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PREFACE

The purpose of UNCTAD's science, technology and innovation policy reviews is to assist governments in developing their national capacities in science, technology and innovation, so that national science, technology and innovation plans and programmes support the various components of the national development agenda and help the productive sectors to compete in a knowledge-based global economy, generating better paid jobs, raising living standards, reducing poverty and promoting a strategy of growth and commercial diversification.

The ultimate objective of the science, technology and innovation policy review of Peru is to provide the Peruvian Government with an up-to-date diagnostic analysis of the effectiveness of its science, technology and innovation-related policies and measures, and strengthen these policies and measures by integrating them in the national development process, and improve technological capacity, encourage innovation and incorporate greater added value into production.

The science, technology and innovation policy review of Peru was instigated at the request of the Peruvian Government and enjoyed the support of the Ministry of Production, CONCYTEC and the Ministry of Foreign Relations. The review was conducted jointly by UNCTAD and ECLAC.

The review was prepared by a team of experts under the direction of Ángel González Sanz (UNCTAD). Marta Pérez Cusó (UNCTAD) coordinated the review in collaboration with Sebastián Rovira (ECLAC). Roberto López Martínez (national system of innovation), Guillermo Rozenwurcel (ICT, biotechnology and nanotechnology), Fernando Villarán and Romina Sol Golup (introduction) contributed the background reports for the review. The team of experts carried out two missions in the field, in October 2009 and June 2010, and conducted over 70 interviews (including 8 round tables) in Lima, Iquitos and Arequipa with representatives of government bodies, research institutes, universities, professional associations and chambers of commerce, experts in science, technology and innovation, companies, non-governmental organizations and foundations.

Many people in Peru, including public officials, researchers, academics and university and research institute staff, as well as entrepreneurs and members of civil society, generously contributed their time and their ideas to the preparation of this review. We are very grateful for their invaluable collaboration.

This review would not have been possible without the support of Mr. José Luís Chicoma Lúcar, Vice Minister of Production, Dr. Augusto Mellado, President of CONCYTEC, and Ambassador Elízabeth Astete, Undersecretary of Economic Affairs in the Ministry of Foreign Relations. Teams from the Ministry of Production, CONCYTEC and the Ministry of Foreign Relations were closely involved in the review and deserve our sincere gratitude. The evaluations and conclusions expressed in the review, however, are exclusively those of the UNCTAD Secretariat.

CONTENTS

TABLES

CHAPTER I

CHAPTER II

CHAPTER III

CHAPTER IV

CHAPTER V

CHAPTER VI

ANNEXES

FIGURES

CHAPTER I

CHAPTER II

CHAPTER III

CHAPTER IV

CHAPTER V

ANNEXES

BOX

CHAPTER II

CHAPTER III

CHAPTER IV

CHAPTER V

ABBREVIATIONS

ANR:	National Assembly of Rectors
APESOFT:	Peruvian Association of Software Producers
APESOL:	Peruvian Free Software Association
CABBIO:	Argentine-Brazil Biotechnology Centre
CABNN:	Argentine-Brazilian Nanoscience and Nanotechnology Centre
CAF:	Andean Development Corporation
CAICyT:	Argentine Centre for Scientific and Technological Information
CEPLAN:	National Strategic Planning Centre
CIISB:	Centre for Exchange of Information on Biotechnology
CINN:	Interdisciplinary Centre for Nanoscience and Nanotechnology (Argentina)
CITE:	Technological Innovation Centre
CMMI:	Capability Maturity Model Integration
CNBAF:	National Centre of Agricultural and Forestry Biotechnology
CNBS:	National Biosafety Council (Brazil)
CNC:	National Competitiveness Council
CNEA:	National Atomic Energy Commission (Argentina)
CNPq:	National Council for Scientific and Technological Development (Brazil)
CODESI:	Multisectoral Commission for the Development of the Information Society
COFIDE:	Development Finance Corporation
CONAFU:	National Council for the Authorization of Foundation of Universities
CONCYTEC:	National Council of Science, Technology and Technological Innovation
CONICET:	National Scientific and Technical Research Council (Argentina)
CONID:	National Advisory Council for Science Technology and Technological Innovation
CONIDA:	National Aerospace Research and Development Commission
CONSUCODE:	Supreme State Contracting and Procurement Council
CPB:	Cartagena Protocol on Biosafety
CTNBio:	National Biosafety Technical Committee (Brazil)
DIGESA:	Directorate General of Environmental Health
DNA:	Deoxyribonucleic acid
EAP:	Economically active population
ECLAC:	Economic Commission for Latin America and the Caribbean
ERP:	Enterprise Resource Planning
FAN:	Argentine Nanotechnology Foundation
FAPESP:	Sao Paulo Research Foundation
FIDECOM:	Research and development for competitiveness fund
FINCyT:	Science and Technology Programme
FITEL:	Telecommunications Investment Fund
FOMIN:	Multilateral Investment Fund
FONAFE:	National Fund for the Financing of State Entrepreneurial Activities
FONDECYT:	National Fund for Science Technology and Technological Innovation
FTA:	Free Trade Agreement
FTAA:	Free Trade Area of the Americas
FDI:	Foreign direct investment
GMO:	Genetically modified organisms
IADB:	Inter-American Development Bank
ICACIT:	Quality and Accreditation Institute for Engineering and Technology Careers
ICT:	Information and communications technologies
IGN:	National Geographical Institute
IGP:	Geophysical Institute of Peru
IGV:	General sales tax
IIAP:	Peruvian Amazon Research Institute
IMARPE:	Maritime Institute of Peru

INDECOPI:	National Institute for the Defence of Competition and Protection of Intellectual Property
INEI:	National Institute of Statistics and Information Technology
INGEMMET:	Geological, Mining and Metallurgical Institute
INIA:	National Institute of Agrarian Innovation
INICTEL:	National Institute for Research and Training in Telecommunications
INS:	National Institute of Health
IP:	Intellectual property
IPC:	International Patent Classification
IPEN:	Peruvian Nuclear Energy Institute
ISIC:	International Standard Industrial Classification
ITES:	Information Technology Enabled Services
ITP:	Institute of Fishing Technology
LMO:	Living modified organisms
MCT:	Ministry of Science and Technology (Brazil)
MENB:	National biosafety framework
MINCETUR:	Ministry of Foreign Trade and Tourism
MINCyT:	Ministry of Science, Technology and Productive Innovation (Argentina)
MSE:	Micro and small enterprises
MSME:	Micro, small and medium-sized enterprises
NBIC:	Nanotechnology, biotechnology, information technology and cognitive sciences
NGO:	Non-governmental organization
OECD:	Organization for Economic Cooperation and Development
OEI:	Organization of Ibero-American States
OSIPTEL:	Supervisory Body of Private Investment in Telecommunications
PCM:	Presidency of the Council of Ministers
PCT:	Patent Cooperation Treaty
PNN:	National Nanotechnology Programme (Brazil)
PPP:	Purchasing Power Parity
PROCOM:	Technological Innovation for Competitiveness Projects
PROCYT:	Science and Technology Research Projects
PRODUCE:	Ministry of Production
PROMPERU:	Commission for Promotion of Exports and Tourism of Peru
PROMPEX:	Export Promotion Commission
PROTEC:	Transfer and Extension Project
PUCP:	Pontifical Catholic University of Peru
R&D:	Research and development
RDI:	Research, development and innovation
RIS:	Regional innovation systems
S/.:	New sol
S&T:	Science and Technology
SCI:	Science citation index
SEACE:	Electronic System for Government Procurement and Contracting
SENAMHI:	National Meteorological and Hydrological Service
SENASA:	National Agrarian Health Service
SINACYT:	National system of science technology and technological innovation
SIS:	Software and information services
SME:	Small and medium-sized enterprises
STA:	Scientific and Technological Activities
STI:	Science, Technology and Innovation
UNALM:	La Molina National Agrarian University
UNCTAD:	United Nations Conference on Trade and Development
UNI:	National University of Engineering
UNMSM:	Mayor de San Marcos National University
UNSD:	United Nations Statistics Division
UPCH:	Peruvian Cayetano Heredia University
UPOV:	International Union for the Protection of New Varieties of Plants
USPTO:	United States Patent and Trademark Office
WIPO:	World Intellectual Property Organization
WOS:	World of Science

EXECUTIVE SUMMARY

In recent years, the Peruvian economy has experienced remarkable growth. Between 2000 and 2009[1], Gross Domestic Product (GDP) grew by an annual average of 5.3% and GDP per capita rose by 40%. During the period 2000-2008, exports rose to 24.7% of GDP in 2008 and the stock of foreign investment increased from 12,306 million dollars in 2000 to 17,953 million dollars in 2008. There was also a considerable reduction in poverty levels, from 54.1% in 2000 to 36.2% in 2008. In qualitative terms, these good results will be reflected in economic and social development to the extent that this economic growth is sustainable in the long term and offers all sectors of the population the opportunity to benefit from this progress.[2] The improvement in the capacity of the Peruvian economy to generate, absorb, disseminate and utilize scientific and technological knowledge in its productive sectors could be a key factor in this process.

The growth seen in the Peruvian economy, albeit limited in 2009 by the serious global economic crisis, shows the potential offered by Peru's resources of all kinds in an appropriate macroeconomic and commercial context. However, the recent strong macroeconomic results should not conceal the weaknesses of a development based chiefly on the exploitation of natural resources and the dangers of relegating to second place the investment and efforts crucial to promoting long-term development of Peru's human, entrepreneurial and institutional capacity to innovate and compete in global markets. This is an area where the assessment of the country's situation is much less positive. As will be seen in the various chapters of this review, Peruvian performance in science, technology and innovation (STI) does not match up to the country's macroeconomic and commercial development.

There is no doubt that a country's sustained development relies increasingly on its ability to use knowledge to serve economic activities and the wellbeing of its citizens. Without undervaluing the contribution of capital accumulation and mobilization of the labour factor, previous experience of countries which have been most successful in developing their economies suggests that innovation in its broadest sense, i.e. the introduction of new products, services and forms of productive organization, based on the capacity to create, adopt and adapt knowledge and technology, is critical in assuring the achievement in the long term of higher levels of diversification, productivity, incomes and, in a nutshell, wellbeing (ECLAC, 2008).

A country's innovative potential goes beyond the existence of a set of scientific entities, a research budget or a national science, technology and innovation plan. This potential depends on the degree of development of various subsystems (political, scientific, productive, financial) and their capacity to interconnect and interrelate, producing, distributing and utilizing scientific and technical knowledge, creating synergies, promoting competition and establishing a macroeconomic, legal, institutional and even cultural framework which provides incentives, resources and support for innovative activities. The effectiveness of this set of actors, institutions and frameworks, known as the National System of Innovation (Freeman, 1987; Dosi, 1988; Lundvall, 1992; Nelson, 1993; Metcalfe, 1995; among others) depends, quite clearly, on individual development trajectories and the accumulation of knowledge and skills available to the many participants in the system. However, although innovative activity essentially occurs in the framework of the company and the generation of knowledge, in the majority of cases, is generally a matter for scientific entities, public science, technology and innovation policies exert a considerable influence on the development of one type of activity or another, by fostering human capacities and creating and maintaining a favourable environment.

The team responsible for carrying out this review as well as the large number of entrepreneurs, scientists, researchers, engineers, teachers and public administrators interviewed agree on one aspect of the analysis of the situation of science, technology and innovation in Peru: the Peruvian system of innovation is weak and poorly integrated.

The level of public and private investment in research and development (R&D) in Peru is meagre in comparison with the leading countries of the region. Although there are no up-to-date objective data, the available indicators (e.g. level of patenting), previous studies[3], and the views gathered from a large number of economic agents, experts and academics, suggest a low level of investment in R&D. There is no critical mass of research in public research institutes and the universities, as they suffer, among other things, from a lack of financial resources and the lack of formal recognition of the researcher as a professional. The R&D infrastructure is incomplete; research equipment and accreditation is insufficient, efforts at incubation have not been able to develop technology-based companies and, although there are projects and studies, no technology parks exist yet. The low level of investment is an important factor, albeit not the only one, in explaining the limitations of the national system of innovation in Peru.

Educational performance in Peru is poor at all levels as a result of inadequate investment in education, excessive commercialization of educational provision, the predominance of short-term considerations both in terms of supply and demand, and inadequate quality control of that provision. In addition, there is a lack of orientation towards scientific and technological disciplines and an insufficient provision of doctorate courses. The majority of Peruvian companies are concentrated in activities with little added value, there is a lack of readiness and opportunity to take on risk and innovate. The regulatory framework, although developed, is largely ineffective and often contradictory. The legal commitment to promotion of competitiveness and innovation is not matched by an effective allocation of resources for R&D, there is duplication of organizations and functions, and problems with the hierarchical position of CONCYTEC. There is no effective control of quality of education and research and there are various legal obstacles to the use of scarce economic resources. Interaction between the private sector, scientific institutions and the responsible state officials is virtually nil and the various institutions encounter serious difficulties in training and retaining a critical mass of scientific and technical staff. In addition, the lack of consensus and institutional coordination that make possible a strong institutional leadership in STI are factors which hinder the systematic and strategic development of STI to the benefit of the economy and the well being of the Peruvian people.

There are a few, more or less isolated, examples of successful innovation support programmes, but a strategy to generate synergies with the principal productive sectors is lacking. There is also broad social agreement that it is desirable to achieve a vision of a prosperous, competitive, less unequal Peru which takes advantage of its heritage, culture and knowledge to achieve a balanced economic, social and environmental development of the country's different regions. Nevertheless, when the detail of how to achieve the development of the national system of innovation and who should design, direct and execute the concrete policies involved is analysed, there are wide divergences of opinion. This lack of consensus and leadership among the participants in the national system of innovation acts as a serious brake on the development of STI in Peru.

Given the current characteristics and trends identified in the Peruvian national system of innovation, the development of STI capacities in Peru in the next few years will depend on the conviction, at all levels of society and the State, that the generation of knowledge and technological innovation has become one of the driving forces of growth and economic development, and on the will to make the changes necessary to transform the Peruvian economy into a knowledge economy.

Based on the diagnostic analysis, six sets of basic recommendations have been identified to stimulate the development of science, technology and innovation in Peru:

1) Establish an institutional framework, as well as an organizational, human and financial structure capable of leading the development of science, technology and innovation in Peru.

Concentrate in two bodies the functions of foresight, intelligence and strategic planning and evaluation of STI policies, on the one hand, and financing and execution of STI programmes, on the other. In particular, it is proposed to establish:

1. A *National Innovation Council* – an independent body, with participation of the various actors in the national system of innovation and linked to the Presidency of the Council of Ministers. The Council would be responsible for setting the main lines of science, technology and innovation policies and would also be responsible for foresight, intelligence, strategic planning and evaluation. Ideally, *the National Innovation Council* should be chaired by the Prime Minister[4], and the Council would necessarily include the participation of the principal ministries and representatives of the universities, research institutes, the private sector and the proposed Peruvian Innovation Agency[5].
2. A *Peruvian Innovation Agency* – a body subordinate to the PCM, responsible for the financing and execution of STI programmes.

2) Design a mix of STI policies and programmes which, combined with economic policy, will strengthen general STI capacities in Peru and the development of STI in a selected number of strategic sectors and technologies.

- Starting with a foresight exercise and a process of consultation identify priority subsectors and technologies of strategic importance for the Peruvian economy and society, in which active policies on strengthening technological capacity and innovation would focus.
- Accompany these policies by others of a more general character which establish the essential conditions for the development of STI in Peru, acting on both the supply and the demand side.
- Progressively and steadily increase the financing of STI activities, so that levels of investment in STI in Peru in the medium term reach at least the levels invested by the region's leading countries. Consider the establishment of incentives to promote private investment in STI. For example, consider the establishment of fiscal incentives for investing in R&D.
- Develop a science, technology and innovation system which allows the design, monitoring and evaluation of STI policies. For example, promote the elaboration of a national innovation survey, the systematic collection of STI data and the development of capacities to process and analyse this information

3) Improve the management of STI programmes and policies

- Develop short-term plans with concrete and measurable objectives, with clearly identified responsibilities and resources subject to a control system.
- Place responsibility for the management of the STI financing programmes (FONDECYT, FINCyT, FIDECOM) under the proposed Peruvian Innovation Agency. Also consider the inclusion of other sectoral funds.
- Relax the conditions attached to the funding resources from the mining canon, so that it can be used in research, innovation and advanced capacity building activities in the area of STI with a broader remit, in accordance with the particular needs of regional research groups.

4) Invest in the development of Peruvian human capital

- Strengthen quality of education at all levels, increasing investment in education and improving systems of evaluation and control of education.
- Review the model of certification and quality control of the university system and, in particular, the mechanisms for authorization of the creation of universities in Peru.
- Establish the profession of researcher as a career path with effective mechanisms for regular evaluation, promote the renewal of the body of researchers, facilitate the financing of research activities and increase the quality of postgraduate training programmes.
- Promote education in scientific and technological fields, starting in primary and secondary education.

- Drive information and awareness raising campaigns to encourage the development of a more science-oriented culture and greater awareness among economic, social and political operators of the importance of STI in Peru.
- Facilitate the contribution of Peruvian scientists, researchers and engineers abroad in achieving national STI policy objectives, through (a) programmes which facilitate their reintegration in the Peruvian labour market in universities or the private sector, (b) other ways of participating in the country's scientific and technological activities which do not involve the permanent return of participants (for example, as advisers, network facilitators or occasional trainers).

5) Promote the participation of the private sector in STI.

Develop a set of programmes and actions which promote innovation in the private sector, including:
- Reducing the cost of innovation, in particular removing administrative barriers or others which affect the acquisition of technology.
- Facilitating the development of the venture capital and seed capital sector in Peru and access to venture capital.
- Supporting the consolidation of business incubators, in particular the capacity to incubate technology-based companies.
- Facilitating public-private partnerships and co-financing through an appropriate regulatory framework.

Facilitate the articulation of the national system of innovation, including:
- Promoting collaboration and technology transfer between universities, research institutes and companies as well as, promoting the role of the university and research institutes both in technological development and scientific knowledge and its transfer and application to the productive sectors. For example, facilitating training in management of the intellectual property that their activity may generate, developing mechanisms for mobility between universities, research institutes and companies, or facilitating private investment in research carried out by universities and public research institutes.
- Stimulate multi-disciplinary programmes which combine the participation of several research institutes, universities and companies. For example, by considering the multi-disciplinary character as a positive factor in the grant of competitive funds.
- Promote the participation of the private sector in the design of STI policies. For example, consulting directly with entrepreneurs, and not only representatives of professional organizations, or facilitating their participation in the formulation of study plans in the education system.

6) Strengthen capacity relating to intellectual property and quality

- Develop institutional capacities in the private sector, universities and public research institutes relating to intellectual property. Drive the development of intellectual property policies in public research institutes and CITEs.
- Establish an action programme which promotes and facilitates the application of quality systems in the productive system.

As part of this review, a more detailed analysis was also made of three cross-cutting sectors (information and communication technologies (ICT), biotechnology and nanotechnology) identified by the Peruvian Government. As might be expected, the performance of each of these sectors is conditioned by the functioning of the national system of innovation in Peru and, thus, actions aimed at strengthening the national system of innovation contribute to improving the performance of these sectors. The conclusions and recommendations for each of these sectors are presented below. These recommendations focus on the specific features of each sector.

The information and communication technologies sector in Peru. Principal conclusions and recommendations

Although a few cases of success in the ICT sector in Peru can be found, they are still far from forming a critical mass. The sphere of private activity is marked by the high level of informal business (limited adoption of international certification and scant quality control), its concentration in activities with low added value, and scant links with research initiatives in universities and other academic institutions. Peruvian companies are also faced with the lack of capitalization mechanisms and bottlenecks in the training of human resources.

In the public sphere, for its part, added to the lack of a legal framework to promote the software industry and generate adequate incentives for the development of the sector, is the obvious institutional weakness of support bodies for scientific, technological and innovative activities, a marked scarcity of resources, a notorious lack of promotion of the sector and also a lack of coordination between bodies which tends to fragment the available funds into a multiplicity of separate initiatives.

To reverse this situation, it is recommended to:

1) **Develop a national vision and strategy for the development of the ICT sector.** Strengthen the productive aspects of the Peruvian Digital Agenda and establish a National Programme for the Development of ICT which includes the development of a human resources training plan, the promotion of ICT research, a set of measures to develop greater entrepreneurship sophistication, and the strengthening of foresight exercises and of information gathering on the sector, as well as the monitoring and evaluation of capacities, policies and programmes.
2) **Establish a human resources training plan** in the ICT sphere, based on an evaluation of existing educational provision in the area and the needs of the sector.
3) **Strengthen the promotion of ICT research in universities and companies**, in particular in the niches identified, continuing the support provided by competitive funds and exploring other research funding options (permanent fund for innovation in ICT, development of venture capital, guarantee funds, fiscal measures).
4) **Foster greater entrepreneurial sophistication in the sector.** Facilitate international certification, progressively redirect support towards more complex activities in areas with greater added value, promote other financing measures (permanent fund for innovation in ICT, development of venture capital, guarantee funds, fiscal measures), promote the development of other complementary sectors (information technology enabled services and the content industry), analyse and generate appropriate conditions to allow domestic companies to be able to respond to demand for complex solutions, promote the creation of university spin-offs through incubators and promote the adoption of ICT by SMEs.
5) **Strengthen foresight studies and the gathering of information on the sector** (including a foresight exercise on ICT which identifies niches on which public efforts should be focussed and an examination of the content industry) **as well as the monitoring and evaluation of capacities, policies and programmes.**

Biotechnology in Peru. Principal conclusions and recommendations

In Peru, there is no consensus on the role that should be played by modern biotechnology in the country's development. The lack of a national biotechnology agenda which sets priorities and guides the allocation of public, private and academic resources acts as a brake on investment and development in the sector.

Peru's biodiversity is a advantage for innovation in biotechnology which has not been exploited up to now. There is little biotechnological development at public level in Peru and even less in the private sector. Research projects are isolated efforts and links between research and the user sector are limited. The capacity for academic training is inadequate. The regulatory framework is developed but incomplete (sectoral regulations need to be established) and capacities in the management of intellectual property are limited.

As a result of this analysis, the following recommendations are offered:

1) **Define a clear and consistent policy and position with respect to biotechnology**, based on dialogue and greater social consensus. Develop a National Biotechnology Policy which offers a consensual strategic vision and includes the legal and regulatory aspects necessary to provide a stable framework for the development of biotechnology in the country[6]. Based on the results of a foresight exercise in the various areas of biotechnology and of a broad dialogue, develop a National Biotechnology Programme which establishes a set of specific coordinated actions which can be evaluated; assign responsibilities for their execution; and establish the financial and human resources necessary to implement them.
2) **Strengthen research and training capacities**, increasing the funding of research in priority areas; facilitating financing for longer-term projects and equipment and promoting international accreditation of masters degree and doctorate courses.
3) **Complete the existing regulatory framework and strengthen capacities for its implementation and management of intellectual property.**
4) **Stimulate transfer of knowledge and products, as well as the commercialisation and economic development of the sector** by developing intellectual property policies in research institutes and universities, strengthening financing of joint projects by universities and companies, promoting the participation of key technology transfer organizations in research projects and establishing a package of incentives for the creation and/or attraction of biotechnology companies.
5) **Strengthen international cooperation.**

Nanotechnology in Peru. Principal conclusions and recommendations

Although there is clearly a growing interest in Peru, current national capacities in nanotechnology (in terms of research, equipment and financing) are scant. The number of researchers, who are concentrated in a few universities and research institutions, is still small and productive applications even fewer. Much of the equipment is of considerable age and much basic equipment is not available in the country. There are shortcomings in terms of training of researchers, both in terms of quantity and quality.

As a result of this analysis, it is proposed, as a first stage:

1) **Establish a working group to steer the establishment of a National Nanotechnology Programme.**
2) **Carry out a foresight study and a consultation to identify one or more national research networks in nanotechnology** (e.g. nanomaterials and filters and nanostructured membranes for water treatment) as well as two or three niches with the greatest potential.
3) **Establish a five-year National Nanotechnology Programme** to support the development of the nanotechnology network(s), investment in equipment, development of one or two international cooperation programmes, development of high-level training and research through the CONCYTEC Chairs, training of researchers abroad and facilitation of their return, and an information campaign on nanotechnology aimed at Peruvian entrepreneurs.

At a later stage, consider:

1) **Establishing a National Nanotechnology Commission** to lead and advise on the development of nanotechnology in Peru.
2) **Expanding the number of networks, projects and financial resources.**
3) **Developing a human resources training plan** in the field of nanotechnology.
4) **Promoting the transfer of technology**, strengthening the management of intellectual property and developing venture capital for nanotechnology projects.
5) **Creating a forum for research, debate and advice on aspects related to the regulation of nanotechnology.**

The favourable evolution of the Peruvian economy in recent years represents an opportunity for the State and other participants in the national system of innovation to be able, without the pressures of a macroeconomic situation which requires immediate adjustments, to use STI as one of the drivers of a process of structural change which will ensure sustainable development in the long term and lead to greater levels of wellbeing for the population as a whole. The principal objective of this review is to contribute to that.

The first chapter examines the general situation in Peru with respect to the development of STI and an evaluation of current performance in science, technology and innovation.

Chapter two presents a diagnostic analysis of the national system of innovation in Peru, based on five strategic functions: production, regulation, control, foresight, and cohesion.

Chapters three, four and five contain a more detailed examination of three cross-cutting sectors (information and communication technologies (ICT), biotechnology and nanotechnology) and their development potential in Peru. These sectors are extremely important because of the development of new technical and productive paradigms and their cross-cutting character. They are capable of influencing the development of a great many other activities and productive sectors. Moreover, it should be borne in mind that the role of public policies is particularly important in the face of changes at the technological frontier and the development of new technical and economic paradigms.

Lastly, chapter six offers a summary of the diagnostic analysis of the national system of innovation and the three cross-cutting sectors, and provides a series of recommendations to the Peruvian Government with a view to identifying these strategic areas in which government policies, programmes and actions can have the greatest influence on the development of STI in Peru.

NOTES

[1] Data for 2009 based on Economist Intelligence Unit estimate

[2] Despite the growth in GDP per capita, the results achieved in 2005 were barely above 1981 levels ($2,539 constant dollars). Furthermore, in relative terms, GDP per capita in Peru fell from 12% of GDP per capita of the United States in 1975 to only 7% in 2006.

[3] Sagasti (2009)

[4] Not necessarily at this level for all the Council's activities.

[5] The list is not exhaustive.

[6] Reconsider, for example, the bill on promotion of modern biotechnology.

I

Background to science, technology and innovation in the Peruvian economy

A. RECENT DEVELOPMENTS IN THE PERUVIAN ECONOMY

The relationship between economic growth and science, technology and innovation (STI) is complex. On the one hand, from a theoretical standpoint, there is broad agreement that innovation is one of the chief sources of economic growth. Empirical evidence also shows that the most innovative countries and those which invest most in research and development (R&D) are also the most developed or most strongly growing countries (ECLAC, 2008).

At the same time, a country's capacity to develop STI is dependent on its macroeconomic environment and structural conditions. A stable and open macroeconomic environment, a priori, encourages investment in general and investment in R&D specifically, stimulates competition and promotes innovation. Foreign direct investment (FDI) may, albeit not necessarily, bring with it new and better technologies which increase productivity in the sectors concerned. Depending on the links between the sectors benefiting from FDI and the rest of the economy, the technological advances and increased productivity may spread to the entire productive fabric. Greater economic growth also involves higher public income and thus greater capacity of the State, the principal actor in developing countries, to invest in STI. With more resources at their disposal, governments can invest more in R&D, support innovative companies, promote SMEs in general and those which are technology-based, allocate more resources to universities and technological institutes, as well as developing and financing other activities to promote STI.

The capacities and incentives for entrepreneurs, companies and industries to innovate, invest in science and technology, adopt and adapt technologies, and the benefit that different economic sectors can draw from STI are conditional on a country's structural conditions and framework, such as the industrial fabric, entrepreneurial dynamism, human capital, physical infrastructure, efficiency of the public administration and the legal certainty provided by the regulatory framework.

However, as we shall see below, the symbiotic relationship between economic growth and STI is not guaranteed. Peru is a clear example of this.

The contribution of STI to the expansion of the Peruvian economy in the last ten years has been limited. Economic growth has largely been due to exports growth, which benefited from favourable terms of trade, and to investment inflows. For example, exports are for the most part commodities, with little added value and limited linkages with the rest of the productive sector, and even though foreign investment in the extractive industry has brought new technologies, these have had limited diffusion across the rest of the economy.

Analysis of the performance of the Peruvian economy in the last 45 years shows, in general, that labour and capital were the main factors which explained the growth in GDP, while the contribution of multifactorial or total-factor productivity (TFP) was very small. Nevertheless, these studies show a change in the long-term trend from 1990 onwards, with a positive contribution from multifactorial productivity (Polastri, 2006; Tello and Tavara, 2010)[1]. The meagre contribution of productivity to economic growth is a general tendency in the countries of Latin America, although it is more marked in the case of Peru (Polastri, 2006; Daude et al. 2010).

Probably the most important feature of the behaviour of the Peruvian economy in relation to STI is the fact that the significant growth in public revenues (which have doubled in the last ten years) does not seem to have been reflected in significant increases in the figures for investment in STI. Although there is little objective and comparable numerical data, such data as is available, earlier studies[2], and the information gathered during conversations with economic agents seem to indicate that investment in R&D in Peru has stagnated. Neither is there any observable improvement in education generally and university education in particular, nor has there been any improvement in the number and quality of research centres. In general, the development of STI, including its institutions, has not been a high priority for government policy.

1. Macroeconomic performance

Since 1950, when reliable figures became available, the Peruvian economy has not had a better period than the one between 2002-2008. In those seven years, the country's economy showed high sustained growth, rising at an average annual rate of 6.7%. In 2008, GDP grew by 9.8% over the previous year (Figure 1)

Figure 1. Variation in real GDP (percentage), Peru, 1980-2009

Source: Central Reserve Bank of Peru (www.bcrp.gob.pe) - 2010.

Two factors can help to explain Peruvian economic growth: on the one hand, the role of the export sector, which has benefited from favourable terms of trade and, on the other, the structural reform and macroeconomic stabilization package put into effect.

