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THE LEAST DEVELOPED COUNTRIES REPORT, 2007

Introduction

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Introduction: Why Technological Learning and Innovation Matter for LDCs

A. Introduction

This Report explores how national and international policies can promote more effective technological learning and innovation in the least developed countries (LDCs). It extends and deepens the analysis in *The Least Developed Countries Report 2006*.

The *Least Developed Countries Report 2006* advanced three major propositions:

- First, sustained economic growth and substantial poverty reduction in the LDCs require the development of their productive capacities in such a way that the population of working age becomes more and more fully and productively employed.
- Second, productive capacities develop through three closely interrelated processes — capital accumulation, technological progress and structural change.
- Third, the development of productive capacities, and the associated expansion of productive employment opportunities, should be at the heart of national and international policies to promote sustained economic growth and poverty reduction in the LDCs.·

Unless the LDCs adopt policies to stimulate technological catch-up with the rest of the world, they will continue to fall behind other countries technologically and face deepening marginalization in the global economy.

The present Report extends and deepens the earlier analysis by focusing on policies to promote technological progress with a view to achieving sustained and accelerated economic growth and substantial poverty reduction.

The basic argument of the Report is that unless the LDCs adopt policies to stimulate technological catch-up with the rest of the world, they will continue to fall behind other countries technologically and face deepening marginalization in the global economy. Moreover, the focus of those policies should be on proactive technological learning by domestic enterprises rather than on conventionally understood technological transfer, and on commercial innovation rather than on pure scientific research.

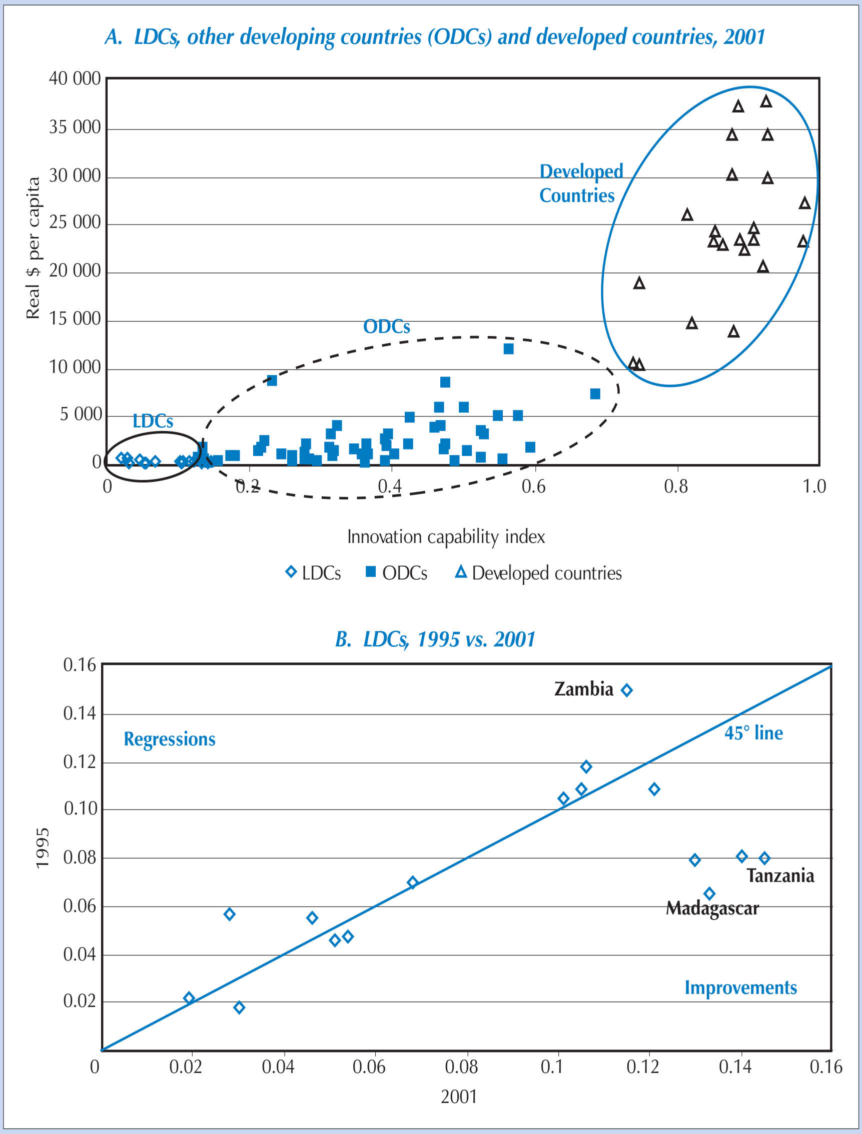
B. Technological development in LDCs in a comparative international perspective

