Chapter 3

The Relevance of Innovation Systems to Developing Countries

by

Erika Kraemer-Mbula*
Watu Wamae

This chapter discusses the relevance of the innovation systems perspective to Sub-Saharan African countries. It argues that so far, the main concern has been the absorption and adoption of established practice. Efforts to adapt the innovation systems framework to reflect the realities of Sub-Saharan remain limited. In addition, it notes that little attention has been attached to deepening and expanding the specific core capabilities that are fundamental to innovation for development. The importance of addressing this issue is necessary not only to tackle existing challenges but also to orient innovation towards sustainable paths.

* Erika Kraemer-Mbula works at the Centre for Research in Innovation Management (CENTRIM), University of Brighton, United Kingdom, and the Institute for Economic Research on Innovation (IERI), Faculty of Economics and Finance, Tshwane University of Technology, South Africa. Watu Wamae works at RAND Europe, Cambridge, United Kingdom, and Development Policy and Practice, The Open University, United Kingdom.

Introduction

This chapter discusses the implications of the innovation systems framework for developing countries. Some of the main issues surrounding the theoretical debate relate to the fact that the innovation systems concept originated in industrialised countries, which undertake relatively significant innovation at the technology frontier, have strong interactions among actors and relatively well-established organisations and institutions. As a result, attempts to integrate innovation systems approaches in development agendas of developing countries have focused on the formal S&T system and emphasised the importance of creating formal institutions and organisations. The main concern has been the absorption and adaptation of established practice. However, other aspects that are important in developing countries have received limited attention. For instance, learning is fundamental to the process of innovation, and the learning process is itself shaped by practical experience and the economic structure in which it occurs. Particularly in developing countries, learning is linked to the indigenous capabilities required to transform and modify knowledge to suit local conditions and the local context. This chapter discusses the importance of adapting the innovation systems framework in ways that take into account the structural specificities of developing countries.

Applying the innovation systems concept to developing countries

Development and innovation

Earlier contributions to development thinking identified development with economic growth and industrialisation. Developing countries were deemed to be at an earlier stage than the more advanced economies along the linear path of historical progress. This notion implied that countries pass through similar historical stages of economic development (Gerschenkron, 1962; Rostow, 1960). The central argument that emerged from this literature was that differences in development stages could be explained by differing rates in the adoption of technology (Kaldor, 1957). The underlying idea was that investment and learning were interrelated and that the rate at which they took place determined technological progress. Gerschenkron (1962), who studied international aspects of the process of innovation and learning, pioneered the idea that technology gaps between technology frontier economies and laggards provide the latter with great opportunities to acquire technology through assimilation of the existing backlog of knowledge.

It was not until the 1970s that the technology gap perspective was revisited (*e.g.* by Gomulka, 1971; Cornwall, 1977; Maddison, 1979; and Abramovitz, 1979) and led to the so-called "technology gap" literature which has widely explored the catching-up process in lagging countries. The main hypotheses are that: technology growth rates have a positive impact on economic growth rates; lagging economies may exploit the backlog of existing knowledge through a catching-up process that allows them to approach the technology frontier; and the absorptive capacity determines a lagging country's ability to embark on a successful catching-up process; it largely depends on direct government intervention, particularly by steering resources to the most technologically progressive sectors of the economy (Fagerberg,1987; Abramovitz, 1986, 1994). Fagerberg (1988) elaborated an interesting technology gap model of economic growth *per se*.

Early studies on catching up suggested that technological shortcuts exist and could allow developing countries to reach the stage of development of advanced economies. This would be achieved mainly by assimilating and adapting mature technologies (Utterback and Abernathy, 1975; Kim, 1980, 1997). In fact, some considered underdevelopment a potential advantage by giving developing countries the chance to distil valuable lessons from the experiences of industrialised nations and "leapfrog" to more efficient developmental stages. However, as Perez and Soete (1988, p. 476) remarked, this view of catching-up was a "matter of relative speed in a race along a fixed track, and technology was understood as a cumulative unidirectional process".

The technology gap literature also stressed the role of investments in science and technology (S&T), thereby highlighting the role of government in determining the speed and orienting the direction of technological change. The original Sussex Manifesto (Singer *et al.*, 1970) and many research contributions in developing countries led to a stream of policy recommendations directed to promoting scientific and technological outputs – scientific research and development (R&D), technical manpower, patents and scientific publications (Tassey, 1997; Patel, 1995; Furman *et al.*, 2002).[1] At the time, theoretical contributions implied a linear process of technological development, driven by the supply of R&D resources and other technical inputs that would sequentially translate into "better" innovations and ultimately economic growth and development. For example, Kim and Dahlman (1992) referred to three stages of technology acquisition in a developing economy: in the early stage, economies acquire mature foreign technologies that essentially involve assembly operations; the second stage is the consolidation of technology through duplicative imitation followed by creative imitation, which relies on enhanced local technological capabilities and infrastructure; the final stage involves generation of emerging technologies through investment in R&D.

The concept of innovation systems[2] was pioneered and elaborated within a framework of evolutionary technical change by Nelson and Winter (1982), Rosenberg (1982) and Freeman (1987), among others. It places technology and innovation at the centre of development and pays particular attention to the history and institutions that shape the interactions of actors in a system that is conducive to innovation (Dosi *et al.*, 1988).[3] Within this framework, innovation is viewed as a process of interactive learning in which actors improve their competences, and in so doing contribute to the conversion of knowledge to value for the socioeconomic benefit of society. Research in developing regions has made it possible to amplify and expand this view and to provide new directions for development, particularly through policy (Lall and Teubal, 1998; Nelson and Pack, 1999; Metcalfe, 2000; Chang, 2002). Despite the wide acceptance of the innovation systems approach, policy decisions still largely tend to rely on the S&T approach.[4] The operational implementation of the innovation systems approach in policy making remains a major challenge.