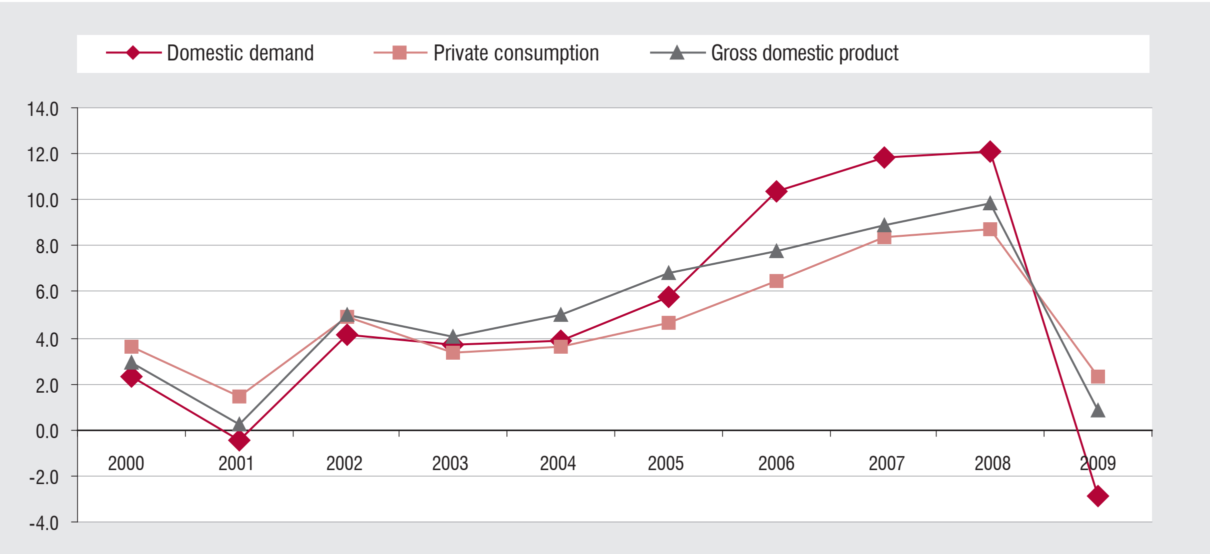
On the demand side, the expansionary cycle which began in 2002 was export and private investment led (Mendoza, 2006). Certainly, Peru benefited from the favourable international environment and the positive effect of the strong growth of the Chinese and Indian economies on the price of minerals and other commodities. This favoured the Peruvian mining and fisheries sectors, firstly because the range of Peruvian minerals (gold, silver, copper, etc.) are stores of value at times of great volatility in global currencies and, secondly, they are basic raw materials for China's and India's industry. Fluctuations in food prices had a mixed effect on Peru. On the one hand, imported staple products were more expensive, but, on the other, they meant higher incomes for the agrarian sector, especially small farmers. The increase in farm incomes led to a shift in the Peruvian economy from 2006 onwards, in that domestic demand complemented exports as an engine of growth and thus allowed more balanced development. The increase in domestic demand delivered three consecutive years of double-digit expansion, higher than variations in GDP. In turn, domestic demand was driven by the growth of private and public investment and private consumption (Figure 2).

The global financial crisis of 2008 and the resulting global recession significantly affected the Peruvian economy, with growth slowing to less than 1 per cent annually in 2009. The variables responsible for this behaviour were the fall in exports, reduction in investment flows and the tightening of international credit. However, the inertia of the high growth in the Peruvian economy during the preceding years, good macroeconomic management, the soundness of the domestic financial sector, the strength of domestic demand and the appropriate crisis package meant that the effects of the crisis were among the least severe in the entire region[3].

Fiscal and monetary policy

The Fiscal Responsibility and Transparency Act (2003) set as an objective that the fiscal deficit in the non-financial public sector should be gradually reduced to less than 1 per cent of GDP. During the period 2004-2005, the fiscal deficit was kept below 1% of GDP and during the period 2006-2008, this fiscal target was exceeded, with consecutive fiscal surpluses of 2%. Tax pressure increased constantly in recent years, reaching 15.6% of GDP in 2007 and 2008, the highest level in the last 26 years (BRCP, 2009). The improvement in the public accounts together with strong growth in GDP allowed a reduction in the debt ratio to 24% in 2008. However, the financial crisis of 2008 and the global recession had a negative impact on tax reve-

Figure 2. Real GDP, real domestic demand and real private consumption (percentage variation), 1999-2009



Source: Central Reserve Bank (www.bcrp.gob.pe) - 2010.

nues while at the same time a crisis package of nearly 2% of GDP had to be financed, which led to a deficit of 1.9% in the non-financial public sector in 2009.

Monetary policy has been driven, since 2002, by a system of explicit inflation targets, in order to enhance the effectiveness of monetary policy, strengthen the role of the local currency as a store of value[4] and increase the confidence of economic agents in future price trends. Currently, the inflation target is 2 per cent, with a margin of +/-1 per cent (BCRP, 2009).

Inflation has kept relatively low (according to BRCP figures, average inflation in the period 2002-2008 was 2.6%) and the volatility of the interbank interest rate decreased. This allowed better development of the domestic capital market in new soles, encouraging a lessening of the financial dollarization of the economy to 58% in 2008.

This macroeconomic strength is the reason why ECLAC forecasts that the Peruvian economy will grow around 8.6% in 2010 (CEPAL 2010a).

2. International trade

Since 2002, Peru has pursued an active export promotion policy and opening to export markets through free trade agreements (FTA). That year saw the creation of the Ministry of Foreign Trade and Tourism (MINCETUR) which was made responsible for promoting exports and conducting international trade negotiations. The Export Promotion Commission (PROMPEX), created in 1996, was integrated in the new ministry[5]. At the same time, the National Competitiveness Council (CNC) was formed as a forum for public-private dialogue in developing and implementing a National Competitiveness Plan.

An important part of trade policy has been the signing of free trade agreements. Following the success of the negotiation of the FTA with the United States, in force from January 2009, Peru set out to propose FTAs with other countries. To date, FTAs have been approved with Canada, China, Chile, EFTA, Singapore and the European Union, and others are nearing conclusion with Republic of Korea and Japan.

International trade (measured as the sum of exports and imports) increased dramatically, rising to 41.8% of GDP in 2006. During the period 2002-2008, exports took off, achieving annual growth of 24% and a balance of trade surplus, which formed the main engine of GDP growth (Figure 3).

One of the variables which can explain this behaviour is the improvement in the terms of trade in favour of Peru (Figure 4). However, although the critical factor was the rise in international prices (152% cumulatively), the volume also rose significantly (58% cumulatively) and there was a diversification of products and markets. In large measure, this diversification was the result of a policy of greater opening of the economy and the pursuit of trade integration agreements (Aráoz, 2007).

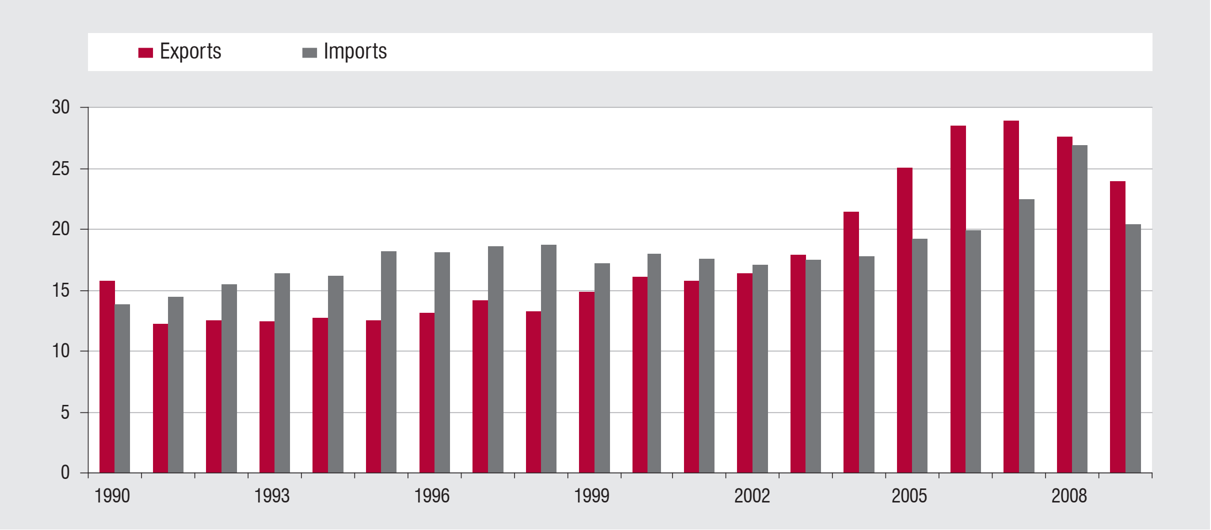
In 2009, due to the effect of the international crisis, the positive trend in international trade came to an end. Exports and imports fell (14.7% and 26.1% respectively compared with 2008) but a positive trade balance was maintained. The fall in demand from some of Peru's chief trading partners was softened by demand from China.

Structural problem: the primary character of exports

An indication of a country's level of technological development, and the nature of its presence in international trade, can be obtained by looking at the breakdown of its exports in terms of technological content or knowledge[6] (Lugones et al. 2007, ECLAC, 2008).

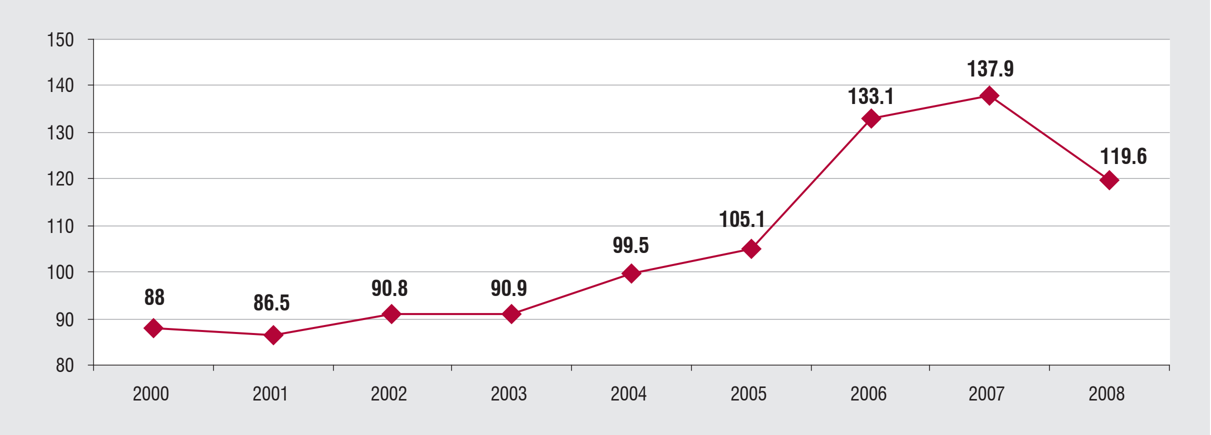
One of the chief problems of the Peruvian economy is that growth during the last expansionary phase did not transform the country's productive structure into a more knowledge-based economy. In 2007, the composition and degree of concentration of exports was the same as in the 60s (Tello and Tavara, 2010). Peruvian exports are mainly composed of raw materials and manufactured goods based on those raw materials. In 2009, exports of these products represented 86% of total exports, and this share has not changed over the last 15 years.

Figure 3. Exports and imports (as percentage of GDP), Peru, 1990-2008



Source: Central Reserve Bank (www.bcrp.gob.pe) - 2010.

Figure 4. Terms of trade (1994=100), Peru, 2000-2008



Source: Central Reserve Bank (www.bcrp.gob.pe) – 2010.

Exports of intermediate and high technology intensive manufactured goods stood at barely 4% of total exports of goods (Table 1 and Figure 5).

At product level, the ten principal Peruvian export products account for over 60% of total exports and all are products with limited technological content (Table 2).

Peru's chief trading partners (in 2008) are: for exports, United States (18.5%), China (12%) and Switzerland (10.9%) and for imports, United States (18.6%), China (13.6%) and Brazil (8.1%).

Imports also showed dynamic growth, even if a little less than exports. The breakdown between consumer goods, intermediate goods and capital goods has remained fairly stable in recent years, with a slight shift in favour of capital goods which rose from 26% in 2002 to 33% in 2009. In 2009, imports of consumer goods stood at 4,256 million dollars, intermediate goods 10,261 million dollars and capital goods 7,285 million dollars (Figure 6).

3. Domestic investment and foreign direct investment (FDI)

The economic reforms launched in Peru, which were implemented in step with the process of globalization during the 90s, expanded opportunities for private investment in the country, both for local and international economic agents. Domestic investment maintained more or less steady growth until 2005 when it grew at ever-increasing rates, representing 26.6% of GDP in 2008 (Figure 7).

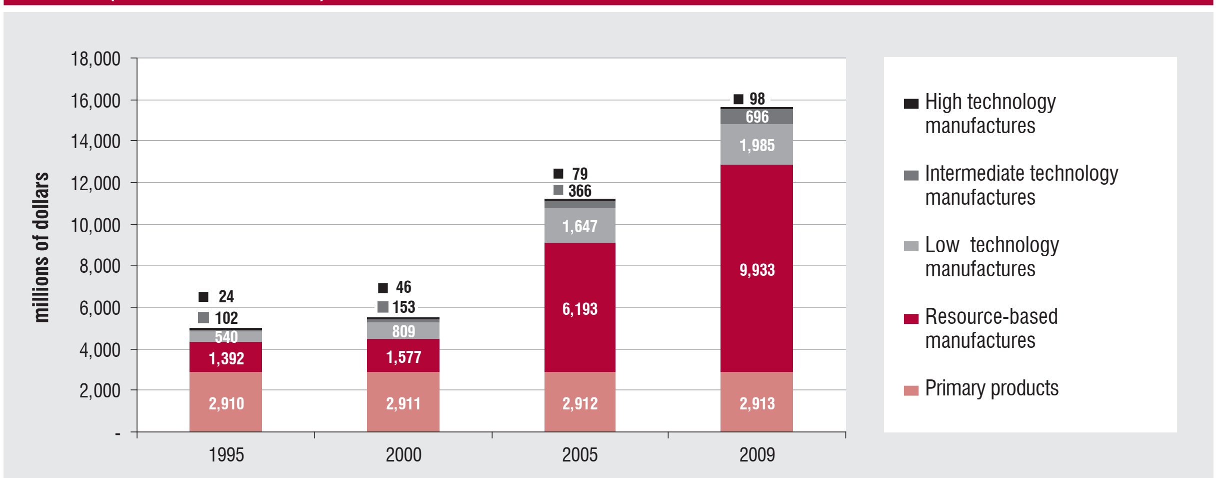
The growth and opening up of the Peruvian economy was particularly attractive to foreign direct investment[7]. This had at least two highly dynamic moments: the beginning of the 90s, at the time of privatizations of state enterprises, and the end of the 90s, which attracted new investment in mining, gas, communications and agro-industry. During the last three years, Peru has obtained "investment grade" rating of its public debt from the three main credit rating agencies,

Table 1. Evolution of the pattern of exports of goods, as a percentage of total exports of goods, Peru, 1995-2009

	1995	2000	2005	2009
Primary products	59	55	41	36
Resourced-based manufactured goods	28	28	44	50
Low technology-intensive manufactured goods	11	14	12	10
Intermediate technology-intensive manufactured goods	2.0	2.7	2.6	3.5
High technology-intensive manufactured goods	0.5	0.8	0.6	0.5

Source: Based on UNSD Comtrade data, 2010.

Figure 5. Evolution of exports of goods, by technological intensity (by Lall classification of products) (in millions of dollars), Peru, 1995-2009



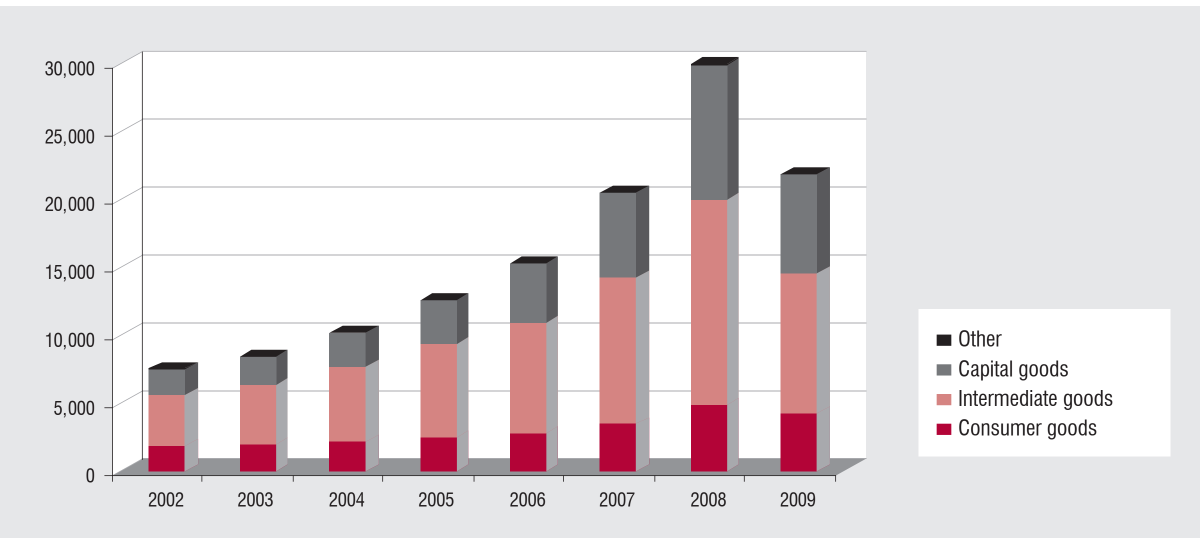
Source: Based in UNSD Comtrade data, 2010.

Table 2. Principal export products (in millions of dollars and share of total exports), Peru, 2009

	Millions of dollars	% Total exports
Gold in various forms, unrefined, including gold plate	6,742	25.2
Copper minerals and concentrates	3,921	14.7
Refined copper cathodes and cathode sections	1,861	7.0
Fish flour, powder and pellets	1,425	5.3
Zinc minerals and concentrates	1,123	4.2
Other molybdenum minerals and concentrates	276	1.0
Lead minerals and concentrates	895	3.4
Tin, not alloyed	252	0.9
Unroasted coffee, not decaffeinated, except for seed	583	2.2
Unrefined silver, not alloyed, including silver gilt and plate	214	0.8

Source: Mincetur 2010.

Figure 6. Evolution of imports (in millions of dollars), Peru, 2002-2008



Source: Mincetur 2010.

which makes the investment environment even more attractive to FDI.

It should be pointed out that this FDI has not had a huge impact on the development of STI in the country. The foreign companies import capital goods and knowledge intensive services and foreign investment has not had a major knock-on effect on the development of productive chains[8].

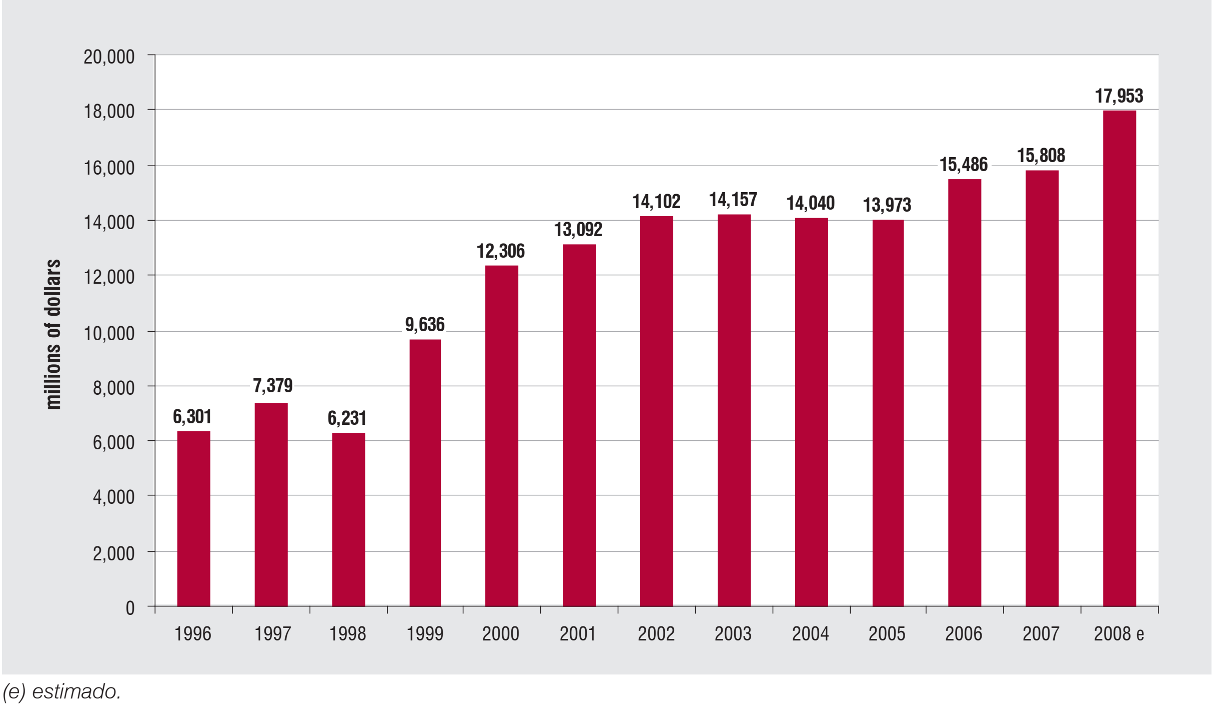
The stock of FDI is clearly concentrated in five sectors: communications, mining, industry, energy and finance (Table 3). Spain, the United Kingdom and the United States are the chief sources of inward investment to Peru. In 2008, they represented 23%, 19% and 15% respectively of the FDI stock.

B. STRUCTURAL CONDITIONS OF THE PERUVIAN ECONOMY

1. Sectoral structure

Peru's sectoral structure is that of an intermediate developing country, with a certain presence of the primary sectors, which account for 16.6% of GDP, a

Figure 7. Stock of foreign direct investment (millions of dollars), Peru, 1996-2008



(e) estimado.
Source: ProInversión.

Table 3. Distribution of the FDI stock by sector, as percentage, 2000-2008

Sector	2000	2004	2008
Communications	37	31	21
Mining	15	15	20
Industry	13	17	16
Energy	12	12	13
Finance	14	13	15
Trade	5	5	4
Housing	0	0	3
Services	1	3	2
Oil	1	1	2
Transport	0	2	2
Construction	0	1	1
Fisheries	0	0	1

Source: ProInversión, 2009.

relatively small secondary (industrial) sector, with 13% of GDP and a rather large group of services (Figure 8).

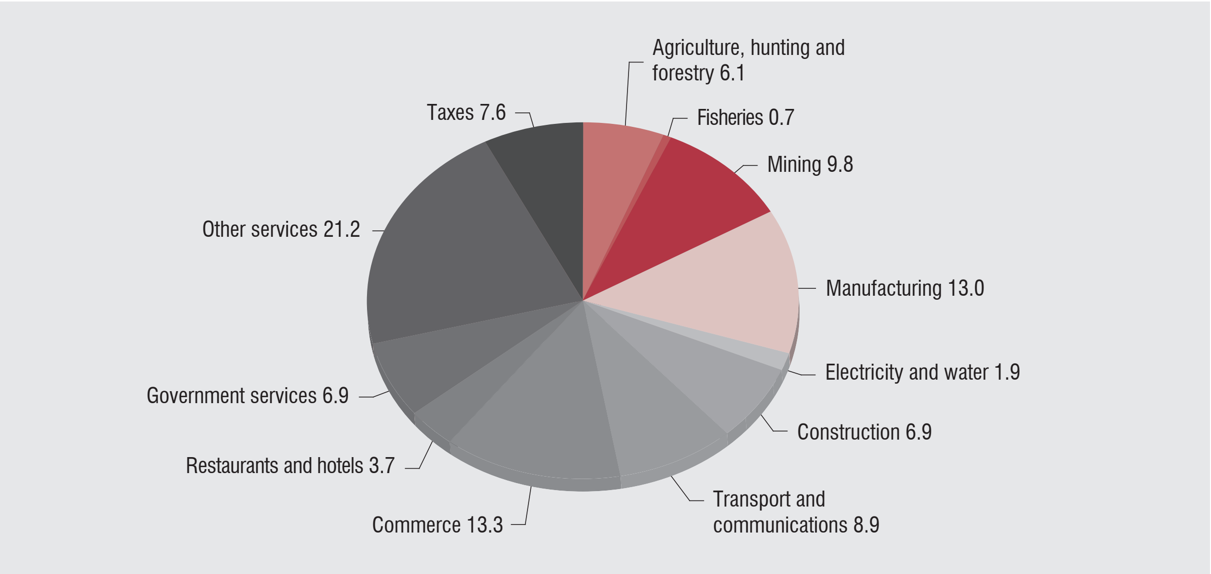
Unfortunately, there is no information available to distinguish more complex activities with higher added value within each sector and their contribution to GDP. For example, the services sector covers low productivity activities, such as street vending, and others of greater complexity, such as financial services.

The entire economy uses technology. From potato growing to the manufacture of microprocessors, technology is an essential prerequisite of production. The differences lie in the level of complexity and sophistication of the technology used and the capacity (or not) to modify, adapt or generate new technology.

Many countries have policies to promote certain sectors, based on the fact that there are sectors "conducive" to technology and innovation (ECLAC, 2008). In these sectors, chiefly industrial and certain types of services, the application of technology and knowledge maximizes its effects in terms of economies of scale and productivity.

However, there are also opportunities to innovate and derive benefits from the use of sophisticated

Figure 8. Weight of sectors in the economy (percentage of GDP), 2009



Note: Calculated based on values at current prices.

In 2008, the manufacturing sector included contributions for the food industry (representing 4.4% of GDP in 2008), textiles and leather (1.5%), wood and furniture (0.3%), paper (1.1%), chemicals (2.8%), manufacture of non-metallic products (1.4%) base metals (1.3%), manufacture of metallic products (1.3%) and other manufactured products (0.3%).

Source: On-line data of the National Institute of Statistics and Information Technology (2010) [National annual accounts/GDP by major activity and GDP by class of activity].

technologies even in traditional sectors. Thus, from the sectoral perspective, a pragmatic approach is called for which, on the one hand, promotes certain technology and innovation intensive sectors and, on the other, encourages innovation in all sectors and activities.

In the case of Peru, policies to promote STI in economic sectors have never been given priority and, since the 90s, sectoral policies (such as industry, agriculture and services) have been sidelined.

2. Entrepreneurial structure

Another way of viewing and analysing the productive structure of countries is to focus on the size of its enterprises or economic entities. This criterion is gaining increasing acceptance in the international sphere, where policies and institutions to support and promote small and medium-sized enterprises are proliferating.

Measuring the presence of small-scale enterprises, especially micro-enterprises, in Peru has always been fraught with difficulty, since part of this category is in the informal sector and thus falls outside the scope of measurement by State organizations. Table 4 provides an approximation of Peru's entrepreneurial structure.

Table 4 shows that microenterprises make a very important contribution to the economy both in terms of employment (55% of the total EAP) and contribution to GDP (25%). In 2009, average monthly wages of employed workers in microenterprises as S/.755, and for workers in small enterprises S/.1,298, while workers employed in medium-sized and large enterprises earned S/.1,854 (ENAHO).

With regard to the degree of informality of enterprises in Peru, Table 4 provides an estimate based on their tax registration[9]. The National Tax Administration (SUNAT) had 892,155 enterprises registered as taxpayers in 2006, of which 1.3% were large and medium-sized enterprises and 98.7% were small and microenterprises.

Peru has a polarized enterprise structure. On the one hand, there is a core of formal large and medium-sized enterprises, which make an important contribution to GDP and with greater capacity and resources for innovation. On the other, there is the great majority of small-scale enterprises, often informal, which make an important contribution to employment but a more limited one to GDP. They also have serious difficulties

Table 4. Entrepreneurial structure of Peru, by size of enterprise, 2006

Category	Number of enterprises	%	Employment (EAP)	%	GDP[3] (en %)	Formal enterprises [4]	%	Average size of enterprise (No. employees)
Private sector	**3,229,197**	**100.00**	**10,128,859**	**70.4**	**82**	**892,155**	**27.6**	**...**
Large enterprise	800[1]	0.02	544,924	3.8	30	800	100.0	681.2
Medium-sized enterprise	10,918[2]	0.34	646,954	4.5	18	10,372	95.0[5]	59.3
Small enterprise	49,728	1.54	1,065,057	7.4	9	34,466	69.3	21.4
Microenterprise	3,167,751	98.09	7,871,924	54.7	25	846,517	26.7	2.5
Public sector	**...**	**...**	**1,058,202**	**7.4**	**9**	**...**	**90.0[6]**	**...**
Self-employed	**...**	**...**	**2,642,633**	**18.4**	**7**	**...**	**13.0[7]**	**...**
Home workers	**...**	**...**	**550,615**	**3.8**	**2**	**...**	**5.0[8]**	**...**
Total	**3,229,197**	**100.00**	**14,380,309**	**100.0**	**100**	**892,155**	**...**	**...**

Source: INEI National Household Survey (ENAHO) for 2006, prepared by Cecilia Lévano for the MTPE-Ministry of Labour and Employment Promotion (2007b), from Villarán (2007a).

Notes:

Definitions: Large enterprise (>251 employees); medium-sized (101-250); small (11-100); microenterprise (1-10).

1. Estimated number based on: (i) CONASEV, (ii) Lima Stock Exchange, (iii) SUNAT: Principal taxpayers and (iv) the TOP 10,000 companies in Peru (Per Top Publications).

2. Different from figures provided by Lévano for large and medium-sized enterprises (11.718).

3. Percentage contribution to GDP based on work of SASE (2001).

4. Number of companies registered with SUNAT and paying some form of tax.

5. Estimated percentage.

6. Estimated percentage [10% of public employees are in the system of non-personal services without social benefits].

7. Estimated percentage [the self-employed have half as many formal as microenterprises].

8. Estimated percentage [only home workers who work in high-income households have full social benefits].

in innovating and scant facilities to develop (e.g. lack of access to sources of financing). In developing an STI policy, these two worlds need to be considered, with relevant interventions for the different types of enterprise.

