

Enhancing the Role of Knowledge and Innovation for Development¹

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1. Introduction

The broad aim of this study is to improve our understanding of the nature, extent and importance of commercialisation of knowledge in developing countries. The commercialisation of “new” knowledge, whether generated locally or obtained from foreign sources, is to a large extent determined by the ability to translate it into socio-economic solutions. This necessarily suggests that the commercialisation of knowledge cannot effectively be analysed in isolation from other core components (actors, activities and linkages) of the science, technology and innovation system. This paper addresses two main issues: (i) *What are the core elements that enable “new” knowledge to successfully undergo transformations that respond to demand dynamics?* (ii) *What are the implications of these core elements for knowledge commercialisation in developing countries?*

The analysis focuses on the process through which “new” knowledge is converted into beneficial socio-economic outcomes. The generation of local knowledge and/or use of foreign knowledge on the one hand, and the commercialisation of knowledge on the other hand, are linked by a range of specific core elements. This study examines these core elements with the aim of illuminating key capabilities (which to a large extent determine the nature of linkages and activities) that shape the innovation process in developing countries². A comparative analysis based on data for commonly used knowledge output proxies such as patents and publications could provide information on patterns and trends of knowledge commercialisation across developing countries. However, the analysis in this paper is mainly concerned with examining the key aspects that determine the ability to commercialise knowledge rather than the output in the form of conventional innovation indicators³.

The discussion is structured as follows. The rest of the introductory section will present the rationale for the study and the framework for analysis. A brief overview of the key scientific and technological features of developing countries will be provided in section two. More specifically, the section will

¹ Background discussion paper for the OECD workshop, “Innovating for development: converting knowledge to value.”

² Innovation is viewed broadly to refer to the process that involves transformations and modifications for commercialisation of a technology.

³ It is increasingly clear that conventional innovation indicators useful as they may be are not equally effective in reflecting innovation activity across sectors. While they may be fairly successful in the manufacturing sectors the same cannot be said for natural resource sectors which remain major activities in developing countries particularly in Africa.

highlight forms of disarticulation within the knowledge systems and discuss the commercialisation of indigenous R&D and use of foreign knowledge against this backdrop⁴. With regard to foreign knowledge, section three will place special emphasis on the role of foreign direct investment in knowledge commercialisation in developing countries. The focus will be based the restructuring that is being brought about by “*disruptive markets*”. Section four will discuss the implications of the changing nature of innovation drivers in developing countries on the role of donors and some specific forms of opportunities for donor assistance in knowledge commercialisation that may lead to beneficial socio-economic outcomes. Some basic issues in relation to policy will be discussed in section five. Finally, a brief summary of the findings will be presented in section six.

1.1 Rationale for the study

The process of knowledge creation, development and commercialisation encompasses a wide range of science and technology capabilities and activities. To understand the nature and extent of commercialisation of indigenous R&D as well as the use of foreign knowledge in developing countries, it is important to identify the characteristics of technological capabilities and activities⁵.

R&D specific capabilities are vital for providing a basis for knowledge creation. However, they remain a single component of the technological capabilities that are required to ensure that the output of R&D activities filters through enterprise-based activities and reaches the final consumer⁶. Non-R&D specific capabilities play critical complementary roles in facilitating knowledge commercialisation.

It is important to recognise that the focus on research and development (R&D) capabilities that is frequent in discussions on technological capabilities perhaps, inadvertently blurs the importance of other forms of technological capabilities that underlie the complex process of knowledge creation and commercialisation. As Bell (2006) notes “*R&D leaves out many other S&T activities and capabilities that play centrally important roles in creatively exploiting knowledge for economic, social and political aims (e.g. a wide variety of design and engineering activities)*”. This observation warrants further comment on the different forms of technological capabilities that underpin technological knowledge production and commercialisation.

1.2 Framing the issues

1.2.1 Defining core technological capabilities for innovation

To a large extent, the bulk of technological knowledge production in developing countries used in dealing with particular challenges in the environment consists of *incremental change* rather than advancing the technology frontier, which draws heavily on R&D. While this is not intended to minimise or negate the important role of R&D, a narrow focus on strengthening R&D specific capabilities (with little or no attention to non-R&D specific capabilities) is not likely to yield a significant contribution to

⁴ The words local and indigenous are used interchangeably.

⁵ Technological capabilities are defined as “the resources needed to generate and manage technical change, including knowledge, skills, experience and institutional structures and linkages, Bell and Pavitt (1993).

⁶ Enterprise-based activities are defined broadly to include any form of activity that transforms/incorporates knowledge into products, processes or services for the consumer. These activities occur across different sectors and sector-specific variations may exist. In addition, they are not restricted to private firms, but may also be carried out by public or public-private firms.

socio-economic development. Bell (2007) discusses three forms of technological capabilities that promote the creation, development and use of knowledge:

- Operating or production capabilities defined as capabilities for using knowledge that is embodied in or closely associated with existing production systems and facilities.
- Design, engineering and associated management capabilities defined as those capabilities for transforming existing knowledge into new, often innovative, configurations for new or changed production systems.
- R&D capabilities defined as those capabilities for creating new knowledge and transforming it into the specifications for application and production.

Operating or production capabilities may not be directly involved in the creation of *new* knowledge. However, they indirectly promote the process by providing an interface for incorporating and implementing new knowledge and skills in the production of goods and services through interaction with the design, engineering and associated management capabilities. In addition, they provide critical feedback to the design, engineering and associated management capabilities for targeting demand for innovations.

Design, engineering and associated management capabilities 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. They may be viewed as a *liaison* between the new knowledge that is generated by R&D activities (whether foreign or local) and the use of new knowledge in the production of goods and services. It is important to note that this category of capabilities is highly deficient in developing economies and constitutes a major draw back to knowledge creation and commercialisation. Indeed, attempts to promote both the generation of local knowledge and the use of foreign knowledge tend to overlook the importance of this category of technological capabilities and consequently subsume it into the R&D capabilities. It is no wonder that the development of technological capabilities is often reduced to strengthening R&D capabilities and activities. The deficiency of design, engineering and associated management capabilities is in part responsible for the disarticulation that characterises the scientific and technological capabilities in developing countries⁷.

The role of R&D capabilities in generating new knowledge and transforming it into applicable forms requires no emphasis. However, it cannot be overemphasised that direct spending on R&D for new products and processes as a primary science and technology activity does not automatically determine technical progress. R&D capabilities are complemented by design, engineering and associated management capabilities in stimulating demand for innovation. Verspagen (2004) observes that *“If we characterise the impact of some innovations as ‘major’, ‘basic’, or ‘radical’, it is only because of a continuous stream of incremental innovations following the introduction of a basic new design.”* Strong interdependent relationships exist between basic and incremental innovations. Moreover, the latter is perhaps ever more important insofar as a basic new design that fails to be sufficiently adapted for commercialisation in a particular economic context may be rendered useless. Design, engineering and associated management capabilities provide a conduit for successful adaptation and commercialisation of *new* knowledge.

⁷ The mechanism through which these capabilities are created will be discussed further in the following section.

1.2.2 Creating design and engineering capabilities

The creation of innovative technological capabilities, which include design and engineering capabilities amongst other forms, relies to a large extent on the technological learning opportunities that are provided within productive activities⁸. This form of technological learning is complementary to the basic technical abilities obtained within formal education and particularly at the tertiary level. This discussion focuses on tertiary education and training rather than on education more generally although it takes into account the importance of basic *cognitive* abilities provided by primary and secondary education, which invariably form the foundation for the tertiary level. Tertiary education and training is viewed with regard to the crucial complementary role it plays in providing the “basic technical abilities” (over and beyond the basic abilities acquired at the primary and secondary levels) that are better predisposed for absorption and further development within productive activities.

The development of innovative technological capabilities in developing countries (and probably everywhere) 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.