Discussions of development have gradually moved away from a narrow perception of development as economic growth to the idea of development as a process of social transformation. Accordingly, shaping the pattern of growth requires greater appreciation of the need for policies that directly address poverty, equity and social development. Recent views on development see it as a process of structural change which involves fundamental and interrelated changes in technology, organisation, institutions and culture. In particular, Amartya Sen (1993, 1999) focuses on human development and formulates development in terms of freedom, entitlement and capability. He argues that a focus on income and capital accumulation may be necessary but that it is not sufficient to achieve development. He places capabilities at the heart of development; they are the means to

address social development issues, such as gender, deprivation, hunger, basic needs and environment.[5] However, his view of capabilities does not make explicit reference to the link between capabilities and innovation (Johnson *et al.*, 2003).

The current debate on innovation and development are of particular relevance to Africa, and the contextualisation of these theories becomes imperative in order to provide tailored solutions that respond to African needs.

A brief presentation of the innovation systems concept

This section provides basic definitions of key innovation systems concepts in the context of development.

What is innovation?

Innovation is the process of converting new or existing knowledge to value for the benefit of individuals, groups or communities.[6] Innovation is a technical process as well as a social and economic one, which leads to a product or process (Edquist, 1997; Lundvall, 1992; Johnson *et al*., 2003). Innovation activities may result in a new or better product (or a product variety) which is offered for consumption. The product may be a new (material) good or a new (intangible) service. An innovation may also result in a new process or way of producing goods and services. A new or improved process may be material (a technological process) or intangible (an organisational process). The *Oslo Manual* defines innovation as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations" (OECD/Eurostat, 2005, p. 46).

In current theoretical work, innovation is recognised as an engine of growth which offers substantial potential for achieving developmental effects (Cassiolato *et al.*, 2003; Rosenberg, 2004; Fagerberg *et al*., 2004; Dutrénit and Dodgson, 2005; Metcalfe and Ramlogan, 2008). It therefore, offers opportunities to directly address poverty, inequality and environmental sustainability.

What is an innovation system?

An innovation system is a network in which actors interact and exchange both codified and tacit knowledge to undertake innovative activities. Knowledge is the key commodity in an innovation system and a network provides channels through which knowledge flows. Such a system is based on complex relationships that involve learning, a fundamental process in innovation. Many actors (such as firms, suppliers, customers, and education and financial institutions) interact in a specific environment that is shaped by history, culture and social relations. The resulting dynamics characterise a specific innovation system.

Ideally, theories of innovation should be supported by empirical evidence that clarifies these relationships and the means by which they contribute to development. However, the innovation process, and in particular its systemic character, is still not well understood (Edquist, 2005). Nevertheless, the idea that innovation occurs within a "system" reflects the recognition that the conversion of knowledge to value is shaped by structural, institutional and social factors.

What are the major components of an innovation system?

The main components of an innovation system are organisations and institutions as well as the relationships that link them (Arnold and Bell, 2001; Edquist, 2001). These three elements should form a coherent whole that provides a milieu for interactive learning, which is central to innovation.

Organisations are formal structures which are consciously created and have an explicit purpose. They are players or actors. Some important innovation system organisations are firms, universities, venture capital organisations and policy-making agencies.

Institutions are sets of common habits, norms, routines, established practices, rules or laws that regulate the relations and interactions between individuals, groups and organisations. They are the "rules of the game" (North, 1990; Edquist, 1997). Institutions influence how organisations undertake innovative activities. Examples of institutions include intellectual property rights (IPR), corporate structures of governance, competition policy and labour regulations.

Linkages are the interactions that occur within and across organisations and institutions. These are knowledge-centred interactions and are based on an underlying tension of collaboration and competition among actors. They influence the nature and degree of knowledge flows through innovation systems and in so doing shape specific trajectories of specialisation and learning.

What are the different levels of systems discussed in the literature?

The concept of innovation systems was originally developed at the national level, but two main variants have emerged in the literature:

- Spatial systems, which include national innovation systems (Freeman, 1982; Nelson and Winter, 1982; Rosenberg, 1982; Lundvall, 1985) and regional innovation systems (Cooke, 1996; Malmberg and Maskell, 1997).
- Sectoral systems (Breschi and Malerba, 1997; Malerba and Orsenigo, 2002).

Other strands of the literature refer to technological systems. Examples include: "technology systems of production" (Carlsson and Stankiewicz, 1991; Carlsson and Jacobsson, 1997; Carlsson *et al.*, 2002) and "national technology systems" (Lall and Pietrobelli, 2002).

All these variants coexist and complement each other. From a "systems" perspective, innovation is regarded as "an intricate interplay between micro and macro phenomena where macro-structures condition micro-dynamics and … new macro-structures are shaped by micro-processes" (Lundvall, 2007, p. 101).

Where does the conversion of knowledge to value take place?

The innovation system framework gives firms[7] a central role in the innovation process. Research on innovation processes is based on the firm as the main unit of analysis, particularly in the sectoral approach.[8] The learning processes that occur within and between firms are crucial in shaping the direction and extent of innovation (Arnold and Bell, 2001; Bell, 2007).

It is important to understand what takes place within firms in terms of innovative activities and learning processes. Learning processes lead to the acquisition of different types of capabilities, which are required to develop innovative products and processes

(Lall, 1992; Figueiredo, 2003; Bell, 2007). However, firms innovate not in isolation but within a system. Other organisations and institutions, such as the education system, financial systems, competition policy and property rights, influence knowledge generation as well as the ability of firms to innovate.