The scarcity of links between the country's large and small enterprises should also be highlighted [10]. While there is a conviction in the public sector of the importance of developing productive chains to stimulate technological and entrepreneurial capacities in small enterprises, this conviction needs to be backed up by the allocation of resources and reflected in the development of those capacities in the enterprise sector. UNCTAD's Business Linkages Programme facilitates the establishment of new linkages, and the strengthening of existing ones, between large and small and medium enterprises. The programme, based on the actors' mutual interest, improves local suppliers' productivity and efficiency through training, stewardship, information exchange, quality improvements, innovation and technology transfer. In Peru, the programme is currently being developed in the agroindustrial and mining sectors, in collaboration with Proinversion and the IPAE - Empretec Centre.

3. Competitiveness

El Peru has an intermediate level of competitiveness. From a global perspective of competitiveness, meaning the "set of institutions, policies and factors that determine the level of productivity of a country" (World Economic Forum, 2009, Global Competitiveness Report 2010-2011 2009, p. 4) and based on twelve pillars of competitiveness (see Figure 9), Peru is in the group of countries which base their competitiveness on efficiency.

None of the countries in the region are in the final stage (innovation-driven) and only Chile, Mexico and Uruguay are in the transition stage to innovation-driven competitiveness. Peru is in the efficiency-driven stage of competitiveness, together with Argentina, Brazil, Colombia, Costa Rica, the Dominican Republic, Ecuador, El Salvador and Panama.

In the global index for 2010, Peru is ranked 78, five places higher than in 2008-2009. As shown in Table 5, Peru has a better score in innovation-related factors and some of the basic development requirements (education and health, infrastructure and institutions).

At national level, the National Competitiveness Council, taking the systemic approach[11], has developed a Regional Competitiveness Index (RCI) to determine the competitiveness of the regions of Peru. This tool shows the heterogeneous nature and potential of the regions to enter the global economy and serves as a guide to the design of government policies. Table 6 shows the ranking of regions based on that index[12] for 2009. Given the important implications of the regional dimension, this issue is further explored in chapter II and Annex B.

4. Physical infrastructure

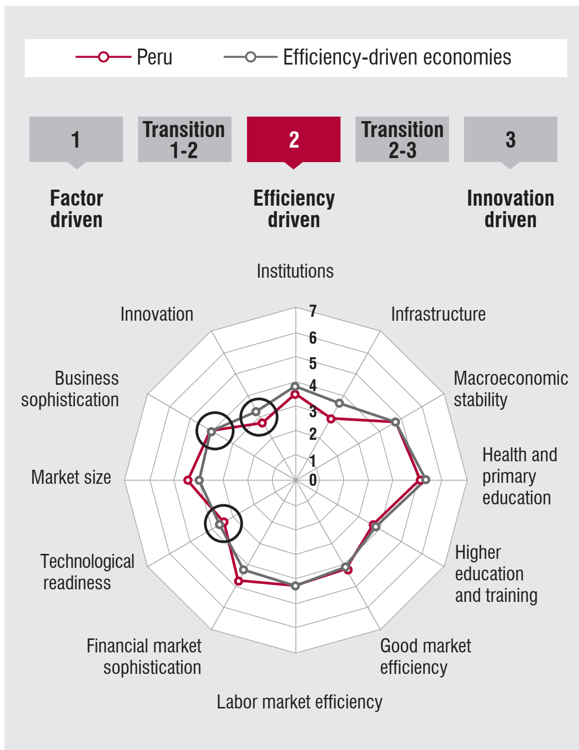
The development of innovative activities, whether based on the development of new products, the application of new production processes or the introduction of new ways of operating in the markets, requires the existence of certain minimum levels of transport infrastructure, energy, communications, etc. Moreover, some types of physical infrastructure are of great importance for technological development.For example, a developed, competitive and efficient telecommunications network is crucial to the expansion of the information technology sector.

As shown in the Global Competitiveness Index, Peru's physical infrastructure lags far behind in terms of roads, ports, airports, urban sanitation, energy and telecommunications, which restricts its economic and productive development.

The Peruvian Economics Institute (IPE) has conducted several studies which estimate the deficit in investment in infrastructure (Table 8). In the case of road networks,

Figure 9. The twelve pillars of competitiveness and diagnostic of Peru's competitiveness 2009-2010

Basic requirements - Institutions - Infrastructure - Macroeconomic stability - Health and primary education	Key for **factor-driven** economies **(stage 1)**
Efficiency enhancers - Higher education and training - Goods market efficiency - Labour market efficiency - Financial market sophistication - Technological readiness - Market size	Key for **efficiency-driven** economies **(stage 2)**
Innovation and sophistication factors - Business sophistication - Innovation	Key for **innovation-driven** economies **(stage 3)**



Source: WEF (2009).

Table 5. Peru in the Global Competitiveness Index, 2009-2010

Global Index		Basic requirements		Efficiency facilitators		Innovation factors	
Rank	**Score**	Rank	Score	Rank	Score	Rank	Score
78	**4.01**	88	4.06	59	4.11	85	3.37

Source: WEF (2009).

Table 6. Ranking of the regions of Peru based on the Regional Competitiveness Index, 2009

Rank	Department	Index
1	Arequipa	0.7353
2	Lima	0.6968
3	Tacna	0.6575
4	Ica	0.6224
5	Moquegua	0.5993
6	Lambayeque	0.5746
7	La Libertad	0.5588
8	Ancash	0.5429
9	Junín	0.5228
10	Piura	0.5109
11	Tumbes	0.5023
12	Cusco	0.4547
13	Ayacucho	0.4399
14	Madre de Dios	0.4303
15	Pasco	0.4272
16	Puno	0.3836
17	Ucayali	0.3824
18	Cajamarca	0.3683
19	San Martín	0.3456
20	Huanuco	0.3233
21	Loreto	0.3180
22	Amazonas	0.3172
23	Apurímac	0.2997
24	Huancavelica	0.2907

Source: CNC (2009).

Peru is far behind compared with the countries in the region; although it is worth pointing out that the country's geographical characteristics are one of the difficulties confronting such development (Figure 10). Peru also lags behind significantly in the field of sanitation if we compare Peru with Chile (Table 7).

According to this analysis, the greatest needs for investment are for the expansion and improvement of the road networks, electricity power generation to support economic growth and expansion of the mobile phone system. Investment in ports, railways, drinking water, drainage and sewer systems is also important.

This investment, which represents 30% of the country's GDP, is much greater than the State's capacity to invest. For this reason, bold and imaginative schemes will be needed to involve the private sector, both domestic and foreign, in projects such as the road network, the interoceanic toll road (IRSA) linking with Brazil and the construction of hydroelectric power stations in the forest rim.

The development of energy infrastructure is a national priority and the Peruvian Government is taking various steps to attract investment in gas, oil and, above all, electrical energy such as, for example, the development of several hydro-electric power stations on the Peru-Brazil border (Madre de Dios Region).

As regards telecommunications, although there are considerable gaps, the presence of three major transnationals (Telefónica, Claro and Nextel) who are in intense competition with each other, suggests that there will be no problem in attracting the amounts of investment required within the necessary timeframe.

5. Human capital

The development of skilled human capital is a central element both in developing capacity for scientific and technological research in a country and stimulating dynamic links between science, competitiveness and development (Jaramillo, 2008). This requires skills development from school through to post-university education.

Peru exhibits broad educational coverage, especially at primary level. This success has been the product of considerable investment by the Peruvian State in state education going back to the 1950s, when the country took advantage of the extraordinary revenues from commodity prices to build "School Units", large educational complexes in the country's main cities. At that time, schools attracted high quality candidates

Table 7. Coverage of drinking water, sanitation and water treatment (percentage of the population), Peru and Chile, 2007

		Drinking water	Drainage and sewers	Water treatment
Peru	Urban	82	73	24
	Rural	62	33	n.d.
	Total	**77**	**62**	**24**
Chile	Urban	100	95	82
	Rural	96	66	n.d.
	Total	**99**	**91 (estimated)**	**n.d.**

Source: Peruvian Economics Institute, 2009.

Table 8. Estimated needs for investment in infrastructure (in millions of dollars), Peru, 2008

	Investment gap (millions of USD)	Percentage of total
Transport	**13,961**	**37.0**
Airports	571	
Ports	3,600	
Railways	2,415	
Road network	7,375	
Sanitation	**6,306**	**16.7**
Drinking water	2,667	
Drainage and sewers	2,101	
Treatment of waste water	1,538	
Electricity	**8,326**	**22.0**
Generation	5,183	
Transmission	1,072	
Coverage	2,071	
Natural gas	**3,721**	**9.9**
Telecommunications	**5,446**	**14.4**
Fixed line telephony	1,344	
Mobile telephony	4,102	
Total	**37,760**	**100**

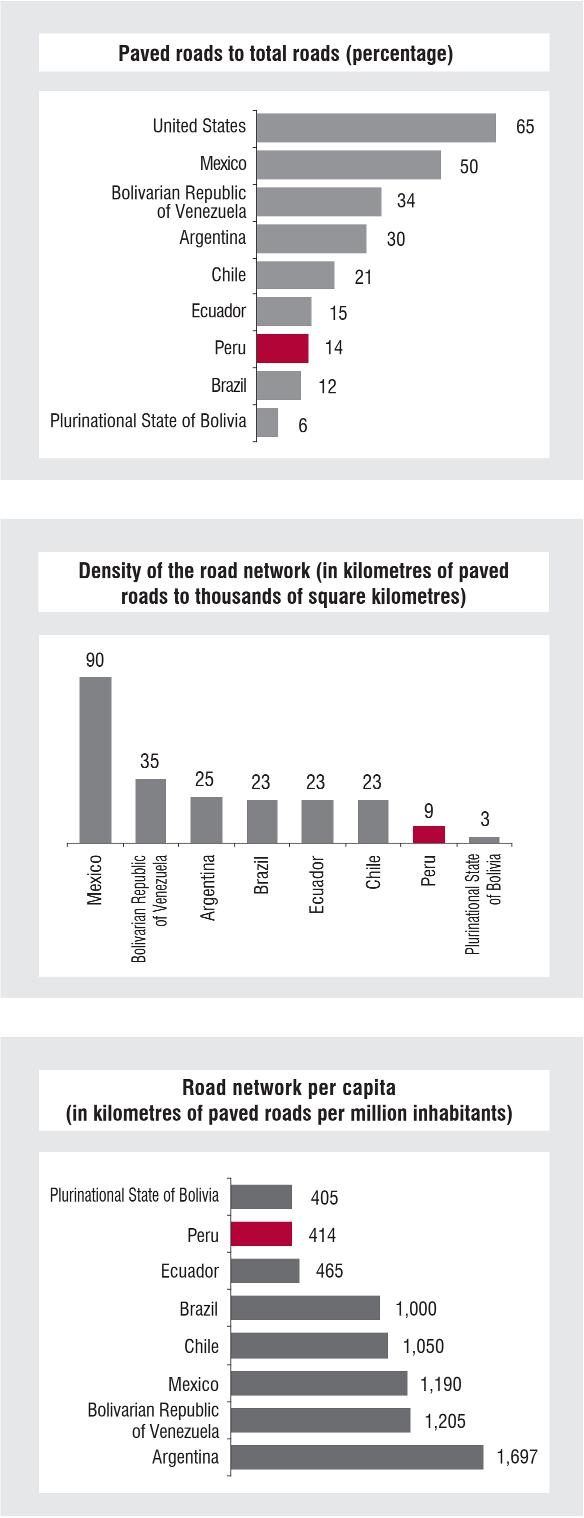
Source: Peruvian Economics Institute, 2009.

and state school leavers performed well in academic and university studies, both at home and abroad. The general level of education appears to have declined since then and the educational infrastructure has deteriorated.

Ordinary basic education in Peru (consisting of initial, primary and secondary levels) covers a total of 7,620,000 pupils (2009 data), employs 428,000 teachers in 88,500 education centres. In addition to ordinary basic education, there are other educational levels, such as alternative basic, special basic, technical-productive and higher non-university, but carrying less weight (Table 9).

Primary education coverage in Peru is high, even in rural areas and poor communities (Table 10). Levels of coverage of secondary education are significantly less than primary but, most of all, there are considerable variations depending on the geographical location and socioeconomic conditions. Thus, in urban areas, the coverage is 82.5% while reaching only 64% in rural areas. Coverage of sectors of extreme poverty is lower (55.1%) (Table 10). In pre-school education, the

Figure 10. Deficit in road networks, selected countries of Latin America, various years



Latest available information for each country: Argentina, Plurinational State of Bolivia and Colombia (2004); Brazil, Ecuador, Mexico and Peru (2006); Chile and United States (2007).

Source: CIA, MTC, Ministry of Transport of Brazil according to Peruvian Economics Institute (2009).

coverage is even less, although this can be explained by the fact that it is the most recently introduced level of education in the country. Pre-school coverage also varies between urban and rural areas, and between social strata.

On the other hand, education spending in Peru is very low. Public expenditure on education is only 2.7% of GDP, even though it represents over 20% of government spending (UIS, 2010). This expenditure is significantly lower than in other Latin American countries, especially comparing public expenditure per pupil (Table 11).

Despite these shortcomings, the central problem of education in Peru is quality, as shown by several national and international evaluations of pupils' educational performance.

Table 9. Enrolment, teaching and non-teaching staff, and educational centres and programmes, Peru, 2006

	Enrolment				Teaching staff[3]		
	Total	% State	% Rural	% Female	Total	% State	% Rural
Total	**8,605,915**	**75**	**21**	**50**	**483,872**	**66**	**19**
Normal Basic	**7,720,577**	**79**	**23**	**49**	**427,848**	**68**	**22**
Pre-school[0]	1,367,651	75	25	49	60,543	52	14
Primary	3,754,547	80	30	49	196,775	72	29
Secondary	2,598,379	78	13	49	170,530	70	16
Alternative Basic[1]	**208,187**	**60**	**1**	**47**	**11,960**	**60**	**1**
Special Basic	**21,296**	**82**	**2**	**41**	**3,672**	**82**	**1**
Technical-Productive[2]	**289,569**	**47**	**1**	**64**	**13,809**	**40**	**1**
Higher non-University	**366,286**	**34**	**2**	**57**	**26,583**	**40**	**3**
Teacher Training	32,257	52	4	65	4,504	48	4
Technology	328,230	31	2	56	20,996	36	2
Arts	5,799	89	2	32	1,083	87	1

[0] *Excludes community education promoters under non-scholastic programmes.*
[1] *Includes adult education.*
[2] *Includes vocational training.*
[3] *Number of persons employed in teaching, management or in the classroom, without differentiating between full-time and part-time.*
Source: Ministry of Education – Schools Census, 2009.

Table 10. Total coverage by age group and gender, area and poverty, Peru, 2008

	Pre-school % ages 3-6	Primary % ages 6-12	Secondary % ages 12-17
Total	**66.2**	**94.2**	**74.8**
Female	67.4	93.8	75.0
Male	64.9	94.6	74.7
Urban	74.0	94.2	82.5
Rural	55.4	94.1	64.0
Not poor	73.8	94.4	81.9
Poor	64.3	93.7	70.6
Extremely poor	51.0	94.3	55.1

Source: Ministry of Education, Education Statistics Unit, 2009.

The student Evaluation Survey carried out by the Ministry of Education in 2009 showed that 23.1% of students at primary level 2 achieved the required standard of comprehension of texts. In mathematics, the results were even worse: only 13.5% achieved the expected standard in this area.

Students' performance levels, shown in various international examinations, are the lowest in Latin America (Figure 11). In the International Student Assessment Programme (PISA) test taken in 2000, with the participation of 41 countries, Peru came bottom. Other countries in the region, such as Argentina, Mexico, Chile and Brazil performed better.

With regard to higher education, the Peruvian university system has a special legal regime which grants universities total administrative, legal and economic independence and is not linked in any way to the

Table 11. Education expenditure, various Latin American countries, financial year ended in 2007 or 2008

	Education expenditure (as % of GDP)			Public education expenditure (per pupil) in PPP dollars			Public education expenditure (as % of public expenditure)
	Total	Público	Privado	Primaria	Secundaria	Terciaria	
Argentina (2007)	5.6	4.9	0.7	1,945	2,903	2,071	13.5
Brazil (2007)	5.1	5.1	…	1,716	1,787	2,942	16.1
Chile (2007)	5.7	3.1	2.5	1,653	1,864	1,591	18.2
Mexico (2007)	5.7	4.6	1.1	1,874	1,901	5,237	…
Peru (2008)	**4.4**	**2.7**	**1.7**	**699**	**849**	**…**	**20.7**

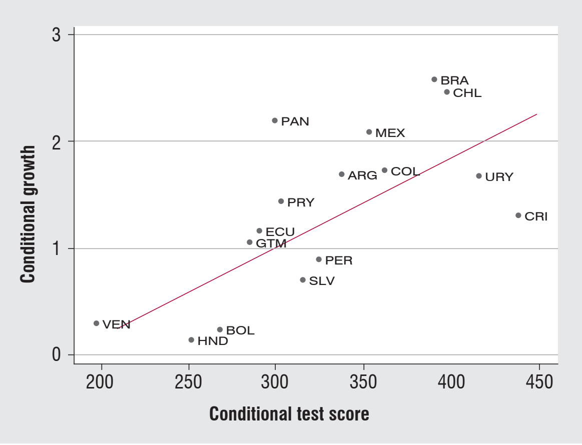
(…) Data not available.
Source: UIS (2010).

Ministry of Education, which distinguishes it from the rest of the education system. The governing body of the system is the National Assembly of University Rectors (ANR). It is worth mentioning that the country's principal universities question the functioning of the ANR and play little part in it[13].

In recent years, under the umbrella of legislation which promoted private investment at university level and which accepted the profit-making character of universities, many private universities were created without proper quality control. In 2006, there were 91 universities in the country as a whole, 35 state and 56 private, with a total of 568,000 students, 285,000 in the state universities and 282,000 in the private (Piscoya, 2006).

Currently, no Peruvian university appears in any of the international indexes or rankings despite the fact that it has the first university founded in America (Mayor de San Marcos National University, founded in 1551).

Figure 11. Cognitive skills and economic growth in Latin America



Regression of aggregated variables of the average annual growth rate of per capita GDP from 1960 to 2000 and average performance in examinations of students in Latin America.
Source: Hanushek and Woessmann, 2009.

Nevertheless, there is a group of universities with a good academic standard in terms of their teachers, modern educational methods, adequate facilities and equipment, with the capacity to carry out scientific and technological activities and with ample experience of international collaboration. Table 12 shows the ranking of Peruvian universities published by the ANR (Piscoya, 2006).

According to the UNESCO Institute for Statistics (UIS, 2010), in Peru, in 2007, the university population was 566,864. 50.4% of university students were enrolled in education, followed far behind by law and political sciences (7.6%), administration (7%) and accountancy (5.6%). The leading discipline in STI (systems engineering) comes in sixth place, with a rather small number of students compared with the most popular subjects (Table 13).

During the interviews, different actors highlighted the weakness of technical education in Peru to provide the required technical training. Among others, technical education suffers from the lower prestige of this type of career and the perception that incomes are lower than those of university graduates.

Section C.1. Inputs, provides data on the level of human resources in research and development in Peru and compares them with other Latin American countries. The results show that there are fewer people conducting R&D activities in Peru than in other Latin American countries.

On the other hand, it should also be emphasized that the existence of a scientific and innovative culture is an incentive to students, entrepreneurs and others to apply their efforts to science, technology and innovation. On several occasions, during the

Table 12. Overall ranking of Peruvian universities, 2006

	University	1. Selectivity of admission to the university (10%)	2. Teaching load (10%)	3. Output of graduates and higher degrees (10%)	4. Impact of postgraduate work on the curriculum and enrolment (10%)	5. Academic qualification of teachers (10%)	6. Academic publications (20%)	7. Research (20%)	Score
1ª	Mayor de San Marcos National University	15.0	1.6	1.5	1.9	2.6	9.3	19.4	**51.4**
2ª	Pontifical Catholic University of Peru	4.3	1.7	0.5	1.2	3.8	20.0	13.8	**45.4**
3ª	Peruvian Cayetano Heredia University	2.9	2.6	2.2	2.8	2.3	0.5	22.7	**36.0**
4ª	La Molina National Agrarian University	7.4	1.7	0.2	2.3	4.2	0.0	10.5	**26.3**
5ª	Altiplano National University	11.5	1.4	0.3	1.9	3.2	0.0	2.6	**20.9**
6ª	Pacífico University	2.2	0.9	0.3	0.9	3.3	12.9	0.0	**20.6**
7ª	Trujillo National University	7.5	2.0	0.7	2.4	3.7	0.0	2.5	**18.9**
8ª	San Agustín National University	8.2	1.5	0.3	1.9	3.2	1.0	2.0	**18.0**
9ª	National University of Engineering	6.9	1.1	0.6	1.5	2.6	0.0	4.8	**17.5**
10ª	La Selva National Agrarian University	7.0	2.5	0.8	0.1	2.7	0.0	1.1	**14.4**

Source: Piscoya (2006).

interviews conducted, comments were received on the lack of interest in science and technology in Peru and the absence of an innovative culture among entrepreneurs and producers.

The various initiatives that have been undertaken in the country, to publicize science and technology (e.g. the annual National Schools Science and Technology Fair organized by CONCYTEC), promote cooperation between scientists and research centres (e.g. International Scientific Forums) or to promote innovation in the business world (e.g. National Innovation Week) are important efforts to develop a culture more favourable to STI which deserve support.

6. Human development

Science, technology and innovation are tools which can facilitate development, by which is meant the process of expansion of human capacities and freedoms[14], through, for example, advances in access to, analysis and dissemination of information, development of medicines and diagnostic tools, improvement of agrarian production, or innovations to reduce environmental pollution in small-scale mining activities. The development of national capacities is important in order to be able to develop, adopt and adapt technological solutions to national social problems, e.g. to tackle local diseases, improve indigenous crops or introduce improvement in local industrial production.

A national STI policy consistent with development needs to address social problems and not just the economic opportunities offered by STI. Moreover, the design of such a policy needs to consider and evaluate the know-how, resources and entrepreneurial capacities possessed by different groups of people in different geographical areas, including indigenous and poor communities, in order to be able to adopt and adapt STI. A consistent policy must address the needs of these groups and be designed so as to take account of their specific capacities.

Based on the Human Development Index[15], which tries to embody this concept of broad development which places the human being as the means and end of development, Peru is a country of high human development (78), behind other Latin American countries. Its greatest shortcomings are in the literacy rate, life expectancy and quality of education.

A monetary definition of poverty[16], a method which fa-

Table 13. University enrolment in Peru, 2007

University discipline	Number enrolled	%
Education	286,813	51
Law and political sciences	43,433	8
Administration	40,045	7
Accountancy	32,847	6
Nursing	21,336	4
Systems engineering	17,306	3
Human medicine	15,959	3
Economics	15,688	3
Civil engineering	13,395	2
Industrial engineering	13,313	2
Psychology	12,933	2
Dentistry	12,776	2
Obstetrics	9,996	2
Communication sciences	9,265	2
Agronomic engineering	8,472	1
Architecture	7,877	1
Pharmacy and biochemistry	5,410	1
Enrolled in UNIVERSITY tertiary education	**566,864**	**100**
Enrolled in NON-UNIVERSITY tertiary education	**383,296**	**...**
TOTAL enrolled in tertiary education	**950,160**	**...**

Source: National Youth Secretariat, Guide to Studies, Ministry of Education, 2009.

cilitates comparability between countries and regions shows that in 1990, poverty affected 57.4% of the population and extreme poverty, 26.8%. In rural areas, however, it rose to 70.9% and 46.9% respectively. In 2000, the overall poverty level fell slightly (54.1%) but there was considerable progress in reducing extreme poverty to almost half (14.8%). This substantial fall was basically due to its reduction in metropolitan Lima and the remaining urban areas[17].

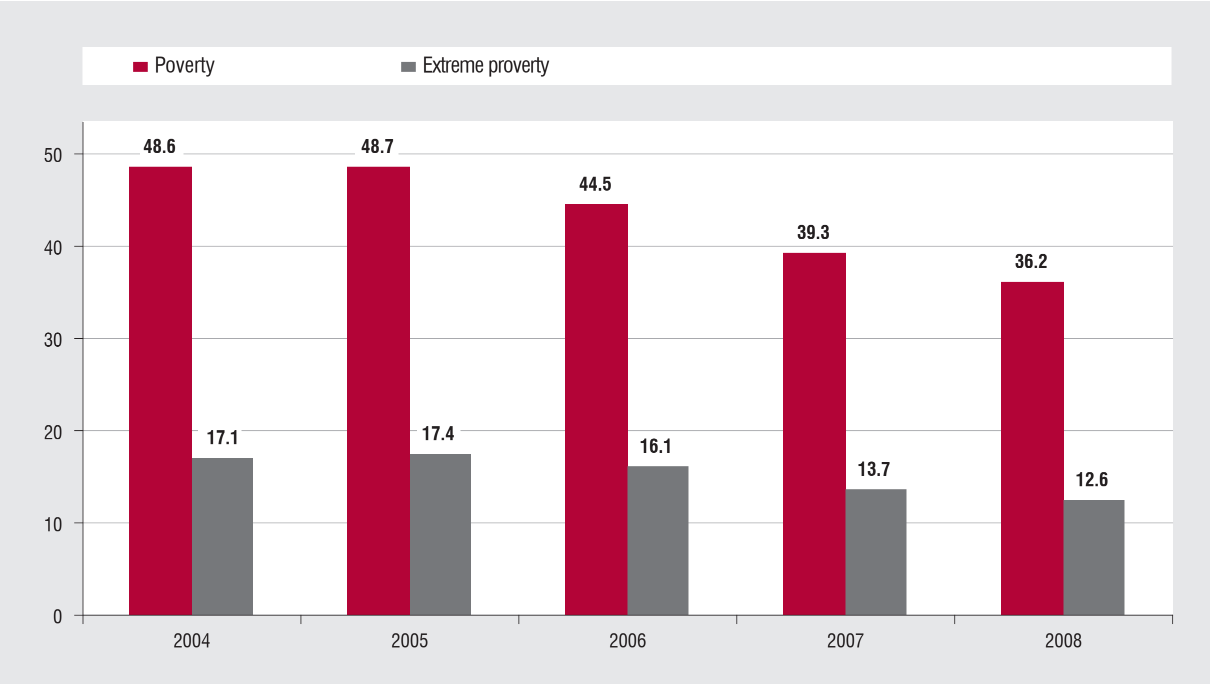
Both overall poverty and extreme poverty have declined steadily over the last five years (Figure 12). Overall poverty fell from 48.6% in 2004 to 36.2% in 2008. When it is analysed by major geographical areas, it is found that the greatest improvements have been in towns and rural areas in the forest region and in rural mountain areas.

The pattern of extreme poverty has been similar even if the downward curve was less steep, since it fell from 17.1% to 12.1%. However, regions like metropolitan Lima, the urban coast and urban mountain areas saw increases in extreme poverty compared with the previous year. One explanation could be that the traditionally poorest and most deprived areas (rural mountain and forest) received most attention. These averages, however, mask the high level of poverty in certain regions: Huancavelica with 88.7% of its population in a state of poverty, Ayacucho (78.4%), Puno (76.3%) and Apurimac (74.8%).

Peru has several poverty reduction programmes which promote technological and innovative development. The Ministry of Agriculture provides technical assistance to small farmers in various areas of the country, especially in the mountains, and promotes productive chains between small farmers and large and medium-sized export companies. In the same vein, both the Ministry of Production and the Ministry of Labour and Employment have urban microenterprise support programmes which consist chiefly of training and technology transfer. These programmes have a significant positive effect on the economic entities concerned. However, all these public institutions have very little in the way of public resources so that their economic and social impact is limited.

On the private sector side, many NGOs and religious institutions, such as Caritas, CARE, ADRA-Ofasa, IT-DG-Practical Solutions, the Poverty Reduction Forum and COPEME (Consortium for Private Organizations Promoting the Development of Small and Medium Enterprises), also work with small rural and urban producers, transferring appropriate technology to them and providing them with training. One of the most successful private programmes is “Sierra Productiva”, under the aegis of the Institute for Alternative Agriculture (IAA). The programme works with over 30,000 families in the Andean South and has over 1,200 peripatetic trainers who teach how to use the technologies developed by the IAA. The results of this programme include: increased productivity of grazing land, cultivated using sprinkler and drip irrigation methods; improved quality and quantity of foods, diversification of diet and greater food security; and increased incomes as a result of the development of the land both for agriculture and livestock and artisanal transformation of the resulting products. The successes of this programme led to its being converted into public policy in 2009 (D.S. 004-2009-MIMDES) (Llosa Larrabure et al. 2009).

Figure 12. Trends in poverty and extreme poverty in Peru, 2004-2008 (%)



Source: INEI. "Poverty Technical Report, 2008", Peru, May 2009.

7. Natural resources and biodiversity

Peru's endowment of natural resources and biodiversity represents great potential for the country's development. Peru has a complex geography in which 28 million Peruvians and an enormous variety of landscapes, species and crops coexist, making it one of the ten most biologically diverse countries in the world (Table 14). The country has vast natural resources, whether in terms of plants and animals or forestry and water resources, as well as genetic diversity, the knowledge of the indigenous communities or inhabited areas which represent a great source of wealth. This heritage offers great potential. Among other things, for diversifying crops or discovering therapeutic substances to be used as inputs for industry or sources of energy.

This abundance and diversity of resources and genetic material gives the country a considerable comparative advantage in developing science, technology and innovation such as, for example, in the field of biotechnology. However, this advantage is only potential. Making use of it depends, in the first place, on the country's capacity to put into practice policies for the conservation and sustainable utilization of this diversity and, secondly, the development of STI and productive capacities.

Table 14. Peru, one of the ten most biodiverse countries in the world

	No. of species	World ranking
Fish	2,000	1º
Butterflies	3,532	1º
Birds	1,816	2º
Amphibians	449	4º
Mammals	515	5º
Reptiles	418	5º
Flowering plants	25,000 descritas	8º

Source: CONAM (2008).

