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Encouraging Innovation and Productivity Growth in Africa to Create Decent Jobs

Susanna Wolf

Accelerated and Shared Growth in South Africa: Determinants, Constraints and Opportunities

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Abstract:
Innovation is the main driver of economic growth but the capacity to innovate is quite low in most African countries, both in the private and in the public sector. Thus the ability to adopt new technologies and adapt them to local conditions will be crucial first step to increase productivity, which is a precondition for growth and decent employment.

The empirical analysis shows that the importance of secondary school enrolment, economic incentives, access to technology through imports, infrastructure and not least a functioning innovation system are likely to increase technological progress that results in labour productivity growth. However, at least in the short run this increased labour productivity is not likely to have a significant direct effect on poverty reduction. Nevertheless as technical progress is one of the main drivers of growth it is a precondition for poverty reduction in the long run. In the meantime poverty has to be tackled by other measures.

Each country must develop an innovation strategy based on its specific reality and situation. The private sector should be involved in designing the innovation strategy. For most African countries, improvements in the educational system, the initiation of interactions between the private sector and research institutions, the provision of risk capital for innovative firms and the improvement of infrastructure for quality controls should feature high on the agenda.

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1. Introduction

Most economists agree that technical progress, brought about by innovation, is the main driver of economic growth. Thus, creative entrepreneurship leading to a Schumpeterian process of destruction and creation is essential for every economy. In the most general sense innovation refers to the adoption of new products, services, processes and organizational methods, or adaptations of existing ones and therefore it is based on new knowledge. Firms need to produce new goods of higher quality, and at the same time reduce costs of production through cheaper production technologies and better management.

Thus, the knowledge-based economy is not restricted to high-tech firms and industries but innovation is also crucial for everyday products, such as food (UNCTAD, 2005). Furthermore, the positive effects of innovation are not limited to the private sector but can also contribute directly to human development. For example medical innovation can improve basic health, and higher agricultural production is linked to better seeds and water use as well as less environmental stress.

However, innovation is currently limited in most African firms. But as many domestic markets in Africa change rapidly through trade liberalization and reduction of transport and communication costs, only firms with the ability to adapt to new technologies and upgrade the quality of their products will be able to survive. Furthermore, the improvement of technological capabilities is a major requirement for changing the low-wage, low-skills pattern of production and therefore reducing poverty (UNECA, 2005b).

The ability of a country to innovate largely depends on its technological capabilities, the information and skills - technical, managerial and institutional - that allow capable researchers to produce new technologies, while at the same time allowing productive enterprises to access, utilize, and commercialize technology efficiently. For an increase in productivity at the firm-level several of the following have to come together: investment in new equipment, reorganization of the production process, research and development activities, access to higher quality inputs, training of workers and marketing of the improved or new products.

In the past two decades it has become cheaper and easier to gain access to scientific and technological knowledge, especially through the Internet. The local innovation capacity of African countries is thus heavily dependent on their ability to access the global pool of existing knowledge through cross-border interactions. For the majority of African countries the benefits will come from the diffusion of knowledge and its translation into goods and services through adaptation, predominantly from thousands of small technological improvements in small and medium enterprises (SMEs).

This paper will first discuss the environment for innovation in Africa with a focus on knowledge and innovation systems and with specific reference to South African innovation policies. This environment is contrasted with innovation policies in other regions. Based on that analysis the paper identifies the major challenges for more innovation and higher productivity in Africa. An empirical test was performed based on the hypothesis from the literature review. A simultaneous equations model was used to take into account possible endogeneity. Productivity growth is assumed to be a function of education, access to information, institutions and some socio-economic variables. Likewise poverty is assumed to be a function of productivity growth, institutions and also socio-economic variables. From this analysis some policy recommendations on how to increase innovation and technological progress are drawn.

2. The environment for innovation in Africa

Transfer of technology

To start the innovation process firms have to build linkages with outsiders who possess the necessary technologies and skills. The sources of external knowledge range from equipment and input suppliers, universities and research institutes to private business associations. The local innovation capacity of African countries is also heavily dependent on their ability to access the global pool of existing knowledge through cross-border interactions (Oyelaran-Oyeyinka and Lal, 2004; UNIDO, 2003).

The global environment, in which the process of innovation occurs, has changed rapidly. It has become cheaper and easier now than ever before to gain access to scientific and technological knowledge, especially through the Internet. For example, automobile spare-part producers in India are using the web pages of their counterparts in Europe to obtain information about changes in technical specifications.

The main channels through which technology is transferred across countries are trade in goods, foreign direct investment (FDI) and licensing as well as labour turnover and mobility. Trade contributes to technology transfer through imports of new equipment and machinery and reverse engineering of imported products. FDI often employs more advanced technology and therefore could imply demonstration effects. Technology spillovers may also arise from labour turnover and vertical linkages. Exporters can learn about new technologies through their interaction with foreign customers. Licensing is associated with the transfer of technical information and know-how. It requires the capacity and investment to apply the technology to the local production process. In addition labour turnover from multinationals to domestic firms and temporary movement of workers could spread innovations (Hoekman et al., 2005; Fafchamps, 2003; Almeida and Fernandes, 2006).

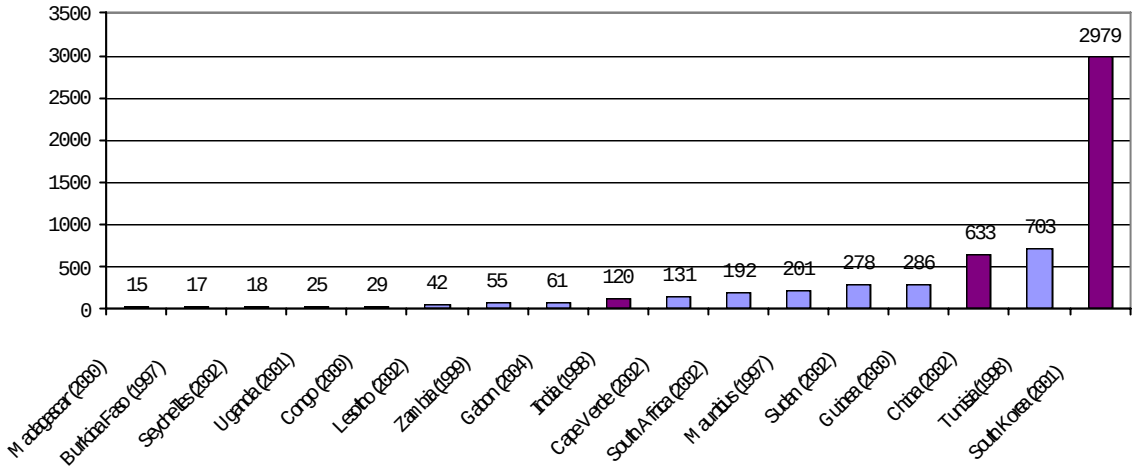
Markets for knowledge are characterized by market failures. First, learning externalities imply that not only the firm that pays for it will benefit. Second, information asymmetries limit the functioning of markets, as different information about the economic value of an innovation exists. For example, a firm that makes the first move exporting flowers from Ethiopia exposes this comparative advantage of the country, and as a result, will attract other firms to enter the same market. The later entrants will also benefit from the initial investments made by the first-mover, but if the first firm does not succeed, it will have to cover the costs alone. This is the reason why, even in mature industrial economies with well-developed markets, institutions, and property rights systems, governments have to actively implement policies to promote innovations and scientific development (Stiglitz, 1999).