Innovation systems and change

Innovation systems are not static. They evolve over time in response to variations in the social, economic and political environment. The innovation systems framework takes an evolutionary approach: changes in components of the system (organisation and institutions) lead to the emergence of new interactions and innovation processes. This evolutionary aspect of innovation leads to heterogeneity across sectors, regions and countries. It is therefore important to understand the different modes of innovation within the micro-structures as well as between micro- and macro-structures in order to better identify the adaptations required within institutions and organisations to support the conversion of knowledge to value. A discussion on how learning as a fundamental process of innovation takes places within these structures is provided below.

The extent to which the system is able to respond and adapt to change is a function of its vitality (Viotti, 2002). If systems are "passive" they mostly rely on external forces to initiate learning and innovation processes. Passive systems have limited ability to adapt to change and are as a result more likely to suffer from the adverse effects of change than to capture opportunities that arise. On the contrary, "active" systems tend to have clearer targets and better co-ordination for learning and developing innovations. This distinction has important implications for questions related to building up, upgrading and transforming innovation systems, especially in developing countries.

What are the implications of innovation systems and innovation practices thinking for developing countries?

Theoretical debate on innovation systems in relation to developing countries

For the most part, the innovation systems approach is based on the socioeconomic contexts of the advanced countries in which it originated. As a result, it focuses on formal organisations and institutions. The concept remains broad and is viewed as lacking a strong theoretical foundation (Lundvall *et al*., 2002). Arguably, this provides some scope for adapting the concept to different contexts, including developing country contexts, in ways that can strengthen innovation for development. However, interactions among actors in developing economies appear much weaker than in more advanced economies, and organisations and institutions are not well established. Furthermore, in contrast to advanced economies, innovative activities in developing countries occur in a socio-economic environment that is largely defined by informal arrangements. Learning in such contexts is under-researched despite its importance in innovation processes.

Focus on the formal sector

Discussions about strengthening innovation systems still focus almost exclusively on formal organisations and institutions. As a result, policy formulation is typically oriented towards fulfilling, expanding or reforming formal organisations, especially those directly engaged in generating knowledge. Therefore, much of the debate about the generation of knowledge focuses on the role of universities and public/private research institutes as major sources of the knowledge.

The focus on the formal sector in the innovation systems perspective creates an important challenge for many developing countries. These countries have highly informal institutions and organisations. Furthermore, most productive activities depend largely on knowledge that is not codified in formal research, education or training institutions. The scant attention paid to the informal sector in the innovation systems framework suggests that its significance is not acknowledged. Yet, it represents three-quarters of non-agricultural employment and over 40% of the gross national product (GNP) of many African countries (see Chapter 4). There is a strong argument for adapting the innovation systems framework as a tool for understanding innovation in a developing country context.

Recognition of the importance of informal organisations and institutions in no way suggests that adapting the innovation systems framework in ways that adequately address them would be straightforward. It is, therefore, perhaps not surprising that the large and expanding informal segments of developing countries have been neglected in discussions of innovation systems. However, as a tool for analysis, the innovation systems framework is likely to be more useful if it provides greater clarity on the relation between learning and innovation for development in less advanced economies.

Knowledge systems in developing countries

The coexistence of "traditional" or "indigenous" knowledge and "scientific" or "modern" knowledge is a typical feature of developing countries. Modern knowledge systems represent the science-based, formally organised creation and exchange of knowledge. Traditional knowledge systems are mainly rooted in local communities and knowledge is transmitted from one generation to the next. However, in the current context of rapid change literacy is critical (see Chapter 5).

Science-based activities represent a small part of the economic activities in developing regions. It is increasingly acknowledged that traditional knowledge plays an important role in the livelihood of populations in developing countries (Bell, 2006), especially in Africa. However, traditional knowledge systems are not well articulated. This makes it difficult for them to be proactive and adapt to new demands for knowledge. Furthermore, links between modern and traditional knowledge systems tend to be weak (Bell, 2007). Therefore, one of the main challenges of the innovation systems approach is to find mechanisms for strengthening the interactions that promote knowledge flows within and between traditional and modern knowledge systems. Bell (2006) argues that efforts should be directed towards articulating and integrating traditional and modern knowledge systems in an interactive process of innovation.

Transformation of innovation systems

Innovation systems are largely shaped by social, institutional and historical conditions. The transformation of innovation systems therefore depends on changes in these conditions, which are varied, multiple and interconnected. For instance, changes in population dynamics (population growth rates, urbanisation), changes in productive systems (a shift from agrarian to manufacturing and services sectors), and other factors (changes in the political regime, civil unrest, etc.) differ from country to country. These and other dynamics stimulate the transformation and evolution of innovation systems.

The transformation of often weak and fragmented innovation systems is a major challenge for developing countries. First, the components (organisations, institutions and linkages) of the system are absent in many cases; and second, improving the overall vitality of the system would require an understanding of innovation processes in the

informal sector as well as linkages between innovation processes in the formal and informal sectors.

Building effective innovation systems in Sub-Saharan Africa may require not only setting up formal organisations and institutions, but also encouraging innovation activities by systematically upgrading the competences of existing components, particularly those with identified potential. This may require identifying the bottlenecks in the system, improving knowledge flows across the system and strengthening linkages among actors. The capacity of the system to transform and adapt will determine its ability to promote successful innovation sub-systems and phase out less productive ones (Metcalfe and Ramlogan, 2006).