C. PERFORMANCE IN SCIENCE, TECHNOLOGY AND INNOVATION

Having a systematic set of STI indicators is a way of tracking the evolution and characteristics of technological innovation. This information is of profound value to public or private decision-makers and members of the scientific and technological community themselves. For the public sector, STI indicators are crucial to design, manage and evaluate STI policies and programmes. In the case of the private sector, the use of indicators is key in defining competitive strategies and also allows them to link up with the academic sector and state institutions. The evaluation of STI in a country requires a set of indicators which can capture not only inputs (human capital, financial resources) but also innovation and its impact, as well as the relationship between different economic, political and scientific actors.

In Peru, there is no systematic collection of information on STI activities which could serve as an effective guide to decision-makers. This lack of information is in itself a major weakness on the Peruvian system of innovation since it inevitably impacts on the quality of design and evaluation of interventions in the STI sphere. What follows here is a summary of the principal STI performance indicators available for Peru.

1. Inputs

Research and Development (R&D)

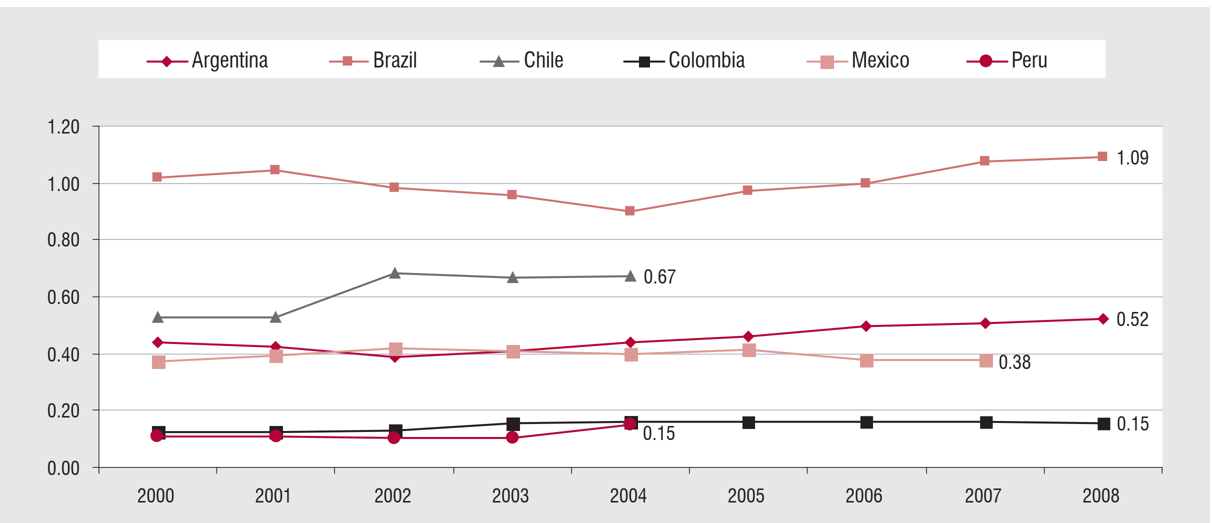
R&D, i.e. "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications" (Frascati Manual 2002), is a key activity in increasing the stock of knowledge and stimulating the development of a country's endogenous capacities for innovation (UIS 2009).

The available figures on R&D investment in Peru show that the percentage and annual variations in financial resources allocated to this activity is statistically very small. This reflects the lack of importance attached by society in general and government and business in particular to the promotion of national scientific and technological development (Sagasti, 2009; Kuramoto and Torero, 2004).

It should be noted that the most recent records held by specialized organizations for the collection and publication of statistics on science and technology date from 2004 and the lack of up-to-date data limits the analysis that can be carried out.

Peru invests little in R&D, even in comparison with other countries in the region which have increased their spending patterns, as in the case of Brazil and Chile (Figure 13). According to data from the Network of Science and Technology Indicators (RICYT), during

Figure 13. Comparative trends in R&D expenditure (as percentage of GDP), selected Latin American countries, 2000-2008



Source: Network of Science and Technology Indicators (RICYT), 2009.

2004 investment under this heading in relation to GDP in Peru was barely 0.15%, far below that of other Latin American Countries and the Latin American average (Sagasti, 2009). The scale of investment (absolute investment in R&D) also shows significant differences. For example, the scale of investment in Peru is 52 times less than in Brazil (Figure 14).

Private sector participation in R&D activities is scant. Expenditure on R&D by sector of implementation shows the predominant weight of the Government and the universities in Peru, in contrast to Chile where the private sector contributes almost 50% of expenditure (Figure 15).

As regards human capital for R&D, Table 15 shows fewer people dedicated to research and development activities, both in universities and the private sector, than in other Latin American countries (2004).

In 2004, and there is no reason to think that the situation has changed significantly, Peru had 8,434 people involved in R&D activities. Of these, 4,965 were researchers, 1,727 were technicians and 1,712 were support staff. In the same year, the country spent 239 million dollars on R&D activities, which represents 0.15% of GDP and equates to 8.69 dollars per inhabitant.

Peru is lagging behind compared with other countries in the region, both in absolute and relative terms. Brazil, the Latin American country with the greatest investment in R&D, has 283,146 people involved in this type of activity. As regards the number of researchers per million inhabitants, Peru, with 181 researchers per million inhabitants, is behind Argentina (1,203), Chile (1,139) and Brazil (812) (Table 15).

Science and Technology Activities (STA)

Scientific and technological activities is a broader concept which encompasses "those systematic activities, closely linked to the generation, production, dissemination and application of scientific and technical knowledge in all fields of science and technology. They include R&D, scientific and technical education and training and scientific and technical services" (Frascati Manual OECD 2002b).

Information on scientific and technological activities for Peru is even less recent (2003) and shows that Peru invested 700 million dollars in 2003, i.e. 1.15% of GDP. The bulk of the expenditure was made by the universities (60%) and by the Government and public institutions (26%) (Table 16). Even if comparisons with other countries in the region present problems of methodology, a rough estimate shows that the scale of expenditure on scientific and technological activities is still small, although relatively better than expenditure on R&D.

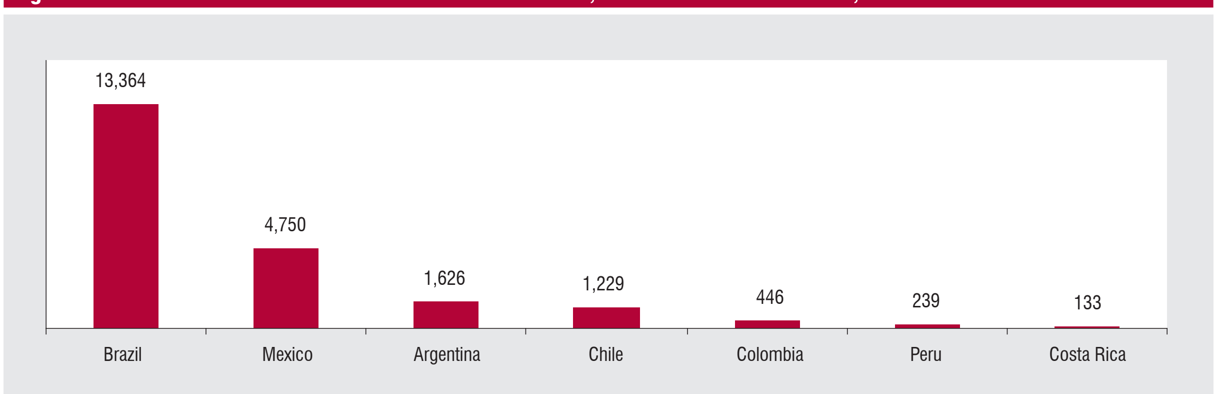
There are no data on the number of people in Peru involved in these activities.

2. Results

The most extensive indicators for measuring results in the area of science and technology are scientific publications (bibliometric indicators) and patents (and utility models and trademarks). These indicators are easy to collect but have some drawbacks.

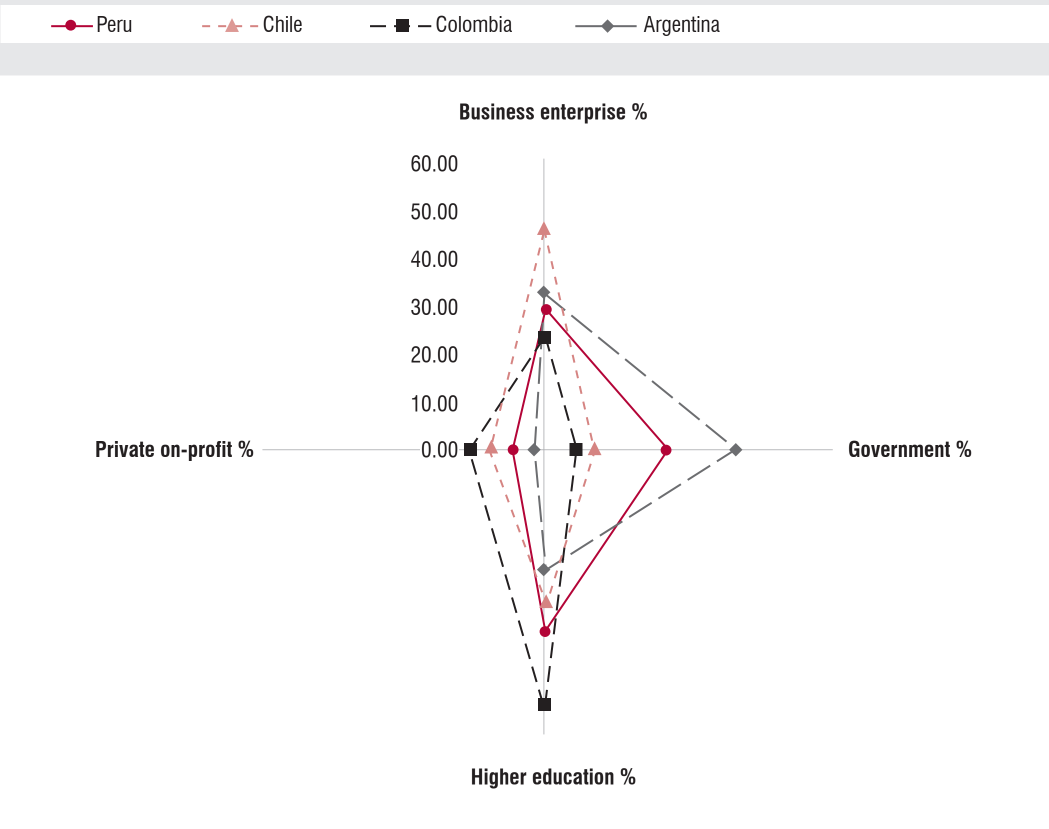
Bibliometric indicators refer exclusively to articles published in indexed journals and do not evaluate the relative importance of the various publications. However, these indicators can be very useful in

Figure 14. Investment in R&D in Latin American countries, thousands of PPP dollars, 2004



Source: UNESCO Institute for Statistics database.

Figure 15. Investment in R&D by sector of performance, 2004



Source: UNESCO Institute for Statistics, 2009.

Table 15. Human resources indicators for science, technology and innovation for Latin America, 2004

Indicator	Peru	Argentina	Brazil	Chile	Colombia	Costa Rica
R&D personnel (thousands)	8.40	59.20	283.10	30.60	...	1.10
Researchers (thousands)	4.90	46.20	149.20	18.40	10.60	...
Technicians (thousands)	1.70	6.90	...	7.90	...	...
Researchers per million inhabitants	181	1,203	812	1,139	250	253

Source: UNESCO Institute of Statistics, 2010.

identifying the principal areas of scientific knowledge of a community, and the degree of collaboration with other countries.

Patents, for their part, only reflect part of the scientific and technological activities of a country or institution. There is much scientific output and innovations which are not necessarily patented. Some minor adaptations, which play an especially crucial role in developing countries, may yield enormous benefits but are not necessarily patented. Furthermore, a company's patenting strategy may lead it to consider it more appropriate not to patent an invention due to the cost of doing so or for reasons of industrial secrecy. Despite these limitations, patents give an approximation of a country's capacity for formal invention.

Table 16. Expenditure on Scientific and Technological Activities (STA) in millions of dollars, as a percentage of GDP and by sector of performance (as a percentage), 2003

Expenditure on STA, millions of dollars	**700.6**
Expenditure on STA, as percentage of GDP	**1.15%**
Expenditure on STA, by sector of implementation	
Government	26.0%
Companies	4.3%
Higher Education	60.3%
Private not-for-profit organizations	9.4%

Source: RICYT, 2009.

A) Bibliometric indicators

For this exercise, a bibliometric study of publications was carried out to assist in the identification of the strongest areas of research in Peru and to provide guidance in decisions on the setting of priorities. The study identifies the principal research themes, the impact of published articles, the research subjects in which there are the greatest scientific output and the collaboration networks established with other countries for research purposes. Annex C presents the details of the methodology used in the study and the results obtained.

In brief, with regard to the volume of Peruvian publications, the study shows that the total output of publications during the period 2003-2009 was 3,663 articles, of which 36% had the primary author based in Peru. In general, the trend in the number of publications was erratic, albeit with an upward trend, a reflection of foreign output. Peru's chief research partners are in the United States (34%), Brazil (7%), Spain (6%), England (6%) and Argentina (5%). Peruvian scientific productivity (measured in relation to per capita GDP) is among the lowest in Latin America and considerably lower than its chief research partners.

B) Indicators of patents, utility models and industrial design patents

Patents

Applications for patents of invention show an upward trend, with rising rates of growth from 2004 to 2008, which could indicate greater interest in companies and institutions in patenting. However, in 2009, the trend reversed with a marked fall. Nevertheless, the grant of patents of invention shows a downward trend in contrast to the rise in applications. This constant rise in the number of not-granted applications suggests weaknesses in the patenting capacity of economic agents (Figure 16). In the period 2000-2009, in aggregate, the efficiency index for patents shows that only 40% of patents applied for were granted.

From the analysis of the patents it can be inferred, on the one hand, that the capacity for patenting is very low, which to a large extent reflects the primary productive structure and the meagre efforts at innovation made in Peru (ECLAC, 2009). On the other, in terms of scale, it shows an incipient development of the patent market. This situation is even more obvious when the performance of certain countries in the region is compared (Figure 17).

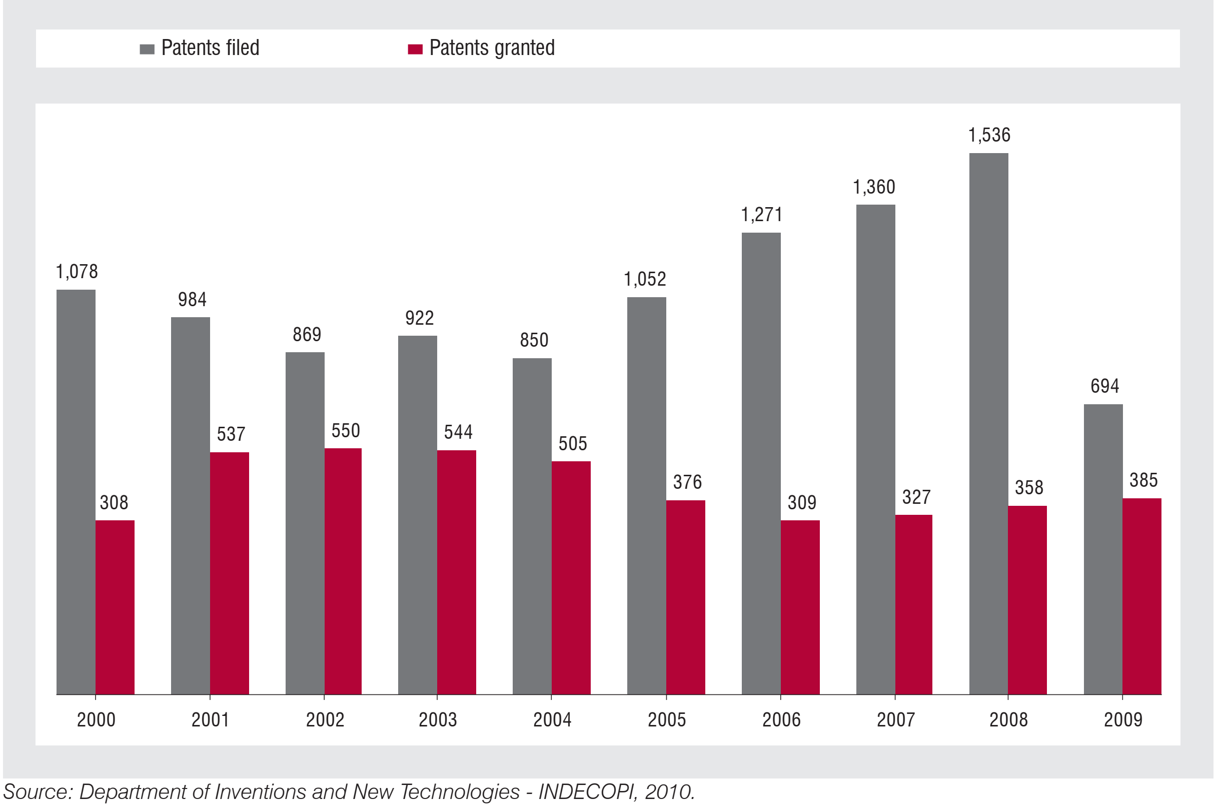
Furthermore, this incipient development of the patent market is accompanied by weak enforcement of intellectual property rights. Based on estimates of the International Intellectual Property Alliance (IIPA, 2009), in Peru, the level of piracy of business software is 74%.

With respect to the breakdown of patents granted, distinguishing between domestic and foreign, there is an overwhelming predominance of patents granted to foreigners, with an average share of 97% in the last 8 years. This fact again highlights the lack of a patenting culture among domestic economic actors (Figure 18).

The continuous deterioration in the rate of technological dependence[18] and its counterpart, the rate of self-sufficiency[19], indicates the scant endogenous capacity for generating knowledge (Figure 19).

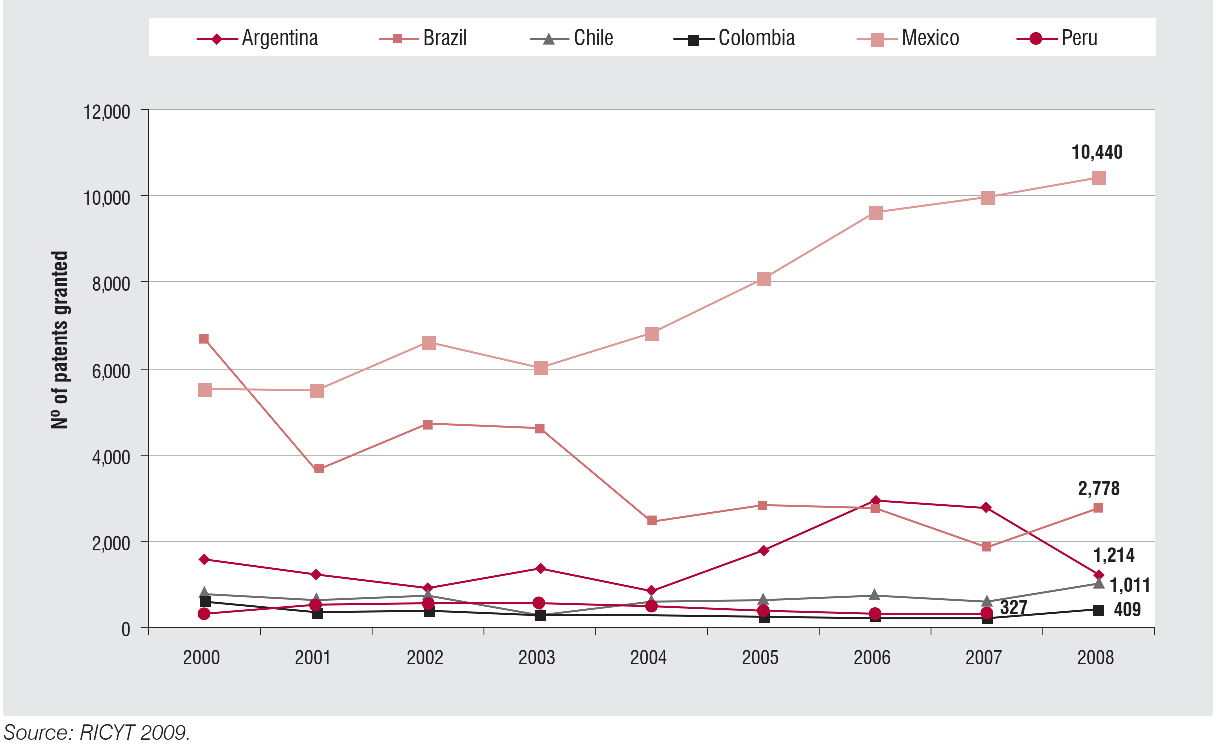
Furthermore, the breakdown of patents under the International Patent Classification (IPC) by section shows that some 60% of the patents of invention submitted in the period 2000-2008 are concentrated in the sections "Human Necessities" (Section A) and "Chemistry, Metallurgy (Section C). Foreign patent applications are especially concentrated in these two areas, which represent 82% of applications but 55% of domestic applications. Applications of domestic origin are more diversified, with greater weight given to "Performing Operations; Transporting" (Section B) and "Fixed Constructions (Section E), even though in recent years their share of the patent market has fallen (Table 17).

Figure 16. Applications for patents of invention filed and granted, 2000-2009



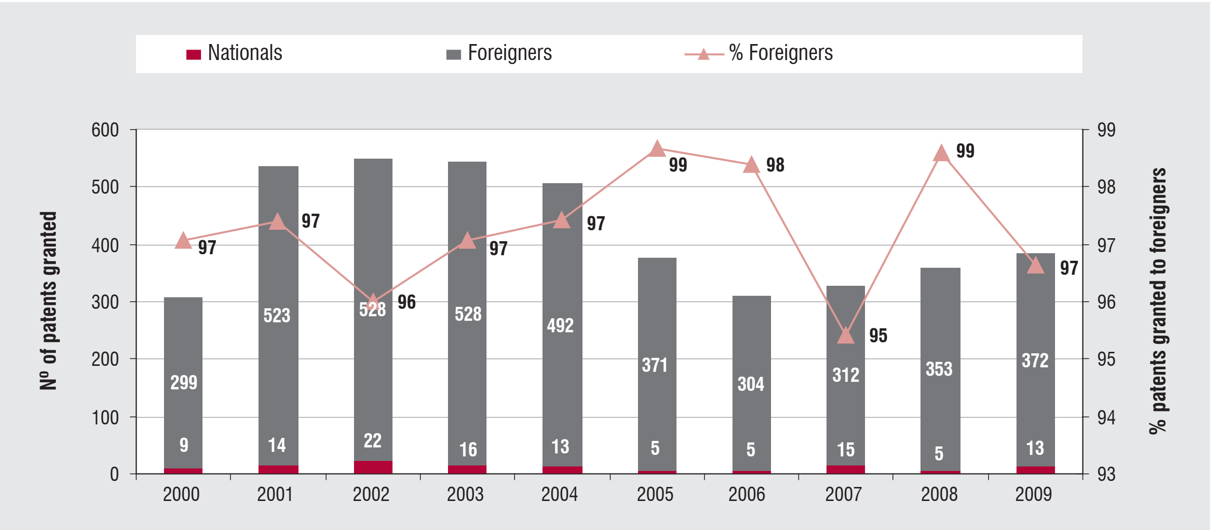
Source: Department of Inventions and New Technologies - INDECOPI, 2010.

Figure 17. Number of patents granted by patent offices, various Ibero-American countries, 2000-2008



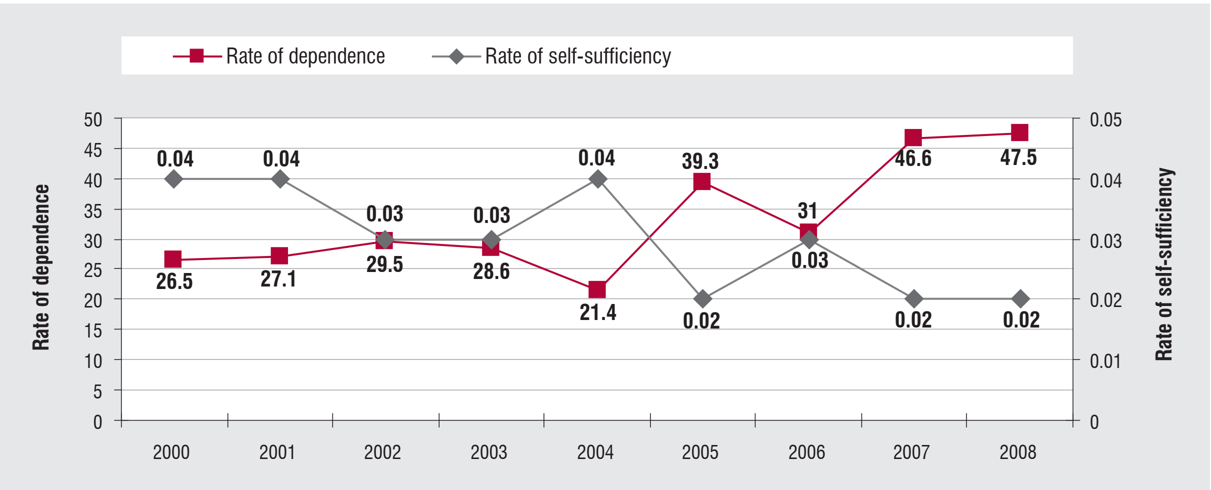
Source: RICYT 2009.

Figure 18. Patent applications granted to nationals and foreigners, in absolute and relative terms, 2000-2009



Source: Department of Inventions and New Technologies - INDECOPI, 2010.

Figure 19. Rate of dependence 2000-2008



Source: Department of Inventions and New Technologies - INDECOPI, 2009.

As regards the breakdown of patents by IPC class, the technological areas with the most applications are "Organic Chemistry" and "Medical or Veterinary Science, Hygiene", always over 60% in the last 8 years (Table 18).

Utility models

Utility models are an important alternative to patents for domestic companies, as the criteria for granting them are less strict with regard to the requirement of an inventive activity.

Unlike patents of invention, applications for utility models have declined although recovering slightly since 2007. The pattern of approved applications is erratic, with a marked decline since 2003, giving rise to an ever-increasing number of refused applications (Figure 20). During the period 2000-2009, at least 65% of utility models granted each year were to domestic companies.

Industrial design patents

This instrument protects changes which are essentially of an aesthetic character in the presentation of products without changing their application or purpose.

In Peru, there has been a growing trend in the number of industrial design patents granted. As in the case of patents, the share of patents of industrial design granted to foreigners has been rising steadily, up to 2009 (Figure 21).

C) Technological balance – Balance of royalties and licence fees

A country's technological balance comprises, on the one hand, income from the sale of domestic technology abroad and, on the other, payment for the acquisition of foreign technology[20]. It is a tool for measuring the amount of a country's income from the export of technological know-how, while at the same time indicating the country's competitive position in the international knowledge market[21]. Often, these transactions reflect transactions between the parent in a transnational company and its subsidiaries.

Presented below are stylized data on the technological balance. In order to facilitate international comparisons and given that there are no sources of information sufficiently disaggregated to cover the parts of the technological balance suggested by the Santiago Manual (2007)[22], the analysis is based only on the balance of royalties and licence fees.

In the case of Peru, income from royalties and licence fees is insignificant in relation to payments (Figure 22). This chronic deficit confirms the earlier diagnosis

Table 17. Patent applications to INDECOPI, by section and origin, 2000-2008

Patent applications by section	Domestic		Foreign		Total	
	Nº	%	Nº	%	Nº	%
A. Human necessities	111	4	3,046	96	3,157	100
C. Chemistry, Metallurgy	69	1	5,243	99	5,312	100
B. Performing Operations, Transporting	43	5	743	95	786	100
E. Fixed Constructions	28	12	199	88	227	100
F. Mechanical Engineering,Lighting,Heating, Weapons,Blasting	26	7	355	93	381	100
G. Physics	26	8	284	92	310	100
H. Electricity	17	6	248	94	265	100
D. Textiles, Paper	4	6	61	94	65	100
Total	**324**	**3.1**	**10,179**	**96.9**	**10,503**	**100**

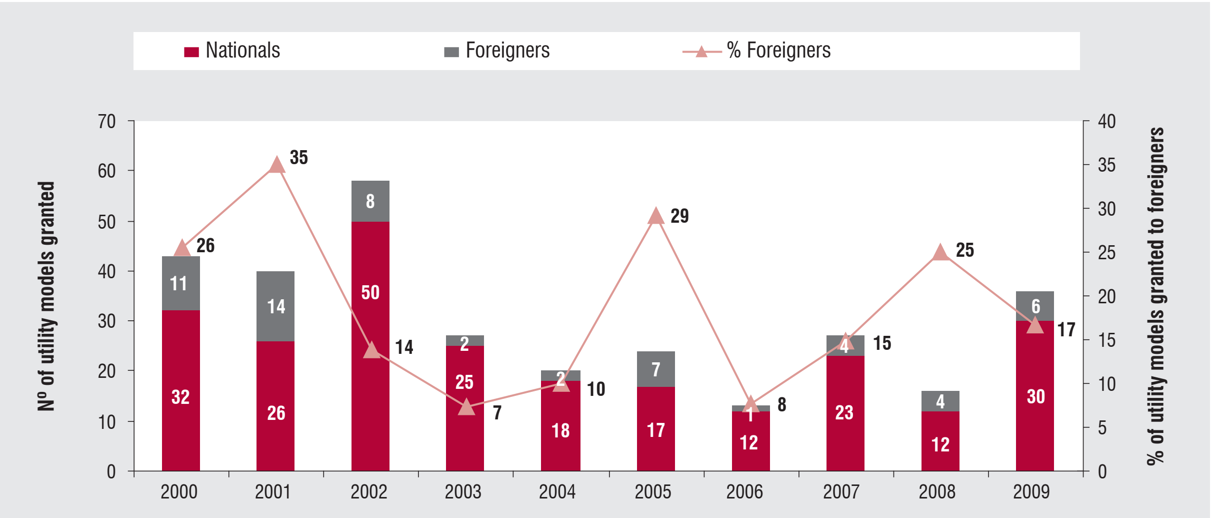
Source: Department of Inventions and New Technologies - INDECOPI, 2009.

