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Innovation Systems and Capabilities in Developing Regions

Concepts, Issues and Cases

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CHAPTER 1

Innovation Systems and Capabilities in Developing Regions: Concepts, Issues and Cases

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The aim of this book is to integrate theoretical and empirical contributions as well as case studies on the subjects of innovation systems (IS), technological learning and technological capabilities (TC) in developing countries. In today's knowledge-driven world, innovation has risen in relevance to become a key policy issue. Unfortunately, the extent of knowledge (both theoretical and empirical) that is available on this concept in the less developed countries is still low. Much of what we know about innovation theory has come from the developed countries and seen in the world view of advanced economies (Oyelaran-Oyeyinka et al., 1996). This critical knowledge deficiency is not without implications for the less developed countries.

For instance, received theory has, for a long time, denied the evidence of innovation for small producers in low-income countries and assumed that these producers will only play a limited role in formal economies, international markets and globalization (Lewis, 1954; Schumacher, 1973; Voeten et al., 2009). However, in current debates about development and technical change, innovation is often represented as providing opportunities and conditions for developing countries to participate in the world economy (see for instance Caniëls and Romijn, 2007; Goedhuys, 2007; Fagerberg and Godinho, 2006). Innovation is seen as a potential way in which low-income countries can strengthen their firms' competitive position within global value chains (Gereffi et al., 2005; Kaplinsky, 2000).

The literature on innovation and learning suggest that firm-level competitive advantage flows from the creation, ownership, protection and use of certain knowledge-based organizational resources. Thus, better organizational performance depends mainly on the firm's ability to be good at technological learning and innovation. At the meso-level, the performance of specific sectors and industries depends largely on the aggregate innovativeness of the constituent firms. At the macro level, effective policies to stimulate and sustain technological development require a good understanding of the dynamics of

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micro- and meso-level innovation and technical change (Lundvall et al., 2009; Egbetokun et al., 2009, 2010).

In recent years, studies examining the mechanisms and characteristics of innovation and technical change have multiplied; albeit disproportionately skewed towards developed countries (Hoffman et al., 1998; Becheikh et al., 2006). However, there is currently a growing focus on how to strengthen learning and capability building in developing economies. From the growing body of research, our understanding of the sources, motivations and obstacles of innovation in less developed countries has also increased to the extent that they are now demonstrating a re-orientation towards the facilitation of strong National Innovation Systems (NIS),[1] and innovation based on the accumulation,[2] assimilation and diffusion of embodied technology. In achieving the foregoing, technological learning and capabilities have a central role to play (Lundvall et al., 2009).[3]

Pulling all of the foregoing together, the specific issues addressed by the contributions in this volume include:

- an explicit application of the IS approach to developing countries;
- the role of diffusion-based innovation linked to technology transfer and acquisition as well as international cooperation in latecomer contexts;
- constraints and drivers of innovation in the developing contexts;
- how firms learn to innovate and build up TC in the developing world;
- the characteristics of actors in developing country IS.

Our Conceptualization of Innovation, Innovation Systems and Innovation Capabilities

INNOVATION IN THE CONTEXT OF DEVELOPMENT

In the 2006 Least Developed Countries Report (UNCTAD, 2006), one of the major points made is that the development and enhancement of productive capacities in any country occurs through capital accumulation, technological progress and structural change; but these three processes are heavily constrained in less developed countries. As a way forward, the 2007 report (UNCTAD, 2007) emphasized the centrality of technological learning to technological progress and structural change in poor developing countries. The argument goes in the direction of what we, following UNU-INTECH (2004), choose to describe as diffusion-based innovation.

> *For poor developing countries, technological change occurs primarily through technological learning based on the acquisition, diffusion and upgrading of technologies that already exist*

1 The NIS is used here to refer to Freeman's (1987) '…network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies.'

2 For example, the experience of large Korean conglomerates suggests that technological accumulation in one field of production can be an important input in the establishment of another (Amsden, 1989).