Innovative activities in developing countries

The literature on innovation in developing countries and particularly in low-income countries emphasises four issues (Edquist, 2001): *i)* product *versus* process innovations; *ii)* innovation in low and medium technologies; *iii)* incremental innovation; and *iv)* absorptive capacity. Each of these is discussed in turn.

Product versus *process innovations*

Product innovations are regarded as more important than process innovations. They are considered to have a greater effect on the production structure than process innovations. For instance, a new product design can allow a firm to enter a new market, while process innovations tend to ensure a market position by lowering the firm's average production cost. In addition, product innovations are employment-creating while process innovations are considered to be labour-saving. These distinctions appear to have been developed for firms operating in the manufacturing sector and inspired by the spectacular export-oriented growth observed in a number of Asian countries. Although the literature points out that process innovations should not be ignored because they offer a basis for increasing product innovations, the link between product and process innovation in Sub-Saharan Africa is under-researched.

In most cases, developing countries operate in mature industries such as food production. It has been argued that improving processes in mature industries is crucial for competitiveness. Moreover, as these industries evolve, process improvements continue to be important in paving the way for product improvement and variation.

Process innovations have modified organisational structures of production, for example in terms of stocks and delivery practices. Previously, production structures were based on limited product diversity and hierarchical labour processes targeted at economies of scale. They involved "just-in-case production", that is, they were essentially supply-driven. That mode of production has been replaced by "just-in-time" production, which requires flexible production systems driven by the diversity of demand. This is reflected in the segmented markets and rapid product differentiation that increasingly defines non-bulk production. These organisational changes have spread from manufacturing to other sectors. For example, there are a number of retail value chains for fresh agricultural products – fruits, vegetables, cut flowers, etc. Success in these value chains depends largely on the transformation of organisational processes, particularly because the products in question have a limited shelf life. It also depends on the ability to improve and adapt technological processes for food processing and storage.

The current global architecture of production is governed by global value chains. Value chains are the combination of activities of multiple firms – often distributed globally – that take a product or service from design to consumption (Kaplinsky and Morris, 2001). Innovation practices at various nodes along the chain have a direct impact on how the chain is organised and governed and determine the nature of benefits accruing to different agents (who gains what).

Firms that are shaping global value chains in agriculture have spread rapidly to developing countries. They include Tesco, Safeways, Sainsbury and Albert Heinz (Rasiah, 2008). Responding to changes in consumer behaviour in the global food market requires complex organisational changes throughout the entire supply chain. This is resulting in changes in domestic markets as well, because "the purchasing decisions and supply network requirements of foreign retailers are leading to a rapid and dramatic consolidation in the distribution, wholesale and manufacturing/agricultural production sectors of host economies" (Wrigley *et al.*, 2005).

In the health sector, private firms are shaping the delivery of services and establishing a supply chain based on referrals from smaller medical practices. For example, in South Africa the three main private health-care providers (Netcare, Life Healthcare and Mediclinic) are not restricted to the domestic market. Netcare "exports" health-care services to the capacity-constrained National Health Service (NHS) in the United Kingdom (Mortensen, 2008).

The focus on manufacturing has at the same time deflected attention from other sectors that are important in developing countries, such as extractive industries and infrastructure. These sectors develop and use sophisticated innovations that could offer significant technological learning opportunities, in addition to supporting innovation in other sectors, particularly in the case of infrastructure (see Chapter 4). Furthermore, in developing countries innovation in organisational processes generally receives scant attention. This may be due to the general bias in innovation systems literature towards the manufacturing sector.

Innovation in low and medium technologies

The innovations systems approach argues that innovation in low and medium technologies is more attainable than innovation in high technology (Edquist, 2001; Lall and Kraemer-Mbula, 2005). Again, the focus is generally on the manufacturing sector, which represents a very small share of gross domestic product (GDP) in Sub-Saharan Africa. Between 1965 and 2005, manufacturing value added in Sub-Saharan Africa has not risen from 15% of GDP in the 1960s (UNCTAD, 2008). The classification of production activities based on the technology intensity of products does not fully reflect the current situation in developing countries. As pointed out above, agriculture is not necessarily a low-technology sector, as the cut flower industry in Kenya or fishing in Uganda demonstrate (Kiggundu, 2006). Both involve the integration of highly sophisticated innovations to ensure that perishable goods meet required standards on arrival in their final overseas markets, particularly specific sanitary and phytosanitary requirements in the case of food items, and increasingly that they meet ecological and environmental requirements. In the health sector, South Africa's private health-care provision in the United Kingdom is a high-technology-intensive service (Mortensen, 2008).

Recent thinking on innovation systems has begun to question the relevance of the classification of sectors by technology intensity and to recommend a focus on innovation in the so-called low- and medium-technology sectors in developing countries.[9] These

sectors consistently demonstrate their ability not only to draw on sophisticated technologies but also to shape innovation in high-technology sectors. Furthermore, innovations based on the use of high technology, particularly in infrastructure, which directly target low-income earners, have emerged in developing countries in banking services, IT services, medical services, etc.[10] Robertson *et al.* (2009, p. 441) point out that "it is a common error to regard dramatic technological advances such as information and communication technologies or biotechnologies as 'industries', tied to particular product ranges… [T]hey represent high-tech activities that become pervasive in the guise of general purpose technologies (GPTs), and their adoption therefore spreads across a wide swathe of user 'industries'."

Incremental innovation

Innovation is a process of experimentation which mainly involves a myriad of modifications and transformations of products and processes. Some are radical changes and others are small improvements. It has been argued (Dutrénit, 2004) that developing countries are more likely to engage successfully in incremental innovations than in radical innovations. Innovation at the technology frontier generally requires substantial investments in R&D, which may not be available in developing countries. Furthermore, the development of radical technologies entails greater risks owing to the degree of uncertainty and is often characterised by long gestation periods. R&D which focuses more on development than on research plays an important role; it provides opportunities to make improvements and adaptations (innovations) and offers opportunities for technological learning. Innovation and technological learning occur simultaneously and are important for the improvement of products and processes.