It is important to emphasize that the acquisition of basic technical abilities from tertiary institutions does not automatically result in improved technological capabilities of an economy⁹. The development of technological capabilities also requires a complex learning process that is linked to innovative efforts within the productive activities. This form of learning requires deliberate investment efforts in knowledge assets within the firm, which may involve substantial deliberate costs¹⁰. Firms play a central role in technological transformations by virtue of the fact that innovation or commercialisation of knowledge, takes place within them. The policy environment of an economy plays a key role in determining the extent to which entrepreneurs are willing to incur this form of costs¹¹.

Over and above learning by doing within productive activities, the complex learning process involves learning by explicit intra-firm training and by managed experience accumulation that make significant contributions, Bell and Pavitt (1993); Lall and Teubal (1998). Subsequent learning within productive employment (in-firm learning) that results in technologically creative competences involves two critical elements: (i) explicit training, and (ii) learning-by-doing. In turn, each of these two critical elements takes two forms:

- explicit training
 - (i) specialised training outside the firm - relatively specialised training that can in principle be provided outside the firm by, for example, universities (though often only with intensive

⁸ Learning is defined as “any process by which the resources for generating and managing technical change (technological capabilities) are increased or strengthened, Bell and Pavitt (1993)

⁹ It is common practice within discussions on technological capability development to assume and consequently prescribe the strengthening of tertiary education as the solution to the creation of technologically creative competencies.

¹⁰ The term “firm” is used here to refer to enterprises across different sectors although the manner in which the development of technological capabilities within the process of generation and use of knowledge may differ to reflect sector specific aspects.

¹¹ This issue is discussed further in section 5.

- involvement by firms, at least in developing the content but often also in providing the capabilities to implement the training)
- (ii) specialised training within the firm - more specialised forms of training that can only be provided within the firm
 - learning-by-doing
 - (iii) learning-by-doing routine operational tasks - this typically adds little to the creative and innovative capability of individuals, Bell, (1984) and Lall and Teubal (1998)
 - (iv) learning-by-doing innovative technology-developing tasks – this is much more likely to add to innovative capabilities

The intensity and combination of these four aspects significantly influence the extent to which tertiary education actually results in additions to technological capabilities. More specifically, one can envisage at least three different outcomes of enterprise-based learning:

INN – skills that constitute components of a domestic innovative capability. These skills are critical for the creation of the design, engineering and associated management capabilities referred to previously. They are a link between R&D activities and the activities related to the production of goods and services. As noted earlier this category of capabilities is a major draw back to knowledge creation and commercialisation in developing countries.

OPC – skills that constitute operational/production and associated capabilities for the production of goods and services

HSE – highly-skilled emigrants who join the international brain drain from developing countries. This category of capabilities may be composed of both INN and OPC to varying degrees

The structure, scale and articulation of technological capabilities are to a large extent influenced by the nature of the technological learning process that exists within productive activities. These technological capabilities lie at the centre of enhancing commercialisation of knowledge for development¹². However, the commercialisation of indigenous R&D and use of foreign knowledge in developing countries is commonly analysed without due reference to the nature of the technological learning process that exists within productive activities despite its critically important role in determining the scope of knowledge-related activities¹³. This process is crucial in strengthening non-R&D specific capabilities (particularly the design and engineering capabilities).

It is important to recognise that focusing strictly on R&D specific activities is not likely to illuminate our understanding of commercialisation of knowledge in developing countries. More specifically, the creation and commercialisation of knowledge is influenced by the process through which innovative capabilities are (i) produced within enterprise-based activities and, (ii) effectively integrated within the Science, Technology and Innovation system to provide a link between R&D and non-R&D specific activities.

¹² See figure 1 below. The section of the diagram illustrating the core activities in the Science, Technology and Innovation System is taken from Bell (2007), who bears no responsibility for any modifications.

¹³ Research based on analysing knowledge output in the form of conventional indicators is common, but it says little about the nature and scope of the technological learning process.

An economy that is deficient in non-R&D specific capabilities (particularly the design and engineering capabilities, and which tend to receive scant attention despite their central role in providing a conduit for successful adaptation and commercialisation of *new* knowledge) is not likely to display a successful record of commercialisation of R&D or even engage in a highly dynamic process of production of goods and services. Arnold and Bell (2001) note that “*OECD countries and the more successful NICs tend to devote significant state resources to fostering technological capabilities, which form the needed foundation for technological dynamism, R&D performance and success...*” Industrialised countries probably have robust non-R&D specific capabilities such that the large emphasis on R&D specific activities in comparison to non-R&D specific activities is of considerable relevance to them, but not at the expense of the latter.

1.2.3 The relevance of demand

The nature of innovation in the broad sense suggests that the proportion of the R&D output, which is exploited for socio-economic gains is contingent upon the extent to which demand factors are taken into account; demand is a key factor in influencing the selection of new basic designs (whether produced locally or obtained from foreign sources) for commercialisation. Demand dynamics of innovation must, therefore, be factored into the creation and use of knowledge, including through non-R&D specific activities, in order to achieve socio-economic benefits. Bell (2006) notes that “... *the ‘demand side’ is not something that exists outside S&T capabilities; it consists very largely of particular kinds of (non-R&D) S&T capabilities*”. The transformation of an invention into an innovation or the successful commercialisation of a technology clearly depends on a wide range of technological capabilities that are not R&D specific, but are also critical for creating supply incentives for new knowledge¹⁴. In addition, other forms of capabilities that may not be technology intensive play a major role in the generation and commercialisation of knowledge. In particular, entrepreneurs are critical in addressing the challenge of identifying technological opportunities that match the nature of the existing demand for innovation in a specific context.

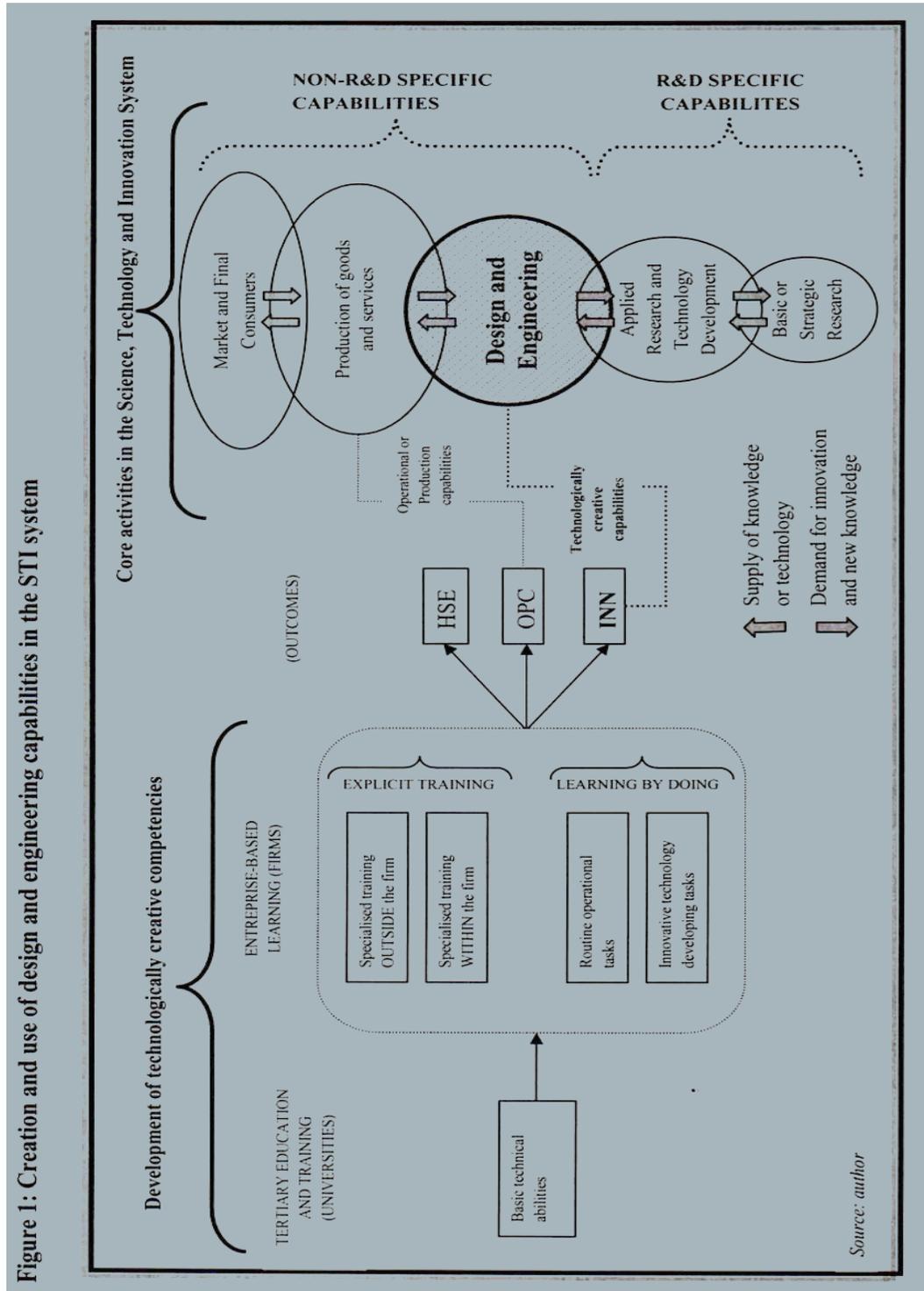
The decisions of entrepreneurs are constantly influenced by both the dynamic nature of demand and the new/existing technologies. Therefore, entrepreneurs play a key role in matching the demand within a specific context to specific technologies and in so doing create technological opportunities (supply incentives) for knowledge generation and commercialisation that meet the market demand. Innovative activity depends on the creation of technological opportunities that are crystallized by specific demands. For example, the M-Pesa innovation is highly successful in Kenya owing to its ability to target the high demand for rapid and secure money transfer services via mobile telephone for the large “unbanked” population. It fills an important gap in a developing country market. The nature of demand for innovations may differ between developing countries and industrialised countries: the nature of demand in an industrialised country may not be met by a similar innovation¹⁵.