Table 18. Patent applications to INDECOPI, by IPC class, 2000-2008

Patentes solicitadas, según clase	2000 (%)	2005 (%)	2008 (%)
C07. Organic chemistry	33	45	44
A61. Medical or veterinary science, hygiene	26	23	22
A01. Agriculture, forestry, animal husbandry, hunting, trapping, fishing	1	3	4
C22. Metallurgy, ferrous or non-ferrous alloys, treatment of alloys or non-ferrous metals	3	3	3
A23. Food or foodstuffs, their treatment, not covered by other classes	3	2	2
C12. Biochemistry, beer, spirits, wine, vinegar, microbiology, enzymology, mutation or genetic engineering	2	1	2
B65. Conveying, packing, storing, handling thin or filamentary material	2	1	1
B01. Physical or chemical processes or apparatus in general	3	1	2
H04. Electric communication technique	2	2	0
G01. Measuring, testing	2	1	1
G06. Computing, calculating, counting	1	2	0
Other	22	16	20

Source: Department of Inventions and New Technologies - INDECOPI, 2009.

Figure 20. Utility models granted to domestic and foreign applicants, in absolute and relative terms, 2000-2009

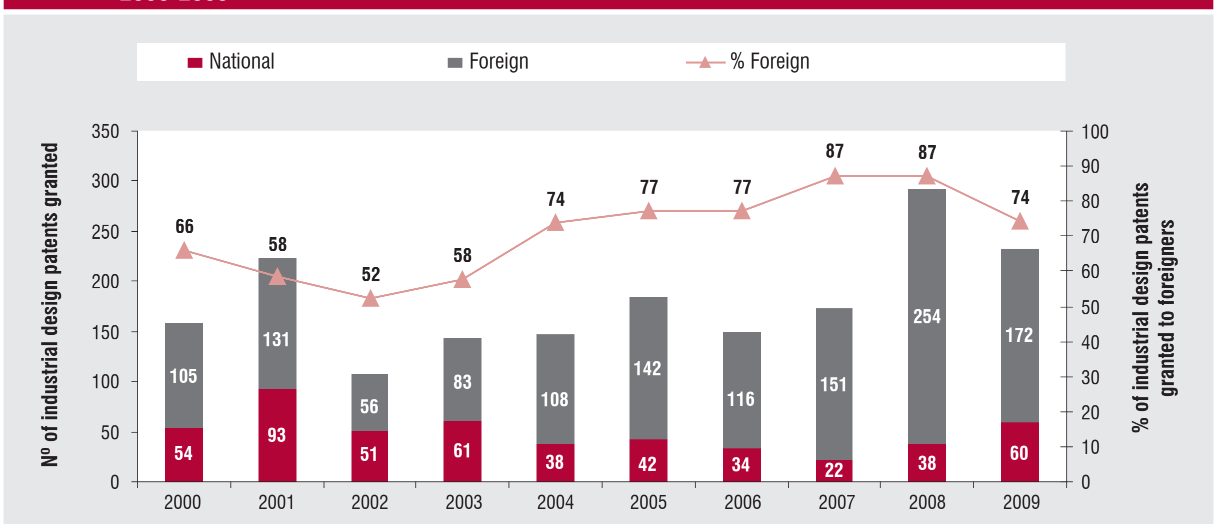


Source: Department of Inventions and New Technologies - INDECOPI, 2010.

of a high degree of technological dependence of the Peruvian economy, a dependence which is reflected in the minimal levels of cover[23]. As well as the deficit, it is important to emphasize the low volume (in absolute terms and in relation to GDP) of these transactions compared with other countries in the region (Figure 23). This is the corollary of specialization in the primary sector with a very low knowledge content.

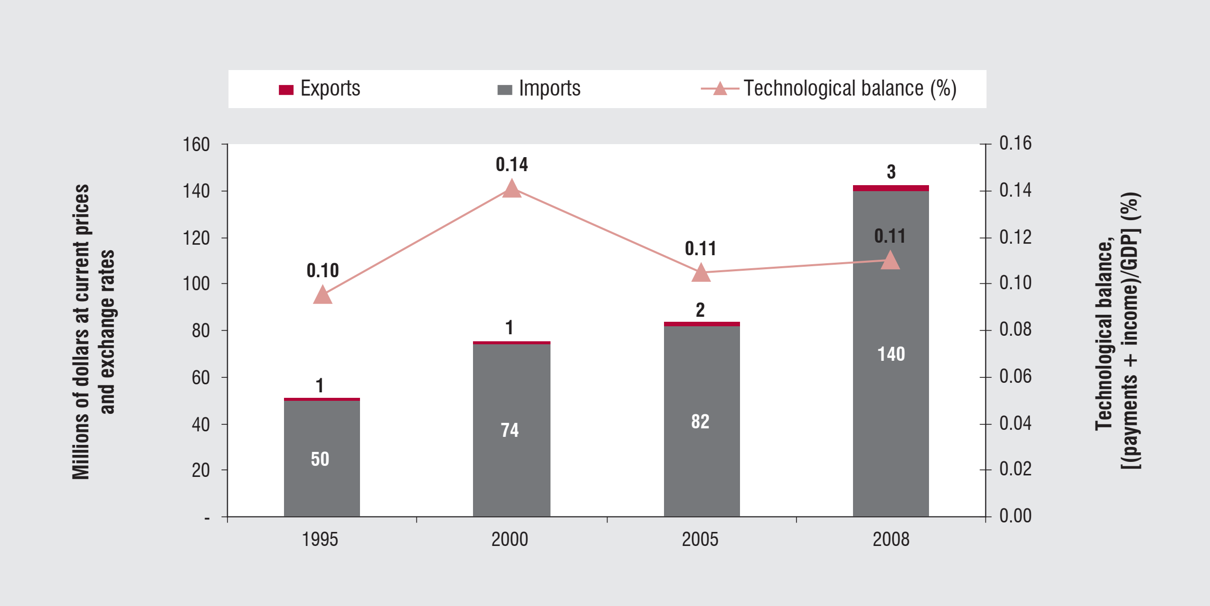
In Peru, a satellite account on science and technology, knowledge and intellectual property to allow an estimate of the knowledge balance has not been created. Nevertheless, a study on this subject for 2004 estimates that the knowledge balance, in terms of trade in goods, was in deficit by 427 million dollars, even though the balance of trade was in surplus by 2,729 million dollars in that year. For services, the deficit was estimated at 59 million dollars (INDECOPI, 2005).

Figure 21. Patents of industrial design granted to domestic and foreign, applicants, in absolute and relative terms, 2000-2009



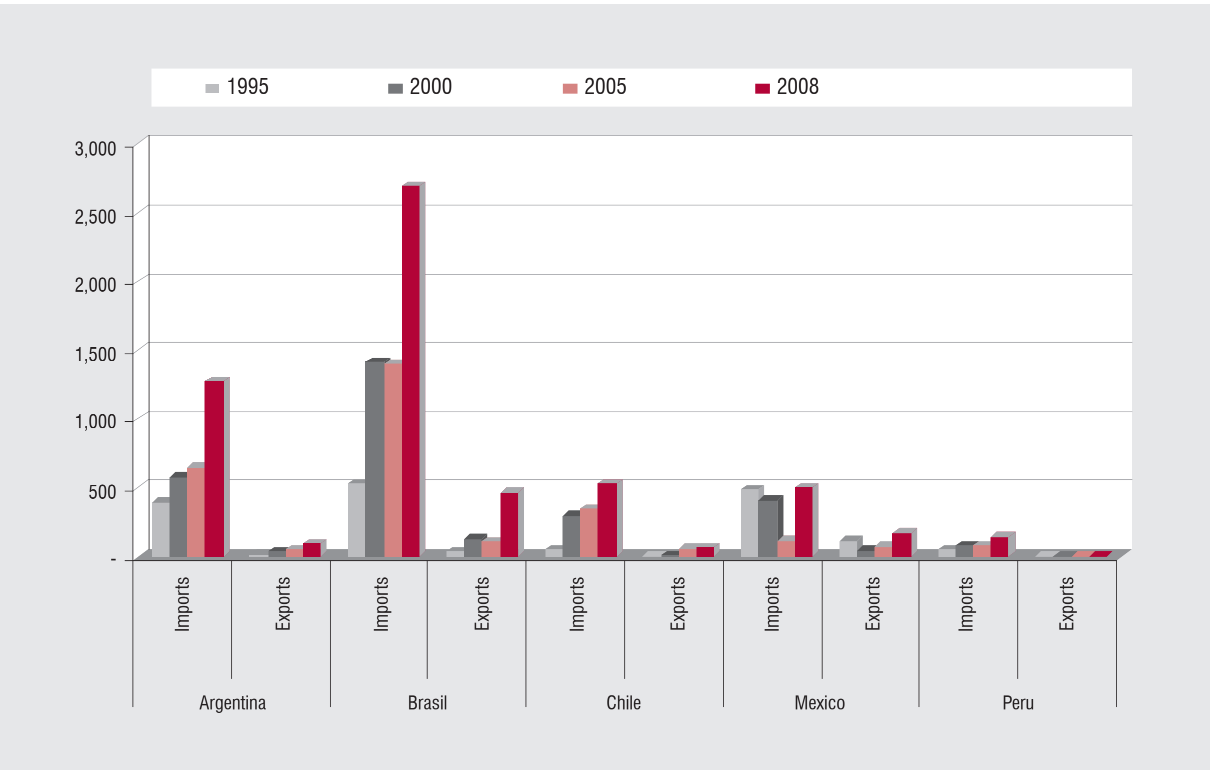
Source: Department of Inventions and New Technologies - INDECOPI, 2010.

Figure 22. Royalties and licence fees, millions of dollars at current prices and exchange rates. Technological balance (payments plus income from royalties and licence fees/GDP), Peru, 1995-2008



Source: UNSD COMTRADE Data, 2010.

Figure 23. Royalties and licence fees, various Latin American countries (millions of dollars at current prices and exchange rates), 1995-2008



Source: UNSD COMTRADE Data, 2010.

3. Innovation activities and their impact

Peru does not have a system for automatic collection of data on innovation activities of companies. In 2005, CONCYTEC carried out an innovation survey[24] but, as the organization itself indicated, the survey had problems with sampling or its representativeness and thus conclusions could not be drawn from the results obtained. Allowing for these limitations, the report's conclusions indicate a low proportion of companies which engage in innovation activities, and these are concentrated in metropolitan Lima and large companies. Product and organizational innovations where the innovation is essentially at the level of the company and the domestic market predominate. As regards to patents, the survey confirms the low number of patents granted. Among barriers to innovation, the companies surveyed highlighted the limited access to sources of financing and the high cost of training.

Given the limited information available, it is essential to have detailed information on innovation processes in Peru, not only on inputs (investment) and the results of innovation (patents) the meagre level of which is more or less predictable. It is particularly important to understand the processes by which such innovation emerges. This includes information on the type of collaboration in relation to innovation in companies, the sources of information they use, the type of innovations produced and the impact on sales and exports. In connection to this, the proposal to carry out an innovation survey (led by the Ministry of Economy and Finance and to be carried out by the National Institute of Statistics and Information Technology) is a task which deserves support.

NOTES

[1] Conversely, another study (Loayza et al., 2004) shows that in the 90s, after adjusting for utilization of capital and labour, the contribution of multifactorial productivity remained negative.

[2] Sagasti (2009).

[3] See ECLAC, Preliminary Overview of the Economies of Latin America, 2009.

[4] It should be borne in mind that the Peruvian economy has a high level of real and financial dollarization.

[5] PROMPEX has now merged with PROMPERU, although it continues with this promotion work.

[6] A rise in the share of goods with a greater technological content would indicate an increase in the capacities required for their design and manufacture.

[7] The legal framework for the treatment of foreign investment, the Foreign Investment Promotion Act, approved by Legislative Decree 662 of 1991, is based on the principle of equal treatment of domestic and foreign capital. Consequently, foreign investment is allowed in all areas of economic activity, without requiring any prior authorization based on its foreign character.

[8] See, for example, Sánchez Tarnawiecki (2003) or Kuramoto and Torero (2005). This opinion was also gathered in the interviews carried out.

[9] For this purpose, a formal enterprise means one which is registered with SUNAT and regularly pays its taxes. This is a de minimis definition because there are other legal requirements that enterprises must meet to be considered 100% formal.

[10] Opinion reflected by the Deputy Director of ProInversión.

[11] Competitiveness is defined as the interrelation of various factors which determine an increase in companies' productivity and the environment in which they operate, and which allows them to make efficient use of factors of production such as human resources, physical capital, financial resources and technology.

[12] The RCI groups a series of 46 indicators and 79 variables in 8 areas (institutional framework, infrastructure, economic performance, health, education, business environment, innovation, natural resources and environment).

[13] Opinion gathered during consultations carried out.

[14] Sen, A.; "Desarrollo y Libertad" Ed. Planeta, Buenos Aires, 2000.

[15] The Human Development Index is a composite index which measures average progress in three basic dimensions of human development: life expectancy and health, knowledge and education and standard of living.

[16] The amount of family income or expenditure used to determine the poverty line is determined by a composite of food goods, material goods and minimum services which forms the basic basket. Families with income or expenditure below the basic basket are considered to be in a state of poverty and those with an income below a basket which only includes food are considered to be in extreme poverty.

[17] Data from Cuánto 1998 and 2001, see IEP (2007).

[18] The rate of dependence is an indicator which measures the ratio of patent applications from non-residents to patent applications from residents.

[19] The rate of self-sufficiency measures the ratio of patent applications by residents and total patent applications in each country.

[20] This balance only includes contractual transactions but not those carried out through direct investment or foreign trade in goods and services with incorporated technology.

[21] Santiago Manual (2007).

[22] Payments and receipts for information technology services, royalties and licence fees, R&D services and architectural and engineering services.

[23] Cover measures the part of imports covered by exports.

[24] Survey of Science, Technology and Innovation, 2004.

II

The national system of science, technology and innovation[1]

A. THE NATIONAL SYSTEM OF SCIENCE, TECHNOLOGY AND INNOVATION. GENERAL DESCRIPTION IN ITS CURRENT CONDITIONS

1. Institutional[2] and legislative framework of science, technology and innovation (STI)

The Republic of Peru has a strongly legalistic tradition (Kuramoto 2006), which is reflected in the legislative framework governing STI activities, which is extremely vast and difficult to cover in its entirety in this study. We will therefore confine ourselves to mentioning and reviewing only those general aspects most directly related to the functioning of the STI system[3].

Currently, the State's responsibility for promoting scientific and technological development is set out in the Political Constitution of Peru (article fourteen) and detailed in the Framework Act on Science, Technology and Technological Innovation of 2004.[4] The objective of this law is "to regulate the development, promotion, consolidation, dissemination and transfer of Science, Technology and Innovation (STI) in the country", setting out, among other things:

- the role of the State in STI activities in the light of national objectives;
- the definition of the national system of science technology and technological innovation (SINACYT), and its basic components (Figure 3);
- the role, location and functions of the National Council for Science Technology and Technological Innovation (CONCYTEC), to fulfil its purpose as governing body of the SINACYT;
- the creation of the National Fund for Science Technology and Technological Innovation (FONDECYT), the budget execution arm of CONCYTEC;
- establishment of the National Advisory Council for Science Technology and Technological Innovation (CONID), as an advisory body of the SINACYT;
- establishment of the National Network of Scientific Information and Telematic Interconnections for the processing and dissemination of scientific and technological information;
- formulation of the National Science, Technology and Technological Innovations Plan, under the auspices of CONCYTEC, as an instrument for proposing and implementing short, medium and long-term STI policies; and
- criteria relating to the funding and incentives for STI, to be gradually and progressively increased and including the promotion of technology parks.

The Act includes as annexes a short glossary of terms related to STI (extracted from the fifth edition of the OECD *Frascati Manual* of 1994[5]) and a list of the entities of which the SINACYT is composed, described in the following paragraph.

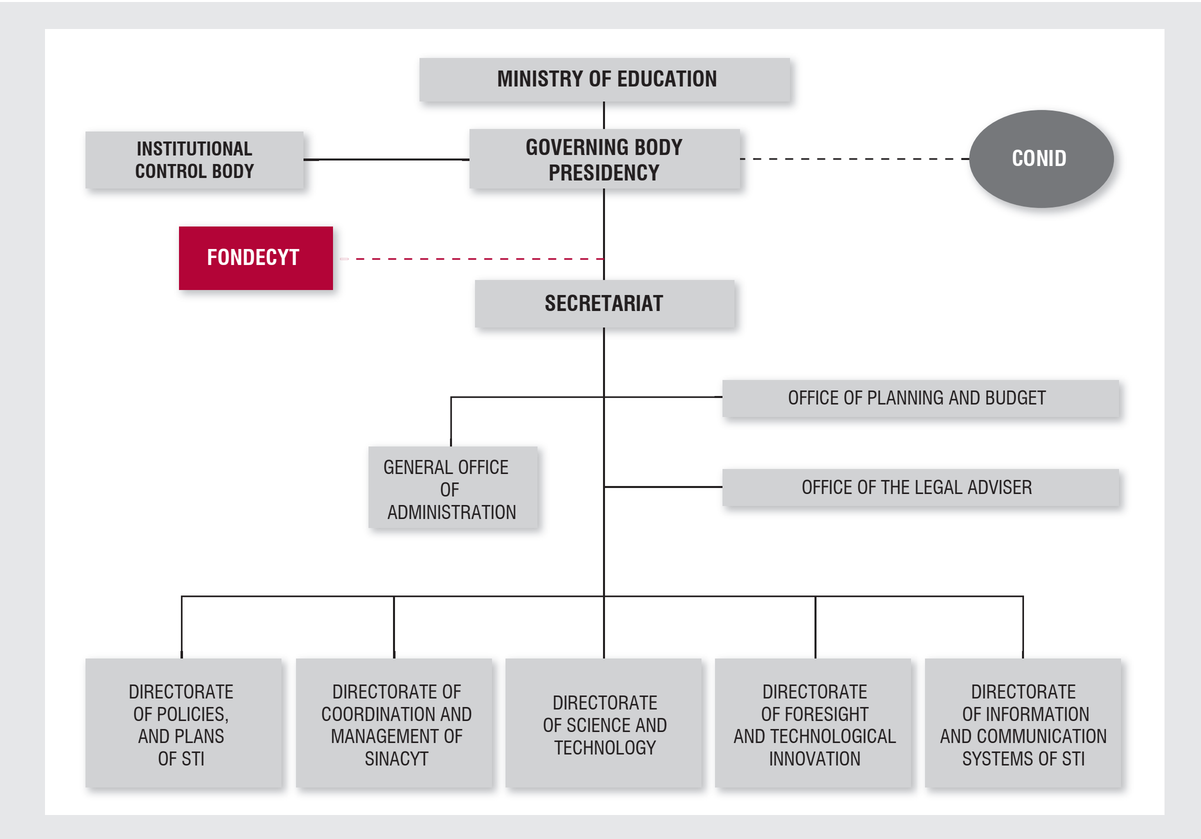
In addition to the Framework Act, the State entities which form part of the SINACYT have their own organic laws which govern their operation and there are also various laws and decrees governing other aspects of the functioning of the system, for example:

- Act No. 28613, the CONCYTEC Act, which contains provisions to align the Institution to the STI Framework Law.
- Act No. 27867, Organic Act on Regional Governments, which provides that regional governments are governed by principles of competitiveness and innovation while at the same time they are given responsibility for regional STI policies (Arts. 8 and 47).
- Act No. 28522, Act on the National Strategic Planning System and the National Strategic Planning Centre (CEPLAN) and their Regulations.
- Act No. 28015, Act on the Promotion and Formalization of Micro and Small Enterprises.
- Resolution of the Presidency No. 072-2003-CONCYTEC-P of 17 March 2003 which, pursuant to the Act declaring the state of emergency of science and technology (Act No. 27690) formed the National Commission responsible for collaborating in the design, elaboration, execution, control and coordination of the National Plan.

2. Legal definition and agents of the national STI system (SINACYT)

The Framework Act defines SINACYT as "the set institutions and natural persons of the country devoted to Research, Development and Technological Innovation (RDI) in science and technology and its promotion". It also provides that the system is conformed, but not exhaustively, by the bodies mentioned in the previous paragraph, the institutions and entities included in Table 1, and the regional and local government agencies devoted to STI activities, public and private universities, the business sector, national and special STI programmes, organizations and members of the scientific community and rural and indigenous communities. The characteristics and basic functions

Figure 1. Organizational structure of CONCYTEC



Source: CONCYTEC

of the principal agents expressly mentioned in the Framework Act are described in Table 1.

National Council for Science, Technology and Technological Innovation (CONCYTEC). The Council is a decentralized public body which traces its origins back to the National Research Council founded in the seventies[6], and was transformed in 1981 into the National Council for Science and Technology. It has now added technological innovation to its name and, as mentioned above, is responsible for managing the SINACYT. Among other functions, this means regulating, managing and coordinating the system, formulating policies and plans in this area, coordinating with other entities the compilation and standardization of information and STI indicators and proposing the allocation of resources to these activities.

It has three directorates: policies and planning, coordination of the SINACYT, science and technology, STI foresight, information and communication systems. In addition, it is responsible for the management of FONDECYT (see organizational chart in Figure 1) and has promoted the creation of regional STI councils (20 to date) with which it maintains close management and coordination links. The latter are made up of regional governments, employers' associations and universities. Their function is to promote the production and dissemination of knowledge among the various economic and social agents in the regions to improve living standards and drive Peru's competitiveness (see also section B.3.b).

National Institute for the Defence of Competition and Protection of Intellectual Property (INDECOPI). Created in 1992 by Decree-Law No. 25868. Its functions are to promote the market and protect consumers' rights. It also promotes a culture of competition in the Peruvian economy covering all forms of intellectual property, from distinctive signs and copyright to rights of breeders of new plant varieties and patents. It is a specialized public body in the Presidency of the Council of Ministers, with legal personality in domestic public law. In consequence, it enjoys functional, technical, economic, budgetary and administrative autonomy (Legislative Decree No. 1033). Figure 2 shows the organizational structure of INDECOPI.

Box 1 provides a brief description of the research institutes and other bodies that compose the SINACYT.

Other entities which are implicitly covered by the Framework Act, because they are involved in STI activities, are:

The Presidency of the Council of Ministers (PCM) and Ministries. Various bodies, programmes, projects and instruments which support STI come under their umbrella: PCM (CEPLAN, described below; INDECOPI; INEI and FINCyT, described below); Agriculture (INIA; SENASA and INCAGRO, described below); Environment (IIAP; IGP and SENAMHI); Defence (IGN and CONIDA); Energy and Mining (INGEMMET and IPEN); and Health (INS). Because of their importance in relation to the framework conditions of the SINACYT, we briefly describe below three other ministries.

Ministry of Economy and Finance. Its purpose is to formulate, supervise and evaluate policies and plans in the economic and financial sector in line with the general policy of the State. Its mission is to propose, execute and evaluate the country's economic and financial policy in order to achieve sustained economic growth and development for the general wellbeing of the population. Accordingly, its functions include: (a) planning, directing and controlling matters related to fiscal policy, financing, debt, budget and treasury; (b) planning, directing and controlling State policies on financial entrepreneurial activity and harmonizing economic activity; (c) planning, directing and controlling matters relating to tariff policy; and (d) efficient management of the State's public resources. Its consultative bodies include the National Competitiveness Council, which is a coordinating committee responsible, in conjunction with public sector entities and in partnership with the private sector, for driving policies and strategies designed to increase the country's competitiveness and that of its companies, in order to improve the quality of life of the Peruvian people.

The Ministry of Education is the lead body in the education sector, responsible for ordinary basic, alternative basic, higher and technical-vocational education. Its mission is human development through the strengthening of individual capacities. Its primary functions consist of formulating national education policies, exercising its regulatory powers in the sector and supervision of compliance with the regulations. As shown in Table 1, CONCYTEC comes under this ministry.

Ministry of Production. Its purpose is to design, establish, execute and supervise, in line with general policy and government plans, national and sectoral policies applicable to fishing, SMEs and industry, and has regulatory powers over them. It issues regulations and technical guidelines to ensure the proper execution and supervision of policies, to manage productive sector resources and to grant and recognise rights, sanctions, control and enforcement. To carry out its functions, it has two under-secretariats, one for SMEs and Industry, the other for Fisheries. The former has two STI policy instruments: the Research and Development for Competitiveness Fund (Innováte Perú-FIDECOM) and the technical innovation centres (CITE), which will be described below. The latter has the above mentioned IMARPE and ITP, and also the National Fisheries Development Fund, whose object is to provide technical and financial support to artisanal, indigenous and rural fishing communities and fish farmers.

The National Agreement. This is a multisectoral forum, chaired by the President of the Republic, to agree State policies to provide the stability necessary for sustained development. Its objectives include increasing competitiveness, establishing a common vision for the future and generating economic growth. It has 31 policies, of which the eighteenth focuses on competitiveness and productivity and the twentieth deals with the development of science and technology (Annex D). The policies set targets for the creation of a culture of competitiveness, promotion of technology transfer, founding of STI, enhancing the quality of research, improving training of human resources and development of national and regional programmes for the application of knowledge in the productive, social and environmental spheres.

The National Strategic Planning Centre (CEPLAN). is the governing body of the National Strategic Planning System and is responsible for managing and developing coordinated planning as a technical tool of government and public policy, directing and coordinating actions necessary to achieve the strategic objective of the integrated development of Peru. In March 2008, CEPLAN published a draft National Strategic Development Plan which draws

Table 1. Bodies which, by law, conform the SINACYT

Status	Acronym	Function	Body	Umbrella entity
Specialized Technical Body	CONCYTEC	Governing Body of SINACYT	National Council for Science Technology and Technological Innovation	Ministry of Education
	FONDECYT	National STI development fund	National Fund for Science Technology and Technological Innovation	CONCYTEC
	CONID	National advisory council for research and development in STI	National Advisory Council for Research and development in Science, Technology and Technological Innovation	CONCYTEC
Specialized Technical Body	INDECOPI	Management of intellectual property, defence of competition, standardization, accreditation and metrology	National Institute for the Defence of Competition and Protection of Intellectual Property	Presidency of the Council of Ministers
Executing Body	CONIDA	Research institute and governing body for aerospace activities in Peru	National Aerospace Research and Development Commission	Ministry of Defence
Executing Body	IGN	Research and technical advisory institute; standardization body for geographical and mapping activities;	National Geographical Institute	Ministry of Defence
Specialized Technical Body	IIAP	Research, advisory and technical and scientific support institute	Peruvian Amazon Research Institute	Ministry of the Environment
Specialized Technical Body	IMARPE	Advisory and research institute	Maritime Institute of Peru	Ministry of Production
Executing Body	IGP	Research and training institute; provision of scientific and technological services	Geophysical Institute of Peru	Ministry of the Environment
Specialized Technical Body	INGEMMET	Research institute and authority in matters within its competence	Geological, Mining and Metallurgical Institute	Ministry of Energy and Mines
Specialized Technical Body	INEI	Governing body of the statistical system of Peru	National Institute of Statistics and Information Technology	Presidency of the Council of Ministers
Executing Body	INIA	Institute of applied research and dissemination of technology	National Institute of Agrarian Innovation	Ministry of Agriculture
Executing Body	INS	Institute for research and dissemination of science and technology; proposes policies and standards in the health sphere	National Institute of Health	Ministry of Health
Executing Body	IPEN	Research and promotion institute; national standards authority for nuclear matters	Peruvian Nuclear Energy Institute	Ministry of Energy and Mines
Specialized Technical Body	ITP	Applied research and technical advisory institute	Institute of Fish Technology	Ministry of Production
Executing Body	SENAMHI	Institute for technical and scientific research, advice and dissemination	National Meteorological and Hydrological Service	Ministry of the Environment
Specialized Technical Body	SENASA	National official authority of Peru on agrarian health	National Agrarian Health Service	Ministry of Agriculture

Box 1. Description of the research institutes and other bodies that compose the SINACYT.

Peruvian Amazon Research Institute (IIAP). Reference and advisory centre on scientific knowledge of the Amazon region. It makes technical recommendations which facilitate the development of its people and sustainable use and conservation of biodiversity in Peruvian Amazonia. To fulfil its Amazon regional mandate, it focuses on problems and locations strategically selected for their potential impact and concludes agreements, contracts and strategic partnerships to extend and project its action throughout the national Amazonian region in coordination with global processes.

National Meteorological and Hydrological Service (SENAMHI). Provides public services, advice, scientific studies and research in the spheres of meteorology, hydrology, agro-meteorology and environmental matters. It participates in global atmospheric monitoring and provides specialized services to contribute to sustainable development, security and wellbeing of Peru.

Maritime Institute of Peru (IMARPE). Studies the marine environment and biodiversity, evaluates fish stocks and provides information and advice for decisions on fishing, fisheries and protection of the marine environment. It also strives to achieve excellence in research into the environment and marine resources, contributes to the sustainable development of fisheries and executes a programme of support for the integrated management of the coastal zone, including protection of the marine environment.

Institute of Fishing Technology (ITP). Contributes to better use of fish stocks, directing it towards development of products with higher added value and promotes improvements in health and hygiene in fishing and fish-farming. To that end, it promotes innovation aimed at making best use of marine fisheries and continental waters, the constant pursuit of higher added value to diversify exports, the use of under-exploited resources, development of human resources in science and technology and the exercise of health monitoring and control of the fishing industry in order to contribute comprehensively to improving the technological level of the Peruvian fishing industry.

National Agrarian Health Service (SENASA). Has the function of protecting and increasing the value of Peru's phytosanitary and zoosanitary heritage in a competitive and changing global environment in order to contribute to the country's food safety and quality, and the competitiveness of agro-exports. SENASA's chief strategic objectives are: (a) protection and improvement of the phytosanitary heritage; (b) protection and improvement of the zoosanitary heritage, (c) ensuring the quality of inputs used in agricultural and livestock farming; (d) guaranteeing organic production and contributing to a safe agro-food industry; and (e) ensuring consumer satisfaction and institutional sustainability.

National Institute of Agrarian Innovation (INIA). Has the mission of transforming itself into the sectoral agent responsible for developing a new approach to research, innovation, extension and transfer of technology. It will thus become the chief supplier of new technologies for the development of the country's native crops and an innovator of others where the versatility of ecosystems so allow, venturing into the development of tropical, Andean and coastal research.

National Institute of Health (INS). Executive agency of the Ministry of Health, dedicated to research into priority health problems and technological development. Its mandate is to improve the population's living standards by proposing policies and legislation, promoting, developing and disseminating scientific and technological research and providing services in the area of public health, control of transmissible and non-transmissible diseases, diet and nutrition, biological products, control of food quality, pharmaceutical and related products, occupational health, protection of the environment and intercultural health.