Other forms of incremental innovations have been described. For example, Srinivas and Sutz (2007), in their analysis of innovation as a means of resolving local challenges, note that there are challenges that are specific to developing countries. Innovation is required to obtain a non-existing product or process and may involve non-existing knowledge. This calls for a fairly different approach to innovation than what is required to improve products and processes for competitiveness. These authors also identify challenges in developing countries that have not been met, not because no solution exists but because it is not accessible to developing countries.[11] Developing an alternative that is accessible to developing countries generally depends on innovation efforts that can require substantial investments and modifications.

Absorptive capacity

Absorptive capacity has been defined as a firm's ability to recognise the value of new external knowledge, assimilate it and apply it to commercial ends (Cohen and Levinthal, 1990). The acquisition of absorptive capacity in developing countries has received much attention in the literature (Liu and White, 1997; Kim, 1997; Criscuolo and Narula, 2002; Narula, 2004; Narula and Marin, 2005); it is mainly associated with the accumulation of human capital and investments in R&D.

The ability to absorb existing knowledge has complex facets and the underlying dynamics are not well understood, particularly in policy interventions in Sub-Saharan Africa (Wamae, 2006, 2007). However, authors commonly agree that absorptive capacity is critical for access to and use of existing knowledge. It is argued that it is important for developing countries to build their absorptive capacities by focusing on exploiting existing

knowledge. The rationale behind this proposition is closely linked to that underlying incremental innovation.

Incremental innovations provide opportunities for extending and deepening technological learning. Technological learning contributes to the development of competences that are fundamental for developing the ability to use knowledge (absorptive capacity) that exists but is new to the context. This capacity can provide the basis for engaging not only in replication but also in innovations that are new to the world. For this to occur, it is crucial to have a clear understanding of the distinction between capabilities that are required for operating production systems and those that are capable of changing production systems (Bell, 2007; Wamae, 2007). The latter capabilities are critical for providing solutions to local challenges by converting knowledge to value. Increasingly, this includes finding new uses for emerging technologies such as information and communication technologies. An example is provided by the mobile telephone money transfer innovation (M-PESA), which offers low-income earners a secure and rapid solution (Hughes and Lonie, (2007).

The creation of the capabilities required to convert knowledge to value largely depends on deliberate efforts, involving substantial cost, to provide opportunities for technological learning. These opportunities provide a milieu for engaging in "innovative technology-developing tasks" (Wamae, 2009, p. 203). Most Sub-Saharan African countries attach little importance to this form of capabilities. Efforts aimed at knowledge generation tend to focus on public research institutes, and in particular on science and technology rather than on innovation or the general application and commercialisation of science and technology outputs. By and large, efforts to exploit the backlog of existing knowledge offer limited opportunities to acquire the capabilities required for converting knowledge to value.

The development of an absorptive capacity that focuses on operating or production capabilities and pays no attention to capabilities for transforming knowledge into new configurations is unlikely to contribute effectively to the innovation for development agenda in Sub-Saharan Africa. There is no evidence in any regions of the world to suggest that is possible to embark on a successful path of innovation for development without intervening directly in extending and deepening technological learning (Wamae, 2006). R&D that focuses on development rather than on research plays an important role in strengthening the ability to improve processes and products. It is also important for extending and deepening technological learning, which is necessary for resolving context-specific problems. Ely and Bell (2007, p. 24) provide a clear statement on this point.

> "But in most … developing countries this approach has been much more idiosyncratic and intermittent, and rarely the subject of explicit policy initiatives. The development of a dynamic and creative engagement with technology has more commonly been left to emerge slowly, sparsely and sporadically, and the two dimensions of innovation-centred interaction with imported technology have not been pursued aggressively with active support from policy – neither *(i)* using the process of importing technology as an important vehicle for strengthening innovation capabilities, nor *(ii)* ensuring that continuing innovation is the central feature of using what was earlier imported."

Changing innovation dynamics and implications for learning and innovation processes in developing countries

The emergence of a knowledge-based economy and globalisation are continuously restructuring the dynamics of innovation. New poles of innovation are beginning to emerge, particularly in Asia's newly industrialised economies and in the so-called BRICS (Brazil, Russia, India, China and South Africa), particularly China. The changing dynamics are also calling for new perspectives and approaches to innovation, including the conversion of knowledge to value that directly targets low-income earners, who have previously been considered as marginal to innovation processes. For Sub-Saharan Africa to benefit from the restructuring that is taking place, it is imperative that the issue of technological learning capabilities aimed at generating new knowledge as well as transforming knowledge to respond to development challenges is addressed.

Changing dynamics and innovative activities

The original Sussex Manifesto estimated that developing countries accounted for only 2% of the global gross expenditure on R&D in 1970 (Singer *et al*., 1970). This figure had risen to 21% by 2000 and Asia represented almost two-thirds of developing country gross domestic expenditure on R&D (GERD) (Ely and Bell 2007). This suggests that developing countries, particularly in Asia, are playing a growing role in the generation and conversion of new knowledge to value.

Table 3.1. World share of developing countries' GERD, 1973, 1990 and 1999/2000

Percentages

	1973	1990	1999/2000
Developing countries	*2.9*	*10.2*	*21.0*
Asia	-	5.0	13.0
Other developing countries	-	5.2	7.9

Source: Ely, A. and M. Bell (2009), "The Original —Sussex Manifesto: Its Past and Future Relevance", *STEPS Working Paper 27*, STEPS Centre, Brighton.