The African technology gap

The processes of innovation and technical progress differ markedly between countries at different levels of development and this implies that the necessary technological capabilities change as countries develop (UNCTAD, 2006). Most African nations enter the global technology market today as late developers, with considerable cost and risk involved in absorbing complex existing technologies, and facing numerous coordination problems. To improve on the technological competence, the productive sector in African countries has to be able to master imported technologies, adapt them to local conditions, improve them and finally use them as a base for creating innovations locally. For example, the processors of agricultural goods not only have to master and improve their own production technology, but also the quality of their other inputs is of crucial importance for the development of new products. Of special importance for most African economies is the agricultural productivity transition, which involves advances in knowledge and

technology. This transition from very low yields per hectare compared to other regions could help to reduce malnutrition, land degradation and deforestation (UNECA 2002).

Figure 1: Scientists in R&D per million people, latest available year



Source: UNESCO, 2005.

OECD countries spend almost as much annually on research and development (R&D) as the value of total economic output of all Sub-Saharan African countries (except South Africa). Absolute R&D expenditure in Africa decreased significantly in the first half of the 1990s, only to recover in the second half reaching USD PPP 5.8 billion in 2000. But the R&D intensity fell from 0.6 per cent to 0.3 per cent of GDP spent on R&D over the same period (UNESCO, 2004).[1] South Africa and Uganda are currently the only African nations with a share of R&D expenditures to GDP close to the average for all developing countries. But even for them it is still below the 1 per cent benchmark established in countries like South Korea, Singapore and China, which represent successful cases of technological upgrading (Figure 1).[2]

This can partly be explained by the low technology nature of most African industry with an R&D intensity of less than 0.7 per cent, for example in paper production, printing and publishing, food products, beverages and tobacco, textiles and textile products, leather and footwear. But within an industry such as textiles there can be a large variation in R&D intensity. Yarn-spinning requires more advanced technical skills than clothing manufacturing and sewing requires fewer skills than designing new fashion products (UNCTAD, 2005).

The gap in human capital between OECD countries and African countries is also tremendous, with OECD countries having twelve times the per capita number of scientists and engineers working in R&D and publishing, and 25 times more scientific journal articles per capita (Watson et al., 2003). The human capital also varies greatly among African countries (see Figure 2). The highest numbers of research personnel (relative to the total population) are working in Tunisia, Guinea, Sudan, Mauritius and South Africa.[3]

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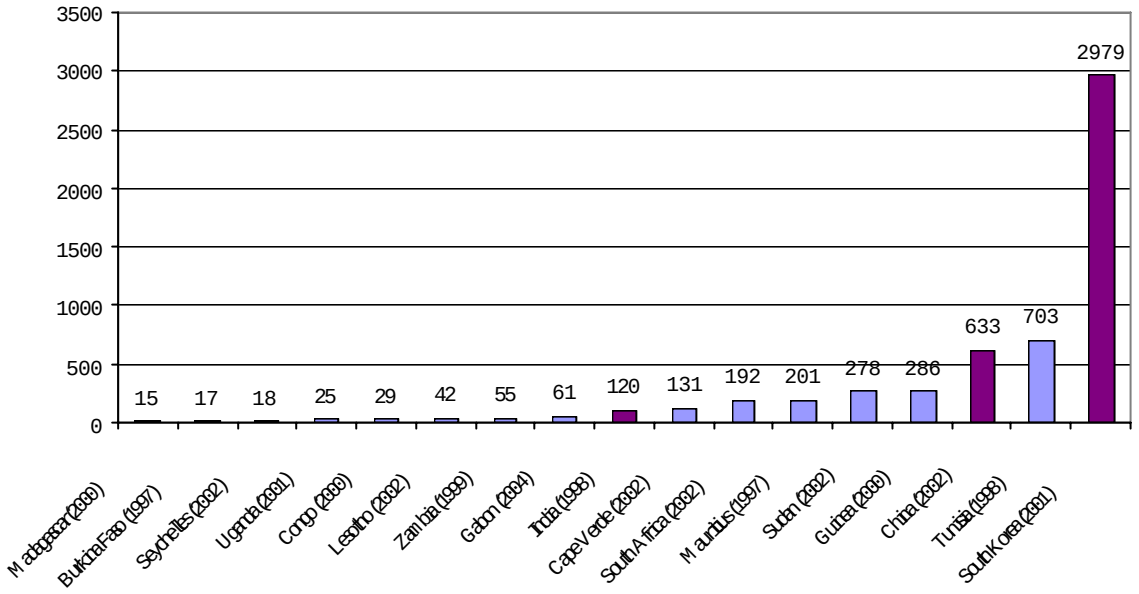
[1] South Africa accounted for 62 per cent of African R&D in 2000. Between 1990 and 2000 Africa's share in world R&D fell from 1.3 per cent to 0.8 per cent (UNESCO, 2004).

[2] Furthermore a negligible part of this expenditure is financed by productive enterprises, whereas in the newly industrialized economies of Asia more than half of R&D is financed privately (Pietrobelli, 2001).

[3] Unfortunately data on the effect of these inputs on outcomes of innovation, such as patents are not available for most African countries. Only for South Africa 404 patent applications are reported by WIPO in 2004, up from 1 in 1990. Despite the innovation efforts in East Asia, South Asia and Latin America, the number of patent applications filed from all developing countries combined is still a mere 4.7 per cent of total patent applications (WIPO, 2005).