The level of technological development in the LDCs is very low. This is apparent in various indices that measure the technological capabilities and knowledge assets of countries. There are a growing number of such indices (Archibugi and Coco, 2004, 2005). For LDCs, the data are incomplete. However, examination of where LDCs are ranked with regard to some of the key indices commonly used for country-level comparisons reveals a uniform picture — most of the LDCs are at the bottom of the rankings:

The level of technological development in the LDCs is very low.

- The UNDP Technological Achievement Index (TAI) classifies countries as leaders, potential leaders, dynamic adopters and marginalized countries. All the LDCs for which there are data are in the last category (UNDP, 2001).
- LDCs are near the bottom of the rankings of the UNIDO Competitive Industrial Performance Index and, apart from Bangladesh and Nepal, their rankings have been falling (UNIDO, 2002: 46).
- An analysis undertaken by the RAND Corporation classifies countries into scientifically advanced, scientifically proficient, scientifically developing and scientifically lagging countries, and of the 33 LDCs in the sample all except Benin are in the scientifically lagging category (Wagner et al., 2001).
- LDCs are ranked at the bottom of UNCTAD's Innovation Capability Index. Moreover, for half the LDCs, their "innovation capability", relative to the

Chart 1. Where LDCs stand on UNCTAD's Innovation Capability Index



Source: UNCTAD secretariat calculations based on UNCTAD, *World Investment Report 2005*; World Bank, *World Development Indicators 2006*, CD-ROM.

Note: LDCs include: Angola, Bangladesh, Benin, Djibouti, Ethiopia, Eritrea, Haiti, Madagascar, Malawi, Mauritania, Mozambique, Senegal, Uganda, United Republic of Tanzania, Yemen and Zambia.