3 In the advanced economies of America and Europe and the Newly Industrialized Countries (NICs), Bell and Pavitt (1997) noted that TC played a long-term role in creating a technological base for new areas of potential competitive advantage, by opening up new opportunities for diversification into related products and new industries.

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> *in more technologically advanced countries – and not by pushing (or even attempting to push) the global knowledge frontier further. In short, the key to technological progress in developing countries is technological catch-up through learning rather than undertaking R&D to invent products and processes which are totally new to the world.*
>
> *(UNCTAD, 2007, p. 4, 6)*

With this broad view, the firm is the locus of innovation; and innovation does not necessarily depend on inventions.[4] This sort of reasoning is reflected in the characterization of innovation given in OECD (2005, p. 138).

> *The acquisition of embodied technology (equipment) for both product and process innovation is a major component of innovation. Minor or incremental changes are the most frequent type of innovation activity in some developing countries, together with innovative applications of existing products or processes. Organisational change is an extremely significant aspect of the innovation process.*

This implies that innovation occurs in latecomer contexts mainly in the form of 'creative imitation' (UNCTAD, 2007, p. 6) which could be of four broad types:

1. the introduction of a product or process to a country for the first time;
2. imitations of the pioneering effort;
3. productivity-enhancing incremental changes and improvements to a product or production process; and
4. performance-enhancing marketing and organizational changes.

At the firm level, the words of Ernst et al. (1998) quoted in Mytelka (2000a, p. 18) aptly summarise the foregoing: "innovation is the process by which firms master and implement the design and production of goods and services which are new to them, irrespective of whether they are new to their competitors – domestic or foreign". This definition is obviously more relevant in latecomer contexts and is central to the purpose of this book.

UNDERSTANDING SYSTEMS OF INNOVATION IN DEVELOPMENT

While there are different interpretations of the notion of systems of innovation (SI), there is a broad agreement on the definition whereby national SI is defined as 'the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies' (Freeman, 1987, p. 1). Lundvall's concept of the national SI emphasizes the diffusion of 'economically useful knowledge' (Lundvall, 1992, p. 12). There is a wide variety of definitions (Nelson and Rosenberg,

4 Notwithstanding, the commercialization of inventions will still be an important form of innovation in developing countries. Moreover, '…to emphasize innovation in this sense is not to deny the role that R&D can play in generating new knowledge. Its purpose is rather to permit the extension of the concept of innovation to cover continuous improvement in product design and quality, changes in organization and management routines, creativity in marketing and modifications to production processes that bring costs down, increase efficiency and ensure environmental sustainability. Innovation of this sort is critical to firms in the developing world today.' (Mytelka, 2000a, pp. 18–19).

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1993; Metcalfe, 1994), but there is also a fairly good convergence of the key ideas at the heart of the SI framework. SI points to the persistent but uneven distribution of the capabilities of firms to innovate across sectors, countries and regions. This skewed effect of innovation performance is a function of specific national or sectoral factors and as such the competitive advantage of sectors and nations depends greatly on how advanced the SI is, and how well it has generated coherence and interactions.

There are four key concepts that constitute the SI framework, namely: the distinct *role of actors* (individuals and organizations), the *nature and types of interaction* between the actors, the underpinning role of *policies and institutions* and the constituted *knowledge bases* of the system. Taking these concepts into account, SI have been analyzed at various levels including national (Lundvall et al., 2002), sectoral (Malerba and Mani, 2009), regional (Cooke, 1993) local and global systems (Mytelka, 2000a, 2000b) as well as relating to specific technologies (Bergek et al, 2008).

TECHNOLOGICAL CAPABILITIES[5]

Building technological capability through learning and continuous innovation are key activities for achieving competitiveness and this has become even more so in developing economies. Firms looking to compete in global markets need to accumulate the requisite knowledge – through human agents, as well as in processes and products.