The low innovative capacity of most African countries had a negative impact on the technological progress of the private sector. World trade in higher value-added products and especially high-tech products has been growing much faster than trade in raw materials that still dominate African exports. The Asian tiger economies with their high technological capability have been able to participate in this development (Watson et al., 2003). By contrast Africa's share in global manufacturing, which was already very low with 1 per cent in 1980, declined to 0.78 per cent in 2002. The lack of competitiveness is partly due to low productivity with the consequence that labour costs per unit of output in Sub-Saharan Africa generally exceed those in East Asia (UNECA, 2005b).

Figure 2: Scientists in R&D per million people, latest available year



Source: UNESCO, 2005.

Innovation Policies in Africa

National innovation systems, which basically are networks based on interaction between creators and users of innovations, play a central role in the innovation process. This concept has been broadened towards domestic knowledge systems which also include institutions like "regulatory framework, formal organizations, regular relationships amongst organisations and routine practices, which enable the creation, accumulation, use and sharing of knowledge." (UNCTAD, 2006). The ability of companies to innovate depends crucially on the knowledge system in which they operate. The primary function of a knowledge system is the establishment of an appropriate incentives regime to correct market and institutional failures in capturing technological knowledge and learning. It also involves the institutional context and strategic policy planning for the economy's long-term competitiveness. Most African countries do not have a coherent innovation policy in place. Innovation policies are often restricted to R&D aspects with a focus on the supply of technology with little consideration of the demand side (UNCTAD, 2005 and 2006).

One exception is South Africa with its South African National Advanced Manufacturing Technology Strategy (AMTS) that was launched in 2003. South Africa's technological vision for the industrial sector aims at increasing objective technology intensity indicators such as R&D spending and the acquisition of foreign technology. The vision also links competitiveness with national and social goals such as economic growth, job creation and equity (see Box 1).

Box 1: The South African National Advanced Manufacturing Technology Strategy (AMTS)

The goals of the AMTS include the identification of priority sectors, the stimulation of technological upgrading in industry, the facilitation of the flow of technological resources to industry through new knowledge networks and the building of a conducive environment for innovation through the supply of skilled manpower, technology infrastructure and funds. Standards, quality assurance, accreditation and metrology and SME development are crosscutting focus areas. Special emphasis is put on facilitating partnerships between industry and academia for example through government-supported and industry-directed technology centres. The strategy aims to integrate technology upgrading of the manufacturing sector with other private sector development factors. The advisory group, which developed the AMTS, and the National Strategy Team, which is responsible for the implementation of the strategy, involves senior staff from different government departments as well as industry and labour leaders.

Source: NACI, 2002 and AMTS, 2005.

3. Innovation processes

Implementing successful policies that foster local innovations faces numerous challenges in the African context, including the lack of a large university-educated skilled labour force, high-quality laboratories and scientific equipment, liquid and efficient financial markets, strong private sector initiative and developed markets, as well as managerial and marketing capacity.

To start the innovation process firms usually have to built linkages with outsiders who possess the necessary technologies and skills. The sources of external knowledge range from equipment and input suppliers, universities and research institutes to private business associations. Firm surveys from a large number of countries show that the sources of innovation and technological progress vary considerably (see Table 1).

Table 1: Drivers of innovation in Africa

Country	World	Other developing	Sub-Saharan Africa	North Africa	South Africa
Use of technology licensed from foreign companies (%)	14.4	16.4	12.0	7.6	22.6
New production technology (%)	36.9	43.4	45.0	22.5	60.6
New product or substantial upgrade of existing product (%)	63.7	77.3	68.9	28.0	89.2
New machinery or equipment is the most important way of acquiring technological innovations (%)	61.9	53.5	57.0	78.6	25.3
Hiring key personnel is the most important way of acquiring technological innovations (%)	7.5	10.8	6.8	1.0	8.2
Licensing/turnkey operations is the most important way of acquiring technological innovations (%)	3.5	2.8	3.1	1.8	10.5
Developing in-house or jointly is the most important way of acquiring technological innovations (%)	19.5	22.1	20.3	10.5	38.7
University Business collaboration is the most important ways of acquiring technological innovations (%)	3.2	3.2	2.7	2.7	4.2
Strongest influence to develop new products/services/markets: domestic competitors (%)	26.8	25.3	26.3	-	24.6
Strongest influence to develop new products/services/markets: foreign competitors (%)	14.0	16.2	8.3	-	8.9

Source: own calculations, based on World Bank, 2006

In both SSA and North Africa ISO certification and use of technology licenses is much lower than in other developing countries, although approximately the same share of firms use new production technologies or produce new products. By contrast, South African firms use more technology licenses and also use new technologies and produce new products more frequently than the average firm in developing countries and even worldwide.

In addition, the ways of acquiring new technologies differ markedly. In general new machinery and equipment is most important, but in South Africa more firms name developing technology in-house, which comes second in other regions. In most regions hiring key personnel ranks third, whereas licensing and university collaboration are least important. Interestingly both play a much bigger role in South Africa than in other regions. In general domestic competition is a more important driver of innovation. However, domestic competition is more important outside Africa.

Almeida and Fernandes (2006) show that there is also considerable heterogeneity at the firm level in the acquisition of new technology, as for example large firms are more likely to adopt new technologies than small firms. This is confirmed by data from South Africa that also shows that the way of acquiring new technology varies by firm size (Table A1). Whereas for small firms new machinery and key personnel are most important, for medium firms its developing technology in-house and for large firms licensing is more important. Innovation activities also differ by sector. In South Africa firms in the food, garments and leather industries are relatively innovative. For them new machinery and equipment plays a bigger role for innovations than on average. Interestingly firms in the electronics sector have one of the lowest rates of using a new production technology or developing a new product.

Almeida and Fernandes (2006) also show that importers and exporters are more likely to innovate than firms that do not trade. In addition, majority owned firms in low-tech industries are less likely to innovate than domestic-owned firms, after controlling for characteristics of managers, access to finance, region and industry.

Providing training for technical and managerial skills

To improve technical progress the education system has to be reformed. Especially in primary and secondary education the focus should not only be laid on learning specific facts - which will become obsolete over time - but rather on learning how to acquire new knowledge and on fostering creativity and encouraging students to find solutions for problems. Knowledge is best acquired not by passive listening and memorizing but by the active involvement of the student (Stiglitz, 1999).