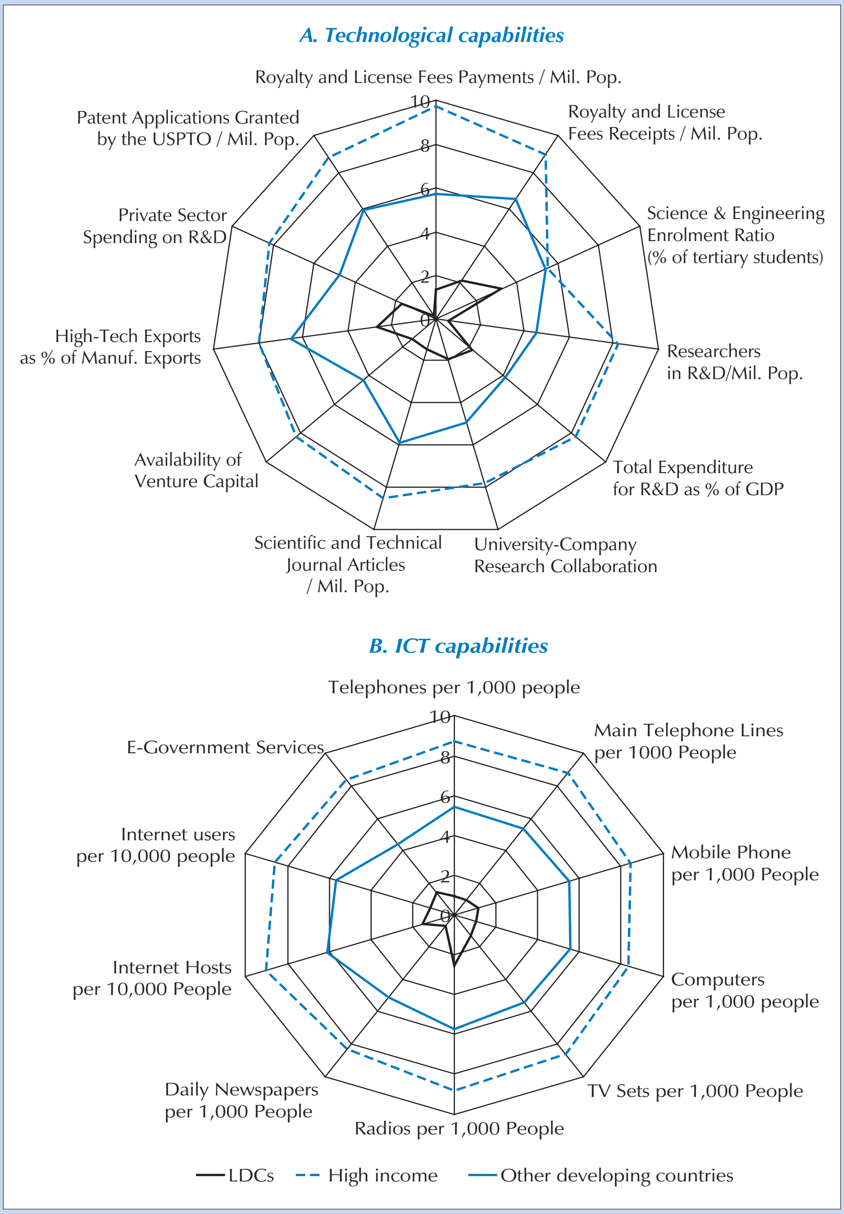
rest of the world, was worse in 2001 than in 1995, as shown in charts 1a and 1b (UNCTAD, 2005).

It should be noted that there are limitations to the relevance of those indicators in an LDC context (James, 2006). For example, industrial R&D is much more important for technological progress in advanced countries than in LDCs. Furthermore, none of the indices actually tells us how technological advances are embodied in countries' productive systems. However, whatever way it is measured, there is a strong sense that there is a major technological gap between the developed and the developing world, and particularly the LDCs, and this gap has grown over the years as a result of rapid technological advances in the developed countries and the relatively slow advances in most developing countries, and particularly the LDCs (Patel, 1995).

There is a major technological gap between the developed and the developing world, and particularly the LDCs, and this gap has grown over the years.

Charts 2a and 2b provide a more disaggregated picture, which compares the performance of LDCs, other developing countries and developed countries with

Chart 2. Selected Knowledge Assessment Methodology indicators for the LDCs, other developing countries (ODCs) and high-income countries: Technological and ICT capabilities



Source: Knell (2006), based on World Bank, Knowledge Assessment Methodology database 2006.

regard to a number of different indicators. The charts illustrate the vast difference in performance between the LDCs and other country groups. The widest disparity is in the number of researchers per million population and patent applications granted by the United States Patent Office per million. The charts also indicate that the LDCs have inadequate access not only to information and communication technology (ICT) infrastructure such as computers and the Internet, but also to more simple forms of communication such as radios, televisions, newspapers and telephones.

The Least Developed Countries Report 2006 showed that many LDCs are locked into primary commodity sectors and low-skill activities.

Table 1 shows a further disaggregation of the position of individual LDCs with regard to the basic physical infrastructure needed to support technological development, human capital and research and development (R&D). Some island countries are doing much better than other LDCs. But both African and Asian LDCs seriously lag behind other developing countries on those indicators. Notable in this regard are the very low levels of basic human capital and physical infrastructure.