Geophysical Institute of Peru (IGP). Institution dedicated to scientific research in geophysics, both inland and in the surrounding ocean and atmosphere, with a view to prevent and mitigate natural disasters. It also provides training for university students and professionals through its research activities.

National Aerospace Research and Development Commission (CONIDA). A support agency of the Ministry of Defence whose objective is to facilitate and develop research and work concerning the country's advance into space for peaceful purposes. It proposes national legislation applicable to space and concludes cooperation agreements with similar institutions, including private, national or foreign, subject to the relevant legislation.

National Geographical Institute (IGN). Body responsible for implementing and regulating geographical and mapping activities in Peru for its development and defence. It is responsible for preparing and updating the national map. Its chief functions include: (a) systematically creating and maintaining the basic map on various scales; (b) development and updating of the country's basic geodesic map; (c) generation and maintenance of the geographical data archive; (d) promotion of scientific and technological research into the geographical and cartographical sciences; and (e) satisfying the information needs of map users through the cartographic information system.

Peruvian Nuclear Energy Institute (IPEN). Its fundamental mission is to regulate, promote, supervise and develop research into nuclear and related applications to improve Peru's competitiveness and living standards. It executes its promotion and applied research activities through projects of socioeconomic interest, in line with the country's needs, encouraging private sector participation through technology transfer. The IPEN is also the national authority for control of the application of activities relating to ionizing radiation.

(cont.)

Box 1. Description of the research institutes and other bodies that compose the SINACYT (cont.)

Geological, Mining and Metallurgical Institute (INGEMMET). Has as its basic mission to grant mining concessions, administer the national mining register and fees and penalties. It also investigates, processes, manages and disseminates geo-scientific information concerning the national territory so as to promote investment, support development planning and contribute to improving the living standards of the Peruvian people.

National Institute of Statistics and Information Technology (INEI). Produces and disseminates official statistical information, in an integrated, coordinated and rationalized form, based on common technical standards, in order to contribute to the design, monitoring and evaluation of government policies and decision-making by socioeconomic agents and the academic community.

its inspiration from the State policies and national objectives defined by the National Agreement. The draft National Strategic Development Plan includes policy guidelines on innovation and technology as well as strategic objectives and actions (Annex D).

The National Assembly of Rectors (ANR). This is an autonomous public body composed of rectors of public and private universities, as a body for the review, coordination and direction of the activities of Peru's universities. It has economic, regulatory and administrative autonomy.

3. Main policy instruments

3.a. Direct financing measures

Public research

This is carried out by the research institutions mentioned and briefly described above and also by the public universities. Government transfers for direct allocations are the principal STI financing mechanism in Peru. They are chiefly based on historic budgets with limited scope for negotiation by the respective bodies. There are special cases, such as INGEMMET, financed at the rate of 10% of the income from mining rights; IMARPE, financed by allocation of part of the income from fishing permits, concessions and other fishing revenues; and the IIAP, which receives 3% of the mining canon.

National Fund for Science Technology and Technological Innovation (FONDECYT)

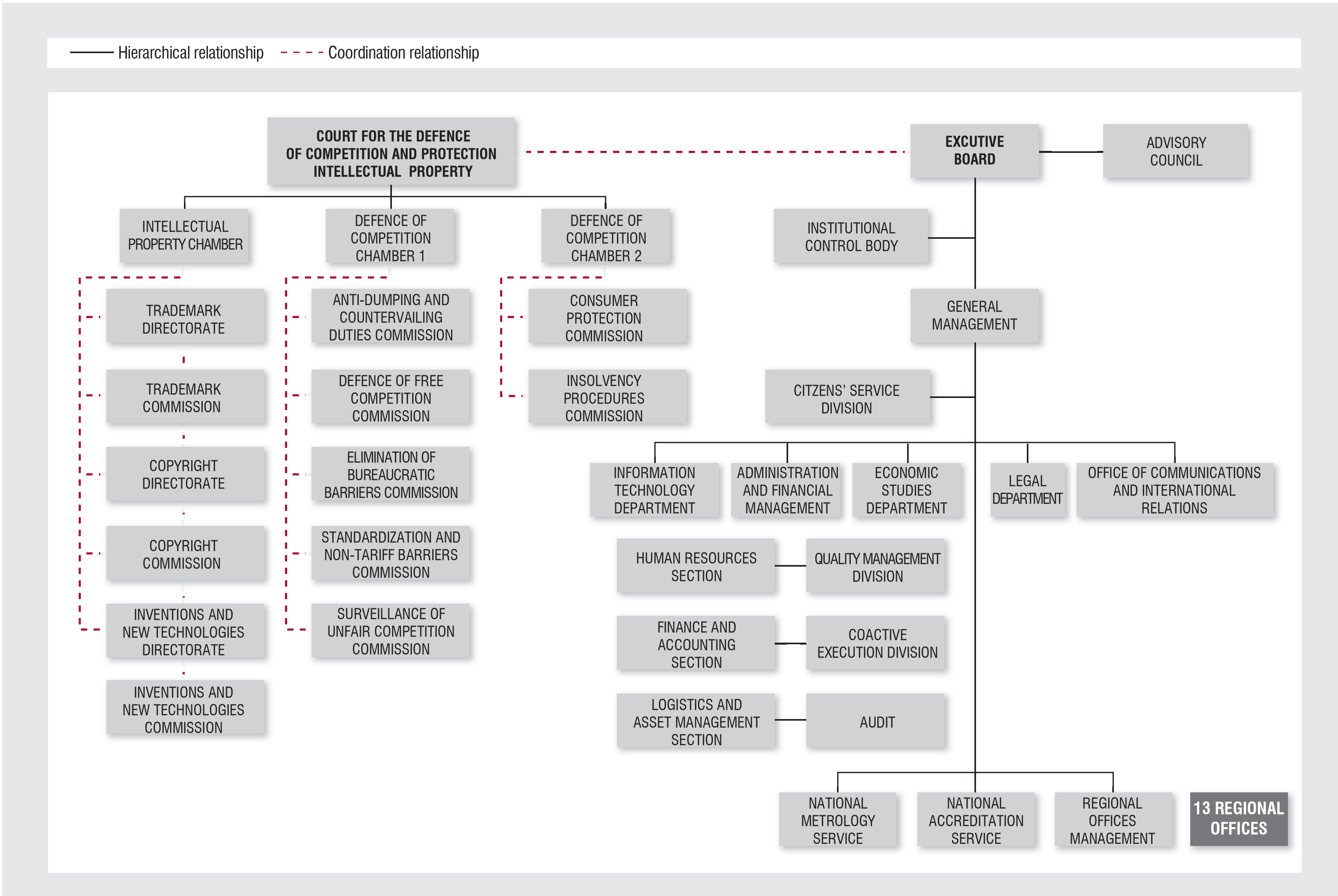
The Fund is the organ of CONCYTEC responsible for mobilizing, managing, administering and channelling domestic and foreign resources destined for SINACYT activities in Peru. Its activities are governed by a framework of priorities, criteria and policy guidelines established in the National Science and Technology Plan for Competitiveness and Human Development 2006-2021 (PNCTI). FONDECYT has a wide range of functions, notably:

- Assessing the economic/financial viability of STI projects.
- Intervening on the financing of regional STI programmes and projects.
- Concluding agreements on technological research and innovation studies and projects with regions and universities.
- Mobilizing funds to finance basic science projects.
- Coordinating with the Peruvian International Cooperation Agency to mobilize sources of financing from international technical cooperation aid.
- Awarding grants, subsidies and financing fellowships.
- Granting direct and indirect financing (i.e. guarantees).
- Administering funds whose purpose is compatible with CONCYTEC's aims.

It fulfils its functions through various programmes, among which the most important are:

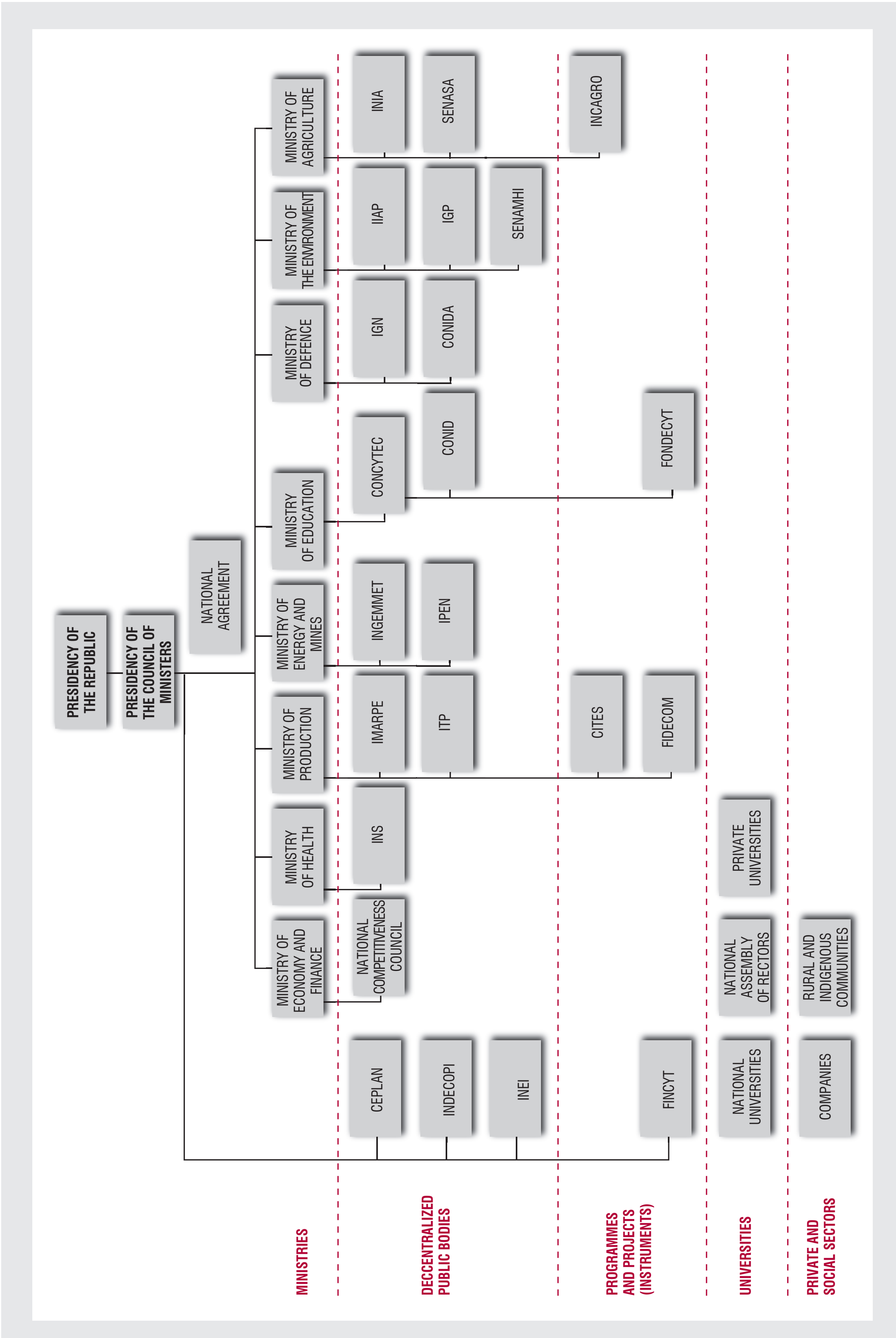
- Fellowship programmes in Peru and abroad;
- Science and Technology Research Projects (PROCYT). It finances basic and applied research projects in universities, companies and NGOs;
- Technological Innovation for Competitiveness Projects (PROCOM). It finances projects that necessarily involve partnerships between universities and companies;
- Technology Extension and Transfer Projects (PROTEC). This financing is subject to participation of a company, cooperative or NGO;
- The CONCYTEC Chair Programme, the object of which is to support the strengthening of regional research groups and promote the repatriation of Peruvian researchers and postgraduate students;
- Supporting the organization of and participation in national and international events;
- Financing of publications.

Figure 2. Organizational structure of INDECOPI



Source: INDECOPI.

Figure 3. Main bodies making up the SINACYT



Source: Own elaboration.

In 2010, FONDECYT disbursed some 2.2 million dollars. Table 2 shows the evolution and distribution of funds between 2008 and 2010.

Science and Technology Programme (FINCyT)

In 2006, the Government of Peru and the Inter-American Development Bank (IADB) signed a Loan Agreement No. 1663/OC-PE to create the Science and Technology Programme. In January 2007, its Governing Board was established and in July 2007 it received the first disbursement of funds from the IADB to launch the Programme. The resources consist of a credit of 25 million dollars from the IADB and 11 million dollars from the Peruvian Treasury. The Programme, which is executed by the Presidency of the Council of Ministers through the Programme Coordinating Unit, finances projects (see Table 3) which contribute to improving levels of competitiveness in the following ways:

- Generation of scientific and technological knowledge
- Promotion of innovation in companies and greater private sector participation
- Strengthening scientific research capacities
- Strengthening the national system of innovation.

For this purpose, the programme finances the following types of project:

- Technological innovation projects in companies
- Technological research and innovation projects in universities and research centres
- Strengthening of science and technology capacities with fellowships and internships
- Projects to strengthen and coordinate the national system of innovation.

Research and development for competitiveness fund (Innóvate Perú –FIDECOM)

This is a fund open to bids whose Executive Board is headed by the Ministry of Production. It has a budget of some 200 million soles (approximately 71 million dollars) and its aim is to co-finance projects to:

- Promote R&D in industrial innovation projects of practical use to companies,
- Develop and strengthen capacities for generation and application of technological know-how aimed at innovation and development of the productive and management capacities of workers and managers of microenterprises.

The fund assists companies, civil productive associations and formal microenterprises which link up with academic institutions to develop industrial innovation products and transfer of know-how for innovation and management. The support consists of co-financing up to 75% of the total project amount.

Programme for innovation and competitiveness in Peruvian agriculture (PIEA-INCAGRO)

This is a government investment programme of the Ministry of Agriculture and the National Institute of Agrarian Innovation created by the Peruvian Government through a loan agreement with the World Bank. It was launched in 2001 and was planned to be executed over a period of twelve years in three phases: implantation, expansion and consolidation.

Its objective is to contribute to the establishment of a modern STI system for the development of the

Table 2. FONDECYT: Investment in science, technology and innovation, in thousands of dollars, 2008-2010

	2008	2009	2010
Innovation projects with companies (PROCOM)	529	779	787
Technology transfer or extension projects with companies and other institutions (PROTEC)	50	139	90
Knowledge generating projects with universities (PROCYT)	281	300	265
Bilateral STI projects	40	95	95
National postgraduate fellowships	254	344	293
International postgraduate fellowships	34	80	65
CONCYTEC Chairs	66	226	413
Science & Technology publications	65	58	85
Support for events	159	174	101
Total	**1,479**	**2,195**	**2,194**

** Includes staff costs.*

Source: Provided by OPP–CONCYTEC, 28 May 2010.

Table 3. Cost and financing of the FINCYT, in thousands of dollars

Investment category	IDB source	Local source	Total	%
Component 1 Technological innovation projects	**9,300**	**1,500**	**10,800**	**30**
by individual companies	6,420	780	7,200	20
by groups of companies	2,880	720	3,600	10
Component 2 Technological research and development projects	**9,210**	**1,590**	**10,800**	**30**
Research in universities and research centres	6,310	690	7,000	19
Into technology transfer	1,440	360	1,800	5
Of national interest	1,460	540	2,000	6
Component 3 Capacity building and development	**4,900**	**860**	**5,760**	**16**
Fellowships for doctorate studies in Peru and abroad	2,160	...	2,160	6
Fellowships for masters' degrees and internships sponsored by companies	1,280	320	1,600	4
Strengthening of R&D capacities	1,460	540	2,000	6
Component 4 Strengthening and coordination of the national innovation system	**777**	**863**	**1,640**	**5**
Administration	500	2,800	3,300	9
Contingencies	113	...	113	...
Audit	200	...	200	1
Financial costs	...	3,387	3,387	9
Interest	...	3,278	3,278	9
Commission on loan	...	109	109	...
Total	**25,000**	**11,000**	**36,000**	**...**
%	**69**	**31**	**100**	**100**

Source: FINCYT, 2009 (http://www.fincyt.gob.pe/web/costoyfinanciamiento.html, downloaded in November 2009).

agrarian sector, driven by demand and led by the private sector, with the aim of increasing its profitability and competitiveness by generating and adopting sustainable and environmentally safe technologies. The programme is focussed on promoting and strengthening the provision of non-financial services for all the links of the value chain in the agrarian sector, including basic research and extension services.

In order to implement this approach, it uses funds open to bidding as its chief tool, aimed at two project lines, each with two pillars. The first concerns exploitation of opportunities by developing an efficient market in agrarian services (Agrarian Technology Fund) with two pillars: adaptive research and extension services. The second involves the generation of opportunities by institutional capacity building (Strategic Services Development Fund), with its two pillars: strategic investment and capacity building of extension service providers. During the first two stages (2001-2004 and 2005-2009), INCAGRO financed 610 projects representing a commitment of over 44 million dollars.

Postgraduate fellowships

These are essentially granted through FONDECYT and FINCYT (see Tables 3 and 4).

CONCYTEC Chairs

The CONCYTEC Chairs represent an instrument that seeks to achieve various objectives, notable among them the creation of centres of excellence in the regions of Peru, attracting human capital from abroad, supporting companies through applied research which can be translated into innovation and advanced education in areas of priority to the regions. Like similar mechanisms used internationally, the CONCYTEC Chairs represent a quality mark for postgraduate or university research groups. They are funded by FONDECYT, regional governments, companies and international cooperation. There are currently five Chairs: information and communications technology for software development in the National University of San Agustin de Arequipa, with the Arequipa Region CORCYTEC and various companies; tropical aquaculture in the National University of Peruvian Amazonia, with the Loreto Regional Government, the IIAP and companies in the region; animal biotechnology in the Peruvian Cayetano Heredia University, with the company Hersil S.A.; nanomaterials in the National Engineering University with the participation of the company Hipertemia Control SAC; and automation, control and optimization of industrial processes in the University of Piura (three of these are described in detail in chapters III, IV and V). In addition, it is planned in 2010 to inaugurate the Chair of environmental chemistry in the Catholic University of Santa Maria de Arequipa.

Support for scientific infrastructure

One of the mechanisms used in Peru to contribute to the improvement of the research infrastructure consists of earmarking a proportion of the mining canon (percentage of royalties from the exploitation of natural resources) to investment projects to strengthen the research capacities of the regional universities. The priority areas by law are those related to public health and prevention of endemic diseases, plant and animal health, preservation of biodiversity and the ecosystem in geographical areas affected by mining. According to data provided by CONCYTEC, the resources transferred to public universities in 2008 for investment in scientific and technological research amounted to some 85 million dollars.

3.b. Indirect regulatory measures

Intellectual property

The body responsible for the management and supervision of intellectual property is INDECOPI, briefly described above in section 1.2 and in detail below in 2.3.c.

Quality system

The body responsible for the quality management system is INDECOPI, briefly described above in section 1.2 and in detail below in 2.3.c.

3.c. Catalytic financial measures

Development finance corporation (COFIDE)

COFIDE is a company under mixed ownership which possesses administrative, economic and financial autonomy. It is 98.7% state-owned, through the National Fund for Financing State Enterprises (FONAFE) under the Ministry of Economy and Finance, and 1.3% by the Andean Development Corporation (CAF). It forms part of the national financial system and can carry out all financial intermediation and similar activities allowed by legislation and its statutes.

Its mission is to promote the sustainable development of Peru's economic agents by financing investment and developing the financial and capital markets. Since 1992, it has acted as a second-tier development bank, channelling resources which it manages

Table 4. STI fellowships financed by FONDECYT, 2005–2009

		Number of fellowships	Total amount (thousands of dollars)
Postgraduate fellowships in Peruvian universities	Masters	142	2,031
	Doctorate	41	733
Postgraduate fellowships for CONCYTEC Chairs	Masters	10	143
	Doctorate	6	107
International fellowships for advanced studies	...	42	170

Source: CONCYTEC.

Table 5. Key financial indicators of COFIDE at 31 December 2009

	Millions of dollars		%
Assets	1,679	Return on capital	3.04
Total portfolio balance	886	Return on assets	1.14
Gross investments	763	Bad debts/gross investments	0.47
Accounts receivable + Off balance sheet 1/	122	Operating costs/average total assets	0.86
Liabilities	1,044		
Capital	635		
Net profit	18.6		

1/ Includes guarantees and portfolio transferred to off-balance sheet
Source: COFIDE http://www.cofide.com.pe/finan.html, downloaded in August 2010.

solely through institutions supervised by the Superintendency of Banks, Insurance and Private Pension Funds (SBS). This operating format allows it to complement the work of the private financial sector in activities such as medium and long-term financing of the export sector and micro and small enterprises. COFIDE mobilizes resources which come essentially from international organizations, international commercial banks and the local capital market. COFIDE's key financial indicators are shown in Table 5.

Its principal programmes and investment lines are: the multisectoral investment programmes, the MSME programme, the mortgage programme, the technological training and development programme, the working capital line and the foreign trade line. It also acts as trustee and depository, administers the Treasury Bond programme and is responsible for placement and management of bonds for the agriculture and livestock recovery programme and strengthening the capital of companies. One of COFIDE's current limitations is that, although it contributes to small company start-ups by managing relations to work with incubators, the loans are offered at high rates of interest.

3.d. Combined or mixed measures

Regional STI councils

The regional STI councils are a decentralization mechanism of CONCYTEC whose function is to promote generation of knowledge (through scientific and technological research) among the various economic and social agents in the regions, to stimulate the country's competitiveness and improve living standards. They are organs of the regional government composed of representatives of the government itself, sectoral R&D institutes, universities, companies and civil society (professional bodies, NGOs), to create a consensus to empower the regions in matters of STI. Notable among their functions are:

- Putting forward STI policies in the regional framework.
- Formulating regional STI agendas.
- Promoting sources of financing for scientific research, experimental development and innovation. This has allow regional institutions to obtain some 50% of the FONDECYT's competitive funding and other sources of national and international financing for research, development and innovation projects which were previously concentrated in Lima.

The councils, 20 by November 2009, have been working closely with CONCYTEC. Their efforts in promoting and organizing actions which complement other instruments managed by CONCYTEC such as the Chairs, channelling of funds for innovation, training, STI meetings and promotion technology parks should be especially highlighted.

Technological innovation centres (CITEs)

These centres are an instrument for the support of innovation and technology transfer promoted and supervised by the Ministry of Production through the Vice-Ministry of MSME and Industry[7]. Their creation is contemplated in Act No. 27267 which promotes the creation of new CITEs, public and private, which provide technological services to companies. The CITEs are technological partners of the companies which it puts in contact with the public, academic and business sector, in order to facilitate and foster change, quality, product differentiation and greater efficiency in companies, primarily SMEs.

The CITEs provide training, technical assistance, information, improvement of productivity, quality control, aided design, finished and intermediate goods and environmental management services. They operate nationally, concentrating on demand from different regions of the country where there is a significant presence of companies in the productive chains served by each centre: agroindustry, wood and furniture, footwear, textiles and clothing as well as logistics and software. The centres operate in a network and rely on international technical cooperation. Up to 2009, there were 14 accredited CITEs in operation, 3 public and 11 private, in Lima, Ica, Arequipa, Tacna, Ucayali, Loreto and Piura. CITEs are highly concentrated in Lima, although there is also a concern to achieve a balanced geographical coverage that reflects the distribution of the country's economic activities.

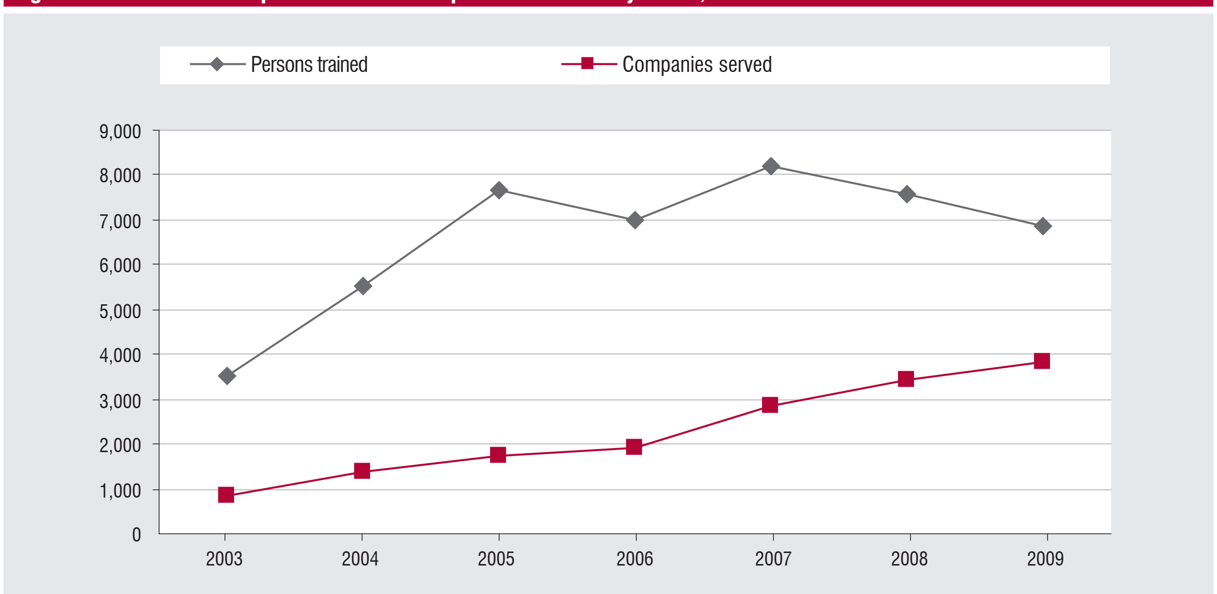
In 2009, CITEs served 3,823 companies and trained 6,872 people (Figure 4). The services provided by the CITEs grew by 10% in 2009 compared with 2008, following stagnation in the previous years. Prominent is the variation between the services provided to different sectors. While agroindustry grew strongly, the reverse occurred in the leather and footwear and textiles and clothing sectors, while the wood sector fluctuated strongly. There was also strong growth (albeit from a very low base) in logistical services (Figure 5).

The CITEs' approach is based on good practices as the problem of SMEs and technological innovation is addressed in a holistic manner, by placing it in its sectoral/regional context.

Nevertheless, the public aim of the CITEs implies two significant challenges. The first is how to respond to a highly heterogeneous group of companies with major structural weaknesses with respect to innovation[8]. The unavoidable choice of the companies to which the types of services provided by the CITEs (e.g. basic or more specialized) are addressed has to be based on a flexible approach which reflects demand and which ensures that the services provided complement each other and that promotes the development by other bodies of more advanced/specialized services or, alternatively, more basic. Secondly, both the public and private CITEs require public financing to expand their objectives. Without such support, these centres would only offer consultancy and training services and would have relatively little impact on the companies' competitiveness. The incorporation and maintenance of R&D activities requires inputs of public funding, as shown not only by the Peruvian case but also international experience[9].

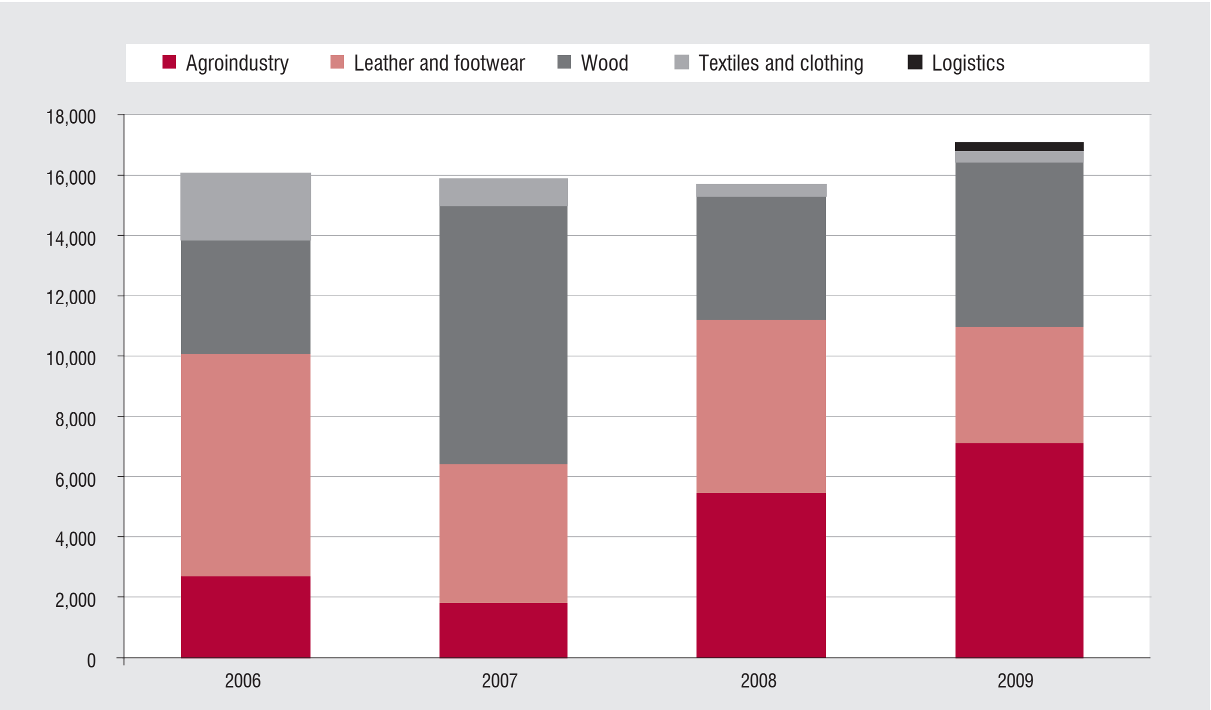
Strengthening the CITE network and the Technical Office of Technology Innovation Centres, over and above the capacity of individual CITEs, is also important in achieving network effects, capitalizing experience and absorbing and rapidly spreading knowledge.

Figure 4. Number of companies served and persons trained by CITEs, 2003-2009



Source: CITE (2010).