There is empirical evidence indicating that internal and external training of workers can markedly increase the productivity of a firm (Oyelaran-Oyeyinka and Lal, 2004). Firms that engage in training provide a credible example for others and might convince them of the usefulness of training activities. On the other hand trained workers might leave the firm, so that the benefits of training are spread. In both cases the benefits of training activities spread beyond the firm that provides the training. Therefore, the government should support them, for example, by direct subsidies or tax deductibility of training expenses.

A primary concern of higher education provision in Africa is the existing mismatch between the skills imparted through the education system, and those demanded by the private sector. Curricula have minimal relevance to the needs of industry, resulting in high unemployment even among fresh college graduates (UNECA, 2005b). An internal environment characterized by the lack of profitable opportunities has led to the mass emigration of the few skilled professionals. South Africa is trying to address these problems with its Joint Initiative on priority Skills Acquisition (JIPSA). It includes identification of needed skills, attracting skilled workers from overseas, and utilising the skills of retirees and unemployed graduates (EIU, 2006).

To foster technical progress not only technical expertise is required but also strong managerial skills. Therefore, curricula in technical subjects should also include some basic understanding of accounting and finance to enable graduates to start their own business. In order to make curricula more relevant and praxis-oriented also more interaction between institutions of tertiary education and the private sector is crucial.

There are some very specialized subjects that require large investments in equipment and therefore cannot be decentralized. For example to be able to do research and teaching in biotechnology it is necessary to have modern laboratories. As today's knowledge cannot be confined to traditional disciplines there is also the need to establish interdisciplinary research centres. One avenue to reduce costs and achieve a critical mass of teachers, students and equipment in these subjects is to concentrate these subjects in only a few universities within a region and create regional centres of excellence through increased regional cooperation (UNECA, 2004).

To strengthen the capacity of the tertiary education system it is necessary to introduce competitive allocation procedures, transparency and peer review, research evaluation and accountability for results (Watson et al., 2003). In general all stakeholders such as education and research institutions as well as the private sector should participate in the design and implementation of the education policy. The skills needs of the economy should be monitored (Pietrobelli, 2001). In addition, priorities in education and policies in other fields have to be coordinated (UNCTAD, 2005).

Spreading innovations through networks between research institutions and the private sector

The largest share of local innovations and technology improvements in less developed countries still takes the form of incremental applied and informal adaptations and improvements made in workshops and small factories. Therefore, technology institutes are most useful if they support and enhance that process, rather than conduct prestigious but expensive basic research (Romijn, 1998).

In many African countries research institutions are weak, meaning that there is little scope for cooperation with the private sector and little impact on industrial production. Since agriculture is the most important sector of most African economies, the largest and most active research institutions are often concentrated in this area, whereas industrial research institutions receive low priority. Even in South Africa, where both research institutions and innovative firms are relatively abundant, research laboratories and universities are among the least used external sources of information (Buys, 2004).

Furthermore, the lack of funds leads to outdated equipment and laboratories and insufficient training (UNECA, 2005a). However, the Kenya Industry Research and Development Organisation provides a good example of how a research institutions can become more market oriented through the use of productivity indicators, which are based on impact on industry rather than research publications, and an improved incentive structure that allows divisions to retain most of their earnings from consultancy. As the largest share of local innovations and technology improvements in Africa still takes the form of incremental applied and informal improvements made in workshops and small factories, technology institutes are most useful if they support that process, rather than conduct prestigious but expensive basic research.

The establishment of public research institutes as autonomous bodies could help to make them more responsive to industry needs. For example, Taiwan's Industrial Technology Research Institute (ITRI) is funded through grants from the Ministry of Economic Affairs, but given organizational independence. Instead of the government directly commissioning research programs that are meant to improve technology in the private sector, research vouchers could be given to private firms in order to commission their own research, given that they provide a percentage of own funds and the

project fulfils certain conditions. This approach would not only target industry needs better but would also increase competition between research institutes and therefore help to improve quality. Since the private sector in most African countries is not very aware of the potential benefits of R&D, demand for such services is generally low (Pietrobelli, 2001).

To increase the motivation of staff, research institutes should be entitled to some share of the royalties created by the products of their research, allowing for the knowledge institutions to gradually become financially self-sufficient and increasing incentives for applicable research. In addition, opportunities for researchers to start their own companies should be provided. Such arrangements may threaten the public-funded programme in the short-term, but do create a dynamism in the economy, which provides incentives for more students to go into science, engineering and management education, thus increasing the overall supply of skilled personnel for these sectors (Watson et al., 2003).

As the costs of searching for adequate technology and adapting it to local conditions are high and economies of scale favour specialisation and concentration of these efforts it could be beneficial to establish technology support organisations or industrial extension services which are subsidised by government. The South Africa's National Manufacturing Advisory Centre provides an example of such an approach (see Box 2). Especially as infant-industry protection, that was meant to enable firms to recover costs of learning, is difficult to provide under the WTO rules, the promotion of innovation and learning through direct support becomes more important.

Box 2: South Africa's National Manufacturing Advisory Centre (NAMAC)

NAMAC in South Africa consists of 9 regional manufacturing advisory centres (MACs) that target and advise small manufacturing firms in various industries. MACs strive to increase competitiveness and efficiency by upgrading firms' technological capabilities and providing other business support services including financial services, plant layout redesigns and export and marketing information. Individual MACs provide their own services on a for-fee basis and direct firms to appropriate service providers or sources of export intelligence.

One success story is the increase in technological capability of Tshepo & Brothers Quality School Uniforms. A major challenge facing this firm was the development of patterns for school uniforms, which were purchased and then adapted to its needs. The provision of training for the staff in pattern making and grading techniques helped them not only to reduce costs but also to increase quality and increase the range of products to include track suits and casual wear.

Source: UNIDO, 2003 and NAMAC, 2005

A first step to fostering linkages between research institutions and the private sector could be to bring people from both sides into closer contact.[4] The exchange of labour between research institutes and industry is one of the most important channels to establish networks between firms and public research. They often build a basis for collaborative R&D. One example is STMicroelectronics in Rabat, Morocco, that has established a training centre for teachers and students from engineering schools to enable them to contribute to innovation activities in the semi-conductor industry (UNCTAD, 2005). In addition, programmes that support higher education abroad should be extended as they help to establish linkages with foreign enterprises and research institutions that are crucial for technology transfer.

[4] One example is internships of students in the private sector. Evening classes at universities for practitioners could increase the ability of the practitioners to innovate and at the same time expose lecturers to more practical questions. Workshops about themes of common interest could stimulate the exchange between researchers in public institutions and the private sector.