The role of the firm in creating technological opportunities, which involves taking deliberate investment decisions to engage and developed technological capabilities through the complex learning process

¹⁴ Bell (2006) analysed the main activities of scientists and engineers in the US in 2003 and found that only 10% undertook R&D as their main activity while the remaining 90% were engaged in activities that are non-R&D specific but play key roles in the innovation process. In addition, a large proportion of the scientists and engineers in the non-R&D specific activities were engaged in design and engineering activities.

¹⁵ See box 2 in section 3.3 for further details on M-PESA.

discussed previously cannot be overemphasised. The creation of new technological opportunities (whether new to the firm or to the world), which successfully fill in important gaps by meeting specific demands necessarily depends on the ability to adapt and up-grade the technological capabilities of the firm. It often requires considerable learning driven by the needs of the final consumers even in cases where the vast majority of final consumers are low income earners as in the case of many developing countries.



Source: author

2. Knowledge systems and commercialisation of knowledge in developing countries

Indigenous knowledge in developing countries largely resides in the traditional knowledge system¹⁶. Large populations in developing countries continue to rely on the traditional knowledge and techniques particularly for the health and agriculture. The use of traditional medicine and crop production techniques make significant contributions, particularly to the livelihoods of rural populations in developing countries. However, the transmission of traditional knowledge and techniques for application at a wider scale and/or commercialisation remains limited due to cultural inhibitions, the non-codified nature of the knowledge etc.

To a large extent, traditional knowledge exists alongside modern knowledge; there are virtually no linkages between the two and fairly weak linkages for the most part within each subset of knowledge. Forje (2006) observes that “...innovations in technological, cultural or institutional subsets often remain isolated and unconnected despite an otherwise reasonably robust informal knowledge network in existence. Indigenous knowledge, innovation, and creativity were not catapulted into the formal productive sector”. Indeed, the knowledge system in developing countries is viewed as being composed of an exogenous scientific and technological base which refers to “the set of unusually rather limited scientific, technological and production capabilities that have little interaction with each other, which are seldom related to the stock of traditional knowledge, techniques and production in the country, which have relatively stronger ties with their counterparts in the developed countries, and which do not foster innovation or efficient production.” (Sagasti, 2004).

In some of the more advanced developing countries, the use of indigenous knowledge that resides within traditional knowledge systems appears to be more widespread than in other developing countries. This is perhaps owing to better articulation of traditional and modern knowledge in the more advanced developing countries. An illustration of this point is provided in the following box on traditional Chinese medicine (see box 1). It is noteworthy that the ability of the Chinese to integrate components of modern knowledge into their traditional knowledge has promoted the commercialisation of indigenous knowledge including in developed countries¹⁷. Perhaps more interestingly, markets that are generally considered to be marginal – low-income earners in an economy that is characterised by weak industrial structures – have been successfully targeted.

Chinese investments across sectors in developing countries, particularly in Africa offer opportunities for “testing” the capacity for success of their innovations before launching them into other regions. This modus operandi is not at variance with the observation made by Christensen (2007) that “disruptive technology is initially embraced by the less profitable consumers in the market”. Another perspective of the relevance of developing country markets for Chinese innovation activities may lay in an even more recent argument in which “disruptive markets” rather than “disruptive technology” are expected to increasingly shape innovation dynamics. “The disruption in this case is not the arrival of new technologies which drive the search for new markets, but the disruption provided by distinctively new types of consumers, based in low income countries.” Development, Policy and Practice (2009)

¹⁶ This is not to suggest that traditional knowledge systems do not exist in industrialised countries. They may however, play smaller (though critical) roles than modern knowledge systems. In addition, their scope for use may be more extensive since their articulation with modern knowledge systems may be better integrated, which also suggested that the distinction between traditional and modern knowledge may not be obvious.

¹⁷ Acupuncture, for example, has been streamlined into the U.K’s National Health Service.

Box 1: Traditional Chinese medicine in Kenya

The fairly successful commercialisation of traditional Chinese medicine across the world may be related to the ability to integrate it into modern forms of commercialisation. In fact, the up-take of Chinese medicine in African countries such as Kenya has had great success in the recent past and displays large potential for expansion. The use of Chinese medicine appears to by-passes that of Kenyan traditional medicine particularly in urban areas*. It may be argued that Chinese traditional medicine has managed to fill a specific niche in the market. It uses modern forms of delivery for products that draw heavily from traditional knowledge. The products appear to be fairly accessible in terms of cost (in comparison with western medicine) and are largely viewed as natural (herbal) rather than chemical and therefore respond to culturally oriented preferences.

The modern forms of delivery include aspects such as *free* group lessons on health, nutrition and medicine targeted at maladies that are common within the context and for which Chinese remedies are available. This particular aspect of delivery clearly serves as an innovative advertising campaign that appears to have advantages over the more conventional forms of advertising. More specifically, the *free* group lessons are viewed as an information bonus for better health practices and therefore fill an existing information gap. The lessons also help to demystify medical treatment, which may be seen as a form of sensitisation, thereby making it more socially acceptable. In addition, a system of network based on the development of complex forms of social capital that use incentives such as network-based price discounts appears to play an important role in improving the up-take and consumer loyalty for Chinese medicine. Furthermore, the forms of medical examination employed in Chinese medicine also appear to be less intrusive than those of western medicine and may therefore display a better understanding of the existing cultural beliefs and practices.

* The use of foreign medicine including both western and Chinese medicine may to some extent be described as alternative medicine owing to the greater reliance on traditional medicine and therefore accessible to a minority largely in urban areas. However, the potential for expanding Chinese medicine in rural area, not least because of the nature of social networks that it is developing, may be large.