Figure 5. Technological services provided by CITEs, 2006-2009



Source: CITE (2010).

Lastly, public procurement requirements, especially for acquisition of equipment and recruiting of staff, are frequently a major brake on CITE activities. This highlights the need to consider adjustments to the system of public contracting and purchasing or to the legal personality of CITEs.

B. ANALYSIS OF THE NATIONAL SCIENCE, TECHNOLOGY AND INNOVATION SYSTEM

1. Introduction and methodology

Many traditional proposals and approaches[10] relating to National Innovations Systems (NIS) suffer from certain limitations which make them difficult to transpose directly to developing countries (see Annex A). It is particularly important to mention its limitations as an approach to address the hierarchical structure of systems, and its inability to identify and locate precisely the two dimensions which operate at different levels of the hierarchy: the productive and innovation system as such and the system of policies drawn up and implemented to promote the former.

It flows from this that in the majority of developing countries, the notion of national innovation systems can be generally used as an analytical framework which assumes the need for articulation or interaction between economic agents, essentially between producers and users of knowledge and institutions. However, this notion does not provide the elements needed to deal with these agents in a systematic way. It does not explain how they emerge and are organized hierarchically to form increasingly complex systems. Consequently, the studies carried out within this framework often merely content themselves with a description of supposed subsystems whose interaction constitutes a national innovation system. However, they do not provide details which would make it possible to evaluate whether in fact these agents actually do form such subsystems, e.g. a sufficiently mature and developed industrial or research subsystem.

In other words, such subsystems are generally taken as given and it is only necessary to consider the development of institutions, organisms, policy instruments, etc. which foster the interrelation of these subsystems. In countries where these subsystems do not exist or are in the process of maturing, the results provided by this approach are of less use.

For this reason, we will carry out this analysis using the systems approach as a means of complementing the national innovation systems approach, enhancing the capacity to understand the processes of designing policies which influence innovation. For the sake of brevity and simplicity, we will only list the fundamental assumptions of this approach:

- The use of the concept of systems does not claim to determine absolute facts but simply to establish a set of conventions which are more or less useful for the purposes of the analysis.
- The approach to be adopted corresponds to that of the policy analyst who observes economic activities and is interested in influencing certain components and processes of the economy to achieve specific goals.
- The activities involved in policy design are a subset of the reality which interacts with another subset which consists of economic/productive processes.
- In order to interact, simplified representations or models of these processes are used as a way of reducing the complexity of the observed reality.

In this way, STI policies and their interaction with part of the economic system can be interpreted as forming part of a system which, to be sustainable[12], must perform two basic functions: immediate and long-term response to surrounding events. These are carried out by the two subsystems: the executive system (productive and innovation as such) and the policy system which operate in different hierarchical dimensions. They then, in turn, perform five local sub-functions: production, regulation, control, foresight and cohesion (see Table 6)[13].

The first sub-function refers to the production of what the system regards as its purpose and which, at the same time, allows it to exist – in this case generation of knowledge and its exploitation for the benefit of society. As there can be various entities responsible for producing it, the second function is responsible for regulating or coordinating them. The third function controls the flow of resources, monitors performance and makes any corrections necessary to ensure that the system meets its objectives. The fourth function concerns the vision of the future and determination of strategies, while the fifth sets management policies which ensure the cohesion of the system.

2. Production function

2.a. Infrastructure

There are two major themes under this heading: the general infrastructure which impacts directly on economic/productive and commercial activities, and the infrastructure which impacts on specific R&D and innovation activities. With regard to the first, it has already been mentioned in Chapter I that Peru's physical infrastructure, i.e. roads, ports, airports, urban sanitation, energy and communications, lags far behind, which limits its economic and productive development.[14]

With regard to R&D and innovation infrastructure, although Peru has an extensive network of research bodies spread among its public institutions and universities as well as the major private universities, there is still room for improving their physical resources and equipment and the establishment and for consolidating other basic R&D and innovation requirements. This would allow the country to improve its competitive position in this area significantly.[15] Three weaknesses stand out:

(1) The infrastructure of incubators and technology parks in Peru is very weak and embryonic.

With respect to incubators, there are a few initiatives by universities such as the Innovation and Development Centre of the Pontifical Catholic University of Peru (CIDE-PUCP)[16] or the Centre for Entrepreneurial Studies of the Graduate School of Business (ESAN), although there have not so far been any noteworthy results in terms of the creation of dynamic technology-based companies. PERUINCUBA, formed in 2006 by 18 organizations which promote entrepreneurship, endeavoured to create technology-based companies (as a result of concerns raised by CONCYTEC). The experiment showed a clear lack of participants as well as a lack of links with research institutions and difficulties in promoting research on related subjects.

At present, there are no technology parks in Peru. There are a few initiatives at the design/development stage, among them the Scientific-Ecological Academic Complex developed by Cayetano Heredia University and the technology park proposed by the Arequipa Regional Government.

Developing a technology park requires a fulfilment of a set of conditions: political conviction at the highest level; availability of funding and a regulatory frame-

Table 6. Functions and dimensions of sustainable systems

Basic function	Local function	Recursive dimension
Immediate response	Production	Executing system
Immediate and long-term response	Regulation	Link between both systems
Immediate and long-term response	Control	Link between both systems
Long-term response	Foresight	Policy system
Long-term response	Cohesion	Policy system

work promoting entrepreneurship and the incubation of technology-based enterprises (not only for infrastructure but also for R&D, innovation, entrepreneurship and incubation activities); a significant core of R&D and innovation capacities; infrastructure; keen interest from the private sector in participating and manifest interest in and conditions for collaboration, innovation and entrepreneurship.

The conversations held with experts and the available information suggest that some of these conditions (e.g. private sector involvement or availability of funding for R&D, innovation and incubation activities) are not addressed in current proposals for technology parks.

(2) The equipment of research laboratories is inadequate.

Various reports[17] point out the need to update the scientific equipment in research laboratories. Problems of equipment could, at least in part, be alleviated through greater cooperation between public universities and technological institutions carrying out research in common subjects, sharing infrastructure, staff (e.g. participation of postgraduate students) and access to scientific publications.

(3) Deficiencies in equipment related to a quality system.

It should be pointed out, for example, that there is a shortage of internationally recognized laboratories and an insufficiently developed metrology service to satisfy demand. There is no national quality system at present and there are ample opportunities to develop close collaboration to optimize the use of available resources.

In this regard, the new studies currently in progress on research institutions and the national quality system will be extremely useful, as they will allow an up-to-date evaluation of institutions and laboratories and identify gaps, overlaps and potential areas of collaboration.

2.b. Companies[18]

Companies constitute the focus and driving force of innovation systems, as they are precisely the ones who initiate the processes of innovation, coordinate their development and complete them by placing their products, services and processes in the market. As seen above in Chapter I, productive activities are concentrated chiefly in: services with a low technology content, extractive industries, agriculture and manufacturing with a low technology content. In the case of the manufacturing industry, there is also a very high percentage of microenterprises (96.4%).[19]

STI activities in general are characterized by low investment in R&D, which indirectly leads to a very low level of innovative activity (see Chapter I and Figure 6)[20]. The structure and composition of the innovative activities mentioned in the previous paragraph also imply a lack of demand for technology and productive knowhow in general. On the one hand, micro and small enterprises have difficulty in identifying their technology needs, or even knowing what technology can do for their companies. On the other, there is no tradition of processing and adding value to the products of extractive industries and agriculture. This naturally leads to scant collaboration with public or private knowledge generating institutions.

The study of the sector through interviews with heads of business associations and chambers of commerce and various companies of different sizes and sectors confirmed the lack of inclination to innovate, due in part to ignorance, lack of disposition and opportunities to take risks and the lack of financing instruments in the market. A passive attitude was also detected, chiefly in micro, small and medium-sized enterprises[21], which expects the State and the knowledge generating institutions to assume the bulk of the financing and risk of research activities.

In a nutshell, based on the aspects reiterated in the interviews, there are two key factors which must be promoted to improve the competitiveness of companies: better education and cultural change. The first applies to all levels of education and steering a greater number of university students to scientific and technological disciplines. The second factor means valuing the potential of scientific and technological knowledge for companies and businesses, and, the necessary entrepreneurship to, once technological and business opportunities have been identified, take risks to implement innovative processes and bring them to the market.

2.c. Financing through the market

In the section on policy instruments, the Development Finance Corporation and its function as a development bank, which has limited operating scope has already been mentioned. In addition, some new institutions are beginning to emerge, such as Fundación Perú, a private entity dedicated to promoting the creation and development of innovative companies and InvertirPerú, a network of investment angels which seeks to promote investment and enterprise-academia-public partnerships to support innovation and new undertakings. However, these agents are too young to be able to evaluate their performance and results.

At the present time, Peru has a low level of performance in the development of financing (see Figure 6 – sophistication of the financial market, and Figure 7). It confirms what was mentioned above based on private sector perceptions of the lack of credit for innovation, especially venture capital.

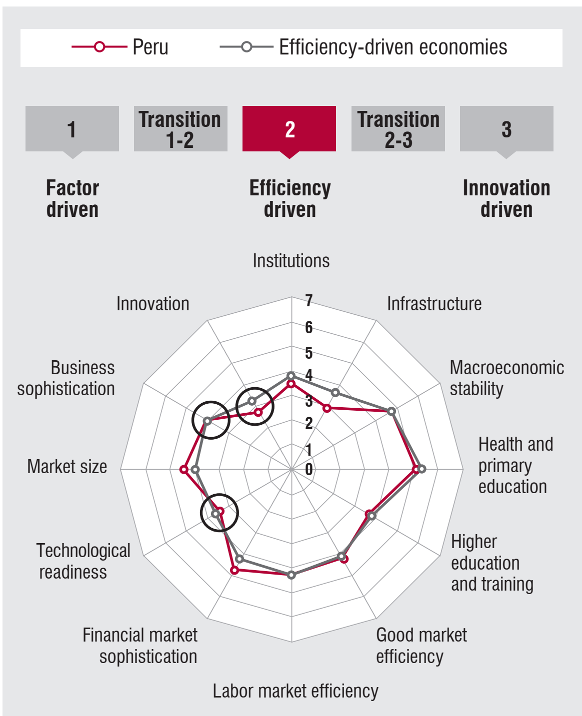
2.d. Knowledge disseminating organisations

The details of the Peruvian education system were described in Chapter I. It should be recalled that public expenditure on education is low, both in relation to GDP and per pupil (UIS 2010). In addition, although there are indications of positive changes concerning educational coverage, student performance levels, as demonstrated in various international examinations, are the lowest in Latin America.

From the standpoint of the contribution of education to the system of innovation, one of the principal problems is the deficient training at primary and secondary level in areas of knowledge which would allow training in scientific and technological disciplines at tertiary level. This is due, according to the interviews, to various factors, among them: (i) regulatory aspects concerning the privatization of education which hinder quality control of educational institutions;[22] (ii) the political and commercial influences on educational provision; (iii) the lack of training of teachers in areas of STI; (iv) the lack of adequate infrastructure and equipment to impart that knowledge; (v) lack of indicators to evaluate performance in STI-related subjects; and (vi) lack of links with the scientific community itself.

With regard to the university sector in particular, Peru has 102 universities (ANR 2010), of which it is considered that less than 5% have adequate standards of teaching and research[23]. This can in large measure be attributed to existing legislation which allows the free creation of private, independent and not-for-profit universities without proper control of minimum standards or subsequent monitoring and evaluation.[24] Peruvian universities are governed and coordinated by an independent public body, the National Assembly of Rectors (ANR), but its operation and functioning is called into question by the country's principal universities which rarely participate in meetings of the Assembly.

Figure 6. Competitiveness in technological capacity and innovation



Source: Schwab, 2009.

In addition to problems of quality and regulation, there are problems of financing, appropriate systematic information, and other regulatory problems which limit recruitment of staff or flexible use of funds from the mining canon, as well as the lack of orientation towards scientific and technological disciplines mentioned above. The latter phenomenon, which was one of the subjects reiterated in various interviews, and not only with representatives of universities, is not exclusive to Peru, but to Latin America as a whole[25].

In short, Peru faces a systemic problem in education which generates a vicious circle that limits scientific and technological training. On the one hand, a good part of education has been left to market forces and, on the other, the private sector, given its characteristics, is not capable of identifying its scientific and technological needs and thus does not provide opportunities for career development in these specialist fields. As a result, the provision of university courses is leaning increasingly towards the social sciences and there are no real incentives to increase enrolment in natural sciences, medicine, technology and engineering, nor to promote better training of teachers in these fields.

2.e. Knowledge generating organisations

As indicated above, knowledge generation activities through private R&D laboratories are virtually non-existent, but are concentrated in public research institutes and bodies and the universities. The former, with a few exceptions, are of recent creation (some 40 or 50 years) and have suffered from organizational and funding upheavals since the seventies (Sagasti 2003). The most important are listed in Table 1.

Currently, public research institutes are facing a number of problems, including lack of finance, ageing of their research teams (who in many cases were trained on the job rather than in formal postgraduate studies[26]) combined with administrative obstacles to their renewal, scant collaboration between research bodies and lack of formal recognition of researchers. Nevertheless, some of them make good use of international collaboration, both in filling gaps in human resources and financing, and provide very considerable support to some of the country's basic productive activities and the health sector.

University research activities are conducted under even more difficult conditions, due to problems similar to those faced by public research institutes, the precarious organizational and quality control situation of higher education in Peru and, above all, the lack of a clear distinction between the primary functions of universities. The lack of career opportunities in research in the university sector (combined with the same situation in the productive sector) has also led to a brain drain hard to reverse. For this reason, according to the interviews, less than 5% of Peruvian universities carry out quality research, with standards still far from being competitive internationally and concentrated in only a very few areas of scientific and technological knowledge (see Annex C).

Despite the obstacles, the universities with the greatest capacity for research are fully involved in international cooperation, both in scientific and financing questions. They also engage in significant activities in conjunction with the productive sector, although these are highly skewed towards technology. These universities have formed the RDI network (research, development and innovation), a civil not-for-profit association aimed at collaboration with the private sector.[27]

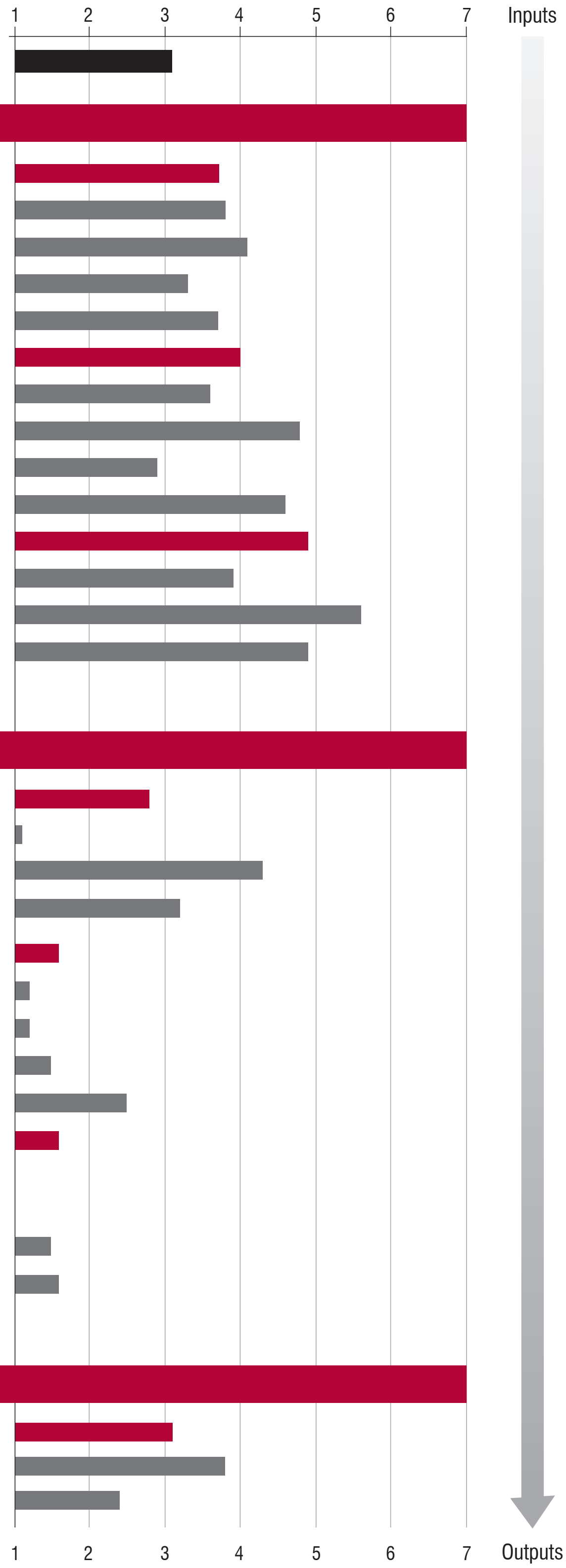
With respect to the scientific output, orientation, quality and productivity of the knowledge-generating bodies, a bibliometric study carried out for this review,[28] while it shows broad international cooperation, it also reveals a degree of scientific dependency, as the output of scientific articles is low and irregular and its fluctuations reflect changes in the output of research partners (see Annex C).

As regards the orientation and trends of research, the study showed six significant categories: health (with interactions with various areas), plant sciences, environmental sciences, physics, food science and technology and surgery (also part of the health area). With respect to the quality of Peruvian research, the areas with the best results are general and internal medicine, multidisciplinary physics and intensive medical care. Immunology, infectious diseases and microbiology should also be highlighted as having high output and good quality standards.

However, the greatest strengths of research in Peru (based on the quality of publications where the primary author lives in Peru) are found in meteorology and atmospheric sciences, operations and administrative science research, oceanography and nuclear medicine and radiology. In addition, general and internal medicine and astronomy and astrophysics show a high scientific output and quality standards.

Figure 7. Financial Development Index, 2009

	Rank (out of 55)	Score (1 - 7 scale)
2009 INDEX	**42**	**3.1**
FACTORS, POLICIES, AND INSTITUTIONS		
1ST PILLAR: INSTITUTIONAL ENVIRONMENT	**40**	**3.7**
Financial sector liberalization	34	3.8
Corporate governance	44	4.1
Legal and regulatory issues	41	3.3
Contract enforcement	44	3.7
2ND PILLAR: BUSINESS ENVIRONMENT	**42**	**4.0**
Human capital	47	3.6
Taxes	25	4.8
Infrastructure	49	2.9
Cost of doing business	42	4.6
3RD PILLAR: FINANCIAL STABILITY	**22**	**4.9**
Currency stability	38	3.9
Banking system stability	15	5.6
Risk of sovereign debt crisis	29	4.9
FINANCIAL INTERMEDIATION		
4TH PILLAR: BANKING FINANCIAL SERVICES	**43**	**2.8**
Size index	53	1.1
Efficiency index	42	4.3
Financial information disclosure	21	3.2
5TH PILLAR: NON-BANKING FINANCIAL SERVICES	**45**	**1.6**
IPO activity	47	1.2
M&A activity	47	1.2
Insurance	50	1.5
Securitization	23	2.5
6TH PILLAR: FINANCIAL MARKETS	**50**	**1.4**
Foreign exchange markets	42	1.0
Derivatives markets	n/a	n/a
Equity market development	46	1.5
Bond market development	38	1.6
FINANCIAL ACCESS		
7TH PILLAR: FINANCIAL ACCESS	**35**	**3.1**
Commercial access	32	3.8
Retail access	37	2.4



Source: WEF (2009).

Finally, Peruvian scientific output, measured in relation to per capita GDP, is among the lowest in Latin America and is considerably below that of its principal research partners (see Figure A.12 in Annex C).

3. Regulatory function

3.a. General situation

The regulatory-institutional framework in general represents one of the links or sub-systems in which considerable progress is needed to assure the functioning of the innovation system as a whole. It has already been mentioned that Peru has a profoundly legalistic tradition, which can largely be attributed to the fact that the legal and regulatory framework as a whole is based on distrust.[29] This gives rise to a series of bureaucratic shackles and procedures for all kinds of transactions which has a significant effect on the articulation and performance of the innovation system.

Furthermore, despite its dimensions, the legislative framework is both ineffective and, to some extent, contradictory. With regard to its ineffectiveness, this was abundantly clear in the opinions collected in interviews conducted during the mission, the literature on the Peruvian system of innovation[30] and various international studies[31].

As regards its contradictions, we have, on the one hand, the assertion and discursive-legal commitment to promotion of competitiveness and innovation, from the Constitution of the Republic and the Framework Act on STI to the policies of the National Agreement concerning competitiveness, national policies binding on national government agencies (see Annex D) and guidelines of the National Competitiveness Plan. On the other, we have a minimal actual allocation of resources for R&D at national level (see Chapter I); duplication of institutions and functions – National Agreement, National Competitiveness Council and CEPLAN for planning, FINCYT, FONDECYT and FIDECOM for financing as well as problems of hierarchical position of key institutions (CONCYTEC, for example); the total lack of control of the quality of education and research; and the various legal obstacles to the use of scarce economic resources – including barriers to the importing and even donation of research equipment, restrictions on the recruitment of researchers or improvement of the remuneration of existing staff combined with a lack of recognition of the research function. This combination of problems significantly limits the possibilities of collecting information, monitoring, evaluating and providing incentives associated with STI activities.

In short, there is an excess of regulation which is both unenforceable and ineffective, which hampers the training of quality human resources, the integration of a critical mass of research in strategic areas, collaboration between science and industry and the development of an entrepreneurial culture. All this has a negative impact on the performance of the production sub-system or function of the innovation system and limits Peru's transition from a country whose competitiveness is based on efficiency to one based on innovation.[32]

A final word on this subject concerns the myths around the national systems of innovation approach and the legislation of science and technology. As regards the former, without underestimating the positive aspects and achievements of this approach in some developed and emerging countries, as mentioned before, it has limitations when applied indiscriminately to developing countries, especially those whose industrial and research systems are not sufficiently developed. We have also indicated the confusion between the analytical and regulatory dimensions of this approach, i.e. the model or representation of real economic-productive activities and the system of policies to influence them in a positive way. Failure to understand these factors may lead to wrong decisions and mere political rhetoric.

With respect to laws on these subjects, it is uncommon (at least in the developed countries) to raise aspects concerning the promotion of STI to the rank of laws. The normal practice is to encourage such activities through government policies and well-designed programmes with achievable and measurable targets. However, some Latin American countries have opted for the legislative route and although we do not have any studies on this approach, experience suggests that its value is limited.[33]

The case of Peru is an example of the latter situation. The Framework Act on STI is confined to establishing a structure and even decrees the creation of a national system of innovation. However, as well as the conceptual difficulties on system approaches to innovation and other defects which have been pointed out by Juana Kuramoto[34], these structures are not provided with resources nor capacity for execution. At the end of the day, they are a modern version of the failed structures created in Latin America towards the end of the seventies (i.e. national science and technology councils or similar bodies) which for 40 years, with rare exceptions, failed to develop science and technology and were unable to take advantage of its potential impact in Latin America.[35]

3.b. The difficult task of CONCYTEC

Throughout its history, CONCYTEC has faced diverse attitudes and views of governments on the role and importance of science, technology and, more recently, innovation. These changes in perspective, whose only constant feature, perhaps, has been the meagre budget allocated to its activities (see Figure 8), have led to the institution having to change its position within the hierarchy of government and has impeded its work in different ways.

As described in the foregoing chapters and sections, the institution has had to deal with the following problems in recent years: (a) a hazy vision of the function and usefulness of the framework of national innovation systems, on occasions on the part of CONCYTEC itself [36]; (b) an excessively low budget to carry out its functions (Table 2, Figures 8 and 9), which does not comply with the provisions of Act No. 28613 related to CONCYTEC; (c) the change within the hierarchy of government by which it became subordinate to the Ministry of Education, which has made it very difficult for it to carry out its function of supervising the SINACYT; and (d) the structural weakness of other subsystems crucial to the development of STI activities, especially the education and industry subsystems.

Despite these limitations, CONCYTEC's work under the following headings is to be commended: (a) promotion of decentralization of STI functions and activities through the creation of regional councils (20 to date); (b) the creation of centres of excellence through the CONCYTEC Chairs (described above); (c) funding for training of human resources and various types of innovation projects through FONDECYT (described above); and (d) fostering of a culture of innovation through various mechanisms such as national STI fairs in schools (FENCYT), support for the organization of national and international events and participation in them, and elaboration of publications for dissemination.

3.c. The special case of INDECOPI

The Institute for the Defence of Competition and Protection of Intellectual Property (INDECOPI) is a key institution in the regulation of the innovation system, as it combines aspects of free competition and market access, protection of intellectual property and standardization and metrology. Although, in the course of its history, the institution has played an important role in the modernization of Peru with regard to the first aspect, representing a "powerful force for reform within Peru and one of developing world's most articulate competition advocates"[37], the same cannot be said of its other two basic functions.

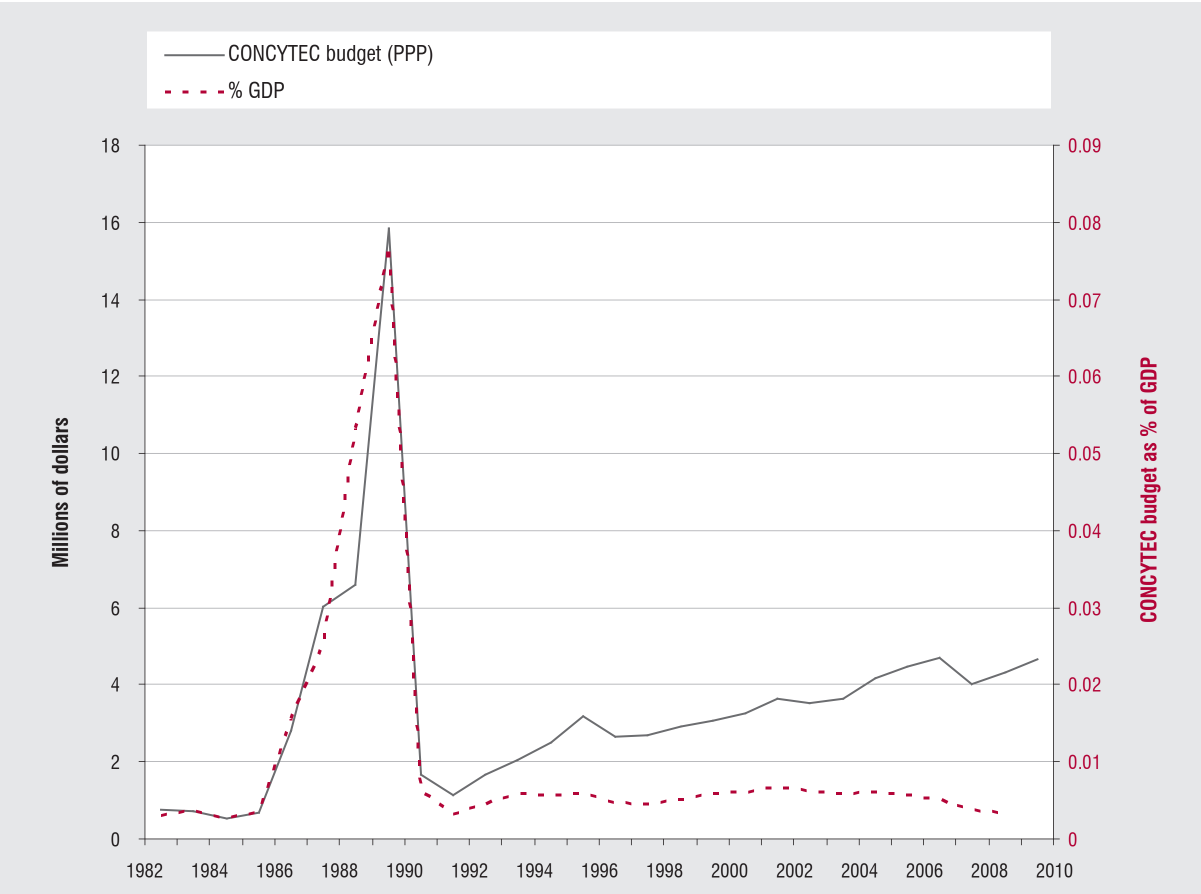
Although the cited OECD/IBD study recognizes that the scope of INDECOPI's mandate has favoured its function as an agency to promote competitive markets in the broad sense, it also indicates that some important aspects of policy on defence of competition remained marginal to the institution's capacity for action and that it had also been ineffective in the elaboration of policies.[38] Similarly, it warns of problems relating to the institution's autonomy as an independent and impartial arbitrator in competition matters, as well as problems derived from its financing.[39]

The interviews with staff in the area responsible for the protection of intellectual property (IP) and with members of the productive, academic and research sectors, show that the IP field still has major shortcomings.[40]

The legal aspects are appropriate and modern, and consistent with the legislation of the Andean Community and have recently incorporated the Patent Cooperation Treaty (PCT). However, INDECOPI has failed in spreading the culture of intellectual property and in providing training and developing capacities in this area. The latter not only with regard to protection, but also the enormous capacity offered by patents as sources of information and as support for innovation and technological development.

The foregoing is reflected in the lack of awareness regarding various aspects of protection and general information which was detected in the private and research sectors which, to a large extent, are responsible for Peru's poor performance in patenting (see Chapter I). The fact is that even if the rate of patent applications increases, performance under this heading will continue to be weak due to the institution's current limited capacity to undertake the formalities and procedures.

Figure 8. Evolution of CONCYTEC's budget, in millions of dollars and as a percentage of GDP, 1982–2009



Source: Own preparation from information provided by CONCYTEC and World Bank data.

There are also shortcomings regarding INDECOPI's services related to the construction of a quality system (metrology, standardization and certification),[41] essentially relating to equipment and specialists, whether in the institution itself or the external laboratories to which it channels much of the demand for services. This lack of capacity hampers the activities of export-oriented companies, chiefly those that are knowledge-based, as their products require highly demanding international certification which INDECOPI cannot provide.

In conclusion, it is observed that the range of functions covered by INDECOPI is excessively broad, as it concentrates within it much of the regulation of the innovation system which in many other countries is covered by separate specialized agencies for each heading. It is no exaggeration to suggest that the poor performance in several of the areas within its competence is due precisely to this high concentration of functions.