In response to the much greater effort to acquire TC, there has emerged detailed and systematic analyses of TC in developing countries; a major shift from the earlier focus on mere technology transfer from developed to developing countries (Bell and Pavitt, 1993, 1995, 1997; Oyelaran-Oyeyinka et al., 1996; Katz 1973, 1987; Lall 1987). In the 1980s, studies shifted to 'diffusion-based innovation', that is, the processes involved in the adoption, adaptation and mastering of imported technologies by developing countries. What we have learnt over time is that the technological path of a given industrial plant – and of a country as well – is 'evolutionary' and has strong elements of time as well as being path-dependent.[6] Consequently, investments made in technologies in the past influence heavily what happens to firms and countries currently (Dosi et al., 1997).

The notion of technological capabilities (TC) received wide treatment in the literature from the mid-1980s through the early 1990s[7] and our conceptualization is rooted in this rich literature.[8] Westphal et al. (1985) defined TC as 'the ability to make effective use of technological knowledge in production, investment and innovation' (p. 171). Dahlman et al., (1987) conceived TC as the ways to use existing technology to produce

5 This section draws heavily on Adebowale (2009).

6 In the early 1980s Carl Dahlman and Larry Westphal directed a major research project, financed by The World Bank, on 'The Acquisition of Technological Capability' (RPO-672-48). The results of this project enriched the conceptualization of TC in four developing countries: India, South Korea, Mexico and Brazil. Several other case studies in different regions and countries include East Asia (Westphal, et al. 1984; Westphal et al. 1985; Kim, 1999); Indonesia (Jonker et al., 2006), Sub-Saharan Africa (Mytelka 1999; Oyelaran-Oyeyinka and Barclay 2003a, 2003b; Oyelaran-Oyeyinka, 2004; Oyelaran-Oyeyinka and Adeya 2004; Oyelaran-Oyeyinka and Lal 2004 2006), Central Asia (Dahlman and Westphal 1982; Dahlman 1989; Romijn 1997, 1999) and Latin America (Katz 1973, 1984, 1987; Katz and Albin 1987; Katz 2000; Tan and Lopez-Acevedo 2003).

7 Notable works include those of Westphal et al., 1985; Dahlman et al., 1987; Lall, 1990, 1992a; Mowery, 1993; Bell and Pavitt, 1993, 1995.

8 Nelson and Winter (1982) developed the notions of 'routines'. Bell (1984), Scott-Kemmis and Bell (1988), Katz (1987), used 'technological capacity' to describe the learning processes involved in building up a minimum base of essential knowledge to engage in innovative activity.

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more efficiently and to use the experience gained in production and investment to adapt and improve the technology in use. Lall (1987, 1990, 1992a) building on Dahlman and Westphal (1982), Katz (1984, 1987) and Dahlman et al. (1987) re-conceptualized TC to include the important aspect of technological and organizational learning. Defined as such, TC refers to the capabilities required to execute all technical functions underlying the setting up, operating, improving, expanding and modernizing of the firm's production base.

Lall's taxonomy (1990, 1992b) comprises three types of TC (that is, production, investment and linkage) of the firm. Production capabilities include the skills, knowledge and experience to operate a plant efficiently and to effect improvements to it. Production capabilities comprise three broad types of technical/engineering functions namely: process, product and organizational. Investment capabilities are the skills, knowledge and experience to identify, prepare, design, set up and commission a new industrial project (or an expansion of it). Lastly, linkage capabilities are the skills, knowledge and experience required to promote or foster interactive learning or transfer technology from one firm to another, from service firms to manufacturers and from the Science and Technology (S&T) infrastructure to industry (Lall, 1990). Linkage capabilities are defined as '…the capacity of forging co-operation between managers and workers within the firm, for securing co-operation between firms in the supply chain, and for crafting co-operative interfaces between firms and the wider institutional milieu, be it local, regional, or international' (Cooke and Morgan, 2000). The firm's external linkages are critical for the building of capabilities, not only in terms of strength but also in terms of the kind of innovative activity pursued (Teece et al., 1997). A firm's capabilities are largely driven by its interaction with other firms, and with non-firm organizations. The collective and multidimensional character of innovation makes it necessary to consider the firm as embedded in the broader system.