China is at the centre of the restructuring that is taking place in knowledge generation and innovation. As Professor Martin Reis observes in the Reith Lectures (2010):

> "Of course the biggest tectonic shift in the world's science stems from the burgeoning growth in the Far East – in China above all. Since 1999, China's R and D spend has risen by 20 percent each year – up to a level that's now second only to the US.
>
> "China's technocratic leadership has astutely targeted its scientific investment in 'growth areas'.
>
> "Look, for instance, towards the city of Shenzhen. There, a 500-strong research team is hard at work, on the front line of genetic research. They were only established eleven years ago. Now they have more sequencing capacity than anywhere in the world – enough to sequence 10,000 human genomes in a year. And China strives to lead, too, in the quite different field of solar power."

China's emergence at the forefront of knowledge generation has implications not only for technological leaders in Western economies, but also for the transformation of knowledge for the benefit of developing countries. Technology platforms for new and emerging technologies, including biotechnology, nanotechnology and communication technologies, are playing a major role in creating technological solutions in the South for challenges in the South. A new perspective on this South-South approach to innovation argues that the relevance of developing country markets for Chinese and Indian innovations is that it is the emergence of new markets in developing countries rather than the emergence of new technologies that is driving the restructuring of innovation dynamics. It is disruptive markets rather than disruptive technologies that are increasing shaping innovation dynamics (Kaplinsky *et al*., 2009).

> "Thus, we anticipate a new generation in innovation systems, with the core development of low-income economy-specific products and processes being located in low-income economies, particularly China and India. Because of the context of their development, they are particularly appropriate for other low-income economies. We can already observe this in Africa, for example. Many of the professional elites examining the entry of China into the continent are dismissive of the very poor quality of many Chinese products. However, from the perspective of very poor consumers, a wireless costing $2 may look and sound tinny, and may have a relatively limited lifespan. But it is cheap, and it is appropriate. Similarly, on health, some generically produced drugs (such as those treating TB and malaria) may not have the same level of therapeutic benefit as the newest variants of treatment, but they are low-cost and will often minimize the worse aspects of a morbidity inducing condition such as chronic high blood pressure." (Kaplinsky *et al*., 2009, p. 191)

Although Sub-Saharan African countries, excluding South Africa which represents a significant proportion of the region's knowledge creation and innovation, represent for the most part a market for innovations rather than a source, this imbalance will only be addressed if local firms engage in innovation. The importance of addressing this issue lies in the fact that the ability to influence the orientation of innovation trajectories, and therefore to provide solutions to development challenges, depends on the existence of significant innovation capabilities (Bell, 2009). There is some evidence that the potential to engage in knowledge conversion for the benefit of low-income earners exists in some of these countries. For example, Equity Bank, a locally owned bank in Kenya has successfully offered banking solutions to the poor who were locked out of conventional banks. The demand for banking services by the unbanked population drove Equity Bank to undertake innovative activities that included the exploitation of information and communication technologies to deliver affordable banking (Wamae, 2009). However, most firms in Sub-Saharan Africa are not able to generate adequate technological capabilities that would allow them to use new knowledge to address local challenges. As discussed above, deliberate efforts are required to develop capabilities that "play a direct and critical role in adapting and modifying specifications for integration into processes, products and services, particularly owing to their close association with the dynamics of demand" (Wamae, 2009, p. 201). This point is discussed further in the following section.

Learning as a key issue in innovation for development

Learning, as the basis for the acquisition of knowledge, both tacit and codified, is essential for developing and upgrading innovation capacity. The nature of the learning process determines the extent to which innovation in both products and processes can be

undertaken. In an innovation systems perspective, there are differences in the ability to learn at the macro and micro levels because learning is a highly complex social process.

Learning at the macro level

For Lundvall and Borrás (1998), the "learning economy" is a fundamental concept. The authors stress that, with regard to economic development, a learning economy primarily concerns the ability to learn and adapt to change. It is not the stock of existing knowledge but the ability to learn that drives progress. Differences in the rate of learning determine an economy's ability to expand and progress. Developed countries tend to have a greater ability to learn than developing countries, and this is the source of a "learning divide" (Arocena and Sutz, 2000). Because many developing countries have low rates of learning, they are locked into activities (such as the production of products with low value added) that offer limited opportunities to improve their learning capabilities.

At the macro level learning is determined by the presence of adequate opportunities. These depend on access to education, on the one hand, and, on the other, on a context that encourages the creative application of knowledge to resolve challenges. Innovation depends on the creation of basic technical abilities at the tertiary level that are predisposed for adoption and further development within productive activities. The acquisition of basic technical abilities in turn depends on the existence of basic cognitive abilities at the primary and secondary levels of education. Learning as a fundamental process for innovation therefore "involves a two-stage process consisting of two sets of necessarily complementary activities: the acquisition of basic technical skills and knowledge via tertiary education and training; and subsequent learning within productive employment that adds critically important complementary skills and understanding" (Wamae, 2009, p. 202)

Learning at the micro level

As discussed earlier, the firm is the main locus of innovation. Understanding what takes place within firms in relation to innovative activities and learning processes is the key to identifying the dynamic interplay that results in innovation. Technological learning capabilities are acquired within the firm and are critical for the process of development. However, this is not an automatic process; it requires deliberate investment efforts and leads to different results depending on the specific learning opportunities provided. The two main outcomes are: skills that offer opportunities to directly alter the configuration of existing knowledge to create wealth; and skills that support the previous skills by generalising the application of the modified configurations. How intensively technological learning capabilities are deepened and extended within the firm depends on specific processes that involve deliberate costs (Wamae, 2007, 2009). These technological learning capabilities facilitate the identification of specific needs and potential solutions because they are the "focal point in systems where the poorly specified demand for knowledge and other inputs to innovation in the production of goods and services is identified and crystallised in concrete and specific forms" (Bell, 2006, p. 19).

