacity to capture and analyse the information. The lack of information on the functioning of the system is particularly acute in developing countries. This may be illustrated by the facts 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, and so on) but not DUI forms of learning. Indicators on organizational change or interactions with users (DUI forms of learning) have just recently been incorporated into innovation surveys. But only few (large) developing countries conduct innovation surveys and most have done it very recently (that is, there is no 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 smaller number of countries.

Policy experimentation then becomes 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 the political project of the nation they are not likely to engage in the creation of the shared vision and so on.
c. Build a 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.

d. Experiment with industrial, education and trade policy which, 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.

e. 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 and so on. 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. Programmes offering 'appetizers' – free access to some services if the firms share their own experiences with other firms – may be one example. Another example of joint experimentation is 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.

13.5 Concluding remarks

In innovation policy in developing countries there are many challenges ahead, particularly with regard 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 still be 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. 'Statistical significance' indicating efficient means–ends relationships in a specific country is no guarantee that the same contribution to successful development can be replicated in a different context (see also Chapter 1 in this volume). One cannot easily transplant a specific

'best-practice' from one system to another (Rodrik, 2008). This is one reason why policy learning should take place through experimentation (Heilmann, 2008; compare 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 labour 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 chapter, 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 throughout this chapter, the specific types of policies for supporting this type of learning require extensive local experimentation and policies supporting this.

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

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Notes

1. 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.
2. This section is based on Chaminade and Edquist (forthcoming).
3. Developing countries display a high degree of diversity in terms of systemic problems as well as cultural and institutional specificities. What is a problem requiring government intervention in one system, might not be considered a problem in another one. While the following discussion attempts to highlight some commonalities, we want to stress that any analysis of a system has to take into account the specificities of that system, its trajectory and socio-economic and political framework.
4. 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 differ-

ences between the two ideal phases in an innovation system. The 'interactions' are highly stylized, as different sectors across time and space will be organized differently.

5. However, behind this the message in this book is also that policy makers should increasingly pay attention to the successful cases of the different types of interactive learning with the aim of up-scaling them to the national level or transmitting and adapting them to other contexts.
6. Nevertheless Schmitz's (2006) recent survey illustrates that the interaction between TNCs and indigenous firms can lead to upgrading for the indigenous firms. Schmitz indicates that upgrading and innovation happens especially 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 undergo to move up the value chain. Hence, functional upgrading maintains a function of relation to the TNC, not experimental learning.
7. Transnational communities can play a fundamental role supporting the creation of trust among users and producers, particularly across country borders.

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Epilogue: which way now?

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There are many different paths to follow for future research on innovation systems and economic development. One important issue that we discussed in Chapter 13 is how research may interact with experimentation in the context of public policy (Rodrik, 2008).

The fact that there is a lot of overlap and interaction between analysis of innovation systems at different levels of aggregation and that the field, while anchored in socio-economics, has been open for interdisciplinary collaboration is a major strength. It makes it more relevant than mainstream development economics where there is little feedback between micro and macro approaches and where disciplines outside economics are regarded with disdain. Several of the issues raised below will require interdisciplinary efforts.

What is development?

A first priority might be to give a clearer meaning to 'development' and to understand better how it relates to economic growth. Sen's capability approach constitutes a kind of micro-foundation for a theory about development. We believe that it might be possible to develop a macro theory of development by combining Adam Smith's economic perspective and the extension of the division of labour with George Herbert Mead's interactionist perspective. According to Mead, 'civilization' grows out of extending who is defined as a 'significant other', and he refers to the spread of markets and religion as forces that extend communities from village, to region, to nation and so on. This may correspond to a transformation of social capital establishing more 'generalized trust'.

Another important dimension of development that is not fully reflected in Sen's capabilities refers to learning and autonomy at the workplace. Economic development has been linked to industrialization. And this is a process where farmers engaged in simple work are brought into factories with Taylorist working conditions. After an immediate period of drastic cultural adaptation the room for learning is limited. This may be contrasted with the patterns in the most developed economies. Here only a small proportion of the workforce has Taylorist (less than 10 per cent

in the Scandinavian countries) or simple (less than 20 per cent) jobs. The rest are engaged in problem solving where they learn new things (Lorenz and Valeyre, 2005). What people do and what they learn in their daily work is fundamental for the structuring of society and we would propose that researchers should pay more attention to this dimension of national systems of innovation. Combining different forms of learning correlates with innovation performance (Arundel et al., 2007) and at the same time it may be used as an important indicator for economic development.