Source: author's unpublished observations and interview notes

The point being made here is that there are extensive innovation opportunities that are being exploited by and in developing countries, but remain “undetected” by the conventional frameworks for analysis because they are “below the radar”. The innovations focus is on the market rather than on the technology. Hughes and Lonie (2007) note that “*The market is littered with first-world solutions that have utterly failed in emerging economies. Many technology-based companies tend to keep R&D focused on technology rather than the market*”. As emphasised in the framework for analysis, non-R&D specific capabilities and particularly the design, engineering and associated management capabilities lie at the heart of knowledge commercialisation. They play a substantial role in aligning technology (which is essentially based on *existing* technology in the case of developing countries) to the varied aspects of the specific context (financial, cultural, regulatory etc) so as to successfully commercialise knowledge. Developing economies such as India and China have made significant progress in this direction, which has enabled them to exploit developing country markets that have previously been ignored by the dominant innovators (western multinationals). These markets are characterised by poor consumers and are increasingly displaying the potential of being disruptive with regard to the fact that they offer a possibility to innovators that have not been dominant in past decades to “*change the pecking-order currently governing global corporate and national hierarchies*”.

Development, Policy and Practice (2009) argues that the “*Below-the-radar-innovation involves the movement of appropriate innovation from the fringes of the growth process and from the purview of the NGO movement to the centre of the globally-dynamic segments of the global economy...Crucially, it is a process predominantly driven in low income economies and by low income economy firms.*” It is clear

that in order to understand these emerging forms of innovations that are predominantly found in developing countries, it will be important to develop appropriate lenses (*grilles de lecture*).

3. The role of FDI in developing countries and the commercialisation of knowledge

There are a number of studies that view FDI as a prominent channel of ‘technology transfer’ to developing countries. Some of the channels through which ‘technology transfer’ is thought to occur include: training and work experience (Saggi 2002); backward and forward linkages (Mattoo and Payton 2007); demonstration effects and competition effects (Blomstrom et al 2000 and Javorcik et al 2005). However, the nature and extent of innovation-related interactions between local firms and foreign firms have received little attention despite being critical in determining the prominence of FDI as an effective source of foreign knowledge. Innovation-related interactions could play a major role in enhancing technological competencies and in particular design and engineering capabilities in both local and foreign firms. Technological competencies form the milieu for innovation-related interactions: they promote (i) the use/adaptation and commercialisation of foreign knowledge that is embedded in FDI and (ii) the generation and commercialisation of indigenous knowledge.

3.1 FDI innovation-related interactions in the host developing countries

It is increasingly being recognised that the FDI has a positive effects on technological capability development in an economy that predisposes of sufficient technological competencies. The results of a study carried out by Borensztein et al (1998) showed that the impact of FDI on growth was positive only for countries that had attained a certain minimum level of human capital. However, FDI analysis in developing countries is underpinned by an assumption that generally points to uni-directional knowledge flows – from foreign firms to local firms. A more recent study on the nexus of technological activities in foreign subsidiaries and domestic firms concluded that some developing economies do “*have reasonably long-established industrial structures and human resource endowments [and] instead of imagining that FDI simply delivers spillovers of superior knowledge via a one-way-pipeline to technologically backward domestic firms, it may be more helpful to imagine a more complex and locally centred knowledge-production and diffusion system*”, Bell and Marin (2004). While FDI inflows offer opportunities for knowledge flows between the MNE subsidiaries and local firms, MNE subsidiaries may not have a competitive advantage over local firms in many activities particularly those served by SMEs, Lall (2002).

Promotion of technological capability development in local firms is not only critical for effective innovation-related interactions to occur between MNE subsidiaries and local firms, and insertion of local firms into global value chains, but also for strengthening competitiveness in the activities in which local firms have a competitive advantage. New ways of understanding and measuring the two-way knowledge flows would be useful in analysing the role of FDI in developing countries including with regard to knowledge commercialisation.

3.2 Where does this leave the majority of developing countries?

It goes without saying that in a majority of developing countries, particularly in Africa, the role of FDI in strengthening knowledge assets may be less obvious. FDI is concentrated in the resource-based industry and infrastructure and this trend is expected to continue (World Investment Report, 2007). At the same time, it has been observed that FDI is viewed as an efficient means for transferring innovations rather than the innovation process itself, (Lall, 1992). It therefore, appears important to direct more attention into exploring ways of enhancing technological learning within these activities with the aim of unveiling opportunities for extending and deepening local technological learning capabilities by engaging them in innovation-related activities.

Goedhuys (2007) analyses technological learning within foreign and locally owned firms in the manufacturing sector in Tanzania¹⁸. Although government policies targeted at attracting FDI are based on the expectation that the activities of MNE subsidiaries will lead to innovation-related interactions between foreign and local firms, the author finds that the links for technological learning between the two sets of firms are weak. Innovation in local firms was mainly based on internal learning and inter-firm linkages among domestic firms, while that of foreign firms on strong linkages amongst the foreign owned firms. The conversion of knowledge to value in low-income countries is more likely to benefit from greater dynamism if there is deliberate development of a technological learning process based on integrated innovation-related interactions between local and foreign firms. Such a process is also likely to be more successful in attuning innovations to specific market niches that are offered by consumers in developing countries.

It is worth noting that although the development of M-PESA took place in an economy that may not be considered as having a relatively well established industrial structure and adequate human resources, it cannot be concluded with certainty that the flow of knowledge assets was uniquely from the MNE (Vodafone) or its subsidiary (Safaricom) to local firms (see box 2 below). Vodafone had to build its “*own service from scratch*” that focused on the market. This process consisted of ironing out the differences that existed between the conventional operations of banks and telecommunication companies. Vodafone partnered with the Commercial Bank of Africa, in order to build a platform that would allow the exact matching of e-money with the real money. It would not be presumptuous to suggest that there may have been knowledge flows from the bank to Vodafone in building such a platform¹⁹. Developing tools that adequately capture the nature and extent of such knowledge flow in economies that are not characterised by well-developed industrial structures and human resources remains a challenge.

¹⁸ The manufacturing sector tends to attract a significant amount of attention including in studies that attempt to analyse technological learning at the expense of other sectors. There is clear evidence that FDI in developing countries is concentrated in the resource-based industry and infrastructure.

¹⁹ The Commercial Bank of Africa originally commenced business as a subsidiary of Société Financière pour les pays D’Outre Mer (SFOM), a Swiss-based consortium bank with interests in financial institutions throughout Africa. CBA is now wholly Kenyan owned and is the largest privately owned bank.
http://www.cba.co.ke/default2.php?active_page_id=117

3.3 Driving knowledge commercialisation at the “bottom of the pyramid”

It has been observed that the final consumer plays a central role in the innovation process, which involves considerable learning. In line with von Hippel’s observations on final user-led innovation, Development, Policy and Practice (2009) observes that *“in an increasing number of sectors, ‘beta-vintages’ are released at a deliberately premature stage of product development to lead-users, aided by the growing sophistication of real and virtual model-making technologies... Lead users then refine the product, ironing out weaknesses, and attuning the product to specific market-niches, before suppliers proceed to large-scale production.”* For example, during the development of the M-PESA service, Vodafone partnered with Faulu Kenya, a local micro-finance institution. Faulu serves thousands of borrowers who run small businesses and Vodafone needed the borrowers as well as existing airtime dealer stores to act as lead-users in the M-PESA trials. The pilot involved extensive training for the borrowers, airtime dealers, the micro-finance institution (Faulu), customer service and finance within Vodafone’s subsidiary Safaricom etc. so as to collect feedback that would be used to improve the service before launching it.