International relevance of learning

Lundvall and Borrás (1998) recognise that globalisation of technology offers new opportunities for developing countries, but note that these opportunities are not available without deliberate efforts to absorb knowledge through endogenous learning. For instance, the South African aerospace industry is currently undergoing a steep process of

technological learning and adaptation as a consequence of global changes in production, consolidation of large aerospace multinational corporations (MNCs) and fragmentation of production. South African aerospace companies are developing new niche markets, introducing process and product innovations, and restructuring in order to attract international investors and become the international suppliers of large multinationals (*i.e.* Boeing or Airbus), against other low-cost locations (*e.g.* Brazil and China). Large MNCs increasingly demand higher capabilities from suppliers in developing countries, and domestic companies need to respond by upgrading their production capabilities as international suppliers. At the same time, the integration of firms into international supply value chains generates new avenues of learning through training, knowledge sharing and joint production with foreign firms (Kraemer-Mbula, 2009). This example remains an exception in Sub-Saharan Africa, where innovation in most economies is based on traditional sectors such as agriculture and extractive industries even though, as already mentioned, the international dimension of learning is also present in these traditional sectors.

The relevance and impact of theories of innovation systems on policy in Sub-Saharan Africa

The innovation systems framework provides developing countries with useful theoretical insights. However, it is important to complement these with empirical analysis in order to adapt them to Sub-Saharan Africa and provide a suitable basis for designing specific innovation strategies. Edquist (2001) points out that the innovation systems "approach can be used as a framework for formulating specific innovation policies. However, this cannot be done on the basis of theories alone. Specific empirical analyses must explicitly compare different existing (national, regional or sectoral) innovation systems." This section discusses some theoretical aspects that are important for innovation policy in Sub-Saharan Africa.

Contextual issues and the innovation systems approach to policy design

Successful innovation requires policy intervention that nurtures learning in order to upgrade technological capabilities and infrastructure (Katz, 1987; Lall and Pietrobelli, 2002). Policy strengthens innovative activities by orienting technological learning and innovation processes. The literature on innovation systems recognises that more innovative countries not only have higher productivity and incomes, but are also better able to deal with social challenges. More specifically, policy determines whether innovation will enhance development outcomes through the design and implementation of innovation policies that are socially oriented, and by ensuring that other areas of policy which are implicitly related to innovation policy, such as procurement policy, do not undermine the ability to integrate social goals (Sutz, 2007).

Innovation can and does occur in the absence of policy, particularly in developing countries where forms of social and economic activities sometimes "bypass" the laws. As a result, some of the innovations that emerge may have negative impacts on development. For example, in developing countries, traditional medical practice often fails to be scrutinised by standards and quality assurance agencies, and innovations in traditional medicine counteract the health-enhancing effects that contribute to social development. Innovations that do not lead to development-enhancing effects exist, and emerging research on "illegal" innovations provides some examples (Rush *et al.*, 2009).

Evidence-based policy

Empirical evidence is required to determine which organisations and institutions require changes in order to adapt and strengthen the innovation system. Such evidence is critical for determining the balance between supporting existing innovation activities and undertaking informed efforts to identify and promote emerging innovative areas (Earl and Gault, 2006; OECD, 2007). It also provides a basis for benchmarking a country's performance over time and important lessons for policy learning. It therefore provides a basis for designing effective policies and implementing appropriate adjustments. It is also linked to issues of benchmarking and the adequacy of indicators that inform policy formulation and evaluation. Some commentators have recently recognised the importance of broadening the scope of innovation indicators beyond traditional input and output measures by incorporating systemic aspects related to the "process" of innovation, linkages and learning (Lundvall and Tomlinson, 2002; Kraemer-Mbula, 2010).

Policy coherence

Most Sub-Saharan African economies are preoccupied with major issues related to poverty, water, sanitation, health, social unrest and the like. These issues require co-ordination of domestic polices in various dimensions. In addition, there is increasing pressure to adhere to international regulations on global issues such as environmental degradation, global warming and international trade rules.

Insights from the innovation systems framework have to be adapted to the characteristics and complexities of innovation at the local level, on the one hand, and to international requirements, on the other. It is important to note that the challenges involved in meeting international requirements may inhibit the ability to direct efforts towards local innovative activities (Sutz, 2007). Nevertheless, local innovations targeted at resolving local challenges can have a major role in addressing international requirements.

Socio-historical aspects

The innovation systems framework is not intended to provide a "one size fits all" solution for Sub-Saharan Africa. These economies have major differences, with regard not only to their structures, but also to their socio-political characteristics. In providing evidence-based research for policy making, it is important to capture the role of history in shaping social interrelations and networks. For instance, in Kenya, South Africa and Uganda, differences in the structure of business ownership are clearly shaped by different socio-historical tensions. In South Africa, apartheid limited business ownership by the majority of the population, thereby curtailing entrepreneurial activity (Schneider *et al*., 2007). Kenya's post-independence period was marked by a strong desire to "kenyanize" the economy in order to break away from the isolation that had set in during the colonial period. Public servants were allowed to operate simultaneously as government employees and businessmen, and this resulted in a vibrant informal sector. In Uganda, the expulsion of Asians during the 1970s resulted in the lack of a middle entrepreneurial class. These socio-historic differences provide very different challenges for policies targeting innovative activities. In turn, outcomes of innovation policies that are shaped by different challenges are likely to produce different results.