Deepening our understanding of the factors affecting development is another fundamental venue for research. Some of the chapters included in this *Handbook* illustrate the importance of social inclusion, governance, adequate business environment, and so on as preconditions for development. As we mention later, understanding the role of institutions in development is another important research venue on which researchers in innovation systems might shed some light.

Understanding knowledge and learning

One important challenge for innovation system analysis both in the more and the less developed parts of the world is to deepen the understanding of how different kinds of knowledge are created and used in the process of innovation. Some elements of knowledge are local and tacit, embodied in people and embedded in organizations. Other elements are global, explicit and can easily be transferred from one part of the world to another.

While information in principle can move freely from one part of the world to another through the use of telecommunication technologies, competence is embodied in people or embedded in organizations or even in institutions. But even in the case of information, the capacity to understand and use it may be very demanding. The geographical distribution of people with the background necessary to make use of scientific information is extremely unevenly distributed and actually today the forces attracting the scientific elite to a limited number of places (such as the universities in Berlin, Paris, Oxford, Cambridge, Harvard, MIT, Stanford and so on) are strong.

To understand how learning takes place within organizations as well as in the interaction between organizations is a key to understanding how systems of innovation work. While it is important to study national characteristics in terms of organizations that pursue R&D, it is equally important to understand national characteristics in terms of how firms interact with customers and to what degree different firms give employees access to competence-building in connection with ongoing economic activities.

One major challenge for research is to develop concepts that can be transformed into measurable indicators. Human capital measurements

may represent formal investment in education, but what people learn at the workplace or as consumers is not easy to capture through standard measurements. The absence of indicators makes the area less visible for policy makers and this contributes to a bias in innovation policy toward promoting STI activities rather than DUI activities.

Innovation systems, institutions and entrepreneurship

To comprehend how learning takes place it is fundamental to understand the role of institutions on learning and innovation. So far most innovation system research has paid attention only to formal institutions or organizations, while informal institutions such as culture, customs, time-horizon and so on are often ignored. Some exceptions are Lundvall (Lundvall, 1992; Lundvall et al., 2006), Johnsson (Johnsson et al., 2003) or Oyelaran-Oyeyinka (2006). This is much in line with business systems research, varieties of capitalism research and the early intercultural communication research represented by authors like Hofstede (1991). Understanding institutions and the role they play in innovation and development is an issue that deserves more attention by researchers.

Equally central is the conceptualization of the role of entrepreneurs. Despite the centrality of the entrepreneur in the initial work by Schumpeter on innovation, innovation system researchers are yet to develop an institutionally grounded theory of entrepreneurship. It is worth exploring the linkages between national innovation styles and the essentially non-institutional entrepreneurship literature drawing on Burt's structural holes and maybe even Kirzner's analysis of the entrepreneur as an 'equilibrium' creator. It is important to sort out different conceptualizations of entrepreneurship. Some developing countries are leading the world in terms of the frequency of start-up firms but suffer from too little entrepreneurship initiative within existing firms. Bringing in the perspective of 'collective entrepreneurship' might open up more fruitful directions for research.

Innovation, inequality and development

In Chapter 2 Tilman Altenburg calls for research linking innovation to inequality, and in Chapter 3 Cozzens and Kaplinsky outline a wide field for such research. Besides traditional measures of inequality the distribution of capabilities as defined by Sen should be considered. Of special interest in the context of innovation system perspective would be the inequality in accessing learning (Lundvall, 1996). Innovation may be seen as part of creative destruction, and while some specific sectors and locations may benefit from it, others may be worse off. Some of the most successful economies in the world have developed welfare states that tax the

winners and compensate the losers by offering them some basic security in processes of change. Research might highlight the potential for building embryonic welfare states that fulfil such functions.

In general it is important to get a better understanding of how income distribution, social cohesion and generalized trust relate to each other as well as to economic processes including interactive learning, networking and innovation. Such research might end up showing that there are different development paths and different modes of innovation where some operate with high degrees of inequality while others build upon social cohesion. Such studies may be helpful in showing that there are alternative policy strategies for developmental states.