It is unfortunately impossible to construct a picture of long-term changes in technological development. However, discussion in *The Least Developed Countries Report 2006* showed that, judged on the basis of various output indicators, many LDCs are locked into primary commodity sectors and low-skill activities. Thus:

In open economies, international competitiveness depends on their having up-to-date technology, even in primary production.

- The share of manufacturing value added in total GDP was only 11 per cent in 2000–2003, and almost 40 per cent of the total manufacturing value added of the LDCs as a group was located in one country, Bangladesh. Over the 10 year period between 1990–1993 and 2000–2003, the share of manufacturing in total value added declined in 19 out of 36 LDCs and stagnated in another two. During the 1990s, the share of medium- and high-technology manufactures in total manufacturing value added also declined in half the LDCs for which data are available.
- Primary commodity exports accounted for approximately 70 per cent of LDC merchandise exports during the period 2000–2003. During that period, processed minerals and metals constituted a lower share of total mineral and metals exports than 20 years earlier (down from 35 to 28 per cent) and processed agricultural goods constituted a lower share of total agricultural goods exports (down from 23 to 18 per cent).
- Low-technology, medium-technology and high-technology manufactures exports from the LDCs are expanding much more slowly than such exports from other developing countries. Their share in total merchandise exports was only 4 per cent during 2000–2003, the same share as 20 years earlier.

Policies to promote technological progress have now become a necessity for the future economic viability of the LDCs.

During the last 20 years, most LDCs have undertaken deep trade liberalization and they now have open trade regimes (UNCTAD 2004: 179–187). International competitiveness depends on their having up-to-date technology, even in primary production. In open economies this is not simply a matter of export development but is also necessary for competing in the national market. Trade liberalization means that policies to promote technological progress have now become a necessity for the future economic viability of the LDCs. The challenge now is how to increase the knowledge intensity of their economies.

C. The importance of innovation and technological learning for LDCs

Effective policy to promote technological progress requires a good understanding of how technological change occurs. For poor developing countries,

Table 1. Selected S&T-related indicators for LDCs, other developing countries (ODCs) and high-income OECD countries, latest years available