Technology diffusion also takes place among firms. The local concentration of firms that produce similar products or belong to the same value-chain is said to increase interactions between these firms and facilitate the adoption of innovations through observation and learning.[5] There is some evidence that the technological development potential in the SME sector is highest in metalworking and light engineering as metal workshops are well equipped to copy and improve on products, which are produced by larger enterprises or imported. The adaptations could take place through simplifying the design or substituting local materials for imported ones, which could lead to significant price reductions. Especially in the manufacturing of simple machines and tools such as shea butter processing and drilling machines this could bring improved technologies within the reach of the rural population (Romijn, 1998).

Increasing availability of start-up venture capital

As innovations usually pay off over a long period they should be financed by long-term finance. Because guarantees are not available for most African firms, banks require a high portion of equity for their loans. Especially in the start-up phase, SMEs in Africa typically do not have many business assets that can be used as collateral and they have no history of repayment or profitability on which financing institutions could rely. For such businesses venture capital is the only source of private financing that might be able to overcome problems of asymmetric information. The advantage of venture capital (VC) is that it provides equity instead of a loan. Thus, no interest payments have to be made and no collateral is needed but the venture capitalist shares the risk and derives his returns from capital gains if the enterprise is successful. Many venture capital funds do not only provide capital but also support the young enterprise with close monitoring and technical and managerial support.

However, financial institutions in most African countries are not able to properly appraise innovation projects, as neither the success of the innovation itself nor the market for the products can be easily evaluated. A further constraint to venture capital is the underdevelopment of stock markets in many African countries, as venture capital funds use them to exit the firms and realise their profits. In addition, most African countries do not have large pension funds, which are the main financiers of VC worldwide.

So far fully private owned venture capital funds only exist in South Africa. One example is Argil, a joint venture between Ernst & Young (Southern Africa) and Worldwide African Investment Holdings (Pty) Ltd that manages 3rd party funds with a focus on investments in technology. The Argil Venture Capital Fund was launched at SAR 100 million and focuses on companies that need between SAR 3 million and SAR 15 million and already have proprietary technology, strong management and clear leadership, like software developers and producers of car parts (Argil, 2005).

Public-private partnerships between commercial investment funds with an experienced private sector equity management and grant-funded technical service funds that would cover the costs of technical support could also increase the availability of risk capital for innovative entrepreneurs. The Industrial Development Corporation (IDC) of South Africa is currently extending its activities towards the rest of Africa. By the end of 2003, its portfolio of African projects under implementation or consideration comprised 69 projects in 23 countries. But even those focus on medium to large enterprises because the costs to serve small enterprises are too high.

[5] SME clustering is widespread in some developing countries like India. In Africa it is only little developed except for Nigeria, Kenya, South Africa, Tanzania and Zimbabwe (OECD/ADB, 2005).

Better infrastructure for technologically advanced products

As markets in Africa are small, innovative products will need to be produced partly for export markets to be viable. Thus, accurate quality measurements of industrial products and processes, and their comparison to established international standards are vital to ensure barrier-free trade in global markets. Reliable metrology systems and testing laboratories are therefore needed for the accreditation of African products and processes (UNCTAD, 2005).[6] For example, after the imposition of EU restrictions on imports of fish in Uganda, the Uganda Integrated Programme (UIP) assisted the government to communicate with the EU Commission, supported the publication and dissemination of a fish-inspection manual, financed the upgrading of local laboratories to reduce costs, and provided training for fisheries inspectors and quality-assurance managers (Oyelaran-Oyeyinka, 2005).

However, most African standards institutions suffer from a number of shortcomings such as old and outdated equipment and a too high proportion of administrative staff as compared to scientific and technical staff. Furthermore, the institutions are affected by the low level of quality awareness prevailing in the business sector, which also limits their capability to self-finance their activities. One positive example is the Mauritius Standards Bureau, which has upgraded its experience through a twinning arrangement with the Singapore Institute of Standards and Industrial Research. Its quality assurance and testing services are self-financing. Furthermore, a Technology Diffusion Scheme, funded by the World Bank intends to create a market for technology services by lowering the costs of these services for some time (Pietrobelli, 2001).

An important body for international standards is the International Standardization Organisation (ISO). Only 17 African countries host full member bodies as of June 2005. The African Regional Organisation for Standardization (ARSO) is providing support for standardisation in its member states and seeks to increase its membership and enhance its role to provide a platform for information, cooperation, coordination and influence of the African region in the area of standardization.

Box 3: Adoption of ISO 9000 standard by Kenyan textiles manufacturer Bedi

Bedi Investments in Kenya was established in 1972 as a family-run firm producing textiles and garments for the local market. Now it is managed by the founder's three sons, all graduates in engineering or business from schools in the United Kingdom. Bedi's adoption of ISO 9000 in the early 1990s was stimulated by a foreign buyer who provided Bedi with information about the ISO programme and helped with implementation. In 1994 Bedi had a 26-strong quality control department (7 percent of employees), and its internal reject rate was under 1 percent. The ISO 9000 system doubled Bedi's labour productivity growth to 6 percent a year (between 1984–1989 and 1989–1994). Bedi Investments has one of the best production capabilities in the Kenyan garment industry (a strong emphasis on quality control, well-maintained equipment, negligible equipment breakdown rates and frequent changes in plant layout), and it has good technological linkages with foreign buyers and equipment suppliers.

Source: UNIDO, 2003.

Only recently African firms have started to get certification under the ISO 9000 series, which is a quality manufacturing standard that relates to processes.[7] The certification of African enterprises has

[6] National metrology agencies are responsible for certifying and calibrating the units of measure and the instruments of measurement that are employed in producing firms, research laboratories and the like. They have to comply with the Bureau International des Poids et Mesures (BIPM) in Paris and have to ensure that its competencies develop in advance of the industrial users needs (UNIDO, 2003).

[7] "ISO 9000 certification is quickly becoming an imperative for potential exporters, signalling quality and reliability to foreign buyers, retailers and transnational corporations seeking local partners and sub-contractors." (UNIDO, 2003)

increased by 70 per cent between 1997 and 2003, but is still concentrated in North and South Africa. Individual countries like Botswana, Cote d'Ivoire, Ghana, Nigeria, Senegal, Sudan, Swaziland and Zambia have multiplied the number of registered enterprises within 6 years. However, the whole of Africa still only accounts for around 4,337 of 567,984 certified enterprises worldwide (see Table 2). One of them is Bedi Investments, a Kenyan textiles manufacturer (see Box 3). Quality management is needed to enhance customer satisfaction in the most cost-effective manner possible.