National, international, sectoral and regional dimensions

Since the national level appears as central in the innovation system approach it is important to analyse the role of the nation state both as a political cultural phenomenon and as a territorial concept. There is little doubt that nation states have played a key role in mobilizing resources and not least as frameworks for building competence through education. For good reason 'nationalism' has gained a bad reputation in the history of mankind but it might be difficult to establish the necessary developmental effort without some common purpose, and here the nation has been an important option. But nation states are very different constructs in terms of the degree of size, heterogeneity and inequality. One priority is to specify the conditions for nation states to become developmental and at the opposite end to explain why some nation states appear to be failed states (Wade, 2004).

Another priority is to understand how the different forms of opening of national and regional economies contribute to or hinder economic development. This has been a theme in several of the contributions to this volume, but more research is needed. While the emergence of global value chains as well as the formation of global champions opens up the national and regional systems of innovation, it is not obvious that the process makes them less important as a framework for economic development. To understand what capabilities and institutions need to be established in order to benefit from different forms of international openness is fundamental.

Innovation systems in developing countries are heterogeneous. Often modern sectors making use of advanced technology co-exist with informal sectors characterized by underemployment, low productivity and stagnation. In classical development, economics development was seen as moving labour from the primitive to the modern sector. This is still an important issue. But more research is needed to find out if there is also room for

modern activities to be built more directly within informal sectors and for stronger links to be created between the two types of sectors. Here the sectoral system approach may play a key role in pointing to cases where such strategies have been successful and to specify the mechanisms at work.

Innovation systems in developing countries are also heterogeneous in terms of the geography of competence and knowledge. The modern activities are often concentrated in regional industrial clusters and they draw upon local knowledge infrastructure as well as on international sources of knowledge. To pursue research that compares and contrasts different regional systems of innovation within major emerging economies such as India and China may be the best way to understand the specificities of innovation systems. Analysis of the degree of integration of such regional systems in the overall local economy, including activities in the informal sector, may inspire industrial and regional policy.

Research strategies

How to organize research? What are the specific circumstances for doing research on and in developing countries? What kind of information can be gathered in research and what kind of research is it most worthwhile to pursue?

One way of organizing research might be rather big national projects with a 2 to 5-year time horizon dominated by local scholars but integrating international experts, including experts from other developing countries. Such big projects may combine data from the micro-level of the single firm, with data on inter-firm cooperation and interaction with knowledge structure with analysis of institutions shaping finance, labour markets and education systems. Within such a framework comparisons would be very relevant between regions taking into account their openness to other regions as well as the international openness.

Another way would be systemic comparative analysis of systems of innovation across countries, regions and industries. Most research on systems of innovation is based on the analysis of one national innovation system, sectoral or regional. While individual analysis is useful to understand the evolution of an innovation system over time, the systematic comparative analysis of different systems across similar dimensions might help to identify similarities as well as differences in innovation systems. We cannot fully grasp the differences between the agro-processing system of innovation and the ICT if we do not compare the same sectoral innovation systems across countries or regions. Only then will we be able to identify the sectoral specific elements that hold across countries or regions.

Often statistics will be lacking and major systematic surveys may be difficult to pursue in a developing country. A good starting point is to contact

some experienced people from business, public sector, trade unions and research, and to interview them about the problems to be analysed. This might lead scholars to other experts and at the end of such an opening round hypotheses about barriers for change as well as unexploited opportunities may be formulated. A wider set of agents may be called upon to qualify the hypotheses and on this basis it might be possible to design questionnaires and rather specific quests for data. This strategy takes as its starting point that there is valid knowledge based upon experience and that this knowledge should be used. It also has the advantage of building up a set of advanced users of the results of the project.

One problem with such strategies is that the incentive structure in current academic life does not promote this kind of research. As mentioned before in connection with the new wave of statistics in developmental economics, what matters most when it comes to getting published is the elegant use of advanced tools. Since scholars in developing countries are rewarded mainly on the basis of publications in international journals, they need to adjust to this reality. On the other hand the big project mentioned here constitutes an ideal training ground for Ph.D. students. But without major backing from outside the academic community the chance to establish and pursue such projects is small.

The road ahead is long but very stimulating and challenging. We are faced with many research challenges and unanswered research questions. But there is a growing community of researchers in innovation systems and development. Networks such as Globelics, Asialics or Cicalics provide a good platform for researchers around the world to exchange ideas, build large projects and contribute to our current and future understanding of innovation systems in developing countries.

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