Countries	R&D			Human capital				Physical infrastructure		
	R&D (% of GDP)	Researchers in R&D (per million people)	Scientific and technical journal articles	School enroll-ment, tertiary (% of age group)	Tertiary students in science, engineering (% total tertiary)	Literacy rate, adult total (% of people ages 15 and above)	Average years of schooling	Fixed line and mobile phone sub-scribers (per 1,000 people)	Internet users (per 1000 people)	Electricity consump-tion p.c. (kwh)
	2003[a]	*1990-2003*[b]	*1999*[c]	*2004*[a]	*1999-2004*[b]	*2004*	*2000*	*2004*[a]	*2004*[a]	*2003*
Afghanistan	..	..	0.0	1.1	..	28.1	..	22.7	0.9	..
Angola	..	..	3.0	0.8	18.0	67.4	2.4	54.0	11.1	178.0
Bangladesh	0.6	..	177.0	6.5	13.0	..	4.2	37.0	2.2	145.0
Benin	..	..	20.0	3.0	25.0	34.7	2.3	38.2	12.2	82.0
Bhutan	..	..	1.0	..	..	..	..	52.9	22.3	218.0
Burkina Faso	0.2	17.0	23.0	1.5	..	21.8	0.9	37.4	4.1	32.0
Burundi	..	..	3.0	2.3	10.0	59.3	2.0	12.5	3.4	23.0
Cambodia	..	..	5.0	2.9	19.0	73.6	..	39.5	3.0	9.0
Cape Verde	..	127.0	1.0	5.6	106.0	..	..	281.1	50.5	100.0
Central African Republic	..	..	4.0	1.8	..	48.6	2.9	17.6	2.3	35.0
Chad	..	..	2.0	0.8	..	25.7	..	14.4	6.4	11.0
Comoros	..	..	0.0	2.3	11.0	..	..	26.5	13.6	32.0
Dem. Rep. of the Congo	..	..	6.0	1.3	..	67.2	..	37.0	..	86.0
Djibouti	..	..	0.0	1.6	22.0	..	..	43.4	11.6	455.0
Equatorial Guinea	..	..	1.0	2.6	..	87.0	..	106.2	10.2	..
Eritrea	..	..	2.0	1.1	37.0	..	..	14.0	11.8	62.0
Ethiopia	..	..	93.0	2.5	19.0	..	1.9	7.8	1.6	33.0
Gambia	..	..	17.0	1.2	21.0	..	..	99.0	33.2	101.0
Guinea	..	251.0	2.0	2.2	34.0	29.5	..	15.3	5.0	89.0
Guinea-Bissau	..	..	6.0	0.4	..	..	..	7.9	16.9	45.0
Haiti	..	..	1.0	..	..	..	3.6	64.2	59.5	61.0
Kiribati	..	..	0.0	..	..	..	..	52.5	20.4	..
Lao People's Dem. Rep.	..	..	2.0	5.9	11.0	68.7	..	48.2	3.6	135.0
Lesotho	0.0	42.0	1.0	2.8	6.0	82.2	..	109.1	23.9	..
Liberia	..	..	1.0	15.5	..	..	..	2.8	0.3	..
Madagascar	0.1	15.0	..	2.5	20.0	70.7	3.7	19.5	5.0	50.0
Malawi	..	..	36.0	0.4	33.0	64.1	4.3	25.0	3.7	77.0
Maldives	..	..	3.0	0.2	..	96.3	..	450.7	59.2	..
Mali	..	..	11.0	2.1	..	19.0	1.1	36.2	3.8	38.0
Mauritania	..	..	2.0	3.5	10.0	51.2	..	134.5	4.7	60.0
Mozambique	0.6	..	14.0	1.2	24.0	..	2.4	26.9	7.1	399.0
Myanmar	0.1	..	10.0	11.3	42.0	89.9	4.4	10.3	1.3	126.0
Nepal	0.7	59.0	39.0	5.6	..	48.6	3.3	21.8	6.6	91.0
Niger	..	..	21.0	0.8	..	28.7	1.0	12.8	1.8	40.0
Rwanda	..	..	4.0	2.7	..	64.9	..	18.2	4.3	39.0
Samoa	..	..	3.0	7.5	14.0	..	..	130.4	32.7	613.0
Sao Tome and Principe	..	..	0.0	1.0	..	..	..	78.9	130.8	102.0
Senegal	..	..	62.0	4.9	..	39.3	2.6	72.4	42.3	192.0
Sierra Leone	..	..	3.0	2.1	8.0	35.1	3.6	27.2	1.9	49.0
Solomon Islands	..	..	6.0	..	..	..	..	17.0	6.4	69.0
Somalia	..	..	0.0	..	..	..	..	87.9	25.1	..
Sudan	0.3	263.0	43.0	6.1	..	60.9	2.9	58.5	32.1	101.0
Timor-Leste	..	..	..	10.2	..	..	..	..	..	301.0
Togo	..	..	11.0	3.6	..	53.2	..	48.1	36.9	91.0
Uganda	0.8	24.0	91.0	3.4	..	66.8	3.3	44.4	7.2	59.0
United Rep. of Tanzania	..	..	87.0	1.2	..	69.4	3.5	32.2	8.9	78.0
Vanuatu	..	..	3.0	5.0	..	74.0	..	83.3	36.2	..
Yemen	..	..	10.0	9.4	..	..	..	92.0	8.9	212.0
Zambia	0.0	51.0	26.0	2.3	..	68.0	6.1	33.7	20.1	631.0
LDC	0.3	94.3	18.2	3.5	24.0	56.5	3.0	58.4	17.4	130.5
African LDCs	0.3	94.7	24.2	2.7	20.0	52.8	2.8	42.4	13.1	115.2
Asian LDCs	0.5	59.0[d]	30.5	6.1	21.3	61.8	4.0	40.6	6.1	133.7
Island LDCs	..	127.0[e]	2.0	4.5	43.7	85.2	..	140.0	43.7	202.8
ODCs	0.8	313.0	628.8	23.0	21.5	86.1	7.1	425.5	97.6	527.5
High income OECD	2.4	3 728.1	532 308.0	68.7	24.7	92.2[f]	11.4	1 321.0	562.7	9 654.4