Prahalad and Hammond (2002), suggest that developing countries offer enormous opportunities for knowledge commercialisation by multinational companies (MNC): *“Markets at the bottom of the economic pyramid are fundamentally new sources of growth for multinationals.”* They argue that the onus is on MNC’s to stimulate market dynamism and knowledge commercialisation in low-income economies in pursuing their profit-making objectives. The authors point out that *“the fact is, many multinationals already successfully do business in developing countries (although most currently focus on selling to the small upper middle class segments of these markets)”*. The focus of MNC’s on the upper middle class is perhaps more than a mere oversight on the part of the MNC’s of the existence of large low-income markets that offer increasing opportunities for technology intensive products. It is more likely that in general *“the existing innovation leaders are unable to either recognise or exploit these dynamic new market opportunities. Their trajectories and market antennae inhibit them from fully recognising these new opportunities which are ‘below the radar’”*, Development, Policy and Practice (2009).

A survey on foreign investment in Africa found that there is a growing relevance of South investors. Western MNEs continue to account for a fairly large share of foreign investment, but their growth is either slow or stagnant, African Foreign Investor Survey (2005). It may be the case that rather than MNC’s attempting to focus on stimulating emerging markets, it may be more useful for them to learn how to get stimulation from these markets. In addition, this form of stimulation is best achieved through localisation of knowledge. Stiglitz (1999) observes that *“the overwhelming variety and complexity of human societies requires the localisation of knowledge”*. This point is reinforced by Hughes and Lonie (2007) who note that *“Sitting in a comfortable office in England and deciding what Africa needs is an approach doomed to failure.”* Innovation is an interactive learning process that encompasses feedback mechanisms and in which firms, customers, suppliers and institutions engage within a specific environment. Its nature renders competence acquisition increasingly *tacit* and thus more difficult to share. The localisation of knowledge is critical in providing a milieu for acquiring *tacit* knowledge, which is *“primarily rooted in practical experience and social learning”*, Lundvall (1996).

Box 2: M-PESA: Mobile Money for the “Unbanked” Turning Cellphones into 24-Hour Tellers in Kenya

In March 2007, Kenya's largest mobile network operator, Safaricom (part of the Vodafone Group) launched M-PESA, an innovative payment service for the unbanked. The customer does not need to have a bank account, but registers with Safaricom for an M-PESA account. Customers turn cash into e-money at Safaricom dealers, and then follow simple instructions on their phones to make payments through their M-PESA accounts; the system provides money transfers as banks do in the developed world. The account is very secure, PIN-protected, and supported with a 24/7 service provided by Safaricom and Vodafone Group.

The project faced formidable financial, social, cultural, political, technological, and regulatory hurdles. A public-sector challenge grant helped subsidize the investment risk. Vodafone had to marry the incredibly divergent cultures of global telecommunications companies, banks, and microfinance institutions – and cope with their massive and often contradictory regulatory requirements. Finally, the project had to quickly train, support, and accommodate the needs of customers who were unbanked, unconnected, often semi-literate, and who faced routine challenges to their physical and financial security.

Getting cash into the hands of people who can use it is limited on the supply-side rather than demand-side; there is no shortage of funds, but it's the ability to move money from the sender to the receiver that is the stumbling block. But the issue is exactly how money transfer is made to happen in an emerging market where the infrastructure is poorly developed and where very few people have or even want bank accounts. Under such circumstances, moving cash is risky, expensive, and slow.

Private sector organizations such as Vodafone are legally bound to use their shareholders capital to achieve the best returns. But many organizations use internal competition to allocate funds to their projects, and this competition is based on potential returns on investment. As a result, any initiatives that relate to the development agenda usually get squeezed out... How could firms raise executive-level interest and get funding to develop products that will be non core and long term but do have some sort of sustainable development theme? One angle could be to position such projects in the Research & Development (R&D) department. This would work in many sectors where new products take a long time to reach market, but many technology-based companies—and Vodafone is no exception—tend to keep R&D focused on the technology rather than the marketplace. Financial services in emerging markets are not about new technology... This wasn't about new technology; it was about a new application of existing technology.

Sitting in a comfortable office in England and deciding what Africa needs is an approach doomed to failure. The market is littered with first-world solutions that have utterly failed in emerging economies. The excellent early adoption rate of M-PESA in Kenya strongly suggests that the service meets a need in the market. Usage is significantly above expectations. Vodafone is already piloting the product in new markets will soon allow person to person transfers across international borders... challenge funds provide a useful mechanism to facilitate private-public sector partnerships.

Source: Hughes, N. and Lonie, S. (2007) “M-PESA: Mobile Money for the “Unbanked” Turning Cellphones into 24-Hour Tellers in Kenya”, *Innovations: Technology, Governance, Globalization*, Winter/Spring 2007, Vol. 2, No. 1-2, Pages 63-81

The argument by Development, Policy and Practice (2009) that the “*disruptive markets*” will increasingly shape innovation dynamics leading to greater innovation activities in and by developing countries may offer some insight on the observed trends of South-South FDI. Similarly, the argument could provide some understanding of the changing nature of the innovation activities that are carried out by locally-owned firms of developing countries in their home countries. For example, Equity Bank in Kenya has designed flexible banking services for the “unbanked poor” who for years have been shut out of the financial system. This includes providing mobile banks to some of the most isolated parts of rural Kenya (see box 3 below).

Box 3: Three million customers and still counting: the bank getting rich by helping the poor

Homegrown lender draws in customers shunned for decades by multinationals

Equity Bank, a homegrown company that has turned the financial services industry on its head. For decades multinationals such as Barclays and Standard Chartered dominated Kenya's banking sector by focusing almost solely on the middle and upper classes. Equity went the opposite way. It targeted the unbanked poor.

In just a few years Equity has gone from being a quirky, fringe player to the third most profitable bank in the country and one of leading companies on the Nairobi Stock Exchange. It claims to have signed up its three millionth customer last month, giving it a 50% share of the Kenyan market.

Equity realised that there were millions of low-wage earners in Kenya - a demographic economists call "the bottom of the pyramid" - who wanted to save and especially to borrow but were locked out of the financial system. As individuals the customers were not worth pursuing, but as a block they represented a huge, and potentially very profitable, market.

Since many of individual customers work in the informal sector and have few assets of value, the loans are often backed by what the bank calls "social collateral". This can include account holders grouping together to guarantee an individual's debt.

With a cutting-edge IT infrastructure keeping transaction costs down, the bank earned £21m before tax in 2007, a return that encouraged the British private equity firm Helios Investment Partners to buy a 25% stake. This year earnings are expected to have more than doubled for the fourth successive year.

Source: The Guardian, Friday 2 January 2009, <http://www.guardian.co.uk/world/2009/jan/02/equity-bank-kenya-james-mwangi>

The success of Equity Bank in exploiting a "*disruptive market*" suggests that it has acquired a substantial amount of *tacit* knowledge that could be deepened and extended to develop and commercialise knowledge targeted at niches markets (which in this case take the form of markets for poor consumers). The sale of a 25% stake to the British private firm, Helios Investment Partners may imply that Equity Bank may offer it practical skills and experiences that could be beneficial for knowledge exploitation and commercialisation²⁰. This may be interpreted as a strategic move by Helios Investment Partners to embed their innovations processes within the "*disruptive market*". Apart from foreign firms, partnerships with the public sector and donors also offer further opportunities for knowledge exploitation and commercialisation. Equity Bank is supporting a government initiative dubbed the *women entrepreneurship fund* by providing flexible credit facilities to women entrepreneurs. In addition, UNDP/Equity bank initiative is offering innovative women-client capacity development (entrepreneurial) training. This issue will be discussed further in the following section.