Bell and Pavitt (1993, 1995) made further additions to the concept by differentiating between production capacity and TC. The former is taken as the 'resources used to produce industrial goods at given levels of efficiency and given input combinations'[9] and the latter as 'resources needed to generate and manage technical change, including skills, knowledge and experience, and institutional structures and linkages'.

The summary of the foregoing is that TCs involve complex interrelationships of skills, experience, knowledge and the organization that enables the firm (and/or sector) to efficiently acquire, utilize, adapt, improve and create technologies (Lall, 2000). They are made up of capabilities in production, investment and innovation (Kim, 1999) and differ considerably in the range of activities that vary in depth and effort required. The process (Fransman, 1984) may include:

1. the search for available technologies and the selection of the most appropriate as well as efforts at and mastering of the technology;
2. technological adaptation in the context of the production and institutional environment;
3. improvements through incremental adjustments and minor innovations;
4. the progressive deepening of the knowledge and skills that result in the systematic

9 Equipment (for example, capital-embodied technology), labour skills (for example, operating and managerial know-how and experience), product and input specifications, and organizational methods and systems used.

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search for and carrying out of innovations which might include research and development (R&D) efforts; and
5. if the firm progresses on a dynamic path, the conduct of basic research.

This description does not suggest that these activities progress in a linear fashion although there is a way in which one level of activity builds upon the previous one. Capabilities tend to grow in an increasing order of complexity with learning creating feedback loops. What is evident is that building these capabilities entail making explicit investments in all sorts of resources which some firms may not achieve.

However, success by firm requires more than technical mastery and includes organizational capabilities that underpin the process of TC acquisition. Organization capabilities are firm-specific, and they allow knowledge to be accumulated through learning. They are an important source of cumulativeness, and they limit what firms learn and their expectations for future learning (Malerba, 2000). Parts of organization capacity include administrative and managerial activities oriented to improving learning processes and developing TC. These organizational capabilities connect and integrate the different areas and functions of firms. Integration of the different functions within the firm is a vital feature for the building of capabilities. Furthermore, the fit between the organization and the institutional environment determine the firm's perception of technological opportunities (Lundvall, 1988). Organizational capabilities are required for the creation of long-term strategies to create new knowledge, products, processes and services in firms (Malerba and Orsenigo, 2000).

Book Structure

Excluding this introduction and the concluding chapter, the book is organized into four parts made up of 14 chapters in all. The first part contains two chapters which make theoretical and conceptual contributions. Chapter 2 examines the role of institutions in supporting technical change as part of the development process, and asks how institutions shape the SI under different contexts. In doing this, the author introduces the idea of a System of Learning Innovation in Development (SLID) that emphasizes individual and organizational competence building. It discusses the differences between 'Advanced' Systems of Innovation (ASI) and two types of SLID using infrastructure as an illustration and Sub-Saharan Africa as a case study. The findings reveal that dynamic SIs function best in a regime of high-quality infrastructure. In Chapter 3, Gonçalves and Peuckert discuss the concept of quality infrastructure, which refers to all the institutions of metrology, standardization, conformity assessment and accreditation and the regulatory framework within which they operate; and how they contribute to the functioning of the NIS. This chapter establishes that a link between quality infrastructure and innovation is an important policy instrument.

Part Two contains four chapters that present case studies of IS in different countries. Prasad's chapter characterizes the Indian NIS. The emphasis is on the policies and the grounds prepared thus far in India towards transforming it into a successful knowledge economy. Towards the end of the chapter, the author introduces the concept of 'inclusive innovation' that is taking root in India in view of the country's unique socio-economic circumstances and a special position it has created in the innovation space. The fifth