Source: UNCTAD secretariat calculations based on UNDP, *Human Development Report 2006*; World Bank, *World Development Indicators 2006*, CD-ROM; and Cohen and Soto, 2001.

a Or latest available; *b* Data refers to the most recent year available during the period specified; *c* 2001 for Bangladesh, Ethiopia, Senegal, Uganda and United Republic of Tanzania; *d* Data refers to Bangladesh only; *e* Data refers to Cape Verde only; *f* Based on data for Italy and Switzerland.

technological change occurs primarily through learning — that is, the acquisition, diffusion and upgrading of technologies that already exist in more technologically advanced countries — and not by pushing the global knowledge frontier further. In short, the key to technological progress in the LDCs is technological catch-up through learning rather than undertaking R&D to invent products and processes which are totally new to the world.

Creative technological innovation also occurs when products and processes that are new to a country or to an individual enterprise are commercially introduced, whether or not they are new to the world.

From that perspective some might argue that innovation is irrelevant to the LDCs. But that view is based on a definition of innovation *sensu stricto*, as occurring only when enterprises introduce for the very first time products or production processes which are new to the world. An LDC can hardly be expected to be already knocking at the frontiers of technological breakthroughs. Whilst this strict definition has wide currency, it is now common to recognize that creative technological innovation also occurs when products and processes that are new to a country or to an individual enterprise are commercially introduced, whether or not they are new to the world (OECD, 2005). This Report adopts this broader definition of innovation. With this broader view, innovation is a critical aspect of technological catch-up even though it does not depend on inventions which are new to the world. Innovation also occurs when a firm introduces a product or process to a country for the first time. It occurs when other firms imitate this pioneering firm. Moreover, it occurs when the initial or follower firms make minor improvements and adaptations to improve a product or production process, which lead to productivity improvements. In short, innovation occurs through "creative imitation", as well as in the more conventional sense of the commercialization of inventions.

In the context of technological catch-up, innovation depends critically on the linkages of a country with the rest of the world. However, there are divergent views on how technological development in follower countries occurs.

The assimilation and the absorption of foreign technology involve costs and risks, and that success depends on technological effort of various kinds, and the development of competences and capabilities at the enterprise level.

In one extreme view, technological acquisition in follower countries depends solely on the transfer of technology. In that process, access to foreign technology is equivalent to its effective use. Such access can be maximized through openness to trade and foreign investment, coupled with investment in education and perhaps increasing access to the Internet and stimulating competition between international telecom providers.

A basic problem with that view is that it largely treats knowledge in static terms, as a commodity with almost instantaneous transformative properties that can be transferred from one context to another quickly and with little cost. From that perspective, technology is seen as a blueprint which can be acquired off-the-shelf by any producer seeking to put together a particular combination of inputs dictated by a given factor endowment. That perspective assumes that knowledge is like any other commodity, without geography or history. Information, knowledge and learning are all collapsed into one simple input into the universal productive process. In that approach, there is almost no discussion of how information is converted into knowledge or how learning occurs in practice; indeed, learning is not really understood or elucidated in any meaningful way. The complex dynamics of knowledge accumulation are essentially excluded from the picture altogether. This conception of knowledge ignores the fundamentally dynamic character and plural aspects shaping knowledge production and generation, as knowledge is perceived as socially disembodied and universally transferable. That perspective essentially ignores the components and processes that shape the production and generation of knowledge.

In practice, it is clear that the assimilation and the absorption of foreign technology involve costs and risks, and that success depends on technological effort — investments in technological change — of various kinds, and the development of competences and capabilities at the enterprise level. This applies to both firms and farms.