4. Donors and knowledge commercialisation in developing countries

The emergence of a knowledge-based economy and globalisation is continuously restructuring the role of donors. The extent to which donors will have an impact on developing countries will increasingly be shaped by knowledge commercialisation aimed at benefiting the marginalised populations in developing

²⁰ Helios Investment Partners is an investment firm making private equity investments in sub-Saharan Africa. Helios' primary focus is the ECOWAS region in West Africa centred around Nigeria, with a secondary focus on South Africa and SADC region. http://www.edcgroup.com/helios_investment.asp

countries. As discussed in the previous section, the “*disruptive markets*” in developing countries are expected to drive knowledge commercialisation. Previously, donor emphasis has focused on supporting the search for “*disruptive technology*” in addressing the concerns of developing countries. This has mainly taken the form of increased investment targeted at establishing and strengthening public research institutions that are generally viewed as the main purveyors and developers of knowledge. From one perspective it may be argued that this is a well founded point to the extent that it relates to developing knowledge assets that are recognised as central to development. However, for donor involvement in the strengthening of knowledge assets to have a significant impact on developing countries, it will have to engage in enhancing knowledge *nodes* and links that have previously received little attention

It is now becoming increasingly clear that while the development of knowledge assets remains central, donor attention has focused on a specific set of *nodes*. The emphasis on public sector R&D has not yielded the expected innovation dynamism. First, although a number of successes have been reported, particularly in health and agriculture (which receives the bulk of donor assistance in the form of R&D support to public research institutes), these successes have not, for the most part, been translated into generalised use and application that would be reflected in enhanced innovation dynamism. In other words, although some commercialisation of health and agricultural inventions have been occurred, greater emphasis remains on S&T rather than on the general application and commercialisation of the S&T outputs.

Donor emphasis on the agriculture and health sectors has perhaps been an attempt to address the most critical aspects of many developing economies, although they continue to face major challenges with regard to food security and preventable diseases. Clark (2008) points out that “*The so-called Green Revolution worked well for maize, wheat and rice in the mid 20th century and where the target farmers had adequate access to land, fertilisers, water and credit. But on the whole these were not the poor farmers that needed help. And many in this category, perhaps most, did not benefit. Certainly the huge superstructure of the Consultative Group for International Research, the CGIAR system, (established as the institutional heir to the Green Revolution), seems not to have produced much poverty alleviation since. Similarly, in health HIV and malaria are the diseases that hit the headlines, but arguably to the detriment of other neglected diseases where the “science” may not be as exciting but where poverty-inducing impacts are probably at least as great.*” The research efforts of public research institutes tend to be disconnected from the demand; public research institutes have not been successful in stimulating demand for their research from the private sector and this is not likely to happen. In low income economies, it is the “*disruptive market*” rather than “*disruptive technology*” that is more likely to produce knowledge-related benefits. This leads to the second point. The private sector rather than public sector may have greater potential for knowledge creation and commercialisation, even in health and agriculture to some extent.

Bell (2007) points out that “*the key STI-related actors, interactions, knowledge bases and learning process in industry/infrastructure sectors are very different from those in other sectors — e.g., in agriculture and health*”. This is not to suggest that the private sector has a very limited role in health and agriculture. In fact, as pointed out in section two above, in developing countries large populations continue to rely on the traditional knowledge and techniques particularly for the health and agriculture. The traditional knowledge and techniques are generally neither the domain of public research institution nor are they dispensed by the public sector. For example, in many instances, traditional healers operate as entrepreneurs and cultural inhibitions that prevent the generalisation of their knowledge (in which their entrepreneurial activities are embedded) are not entirely at variance with the use of trade secrets in

the modern knowledge systems. Indeed, most of the knowledge even in modern knowledge systems resides in the private sector. Arnold and Bell (2001) observe that “*the required knowledge mostly does not reside within the public research institutions. Rather, it needs to exist right across the economy and society- in firms, on farms and in the hospitals as much as in the universities.*”

While acknowledging that differences across sectors (agriculture, health, industry etc) may result in variations in the nature of private sector engagement, Clark (2008) argues that “*In fact it is at least arguable that successful technology development for agriculture and health is not in principle dissimilar to that for industry. Though its required enterprise-led nature may not be so easy to achieve, surely we should be able to make a better attempt than we have so far.* One way of making a better attempt at enhancing enterprise-led innovation or general application and commercialisation of knowledge takes us to the issue of enhancing knowledge *nodes* and links that have previously received little attention. Undoubtedly a critical node at stake here is that of design, engineering and associated management capabilities. These capabilities are in part responsible for the disarticulation that characterises the innovation in developing countries. The role of donors in knowledge commercialisation in developing countries is unlikely to achieve a substantial impact on the innovation dynamism, unless it addresses these capabilities, and to a large extent within the private sector. More generally, the peculiar nature of technological learning in non-R&D specific activities requires concerted attention within the broader effort of strengthening the general innovation environment.

Of course, placing the private sector on the agenda of donor assistance raises a fundamental question with regard to the general *principle* of limiting the benefits that may accrue to the donor while maximising those intended for the beneficiary. This may be construed as shifting attention from the public sector that is thought to be better placed at ensuring equitable distribution to the private sector. The public sector has historically been the main beneficiary of donor assistance and efforts have been made over time by changing the nature of relationships between donors and beneficiary. For example, there has been radical change from *tied* aid to more collaborative assistance. In practice, however, it may be argued that other forms of misalignments may have emerged or been reinforced and the *principle* may not render donor assistance significantly more successful in strengthening the delivery of knowledge assets for the socio-economic benefit of the vast majority of the populations in developing countries.

As suggested by Hall and Dijkman (2008), “*instead of incentives for developing effective alliances for co-development, development assistance is a professional environment where succeeding (in reducing poverty) means working your way out of a job.*” Similarly as suggest by Clark (2008), some donor funded structures such as the CGAIR may not be abreast with the knowledge-related restructuring that is occurring in developing countries and hence the dismal outcome observed over the last few decades. Perhaps it is not too early to make better attempts at integrating the “*disruptive markets*” into the relationships between donors and developing countries, which may involve some rethinking with regard to the general *principle* or put more bluntly, on reciprocal knowledge benefits in donor assistance. Besides, international research and innovation collaboration between donor countries and developing countries includes not only the public sector, but also the private sector. The quest for knowledge is likely to lead to increased knowledge links between the private sector from donor countries and developing countries. This will continue to bring about an array of opportunities and challenges (for example, possibilities of incidents such as bio-piracy cannot be dismissed).

There is some documented evidence of how donors attempt to reconcile the provision of opportunities for knowledge exploitation and commercialisation by the private sector on the one hand and, on the other delivery assistance to developing countries. In the development of the M-PESA service presented elsewhere in the document, Hughes and Lonie (2007) noted that *“There has been much positive discussion in recent years about donor agencies seeking new ways to deliver funds to those who need it most, directly and in a more efficient manner, so that the capital is productively deployed. At the core of these initiatives is a willingness to find more effective ways of delivering assistance.”* And this donor interest is increasing resulting in funding of the private sector, including industrialised country firms as was the case for Vodafone reported by Hughes and Lonie: *“In 2000, the U.K. government’s DFID established the Financial Deepening Challenge Fund (FDCF). The FDCF fund managers and the proposal assessment team were looking for innovation. This could involve the development of a product or service that was not previously available in a target market, a new service that gave customers access to goods or services that would previously have not been available, or the application of a technology that reduced the costs of service provision. Many of the successful applicants were large, well-known private sector companies that faced challenges similar to Vodafone’s in pursuing what would be perceived as low yield projects. The entrance of a telecom company into a funding competition for the financial services sector took a few of the FDCF proposal review team by surprise, but we overcame some initial cynicism and were awarded funding of nearly £1 million, which was matched by Vodafone.”*

The provision of funding by DFID has benefited the “unbanked” population who now have access to rapid and secure money transfer services via mobile telephone. It has also benefited the industrialised country multinational Vodafone not only through the benefits that accrue from the provision of the money transfer service to the unbanked, but it now also holds a patent that has resulted from focusing on a *“disruptive market”*. The extent to which donors will have an impact on developing countries will increasingly be shaped by knowledge commercialisation aimed at benefiting the marginalised populations in developing countries. Donors are likely to have much more far reaching effects on the populations of developing countries if they extend support not only to foreign firms operating in developing countries, but also to developing country local firms engaging in innovation activities that are *below the radar*. It cannot be overemphasised that supporting such local firms in developing countries will involve paying great attention to their design, engineering and management associated capabilities.