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chapter analyzes the historical development of the Iranian nanotechnology sector using the functional approach to the analysis of Technological Innovation Systems (TIS). Among other things, the authors show that government has a key role to play in the emergence and evolution of TIS in latecomer settings. They refer to this as the motor of government's pressure and support. Chapter 6 analyzes the changing structures of collaboration between the key actors within the Taiwanese biopharmaceutical IS, and the role played by the emerging institutions which specifically promoted biopharmaceutical innovation. Noting that the factors influencing the growth of the stock of knowledge have strengthened gradually in recent years, whereas the factors relating to knowledge flow have not been enhanced, the authors suggest that the commercial orientation of academic research should be enhanced, more professional in-licensing selection mechanisms in the firms should be established, while the social and historical context of Taiwan should be considered in the future policy-making process. In Chapter 7, the author provides insights into the urban water supply and sanitation sector in Brazil, China, India and South Africa. The chapter demonstrates the interdependences of the systemic functions and the consequent complexity of establishing a functioning sectoral innovation system (SIS) with Brazil and China showing great innovation potentials for sustainable water technologies, while the Indian and South African IS showed severe weaknesses.

The four chapters in Part Three are empirical and qualitative analyses of the complex interactions among technological learning, capability building, innovation and industrial catch-up. Chapter 8 attempts to extend the mainstream technology and innovation management literature regarding the development of innovative activities in emerging economies. The author notes that this literature does not adequately explain the process of how a company becomes an innovative organization, and seeks to fill the gap using a successful Mexican steel company (Hylsa) which was capable of transforming itself from a laggard into a technology leader as a case study. Chapter 9 seeks to explain how firms in a less developed economy where resources are constrained manage to develop their TC through foreign technology acquisition. Four firms with foreign partnerships in the Sri Lankan garment accessories and rubber products manufacturing industries are used as case studies. The chapter argues that foreign technology provided a critical factor that was the base for innovation to occur in the host firms and that technological development requires a symbiotic presence of learning, innovation capabilities embedded with the technology management practices of the firm, and evolving technology management strategies. Rho's chapter explores the pattern of industrial catch-up in the Chinese flat panel display (FPD) industry using theories and concepts on technological discontinuity as well as the catch-up model of Lee and Lim (2001). The author concludes that Chinese companies' catch-up efforts may not overturn the current situation of the FPD industry led by Japan, Korea and Taiwan in the near future. In Chapter 11, Ama explores how researchers in the universities and research institutions in Botswana have been involved in innovative researches that produced patentable inventions. The most pressing challenges of the patent system to the researchers include unawareness of conventions/laws governing patent practices, inadequate information on the patents and restricted access to patent information. The author suggests that research exemptions be granted to universities and research institutions to overcome these challenges. Intensified collaboration between the universities and the industry are also suggested to enhance motivation to innovate.

Part Four concentrates on the issues of learning and interactions within IS. The first chapter in this part explores the drivers and barriers to the interactions between public

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research institutions and industry in the Mexican pharmaceutical sector, and how it differs throughout the distinct phases of pharmaceutical R&D. The authors show that PRO-industry interactions respond to several somewhat reinforcing factors and discuss how the different phases of the pharmaceutical R&D process involve distinct kinds of agents, activities and knowledge flows. This knowledge should assist policymakers in identifying strengths and weaknesses of the actors involved. In Chapter 13, the influence of social capital on innovation among bamboo handicraft producers in Indonesia is the focus. The results indicate that trust – which is the author's proxy for social capital – does not significantly contribute to the probability of producers to implement innovations, but it is significantly associated with the number of sub-types of innovation that they implement. Chapter 14, based on the case of a producers' cooperative society in El Salvador, argues that networking capabilities are an essential complement to interactive learning capabilities in driving innovative performance within a fragmented IS. In Chapter 15, Adebowale and Egbetokun compare the Malaysian and Nigerian oil palm sector and offer some explanations for the divergent paths of evolution of this high-potential sector in Nigeria and Malaysia. Oil palm seeds and seedlings were initially procured from Nigeria to prime the sector in Malaysia but the Malaysian oil palm sector overtook and has gone much ahead of Nigeria's.

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