For agriculture, the type of technological effort that is required reflects the fact that a key feature of agricultural technology is its high degree of sensitivity to the physical environment (circumstantial sensitivity). The strong interaction between the environment and biological material makes the productivity of agricultural techniques, which are largely embodied in reproducible material inputs, highly dependent on local soil, climatic and ecological characteristics (Hayami and Ruttan, 1985; Evenson and Westphal, 1995).

For industry and services, such circumstantial sensitivity is less important, but nevertheless technological effort is required because technology is not simply technological means (such as machinery and equipment) and technological information (such as instructions and blueprints), but also technological understanding (know-how). The latter is tacit and depends on learning through training and experience. The whole process is complex because firms work in an environment of uncertainty with imperfect knowledge; time, effort and costly investment are required in order to learn to use technology efficiently; and learning is cumulative and path-dependent.

Technology is not simply technological means (such as machinery and equipment) and technological information (such as instructions and blueprints), but also technological understanding (know-how). The latter is tacit and depends on learning through training and experience.

The idea of tacit knowledge is particularly important. It is based on the fact that knowledge is formed gradually, over time, through repetition, and recurrent interaction, is situated in systems of ongoing practices and routines, and is a product of social, cultural and economic and political conditions. While codified knowledge is partly transferable and universal, tacit knowledge is embedded in social and cultural practices — that is, it is context-specific. Tacit knowledge that represents the outcome of learning and experience is deeply rooted in the context of social interaction, practices, routines, ideas, values and emotions. In short, "it does not travel well" (Nonaka, Ryoko and Boysière, 2001: 7). Knowledge can be acquired only through some form of participation in practice; and it is transformed by the process of circulation itself. Knowledge is thus conceived as a social learning process, which is situated in social institutions; hence it is socially and culturally embedded, and context-specific. The process of acquiring and transforming knowledge is neither linear nor timeless, nor is it costless. Knowledge itself is neither bounded nor fixed (Nelson and Winter, 1982).

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Against that background, technological learning is critical for innovation in LDCs.[1] It is the development of the capabilities to use and improve technologies, and encompasses:

- Core competences, which are the routine knowledge, skills and information needed for operating established facilities or using existing agricultural land, including production management, quality control, and repair and maintenance of physical capital and marketing; and
- Dynamic capabilities, which refer to the ability to build and reconfigure competences to increase productivity, competitiveness and profitability and to address a changing external environment in terms of supply and demand conditions.

The latter are particularly important for the process of innovation. The effective absorption (or assimilation) of foreign technologies depends on the development of such dynamic technological capabilities.

R&D can be part of those capabilities but it is not the only one. Design and engineering capabilities are particularly important for establishing new facilities and upgrading them. Moreover, technological capabilities are best understood not simply in the narrow sense of mastering "physical" technologies which are associated with machinery and equipment, the properties of materials and the knowledge possessed by engineers and scientists. Beyond this, production processes involve various complex organizational processes related to the organization of work, management, control and coordination, and the valorization of output requires logistic and marketing skills. All of those can be understood as part of "technological learning" in a broad sense.

The enterprise (firm or farm) is the locus of innovation and technological learning. But firms and farms are embedded within domestic knowledge systems which enable (or constrain) the creation, accumulation, use and sharing of knowledge.

The enterprise (firm or farm) is the locus of innovation and technological learning. But firms and farms are embedded within a broader set of institutions which play a major role in those processes. In advanced countries, national innovation systems have been established to promote R&D and link it more effectively to processes of innovation (OECD, 1997). In LDCs, what matter in particular are the domestic knowledge systems which enable (or constrain) the creation, accumulation, use and sharing of knowledge (UNCTAD, 2006). Those systems should support effective acquisition, diffusion and improvement of foreign technologies. In short, there is a need to increase the absorptive capacity (or assimilation capacity) of domestic enterprises and of the domestic knowledge systems in which firms and forms are embedded.[2]

D. Technological progress and poverty reduction

There is wide agreement that technological progress is a critical source of economic growth.[3] Technological change increases the productivity of land, labour and capital, reducing costs of production and improving the quality of outputs. It is through innovation, in the broad sense used here, that diversification and structural transformation occur. Knowledge and creativity are also becoming more and more important for competitiveness. They are now widely hailed as the key engines driving growth in the new millennium.