This section shows why the theoretical link between innovation and development requires contextualisation through evidence-based research. This is important in order to orient innovative activities appropriately. Furthermore, coherent explicit and implicit innovation policies are necessary to create and maintain an environment which induces opportunities for innovation. Rapid technological change requires policies to be flexible and anticipatory in order to effectively strengthen learning and innovative activities aimed at achieving developmental goals.

Other policy-related issues

The innovation systems approach is attracting interest in other types of policy issues, particularly in developing regions. These include autonomy and possibilities for policy experimentation, the need to extract high-level lessons from policy making or policy learning, and the importance of intermediary institutions and the demand for policy design and implementation.

Policy experimentation

Many authors have stressed the need to create room for policy experimentation in developing countries (Rodrik, 2008; Chaminade *et al*., 2009; Srinivas and Sutz, 2007; Juma and Yee-Cheong, 2005). Their views highlight the need to open up new development trajectories with greater emphasis on generating knowledge and learning not only at the level of the entrepreneur, but also at the level of policy. However, effective policy experimentation requires the existence of adequate learning mechanisms. It also requires a certain degree of policy autonomy and flexibility. An example can be found in Kenya's cut-flower industry in relation to carbon emission debates on environmental impacts (Wijnands, 2005; Bolo, 2008).

Policy learning

Policy learning requires the gradual development of a common vision on how to cope with the challenges and contradictions of the globalising learning economy (Lundvall *et al.*, 2002). Lessons from successful innovation experiences as well as from failures need to feed effectively into policy learning. Policy learning helps to identify not only new strategic priorities but also the specific causes of system failure. It can also help to achieve policy coherence.

Importance of intermediary associations

Intermediary institutions, such as business associations, community organisations, non-governmental organisations (NGOs) and donors, play a role in stimulating innovation system interaction and in strengthening the innovation capacity of the innovation system in poor communities in developing countries (Klerk *et al*., 2009). Given the multi-dimensionality of innovation and the complexity of integrating various types of knowledge in developing countries, the role of knowledge brokers in collecting, packaging and transmitting relevant knowledge for effective policy formulation requires further attention.

Demand-led innovation

In Sub-Saharan Africa innovation strategies have been traditionally driven by supply-side policies, with little regard to the role of demand in shaping innovation strategies. However, users are increasingly recognised as having an important role in the innovation process (von Hippel, 2005, 2007). They can solve problems and adapt existing goods, services and technologies for transfer to producers as "user innovations". Demand from users can also influence the direction and nature of innovation. The implications for policy, including intellectual property regimes, are still being studied (von Hippel and Jin, 2009; Gault and von Hippel, 2009). Chapter 4 stresses that demand in developing countries is largely shaped by the dominant informal sector. Responses of innovation systems to this demand are explored in Chapter 7.

Conclusion

This chapter has provided an assessment of insights from the literature on innovation systems as they relate to innovative activities in developing countries. These insights are more useful for providing general orientations than for specific rules for adapting the innovation systems perspective to developing economies. The complexity of the innovation process makes it fairly difficult to define closely the types of innovative activities that take place in developing countries. It is, nevertheless, important to seek a more comprehensive understanding of learning and innovation processes in developing countries. The dynamic nature of innovation often presents an array of choices that require heuristic selections that occur through productive activities. Such selections may orient innovation into unpredictable paths that may support or inhibit innovations that are beneficial to society. Therefore, the selection of appropriate choices is critical for innovation for development.

Notes

1. A new Sussex Manifesto was launched on 15 June 2010.

2. The innovation systems concept was first mentioned by Freeman (1982). His ideas about the link between technology and development were inspired by the much earlier work of List (1841) on German's strategy for development. List argued for the need to build national infrastructure and institutions as a way of enhancing human competences and consequently spur economic development.

3. The elements of the national innovation system (NIS) have close similarities to structuralist views stressing that development is neither linear nor sequential, but a unique process shaped by a specific history, culture and socioeconomic context. A major contributor to this view stated that "underdevelopment is ... an autonomous historical process, and not a stage through which the economies which have reached a higher level of development have necessarily passed" (Furtado, 1961, p. 180). In other words, development should be understood not as a universal process but as an individual country's specific path of structural transformation. A perspective on the potential for convergence can be found in Motta e Albuquerque (2007).

4. "The dominant mode of thinking about innovation was to characterize this as a challenge involving the application of S&T (measured through R&D expenditure) to economic production." (Kaplinsky et al., 2009, p. 189)

5. Sen's work in the field of development economics has considerably influenced the Human Development Report, published by the United Nations Development Program (UNDP, 1990-2006), including the "human development perspective".

6. Schumpeter (1939), in his analysis of business cycles, was the first to highlight the importance of existing knowledge in creating value. He referred to innovations as new combinations, thereby underlining the fact that "existing elements" provide opportunities to produce "change" in innovation activities.

7. The term "firm" is used here to refer to units that convert knowledge to value across different sectors.

8. The firm had been identified as the key player in the innovation process even in the S&T approach. Bell and Pavitt (1993) point out "failure to recognise the firm as the central player in the accumulation of technology has been the major short-coming of technology policy".

9. Robertson et al. (2003) note that "it is not always possible to distinguish between high, medium, or low-technology industries in a way that is operationally meaningful. In practice, many industries employ a wide mix of product and process technologies."

10. See for example, the case of M-PESA in Hughes and Lonie (2007).

11. They mention a biological vaccine developed in the United States to demonstrate how its high costs have led to efforts to develop an alternative (a synthetic carbohydrate-based vaccine) that would be significantly cheaper.

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