Table 2: ISO 9000 certifications in Africa, 1997, 2002 and 2003

	1997	2002	2003
Algeria		39	45
Angola		5	1
Benin		2	
Botswana	4	6	11
Cameroon	5	7	2
Central African Republic		2	
Chad		2	
Congo, Dem Rep.	1		
Congo, Republic of	2		
Cote d'Ivoire	4	25	14
Egypt	344	642	754
Ethiopia		1	
Gabon		5	
Ghana	2	5	10
Kenya	28	46	41
Libyan Arab Jamahiriya	1	7	5
Malawi		2	6
Mali	5		
Mauritius	72	210	122
Morocco	60	164	78
Mozambique		7	7
Namibia	2	17	15
Niger		3	
Nigeria	3	85	83
Senegal	1	15	10
Seychelles	2	9	4
Sierra Leone	1		
Somalia		1	
South Africa	1915	2625	2537
Sudan	1	10	26
Swaziland	2	29	20
Tanzania		5	2
Tunisia	51	376	403
Uganda		72	120
Zambia	3	21	15
Zimbabwe	49	91	19
Total	**2558**	**4497**	**4350**

Source: ISO, 2004.

However, it is not sufficient to improve specific technology related infrastructure. Especially the increased availability and reliability of electricity is likely to have a big impact on investment and innovation levels in the non-agricultural sector. If firms do not have access to reliable electricity they cannot use a number of technologies. If they have to buy a generator this will limit their capacity to invest in new technology. Empirical analysis has shown that higher electricity production is closely related with a higher share in the share of manufactures in merchandise exports (UNCTAD, 2006).

Improve business services and marketing of innovative products

As entrepreneurial capacity is low in most African countries support is needed to enable firms to make the investment that is necessary for innovation. This includes the formulation of business plans, accounting and bookkeeping, procurement of inputs, and organisation of the production process. There are two reasons for the low usage of such business services in Africa. First, entrepreneurs are often not aware of the prospective usefulness of these services, and second, the provision of these services is limited or of low quality. Therefore, there is some scope for the

government to subsidize them so enterprises can experience their usefulness. However, it might be better to give vouchers for business services to enterprises instead of subsidising service providers directly as this will promote the establishment of private providers and improve their quality through competition. This support has to be complemented by training in the respective fields to create the basic capacities.

There is evidence that SME support programmes are most effective when they are directed towards groups of enterprises because transaction costs are lower. Clusters of SMEs might have advantages for innovation over large firms because of their greater flexibility. Clustering helps firms to specialize, which in turn attracts suppliers and customers and generates a pool of specialized workers. At the same time competition is quite strong among clustering producers, raising the incentives to innovate. But, clustering does not only have a positive effect on innovation but also on access to inputs (Humphrey and Schmitz, 1995).

A successful example of an SME cluster is the Farm Implements and Tools (FIT) program in Kenya, which facilitated a process of technological learning among producers of farm and food processing equipment. The participating firms must show a willingness to pay at least part of the costs right from the beginning.[8] The entrepreneurs got new ideas about improved farm equipment and decided to acquire new tools as a result of the group visits. Furthermore, improved linkage with suppliers of spare parts and raw materials were observed and managerial skills were apparently improved. One key factor for the success of the programme was the demand-driven approach of all its components (Romijn, 1998).

One important precondition to increase the demand for innovative products is raising the awareness of customers through marketing. One form of marketing that has proven to be very successful is the organization of trade fairs. They do not only enable producers to display their products but also give them the opportunity to interact with customers and better understand their needs. Furthermore, producers learn about products of their competitors and can get information about demand by observing which products raise most interest of the public. A survey of South African firms showed that exhibitions and competitors were the most important external sources of information for innovation (Buys, 2004). Especially for small firms, participation in trade fairs will have to be subsidized in the beginning. Marketing support for potential exporters could include the sponsoring of exhibitions at foreign trade fairs where the learning effects will be bigger, but which of course incur much higher costs (Humphrey and Schmitz, 1995).

Box 4: Public procurement scheme helps jumpstart furniture industry in remote area in Brazil

The production of school furniture in the Brazilian State of Ceara was organized by the Industry and Commerce Department together with the Brazilian SME assistance agency. The procurement of the desks by the Education Department was not automatic but small producers had to complete small orders at a lower price and better quality than existing large-firm suppliers. The absence of a protected market prevented the establishment of inefficient low-quality producers that often result from public purchasing programmes. Furthermore, the promotion of small-producers associations contributed to the success of the programme. Contracts were only offered to associations and they were responsible for quality and product warranties. To generate working capital one half of the payment was advanced with the order. The use of associations reduced the transaction costs and put peer pressure on the small producers to fulfil orders. The programme not only increased the number of workers in the woodworking industry manifold, but after some time 70 per cent of output was going to the private sector.

Source: Humphrey and Schmitz, 1995.

[8] Several services are provided such as the organization of group visits to bigger enterprises, the facilitation of direct communication with the farmers through trade fairs, and the identification of new markets through teaching a simple form of market research.

To encourage firms to replace previously imported materials, South Korea employed a pool of technicians who collected information about the technological capabilities of existing firms and matched it with information on imports. This information was then used to help domestic firms to produce the previously imported goods, provided they could deliver similar quality at the same price. Together with technological assistance this strategy helped to upgrade the technological capability of domestic firms. One advantage of the approach is that in contrast to many industrial policy measures it does not conflict with WTO rules and it is relatively cost efficient. Another approach is to use public purchasing schemes for establishing a new industry, which was successful in Brazil (see Box 4).

4. Empirical analysis of productivity growth through innovation

Of course most of the measures discussed above are complementary. To prioritize among them a cost benefit analysis at the country level would be needed. To get an idea about which factors are in general most important for increasing productivity a cross-country analysis was carried out. To analyse the determinants of productivity growth and the effect of productivity growth on poverty a simultaneous equations model was used to take into account possible endogeneity. Labour productivity growth between 2000 and 2003 was calculated from growth in GDP and economically active population and is assumed to be a function of education, economic policy, democracy[9], access to information (through ICT), access to foreign technology through imports and FDI, access to credit, infrastructure and some socio-economic variables.[10] As indicator for innovation capacity a recently constructed World Bank index that combines R&D personnel, R&D expenditure, and innovation infrastructure, among others has been used. In addition an Africa dummy was included. The availability of data for a reasonable number of countries restricted the selection of independent variables.[11] Some variables that are commonly assumed to have an impact on productivity growth like GDP per capita are highly correlated with other variables of interest an thus could not be included.