Promoting technological progress should not be seen as something that is different from promoting poverty reduction. The achievement of inclusive development (or pro-poor growth) depends on technological choices and technological development trajectories.

Through its effects on economic growth, technological progress should have long-term positive effects in reducing the incidence of poverty. However, if economic growth is based solely on labour-saving technological progress, there will be a strong tendency for jobless growth. Skill-biased technological change, which increases demand for skilled labour only, will also be a cause of growing income inequality.

The poverty-reducing impact of growth can be increased if more labour-using technologies are adopted. Poverty reduction will occur if all opportunities for labour-using technology are exploited, and if the negative employment effects of technological change in some sectors are offset by positive effects in other growing parts of the economy. If technological progress leads to a reduction of the demand for labour in some sectors, this will not necessarily worsen unemployment, underemployment and poverty if technological progress is at the same time leading to the introduction of new growing sectors into which the labour which is released from the declining sectors can be absorbed.

Promoting technological progress should thus not be seen as something that is different from promoting poverty reduction. The achievement of inclusive development (or pro-poor growth) depends on technological choices and technological development trajectories.[4]

E. Organization of the Report

The Report examines various aspects of the policy challenge of promoting technological learning and innovation in the LDCs. Chapter 1 discusses the extent to which technological learning and innovation are currently taking place through international market linkages, and in particular international trade, FDI and licensing. Chapter 2 focuses on national policies to promote technological learning and innovation. It discusses the way in which science, technology and innovation (STI) issues are currently treated in the LDCs, focusing on their Poverty Reduction Strategy Papers (PRSPs), and explores how the idea of technological catch-up can be applied within an LDC context. Chapter 3 explores the current controversies about how stringent IPR regimes affect technological development processes in LDCs, and policy options for improving incentives for innovation and learning. Chapter 4 looks at the loss of skilled human resources through emigration and at policy options for dealing with that issue. Chapter 5 examines how ODA is supporting technological learning and innovation in the LDCs and ways to make it more effective.

This Report is intended to provoke fresh thinking about development strategies and poverty reduction in the LDCs by both LDC Governments and their development partners.

The Report does not provide all the answers to the issues which it raises. It is intended to provoke fresh thinking about development strategies and poverty reduction in the LDCs by both LDC Governments and their development partners. There is at the present time a search for alternatives to the current development paradigm, and the role of knowledge in development is critical for the formulation of new approaches. The Report should open up policy dialogue and avenues for policy innovation and further policy-oriented research.

Notes

1. The notion of technological learning has been most applied extensively to the development of technological capabilities for manufacturing in developing countries (see Lall, 1992; UNIDO, 2002; UNIDO, 2006). But it is also relevant for agriculture (Omamo and Lynam, 2003; Lele and Ekboir, 2004) and services. In the present Report it encompasses both firms and farms, and includes services as well as industrial activities.
2. The idea of "absorptive capability" derives from Abramovitz (1986), who speaks of the "social capability" for technological advance during catch-up. Cohen and Levinthal (1989: 569) define "absorptive capacity" as "the firm's ability to identify, assimilate and exploit knowledge from the environment", whilst Rogers (2004: 578) defines "absorptive capability" as "the capability to access, learn and absorb relevant overseas technology". For analyses of East Asian development success in terms of the ability of countries to assimilate and absorb foreign technology, see Nelson and Pack (1999) and Kim (1995).
3. For a review of different perspectives on technological change and economic growth, see Nelson and Winter (1982), Nelson (1998) and Verspagen (2004). The importance of innovation for structural change and economic growth is argued in Ocampo (2005). Like the *LDC Report 2006*, this Report is based on evolutionary and structuralist approaches to economic growth.
4. For a discussion on bridging the gap between policies for technological change and policies for poverty reduction, see Mackintosh, Chataway and Wuyts (2007).

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