The box below on Ugandan oil brings out various opportunities for donor support in the development of local technological capabilities in the oil sector (see box 4). It is noteworthy that although the technological capabilities required in the sector would naturally involve R&D specific skills, non-R&D specific skills clearly have a critical role in dealing with the various complex issues in the sector. For example, drafting a suitable policy and negotiating favourable terms with foreign companies can significantly determine the success of creating technological learning opportunities for local firms through innovation-related interactions with foreign firms. This would in the longer term influence the ability of local firms to produce and convert knowledge to value. As pointed out earlier and discussed in more details in section 5, technological learning within enterprises involves deliberate cost by the firm and policy influences the extent to which entrepreneurs are willing to incur this form of cost. Donors could, for example, support the extension and deepening of the technological learning process within firms as demonstrated in figure 1 (page 7): the development of technologically creative competencies involves substantial costs that firms may be willing to incur if support is provided to them.

Box 4: Ugandan Oil: no local technological capabilities, no oil?

Petroleum in Uganda is reported to have been discovered in the 1920's, yet oil production is expected to begin next year – close to a century later. Various explanations could be put forward regarding the apparent excessively long duration between when oil was discovered and when its production is expected to commence, including the Second World War down to a civil war that ended in the 1980's. The period that captures attention here is that of the last two decades during which there has been a relatively favourable investment environment in the country.

The principal prospective area for petroleum exploration in Uganda is the Albertine Graben, which extends into DR Congo; the Ugandan part covers some 23,000 sq. km. To date, only less than half the area has been explored and it is estimated to have about 600 million barrels of resource i.e. 100,000 barrels of oil per day for 20 years. The Albertine Graben has been divided into nine exploration blocks, five of which have been licensed to oil companies which include Heritage Oil and Gas Uganda Ltd (UK), Tullow Uganda Operations Ltd (UK), Neptune Uganda Ltd. and Dominion Uganda Ltd.

Over the last 20 years, the government of Uganda has resolved not to authorise petroleum production until local expertise is developed. Systematic training in various disciplines of petroleum exploration, petroleum economics, petroleum law and petroleum engineering was undertaken during the period. A local team of professionals drafted the policy on oil exploration and has helped the government to sign favourable agreements with the explorations companies.

The president of Uganda in a visit to Nigeria last year for a learning experience stated that Uganda needed to develop its local manpower in the sector and was particularly interested in training its personnel at Nigeria's Institute of Petroleum. Uganda also has plans to start its own petroleum institute. The government appears to be focused on prioritising the socio-economic benefits of Ugandans, including improved roads and railways, access to clean water, health care and education etc.

One important observation is the concerted government effort to develop local technical skills for the sector. The President is reported to have said that the country would be ready when there were Ugandans well trained to be part of the exercise. The Ugandan energy minister is quoted to have recently reiterated the government's emphasis on the need to develop local expertise: "Our objective is to process the oil. We don't want to export it... Our aim is to get an economic return, to get jobs, investment. We don't want anything raw to get out".

Sources:

Assimwe, A. (2009) "Oil, oil, everywhere!" *New Africa*, March 2009, pp. 42-43

Watkins, E. (2009) "Uganda wants all of its oil refined domestically", *Oil and Gas Journal*, Vol 107 Issue 11 March 16, 2009

East African Petroleum Conference (2009) "Uganda: History of Petroleum Exploration, Current Status and Future Programs" <http://www.eapc09.org/eac.php?c=ug>

5. A discussion on the role of policy in the commercialisation of knowledge

For policy to have an impact on knowledge commercialisation in developing countries, the peculiar nature of technological learning in specific activities, including within the private sector on the one hand, and the structure of economic activities on the other will have to be addressed in efforts targeted at strengthening the general innovation environment. This suggests that policy must be addressed at two levels that are mutually inclusive: (i) policies that explicitly address innovation, and (ii) the broader socio-economic policies such as health policies, macro-economic policies, competition policies etc. Bell (2007) notes that "*the areas of public policy that have the greatest impact on scientific, technological and innovation activities and capacities are not the areas of policy that are explicitly focused on those activities and capacities. Instead, they are aspects of broad economic policy — macro-economic policy, trade policy and so forth — that do not specifically address issues about science, or technology or*

innovation but nevertheless have a huge influence on the technological behaviour of enterprises across the economy.” This is evermore important for developing countries because as indicated by Sagasti (2004) knowledge systems in developing countries are composed of an exogenous scientific and technological base which is characterised by large social divides. Achieving an endogenous base will invariably involve integrating broader policies with innovation policies to reflect long term social goals. This section discusses some of the issues that will require critical attention in policy. It does not attempt to provide specific policy recommendations.

5.1 Integrating development into innovation policies

The *disruptive markets* will increasingly drive innovation. However, for governments to realise the full potential of these *disruptive markets*, social policies have to be closely integrated with innovation policies. Even some of the developing economies that are seen as innovation leaders in the developing world such as Brazil, India and South Africa have not been very successful in addressing inequality issues.

The innovation potential offered by the *disruptive markets* suggests that designing innovation policies that are socially oriented could be fairly elusive for at least two reasons: (i) by virtue of the fact that the innovations in question are below the radar of conventional forms of innovation and the dynamics of these forms of innovation are probably not well understood, and (ii) other areas of policy that are not explicitly related to the innovation policy may also undermine the ability to integrate social goals and particularly those that relate to longer term aspirations of endogenizing the knowledge systems of developing countries. Sutz and Arocena (2006) observe that “*endogenous innovation is often a vulnerable process in developing countries; socially oriented innovations will probably be at least as vulnerable.*” An example of this vulnerability is presented in box 5 below.

Box 5: The case of a Brazilian bio-pharmaceutical firm

Biobras is a bio-pharmaceutical firm, located in the Brazilian state of Minas Gerais. It was founded in 1971 and began the production of enzymes in 1976, developing later in the industrial production of insulin and pioneering this type of production—by a national firm—in Latin America. Its birth was heavily related to the Faculty of Medicine of the Federal University of Minas Gerais; it can be said that the firm was incubated there.

By the end of the nineties, Biobras belonged to the very exclusive clan of firms that produced insulin by recombinant DNA methodologies, alongside with Ely Lilly, Novo-Nordisk and Aventis. In 2000, Biobras held a vast majority of the Brazilian market, around 80%, and 65% of the purchases made by Brazilian pharmacies. The firm commercialized human insulin from both productive processes, one by pancreas extraction and further purification and the other by genetic engineering procedures; the former was sold at two thirds the price of the latter.*

However, Biobras, as a Brazilian company, does not exist any more. It was sold to Novo-Nordisk. This part of the story started in 1999, when the Ministry of Health installed an international bid to acquire insulin. Biobras, Ely Lilly and Novo-Nordisk participated in the bid, the latter being proclaimed winner by the Ministry. This resolution was disputed by Biobras, arguing that two national laws were not taken into account, one stating that Brazilian and foreign firms should have the same tax treatment and the other dictating the procedure to calculate the final price of the products to be sold in the Brazilian market, this last calculation having favored Novo-Nordisk by a few cents. (Cruvinel, 2004) The dispute reached the Supreme Court of Justice, giving reason to Biobras. The plant was sold, however, in 2002.

“We were competing with a high-tech firm, 50 times as big as ours. If we could not count on a minimum support of the Brazilian government, there was nothing to be done: the alternative was to sell or to wait until the firm went

into bankruptcy under the competition”, stated one of the owners in a press interview given in 2004 (Cruvinel, op cit).

* Seven million Brazilians suffer from diabetes; it is estimated that only one million uses insulin due to the price of the medicine.