The regression results confirm that secondary school enrolment seems to be particularly important for labour productivity growth in the non-agricultural sector, whereas the coefficient for tertiary school enrolment was not significant for both non-agricultural labour productivity growth and total labour productivity growth (Table 3).

The economic incentive regime[12] seems to increase labour productivity as it can provide an enabling environment for entrepreneurial activity and risk taking. However democracy, which is linked to participation in decision-making, does not have a significant impact on labour productivity growth. Contrary to expectations both domestic credit and FDI as percentage of GDP as well as the ICT index have a significant negative association with non-agricultural labour productivity growth. This result might be due to some collinearity in the data. However, access to technology through imports, better infrastructure through paved roads and a better innovation system seem to increase both non-agricultural labour productivity growth as well as total labour productivity growth. Interestingly the coefficient for the Africa dummy is not significant in both regressions.

[9] The Polity variable ranges from +10 (strongly democratic) to –10 (strongly autocratic) (Marshal and Jaggers, 2002).
[10] 2002 data was used for these indicators as this was the last year for which data was available for a reasonably large number of countries.
[11] All data except for economically active population (that was taken from FAO (2006)) and Polity are from World Bank World Development Indicators (2005) or World Bank, Knowledge Assessment Methodology (2006).
[12] The economic incentives index includes tariff and non-tariff barriers, protection of intellectual property, soundness of banks, cost to register a business etc. (World Bank, 2006).

Table 3: Regression results: Labour productivity growth

	Non-agricultural labour productivity growth			Total labour productivity growth		
Secondary school enrolment	0.002	*	[2.25]	0.001		[1.50]
Tertiary school enrolment	-0.002		[-1.46]	0.000		[-0.40]
Economic Incentives Index	0.026	*	[2.37]	0.018	+	[1.87]
Polity	-0.003		[-0.96]	-0.002		[-0.82]
Domestic credit (% of GDP)	-0.001	**	[-3.09]	0.000	+	[-1.81]
FDI (% of GDP)	-0.002	+	[-1.94]	-0.002	+	[-1.81]
Imports (% of GDP)	0.003	**	[3.68]	0.002	**	[3.16]
Urban population (% of total)	-0.002	*	[-1.63]	-0.001		[-1.11]
ICT Index	-0.053	**	[-3.24]	-0.049	**	[-3.33]
Paved roads (% of total)	0.001	+	[1.76]	0.001	+	[1.90]
Innovation Index	0.039	**	[3.52]	0.030	**	[3.09]
Africa dummy	-0.020		[-0.48]	-0.010		[-0.27]
Constant	-0.094		[-1.48]	-0.038		[-0.69]
Number of obs.	60			68		
R-squared	0.593			0.502		
Adjusted R-squared	0.490			0.394		

Source: Author's calculations
Note: For all regressions t-statistics are shown in parenthesis. ** indicates significance at the 1 per cent level; * significance at the 5 per cent level, and + significance at the 10 per cent level.

Poverty is assumed to be a function of non-agricultural labour productivity growth, corruption, the economic structure, aid inflows, inflation and also some socio-economic variables such as inequality, population density and fertility. In one of the specifications an Africa dummy is used. It has to be said that poverty headcount data are still scarce and not always reliable. Thus the results of this regression have to be interpreted very carefully.

Surprisingly non-agricultural productivity growth has a positive coefficient, although it is only significant at the 10 percent level for specification [1] (Table 4). Thus an increase in labour productivity in the non-agricultural sector does not seem to reduce poverty.

However more control of corruption, a higher share of agriculture in GDP, a reduction of inequality, population density, fertility or inflation are all likely to reduce poverty as expected. The positive association between per capita aid and poverty could be due to a higher allocation of aid towards poorer countries. Again the Africa dummy is not significant, indicating that African countries are not different from other developing countries in this respect.

Table 4: Regression results: Poverty headcount (USD 1/day)

	[1]			[2]		
Non-agricultural productivity growth (fitted values)	38.46	+	[1.68]	33.90		[1.50]
Control of Corruption	-2.79		[-1.22]	-3.79		[-1.63]
Agricultural value added (% of GDP)	-0.33	+	[-1.73]	-0.28		[-1.48]
Aid per capita	0.21	**	[3.43]	0.19	**	[3.12]
Gini Index	0.41	*	[2.13]	0.43	*	[2.28]
Population density	0.03	**	[3.74]	0.03	**	[3.95]
Inflation rate	0.11	*	[2.15]	0.10*	*	[2.15]
Fertility	10.64	**	[4.82]	8.76	**	[3.56]
Africa Dummy				7.76		[1.57]
Constant	-40.11	**	[-3.89]	-37.76	**	[-3.71]
Number of obs.	41			41		
R-squared	0.739			0.759		
Adjusted R-squared	0.674			0.689		

Source: Author's calculations
Note: For all regressions t-statistics are shown in parenthesis. ** indicates significance at the 1 per cent level; * significance at the 5 per cent level, and + significance at the 10 per cent level.

5. Conclusions and policy recommendations

Innovation is not restricted to high-tech applications. Innovation that leads to higher efficiency and better quality goods is also essential in such sectors as food processing and textiles to enable them to survive rising competition. The largest share of innovations in Africa takes place in the form of incremental applied and informal improvements made in small and medium enterprises. Hence African governments need to improve the environment and create more incentives to increase the level of innovation in these enterprises.

To improve the functioning of knowledge systems in Africa the scarce resources have to be better linked and given more support. Governments can contribute to enhancing the capacity of firms to adapt or create innovations in different ways. These include the provision of direct incentives for technology learning and upgrading such as tax holidays and R&D grants, the improvement of skills and the provision of appropriate infrastructure and regulatory frameworks. To assist domestic firms to develop dynamic comparative advantages high quality information not only on technologies but also on potential markets are needed. Only in dynamic sectors where labour productivity is increasing through technical progress based on better skills and innovative efforts can decent employment be generated and maintained.

From the empirical analysis the importance of secondary school enrolment, economic incentives, access to technology through imports, infrastructure and not least a functioning innovation system are likely to increase technological progress that results in labour productivity growth. However, at least in the short run this increased labour productivity is not likely to have a significant direct effect on poverty reduction. Nevertheless as technical progress is one of the main drivers of growth it is a precondition for poverty reduction in the long run. In the meantime poverty has to be tackled by other measures.