Source: Sutz, J. (2007) “Strong life sciences in innovative weak contexts: a ‘developmental’ approach to tantalizing mismatch”, *The Journal of Technology Transfer*, vol. 32, number 4, pp. 329-341

The development of local knowledge and capabilities as well as the commercialisation of knowledge by Biobras had involved extensive and sustained efforts over three decades. Biobras had succeeded in acquiring core technologies through the cumulative process of knowledge accumulation that is critical in effectively embarking on an innovation trajectory. Some of the strong linkages that had been developed by Biobras, for example, with the Federal University of Minas Gerais involved important aspects of technological learning through the participation of graduate students. However, these efforts were undermined by a procurement policy.

On the whole, innovation-related activities in many developing countries have generally suffered from intermittent support and frequent changes in the institutional organizations. This situation may have interfered with the ability to strategically focus on STI activities over sufficient periods of time to ensure that they progressively become demand-driven - based on emerging opportunities for the private sector to engage in the innovation process. Within such policy environments, modalities vary randomly, priorities may be divergent, and conflicting policies may exist. It is difficult to expect statements within policy documents resolving to promote STI for development to result in much progress in terms of creating a dynamic innovation environment.

5.2 Policy and technological learning in specific innovation activities

The section above suggests that policy areas that are not explicitly focused on innovation could undermine the ability to develop dynamic innovation processes in developing countries. However, technological learning particularly within firms and which has critical implications for the development of technologically innovative capabilities is rarely adequately, if at all, integrated into innovation policies of developing countries.

For the most part, innovation policy in developing countries continues to reduce innovation to R&D and is generally geared towards funding public research institutions. The private sector is merely viewed as a possible client of the rare outputs of public R&D activities. Placing private firms at the centre of the innovation process within policy documents will require concerted efforts to alter the views of policymakers. However, it is critical that steps into this direction are undertaken with urgency because as 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.*” Otherwise, it can hardly be expected that the disarticulations in the knowledge systems of developing countries will be redressed.

Firms play a central role in technological transformations by virtue of the fact that innovation or commercialisation of knowledge takes place within them. And the extent to which technological learning occurs within the firm lies at the heart of the firms’ ability to engage in innovation. In turn, the nature and extent to which firms provide technological learning opportunities is to a large degree

contingent upon policy. Technological learning involves deliberate cost by the firm and policy influences the extent to which entrepreneurs are willing to incur this form of costs.

The importance of innovation policies is increasingly being recognised and many developing countries are designing them. Nevertheless, the innovation policies generally give little attention to technological learning within the firm, which is key to addressing the observed deficiency of design, engineering and associated management capabilities particularly in African countries. More specifically, this tendency is at variance with the commitment to innovation that is generally strongly expressed in innovation policies. Innovation policy must, therefore, recognise that the deficiency of design, engineering and associated management capabilities is to a great extent responsible for the disarticulation that characterises the scientific and technological capabilities in developing countries. This issue is particularly important because “*enterprise investment in design and engineering capabilities faces exactly the same kinds of problems about non-appropriability and externalities as investment in creating other kinds of knowledge assets*”, Bell (2007). Unless, this lacuna is addressed not only in the innovation policy documents, but also in the implementation of policy it is unlikely that firms will effectively invest in technological learning and that the deficiency in design and engineering capabilities will be addressed.

5.3 Science and technology policy research

The importance of STI policy research in supporting governments to make well-informed strategic interventions in relation to innovation issues has over the past decades led to the creation of a number of initiatives that span the developing world. The relevance of STI policy research rests within its ability to influence innovation policies for the enhancement of sustainable development. This requires that linkages between STI policy researchers and STI policymakers go beyond interaction and communication between the two groups, which is commonly the situation in many developing countries, particularly in Africa. Although such interactions may be useful in developing the STI awareness of policymakers, which is a necessary condition for providing prominence to STI issues, it is not sufficient to ensure that STI policies will be successful in facilitating the creation of desirable impacts on society. The work of the STI policy researchers must adequately inform the tasks of policymakers in promoting the utilization and commercialisation of knowledge.

The efficiency with which policymakers promote knowledge utilization and commercialisation is closely related to organizational and institutional arrangements. An important role of STI policy research, therefore, relates to its ability to provide practical solutions for creating and strengthening nodes and linkages for knowledge flow and exploitation to achieve desired outcomes. The inadequate attention paid to critical nodes such as design and engineering capabilities and related linkages suggests that policy needs to strengthen STI policy research capabilities as well as their role in informing policy. For example, in the Tanzanian case discussed in section 3, although government policies targeted at attracting FDI are based on the expectation that the activities of MNE subsidiaries will lead to innovation-related interactions between foreign and local firms, this has not taken place because the links for technological learning between the two sets of firms are weak. Effective STI policy research would be useful in providing evidence-based information for policy design that would ensure that the expected outcomes occur.

6. Concluding remarks

Converting knowledge to value is a process that encompasses a wide range of science and technology capabilities and activities. Technological capabilities including non-R&D specific capabilities (which play a critical complementary role in converting knowledge to value) lie at the heart of this process. In particular, design, engineering and associate management capabilities, which may be viewed as a *liaison* between the new knowledge that is generated by R&D activities (whether foreign or indigenous) and the use of new knowledge in the production of goods and services; they provide an important conduit for successful adaptation and commercialisation of *new* knowledge. However, design, engineering and associate management capabilities despite their direct role in adapting and modifying specification for integration into processes, products and services are highly deficient in developing economies. This deficiency constitutes a major draw back to knowledge creation and commercialisation. It is in part responsible for the disarticulation that characterises knowledge systems in developing countries. Some of the issues that need to be considered in attempts to tackle this problem include:

- (i) Providing technological learning opportunities within productive activities i.e. enterprise-based learning opportunities, which must necessary complement the basic technical skills obtain from formal education; enterprise-based learning opportunities are crucial for the extension and deepening of the technological learning process.
- (ii) Creating *new* technological opportunities in developing countries. This requires a better understanding of the specific nature of demand (which is predominately related to the needs of poor consumers) so that it is adequately factored into the conversion of knowledge to value for the benefit of the vast majority of populations in these economies.
- (iii) Addressing the dualistic nature of knowledge systems in developing countries (modern versus traditional), which stands in the way of knowledge conversion to value. Some developing countries have been fairly successful in integrating components of modern and traditional knowledge. This has not only promoted the commercialisation of local knowledge, but has perhaps more importantly provided opportunities for technological learning, which offer longer-term benefits: they provide an economy with the opportunity to make headways along innovation trajectories.
- (iv) Integrating innovation-related interactions between firms, including between local and foreign firms. The conversion of knowledge to value in low-income economies is more likely to benefit from greater dynamism if there is deliberate development of a technological learning process based on integrated innovation-related interactions. The underlying assumption in policy and research that local firms have a lot to learn from foreign firms, but the latter have generally nothing to learn from the former that would be beneficial to their innovation activities owing to their generally more superior technology is neither correct nor benign. Knowledge flows are not uni-directional and failure to recognise this fact can only be counter-productive to efforts targeted at the creation of innovation-related activities between foreign and local firms that are favourable to the latter.
- (v) Placing the private sector on the agenda of donor assistance. While this may cause “unease” in some quarters there are documented cases that it is increasingly taking place and even recording successes that are otherwise rarely forthcoming from the traditional partner – the

public research institutes. There is evidence that knowledge mostly resides in enterprises. In addition, donor assistance has traditionally focused on health and agriculture. Extractive industries, despite their potential for development, are generally left to the wits of foreign multinationals. Donors could, for example, support the extension and deepening of the technological learning process within local firms be they public or private: the development of technologically creative competencies involves substantial costs that firms may be willing to incur if support is provided to them.

- (vi) Integrating innovation policies with social policies. If governments are to realise the full potential of the *disruptive markets*, social policies have to be closely integrated with innovation policies right from the onset in order to achieve extensive desirable outcomes. These include the longer-term benefits that emanate from the provision of enterprise-based opportunities for technological learning, which is central to the innovation process.

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