More than any other factor, political consensus between the government, business leaders, foreign investors and knowledge institutions, is critical for the success of an innovation strategy. It can succeed only with committed leadership, where the government formulates a coherent and functional incentive regime that targets strategic and performance-based technology development, rather then pursue discretionary policies that favour political business allies. In addition, support measures that are meant to enhance innovations have to be complementary. Therefore, the binding constraints for innovation in the private sector have to be identified in each African country and a coherent technology strategy has to be formulated. Specifically countries should consider at least some of the following measures to improve the environment for innovations:

- **Improvement of education at all levels.** Education has to be targeted more towards the needs of the private sector to reduce the skills-mismatch. As knowledge is changing fast the focus has to be on learning how to learn, which is usually associated with secondary education. This includes improved apprenticeship systems, support for on the job training within firms, and managerial skills. To strengthen the capacity and increase the quality of the tertiary education system it is necessary to introduce competitive allocation procedures, transparency and peer review, research evaluation and accountability for results. In general all stakeholders such as education and research institutions as well as the private sector should participate in the design and implementation of the education policy. The skills needs of the economy should be monitored. In addition, priorities in education and policies in other fields have to be coordinated (UNCTAD, 2005).

- **Creation of innovation networks.** As a precondition research institutions need to be strengthened in order to make them viable partners for innovating firms. Then they could provide meaningful consultancy services. Thus, research institutes should be given more autonomy, so they can react to demand in the private sector. To initiate networking between firms and research institutes the mobility of employees for short time assignments should be increased. Once the R&D potential has increased Science and Technology Parks could be used to foster cross-fertilization of ideas between entrepreneurs and researchers for the purpose of enabling academic knowledge to be applied to effective commercial use. STPs can contribute to commercialising university-based knowledge and technology and can serve as an important link in the knowledge system.

- **Provision of start-up finance.** Through the provision of venture capital firms are provided with equity instead of loans and are therefore better able to cope with the risk of innovations. Public-private partnerships between commercial investment funds and grant-financed technical service providers could fill the existing gap in Africa.

- **Better Infrastructure for advanced products.** To enable firms to use new technologies it is not only essential that traditional infrastructure, especially electricity and communication is in place. To achieve high quality access to laboratories and standards institutions is essential. Certification through the International Standardization Organisation (ISO) will signal high quality especially to foreign buyers.

- **Demand driven business services.** As entrepreneurs are often not aware of the benefits of business services there is a need to initially subsidize them. But these subsidies should be carefully targeted so the provision of business services is demand driven and private providers are not driven out of business. Thus, participating firms should be asked to cover at least part of the costs. And SME support programmes should be directed towards groups of enterprises to make them more efficient.

- **Marketing innovative products.** To enable firms to produce products that are not only new and of higher quality but for which a market exists the interaction between producers and consumers has to be increased, for example through trade fairs. The provision of market intelligence of both exports and imports could also help firms to better target their potential customers.

Through public procurement schemes firms can be encouraged to develop new products, which can subsequently be sold to the private sector as well.

- **Doing selection right.** Instead of using a pick-the-winner strategy for providing business support it would be better to select firms with strong backward and forward linkages as this would increase the externalities of technological upgrading. It would increase demand for higher quality inputs and at the same time provide cheaper or better inputs for other sectors. One example of this approach is to target the packaging sector as it is a crucial input for many agricultural processing industries and in many African countries most of the packaging material is imported.

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Table A1: Drivers of innovation in different sectors and firm sizes in South Africa

Innovation	South Africa	Chemicals and pharmaceuticals	Electronics	Food	Garments	Leather	Metals and machinery	Non-metallic and plastic materials	Other manufacturing	Textiles	Wood and furniture	Small (1-19 employees)	Medium (20-99 employees)	Large (100+ employees)
ISO certification ownership (%)	42.4	55.56	44.44	32.26	13.04	9.09	53.08	40.32	50	34.62	34.02	24.56	29.6	56.84
Use of technology licensed from foreign companies (%)	22.55	29.09	22.22	22.58	26.09	0	27.48	12.9	23.58	15.38	22.22	5.17	17.46	30.42
New production technology (%)	60.57	52.73	55.56	59.68	73.91	63.64	60.77	51.61	66.98	76	57.58	44.83	55.38	68.07
New product or substantial upgrade of existing product (%)	89.18	90.91	77.78	95.16	86.96	90.91	89.23	85.48	87.74	92	89.9	70.69	87.25	94.74
Spending on R&D (% sales)	0.53	0.79	0.11	0.6	0.27	0.55	0.41	0.24	0.95	0.32	0.4	0.7	0.46	0.56
New machinery or equipment is the most important way of acquiring technological innovations (%)	25.31	19.23	11.11	39.66	26.09	27.27	13.11	33.9	29.9	37.5	21.98	32.65	23.68	25.18
Hiring key personnel is the most important way of acquiring technological innovations (%)	8.2	13.46	33.33	5.17	13.04	9.09	7.38	11.86	6.19	8.33	4.4	14.29	7.46	7.55
Licensing/turnkey operations is the most important way of acquiring technological innovations (%)	10.52	13.46	0	8.62	21.74	18.18	14.75	13.56	6.19	0	7.69	8.16	7.89	12.95
Developing in house or jointly is the most important way of acquiring technological innovations (%)	38.68	32.69	44.44	31.03	17.39	45.45	42.62	35.59	40.21	37.5	49.45	30.61	44.3	35.97
Other methods are the most important ways of acquiring technological innovations (%)	17.29	21.15	11.11	15.52	21.74	0	22.13	5.08	17.53	16.67	16.48	14.29	16.67	18.35
Strongest influence to reduce production costs: domestic competitors (%)	35.41	35.85	44.44	40.32	17.39	20	36.92	41.67	33.65	11.54	37.76	28.07	39.52	34.04
Strongest influence to reduce production costs: foreign competitors (%)	13.32	3.77	22.22	6.45	34.78	10	11.54	18.33	14.42	46.15	9.18	12.28	7.66	18.44
Strongest influence to develop new products/services/markets: domestic competitors (%)	24.57	30.19	66.67	25.81	8.7	20	20.97	28.81	20.39	8	31.96	22.22	27.5	22.7
Strongest influence to develop new products/services/markets: foreign competitors (%)	8.93	7.55	0	4.84	17.39	10	13.71	10.17	8.74	16	4.12	9.26	7.08	10.28

Source: World Bank, 2006