4. Management and financing function

It has already been mentioned in the above sections that there is a dispersion and duplication of functions in several areas of STI promotion. The question of the management of incentive policies is not immune from this reality. As can be inferred from the above, and will be discussed in greater detail in the following section, the instruments are limited and practically all concentrated in financing of R&D. There are at least three different general purpose funds in this area, FONDECYT, FINCYT y FIDECOM, plus those with specific aims, like INCAGRO, and resources from the mining canon, allocated to STI, which are administered regionally.

However, there is no coordination between them, which does not necessarily mean that they get in each other's way, but they fail to take advantage of opportunities to create synergies and achieve better results.[42] In the course of the interviews, there were frequent comments on differences of opinion, even fights, between the agencies responsible for the funds.

What is signally lacking in the management of the innovation system is strong and decisive leadership, capable of coordinating and exercising the function of interface between the needs and demands of the production subsystem and the upper echelons of national policy. The low national expenditure on R&D activities is clear evidence of this weakness and lack of leadership and also reflects the lack of a common front in favour of STI.

With regard to the monitoring, evaluation and control functions,[43] we have frequently referred to the lack of reliable up-to-date information on various aspects of the innovation system and concentrated in a single body. This means, of course, that the monitoring of activities, programmes, specific projects, etc., and their evaluation, is unsatisfactory. Consequently, policy decisions are taken "in the dark", without any real-time feedback on the characteristics of economic agents, the operation of policies and programmes and the adjustments required to improve their functioning.

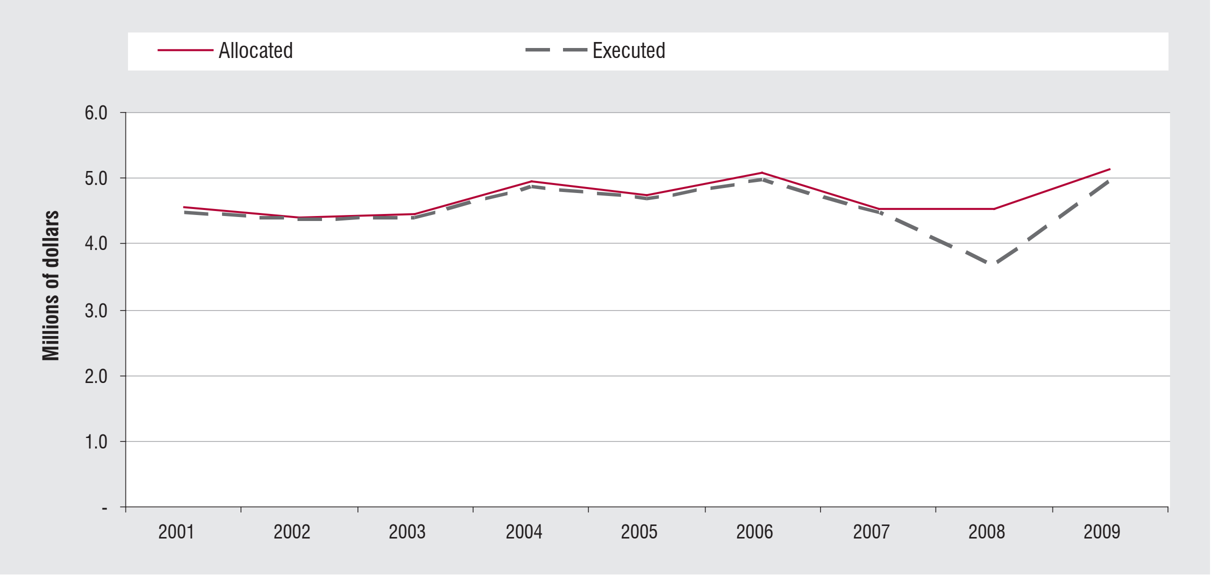
5. Foresight and design of plans, programmes and instruments function

This function, which should be responsible for the long-term functioning of the innovation system, suffers from the same problems as those described above with regard to the existence of separate institutions which carry out similar actions. The essence of this problem lies in the lack of a comprehensive conception of the national innovation system, i.e. the lack of a vision which, at the very least, draws together economic and STI policies. As a result, there are no synergies between the different bodies which elaborate medium and long-term plans, programmes and policies, primarily the National Agreement, the National Competition Commission, the National Strategic Planning Centre and CONCYTEC.

There exists, for example, the National Science and Technology Plan for Competitiveness and Human Development 2006-2021, the National Competitiveness Plan, the Strategic Orientations for National Development 2010-2021 and the National Plan of Science, Technology and Technological Innovation for Sustainable Productive and Social Development 2009–2013.[44] These documents, although generally correct and well formulated, are to some extent repetitions of the same good intentions which do not generate cohesive prioritized actions by government agencies or specific economic-productive agents.[45]

Indeed, while recognizing that these plans contain correct analyses and in some cases are representative of the various bodies involved in the elaboration of the documents, there is no evidence that more extensive,

Figure 9. CONCYTEC budget, 2001-2010



Note: In 2008, the MEF imposed a spending limit. Execution in 2009 up to September 2009.
Source: CONCYTEC, prepared from MEF–SIAF data.

more in-depth foresight studies have been carried out in the design of those plans. Such studies would involve the agents who make up the subsystems of the national innovation system such as decision-makers, managers, businessmen, researchers and social communities.

Although different efforts have been made to carry out and promote foresight studies (e.g. PROSPECTA PERU congresses and the Andean foresight studies financed by UNIDO), the lack of a foresight culture also implies the incapacity to translate existing plans (to some extent over-ambitious) into programmes and instruments of policy which are achievable, varied and with specific and measurable objectives. Added to this, and as a consequence of these shortcomings, important policy decisions are taken, on occasions, without taking into account their impact on national STI. For example, in the negotiations of free trade agreements, considerations of the impact on national STI seemed to have been secondary to the objectives of trade liberalization, and aspects of cooperation in science and technology are contemplated in very generic terms. Similarly, the promotion of technology parks is raised to the status of law, when there is no evidence of the long-term success of this mechanism in Latin American countries, except in very isolated cases.[46]

With regard to the design of policy instruments, these are aimed more at first generation policies, i.e. they are based on a linear concept of innovation.[47] The former involves giving priority to scientific and technological supply, ignoring demand side aspects. They reflect an orthodox economic view of correction of shortfalls in the market by direct financing of R&D[48] (usually with the application of cross-cutting or general instruments) and protection of intellectual property.

Other types of instruments or mechanisms which are more systemically oriented, which will be proposed later, have not been explored. Neither are there very clear sectoral policies (other than those dictated by strategic economic areas such as mining and fisheries, but even they have not been intensively instrumented) or the pursuit of exploitation and improvement of certain scientific areas where there are strengths, such as health, medicine and biotechnology. In general terms, the policy mix is very limited and skewed.

We cannot, however, pass without mention the positive aspects achieved by these instruments. One of the successes, although it needs to be refined, is the promotion of decentralization through the regional councils. With good direction, monitoring and better coordination and management of resources, where efforts are concentrated on capacity building rather than infrastructure, this type of policy can be very efficient in creating a real innovation system from the bottom up.

Moreover, the way in which FINCYT and FONDECYT have been operated,[49] seems to be encouraging collaboration between science and industry (albeit with a passive low-risk approach on the part of industry). Also noteworthy is the work of transfer and adaptation of technology done by the CITE network. Although the results may still be modest and perhaps very localized, it is a vein which must continue to be exploited and improved.

Finally, another success in policy terms, although still seriously under-funded, is the efforts at repatriation and formation of a critical mass through the CONCYTEC Chairs. To the extent that this type of effort remains focussed on exploitation of local strengths and taking advantage of regional opportunities, it will offer a real possibility for scientific and technological development, consolidating the foundations of regional innovation systems.

6. Cohesion and execution function

The majority of the problems mentioned in the above sections highlight what has already been expressed, that it is not possible to constitute a national innovation system by issuing a decree, especially when the very concept of what makes a system has defects and when there is a tendency not to implement this type of ordinance.

As we have also said, there is no real conviction that science, technology and innovation form part of a whole, a combination of aspects which constitute the national agenda. In other words, decisions on economic matters and competition, social development, education, health, agricultural and industrial output, foreign relations, defence, etc, impact on and are in turn influenced by decisions on STI.

This lack of a systemic vision and conviction of the relevance of STI thus impedes a real political commitment at the highest levels to create a system of consistent policies in all areas going beyond words and general legislation. In consequence, the STI sector has been marginalized in national decisions, lacking leadership and with scattered actions which are not aligned with the country's development objectives and goals.

That is why at present there is no consensus and, on the contrary, there are significant differences on the location, objectives and scope of the responsibility for coordinating and implementing decision-making on STI. In the pages that follow, various actions are suggested to contribute to the solution of the various problems faced and to re-direct efforts to coordinate the innovation system.

C. RECOMMENDATIONS

1. Conviction, will and commitment

The most important step for Peru to take in order to set in train a process of transformation into a knowledge and innovation-based economy involves promoting:

- The conviction, at all levels of society and the State, that the generation of knowledge and technological innovation has become one of the driving forces of growth and social and economic development.
- The will to overcome differences between political institutions and economic agents and to be able to effect the modifications necessary to ensure that STI activities actually do become the driving force of the economy and benefit society as a whole.
- The establishment of realistic plans, programmes and policies, with clearly defined goals and objectives and with appropriate performance indicators to measure achievement of the goals within the deadlines set.
- The allocation of the necessary human and financial resources to achieve the goals set in the plans, programmes and policies.

Although the following sections give details of the various areas or mechanisms which could be modified, the commitment to become a knowledge-based economy must be founded on four basic pillars: investment, education, research and enterprise development. Responsibility for building and strengthening these four pillars must be shared between the public and private sectors.

The launch of this transformation process means that the highest authorities of the State must take charge of the management and cohesion of the potential innovation system in Peru, without confusing this with the creation of new government agencies or departments.

2. Foresight and setting of priorities

The transformation process and the development of its pillars must be defined and oriented through an in-depth foresight exercise at national level which so far has not happened. This type of study or exercise must only be carried out when there is the will and the capacity to take the necessary decisions to implement the resulting recommendations. This also means that the participation of decision-makers in these exercises is equally crucial.

The majority of the various plans and studies which have been drawn up for the development of STI in Peru agree on their analyses, although they differ in their proposals. This means that different organizations, agencies or individuals are quite clearly aware of the country's deficiencies, weaknesses and problems, but have not reached agreement on the future it is desired to attain and, consequently, the means to achieve it. This is because the elaboration of the plans and studies concerned was not sufficiently inclusive nor able to resolve conflicts of interest.

On the one hand, key decision-makers were not involved, i.e. those who have the real capacity to influence the allocation of resources and the execution of policies and programmes. On the other, there was no involvement[50] of direct economic-productive agents (i.e. entrepreneurs and researchers, for example, and not their representatives through chambers, associations, university authorities or institutes). As a result, these efforts were left in the hands of a few experts and representatives of organizations, agencies or bodies which did not include all the groups or views on the subject.

Neither was any detailed analysis carried out of real industrial, scientific and technological capacities. It is necessary to have a complete and up-to-date analysis of industrial sectors and areas of research. It would then be possible to review whether there is consistency in the strengths and in what areas immediate results could be achieved, those which need to be strengthened and developed in the medium term, and even deciding whether some of the areas should be abandoned or developed over a very long time scale.

The foregoing is a starting point for establishing priorities, setting specific targets to be achieved in specific timeframes, identifying appropriate indicators to measure performance and allocating budgets to each of these priorities. The results of the foresight exercises should be reflected in specific programmes which are clear as to their contribution to achieving the general goals, with well defined time horizons, designating the bodies responsible for their execution and establishing clear performance evaluation criteria.

3. STI policy instruments

The foresight studies will also, to some extent, provide information on the appropriate policy instruments or mechanisms to achieve the proposed goals. Two important aspects of STI policy instruments should be emphasized. Firstly, there is no generally accepted set of policies, although we shall later briefly review suggestions to define a suitable combination.

Secondly, there is the issue of the justification required to accept government intervention in the economic sphere. Even from the most theoretical positions most opposed to the regulatory function of the State in economic activity, it is accepted that the government must intervene when market mechanisms fail to achieve an optimal distribution of resources. The generation of knowledge, especially R&D activities, is precisely one of those situations when, from the standpoint of economic orthodoxy, it is accepted that there is a failure in the distribution of resources.[51]

Probably one of the reasons for the success of the neo-Schumpeterian and systemic approaches to innovation in some developed countries is that they made it possible[52] *to refine and relax the criteria for identifying market failures*. In other words, they equipped policy and decision makers with tools which allow them to increase government support to local industries without violating the principles of economic orthodoxy.

Returning to classifications of instruments, these have generally been approached from two major perspectives: the nature, characteristics or mechanisms for their deployment; and their objectives or goals. The first approach distinguishes, for example, whether the measures are financing or otherwise, direct or indirect, or cross-cutting (of general application) or targeted on certain sectors or specific groups.

The second approach tries to identify the deficiencies or defects which the instruments seek to correct. A general way of identifying these deficiencies uses the concept of the innovation possibilities frontier,[53] distinguishing between policies which modify the innovation possibilities frontier of all enterprises and policies which induce enterprises to position themselves at a different point within their actual possibilities frontier. The former are policies which could be called facilitating or systemic, while the latter comprise corrective policies, in a nutshell, more orthodox.

The most common practice consists of using a mixed approach, constructing matrices which combine the range of types and objectives to characterize what some authors call the policy mix of a particular country.[54] Table 7 shows a possible policy mix and tries to approximate the actual use of these mechanisms in Peru, as an example of the instruments which can be explored in the future.

3.a. Regional and sectoral strengthening

One of the aspects of current STI policies which is considered correct is the aim of promoting regional development which, because of their natural, geographical, historical characteristics etc., have particular features and needs. The creation of regional STI promotion and management bodies must be strengthened to take advantage of their existing capacities, in the light of the defined priorities. Aspects such as flexibility in the use of resources (e.g. from the mining canon, which places restrictions on the application of resources) as well as substantial improvement in services such as IP training and streamlining of the related procedures must be addressed in order to achieve better results in this regard.

Nevertheless, the possibilities of establishing industrial sectoral development policies have been little explored. Although some aspects of regional development policies contemplate this factor to some degree, there is still considerable room for developing and improving what has been achieved up to now.

Additionally, as indicated in the analysis, some projects in progress, like the creation of technology parks and enterprise incubators need to be seriously evaluated in the light of the Foresight planning and analysis of the use of financial resources in order to obtain more precise analyses of their feasibility and viability. There is a danger that the construction of buildings and the development of infrastructure will fail because of the lack of a critical mass of research and the shortage of entrepreneurs with the necessary commitment and access to sources of financing willing to take on high levels of risk.

As indicated above, successful international experience in this type of undertaking is very limited,

Table 7. Example of a policy mix and approximation to actual use in Peru

		Target deficiencies[a]		
		Corrective or orthodox policies		Facilitating or systemic policies
Deployment mechanisms	Policy instruments	←-----------------------→		
Direct financing measures	Research in public bodies		■■■	
	University research funds		■■■	□
	Human resources training			■■
	Infrastructure support			■■
	Funds for entrepreneurial R&D	■■		□
	Support for R&D in collaboration			■■
	Public sector procurement			□
Indirect financing measures	Fiscal incentives for R&D by volume	□		□
	Progressive fiscal incentives for R&D	□		□
Catalytic financing measures	Venture capital		□	
	Loan guarantee funds for MSMEs			□
	Net capital guarantee funds for MSMEs			□
Other direct measures	Scientific and technological information services		□	
	Technology brokerage services			■■
	Schemes for the dissemination of an entrepreneurial and innovation culture			■■
	Promotion of networks			■■
Indirect regulatory measures	Intellectual property rights		■■	
	Competition policies	■■■		
	Metrology and standardization			■■
Mixed measures	Creation of 'clusters'			■■
	Foresight studies			□

[a] *Note that the range of orientation of the instrument may vary in many cases. For example, R&D tax incentives may be of general application (same rules for all companies), or they may be targeted in particular directions to certain groups (less strict requirements or greater benefits for MSMEs).*

■■■ *Intensive use of the instrument*
■■ *Limited use of the instrument*
□ *Not used*

especially in Latin America. This is largely because the models that it is sought to imitate or adapt have been the result of spontaneous articulation due to particular factors and conditions which are not easily reproduced.

In this respect, schemes adopting regional and sectoral approaches to innovation have been much more successful and less costly, since, although the planning work required is considerable, they operate almost in a virtual reality, without the need for major investment in infrastructure (see Annex B).[55]

3.b. Financing

While the urgent need to increase expenditure or the national commitment to R&D is obvious, this increase is not only the responsibility of the State. It is vital that, through a package of policies, the involvement of private capital in financing STI activities is increased. These policies must help, through training, cultural change and well designed incentives (indirect, fiscal or competitive funds for research projects), to ensure that private investors take a stake in the national commitment to become a knowledge and innovation-based economy, and to undertake ventures with higher levels of risk.

Likewise, the extensive efforts already made, quite rightly, to obtain funding from international cooperation must not be ignored but must be increased, taking advantage of the interest aroused in companies and researchers around the world in Peru's natural resources and local knowhow (both scientific and traditional). This, of course, not forgetting Peruvian sovereignty and ownership of these resources, knowledge and riches.

3.c. Promotion of the systemic vision and innovative culture

We have emphasized that the systemic approach to innovation can be applied and operates at different hierarchical levels. Part of the portfolio of STI policies must be aimed at informing and training entrepreneurial and research sectors on the advantages of using this approach. The application of these concepts in the organization and operation of productive enterprises and knowledge generating institutions is one of the foundations or basis required for the construction, from the bottom up, of regional and sectoral innovation systems. These, in turn, are the facilitators of the articulation of the national and even supranational innovation system.

This dissemination of information and training must culminate in a cultural change which brings about the commitment of all the parties concerned with the transition towards an efficient knowledge and innovation-based economy. Responsibility for this transition is shared. Those involved must realize that, although it may be directed and coordinated by the State, it is the economic-productive actors who will make it possible through their investment and hard work.

4. Training of human resources. The importance of education

Reform and restructuring of the education system at all levels is essential to support change in the medium and long term. Education policies have an impact in all areas of national development and have been vital companions of STI policies in many countries, irrespective of their level of development. In the case of Peru, not only it is necessary to ensure actual compliance with existing provisions on monitoring and quality of primary, secondary and tertiary education, but also to make changes in the curriculum which allow the training of future technicians, engineers and scientists.

Recent attempts to introduce science, technology and environment related courses are very positive but insufficient. Fundamental changes are needed, ranging from the training of teachers and their access to continuing education, to the reformulation of study plans and programmes to strengthen teaching of mathematics and the natural sciences. An interest in science and technology, stimulating curiosity and the ability to solve problems must be instilled from infancy.

In the case of tertiary education, it is also necessary to increase significantly the funding for postgraduate studies. It is possible to explore schemes which represent targeted support, both for academic institutions which offer quality programmes (strictly evaluated) in areas defined as priorities, and to students who take master's and doctoral courses in these subjects.

It is also important to increase bilateral and multilateral international cooperation agreements which can significantly increase the number of Peruvian postgraduate students in quality programmes in different countries.

Finally, it is also crucial to strengthen the meagre efforts to repatriate Peruvian talent which has stayed abroad after completing postgraduate studies or has emigrated in search of better opportunities to use their talents. We have already mentioned how the CONCYTEC Chairs are a step in the right direction in this respect, but its resources are very limited at present. In addition, it is possible to explore and design new repatriation schemes which envisage the incorporation both in education and research and in industry of those who have obtained their postgraduate qualifications abroad.

5. Organizational and management structure

From the foregoing analysis, it is evident that the current structure for the development of national STI capacities has serious shortcomings, chiefly duplication of efforts, dispersion of actions, hierarchical differences between agencies and a general lack of coordination. These factors create a weak and inefficient support system for STI activities. It is therefore advisable to undertake a fundamental reform of the general STI support structure, reducing the number of organizations and locating them in a position within the hierarchy of the State, from which they can function as effective and efficient interlocutors between the highest levels of government and economic-productive agents.

Among the various national actors, there are varying opinions concerning this problem, ranging from relocation of certain organizations to the creation of an STI Ministry. Without dismissing the latest option, the team behind this report considers that the latest generation of innovation policies inclines to more flexible structures which allow crosscutting actions involving different ministries.[56]

For the above reasons, and taking advantage of the fact that Peru already has a crosscutting structure of this kind, it is considered more appropriate that the design of STI policies would be independent of their management and they should be located high up in the hierarchy of this structure (Presidency of the Council of Ministers). Using the terminology of the model used in the analysis, it is to be recommended that the functions of foresight, intelligence, strategic planning and evaluation, on the one hand, and financing and execution of STI programmes, on the other, should be concentrated in only two bodies adequately equipped with human and financial resources and located in direct contact with the highest policy-making levels. Both bodies should therefore work closely together. As regards the financing and execution functions, as well as having its own funds, it should coordinate those allocated by other ministries through offices or branches in those Ministries which are naturally involved in STI actions, such as agriculture, environment, defence, economy and finance, education, energy and mining, industry and health.[57] This coordination could be realized, for example, through a joint funding policy which would ensure greater cohesion between sectoral actions and those of the fund.

Given these basic criteria, the establishment of the following is suggested:

1) A *National Innovation Council* - an independent body with participation of different actors in the national innovation system and directly linked to the Presidency of the Council of Ministers (PCM). The Council would be responsible for establishing the broad policy directions for science, technology and innovation. It would also be charged with the functions of foresight, intelligence, strategic planning and evaluation, for which it should be equipped with the necessary human and financial resources. Ideally, the National Innovation Council would be chaired by the Prime Minister[58], and the Council would require the involvement of the principal ministries and representatives of universities, research institutions, the private sector and the proposed Peruvian Innovation Agency[59].

2) A *Peruvian Innovation Agency* - a body independent of the PCM, responsible for the financing and execution of STI programmes.

The functioning of this model depends on the capacity of the PCM to guarantee the participation of, and coordination and collaboration between, the various ministries in establishing policy directions, allocation of resources, execution and evaluation For that, the PCM must allocate high level human resources and the necessary financial resources to the Secretariat of the National Innovation Council.

This proposal would take advantage of the existing structure (chiefly CONCYTEC and FINCyT). On the one hand, increasing the responsibilities of CONCYTEC for policy design to the level of adviser to the PCM would only work on condition that CONCYTEC's current human and financial resources were strengthened. On the other, it would mean combining the responsibilities and capacities of FINCYT and the financing functions of CONCYTEC and, as far as possible, other STI financing capacities, consolidating the financing and management of STI programmes in a single agency.

Although views differ on the desirable institutional model, and this proposal is not without its weaknesses, any coherent proposal must ensure two capacities: the capacity to be a benchmark for STI themes, to influence national policy and work closely with different ministries, and, secondly, the capacity to improve efficiency, by eliminating duplications and generating a critical mass of resources.

In addition, as suggested in the analysis above, it would be advisable to evaluate whether the concentration of functions in INDECOPI does not detract from its efficiency and consider its possible break up into specialized agencies for its three fundamental tasks.

5.a. Information and indicators

In order for the abovementioned bodies to exercise their functions properly, there is an urgent need for modernizing STI information and the generation of specific STI indicators. This means, firstly, modernizing the digital and telecommunications infrastructure to allow linking the various regional and national bodies which perform services and actions related to STI. Secondly, modernizing information collection models and their conversion into indicators to provide information that can be used for decision making.

At present, for example, there is no up-to-date (or at least easily accessible) information on national expenditure on R&D, the public and private breakdown of this expenditure, productive activities and innovation in the private sector, the number of researchers, university enrolment broken down by career, classification of patent applications through INDECOPI, scientific output, etc.

These and other information gaps must be corrected, as far as possible adapting the data collection models to international standards[60] to allow international comparisons of the performance of R&D.

6. Regulation

Finally, the function of regulation of the innovation system also requires some important adjustments, among which we highlight the following. Firstly, it would be advisable to simplify various aspects of the regulation which hinders, for example, the flow of financial resources and equipment for STI activities, the operation of productive enterprises and, in general, the interaction between economic-productive agents.

Secondly, accompanying the reform of education policies suggested above, it would be advisable to reform various regulatory aspects which affect the sector, especially the monitoring of its activities and the quality control of results.

Thirdly, it is recommended that the status of researcher should be formally recognized in higher education institutions and research institutes. This does not mean the creation of lists and special incentives, as have been introduced in some other Latin American countries (so-called researcher systems), as that can, in certain circumstances, be counterproductive. It simply means recognizing the importance of the activity, distinguishing it (but not separating it) from teaching, and ensuring as far as possible that the researchers' remuneration is fair and competitive with neighbouring countries.

Fourthly, it is considered advisable to relax the regulations and promote the growth of research in public institutions such as universities and research institutes, accompanied by programmes which allow the renewal of research teams with advantageous schemes for the researchers who currently work in these institutions.

Finally, and closely related to the previous point, it is recommended to reform and relax the rules on the use of resources from the mining canon, so that they can be used in a broader range of research activities consistent with the particular needs of regional research groups.

NOTES

[1] Although the concept of national system of *science, technology and innovation* is commonly used, the notion of innovation policy (Rothwell and Zegveld 1981) and national innovation systems (Freeman 1987; Lundvall 1992a; Nelson 1993), include science and technology. We will therefore employ both the former concept or national innovation system without distinction.

[2] For the sake of consistency with the literature on innovation systems, we will use the term *institutions* in the sense of laws, decrees, regulations, etc., which govern the functioning of the innovation system. On the other hand, we shall apply the terms *bodies, organizations or agents*, to public, private or social entities which execute specific actions within the system.

[3] It should be noted that the scientific community of Peru, CONCYTEC and the main public research institutions made the National Congress debate and approve Act No. 28303 or Framework Act on Science, Technology and Technological Innovation, approved in 2004, aimed at building a new regulatory framework that would update the national system.

[4] Act No. 28303, approved in July 2004, the Single Consolidated Text of which was published on 18 December 2007.

[5] The concepts of STI used in the glossary were limited to science and technology, without including other basic elements of the notion of innovation included in the sixth and last edition of the *Frascati Manual* (2002), the second edition of the *Oslo Manual* (1997), devoted exclusively to technological innovation, and, in the Latin American context, the *Bogotá Manual* (2001).

[6] The moment when various international bodies promoted planning criteria in Latin American countries, leading to the creation of entities responsible for the oversight of science and technology.

[7] The Ministry of Production is the competent authority for the coordination and integration of actions by different public and private entities in innovation and technology transfer to: (i) design the technology support policy to promote innovation in the productive sector, (ii) propose and advise on the creation of CITEs under public law, (iii) register and supervise the functioning of CITEs, (iv) promote the consolidation of a Network of Technological Innovation Centres.

[8] The majority of companies served by CITEs are not aware of the need to innovate or if they are aware, they do not know how to deal with it.

[9] Even in countries with highly developed market economies, such as the United Kingdom or the United States, the contribution of public funding to this type of service is considerable.

[10] Developed in the international literature, mainly European, see Annex B.

[11] See, for example, Lundvall *et al.* 2002.

[12] Capacity to maintain its identity independently of other systems within a shared environment, i.e. the system's ability to maintain a separate existence.

[13] Model based on: Beer, S. (1972, 1984 and 1985).

[14] This view based on descriptions by the World Economic Forum (Schwab 2009), was confirmed in the course of field work, in particular in the interview with the deputy director of ProInversión (24 June 2010).

[15] It should be noted that according to the Global Competitiveness Report (Schwab 2009), under Heading 12.02, Quality of Scientific Research Institutions, Peru is ranked 118 out of 133 countries.

[16] CIDE has incubated 20 companies, of which 3 are technology based. The UNI has incubated one company.

[17] Mullin 2002, INCAGRO 2008, Gutarra 2010.

[18] It is important to point out that the lack of reliable information limits access to data under the heading of enterprise, thus considerable use has been made of various international studies.

[19] Ministry of Production data.

[20] This assertion is based, for lack of reliable indicators, on a definition of innovation in line with the second edition of the Oslo Manual, i.e. technological innovation in products and processes, which is not the most recent. If more recent and reliable data were available, it would also be possible to identify organizational and market innovations, and employ criteria of newness with respect to the market or the company; see OECD and Eurostat, 2005).

[21] Which, as mentioned earlier, constitute a very high proportion of the productive fabric. Moreover, the large foreign-owned companies carry out innovation activities in a limited scale in Peru.

[22] Despite having Act 28740 of 2006 which established the National System of Evaluation, Accreditation and Certification of Educational Quality (SINEACE) and its operating agencies: the Peruvian Institute of Evaluation, Accreditation and Certification of Basic Education (IPEBA), the National Council for Evaluation, Accreditation and Certification of Higher University Education (CONEAU) and the National Council for Evaluation, Accreditation and Certification of Higher Non-University Education (CONEACES).

[23] Assessment data provided during interviews with representatives of the most important universities in the country and the National Assembly of Rectors. From the perspective of knowledge generation, the bibliometric studies carried out for this review confirms this assessment (see Figure 12 in Annex C).

[24] Despite having an independent control body, the National Council for the Authorization of Universities (CONAFU), which authorizes the commencement of the activities of new universities and evaluates them at least once over five years before granting them institutional accreditation (granting definitive authorization and membership of the ANR). Once accredited,

these universities are not monitored or evaluated.

[25] In Latin America, over 60% of university science graduates belong to the social and humanitarian sciences, and the number of doctorates in these disciplines has grown exponentially since the mid-nineties (see Lemarchand 2010).

[26] Information provided in interviews with representatives of research institutes.

[27] The RDI Network consists of the Mayor de San Marcos National University, the National Engineering University, the La Molina Agrarian University, the Pontifical Catholic University of Peru and the Peruvian Cayetano Heredia University.

[28] See details of methodology in Annex B.

[29] Comment received during the interviews.

[30] GRADE 2007; Kuramoto 2006; Mullin Consulting Ltd. and Associates 2002; RAMP-Perú 2007; Sagasti 2003.

[31] OECD/BID 2007; Schwab 2009.

[32] Using WEF terminology.

[33] Colombia, Bolivarian Republic of Venezuela and Mexico, among others, have had laws of this type for over nine years. STI indicators of the RICyT indicate low innovative performance in these countries. In Mexico, since 1999, the law has required national expenditure on R&D of 1% of GDP, but at present it is still less than 0.45% of GDP.

[34] See Sagasti, 2003.

[35] The long-term indicators of STI expenditure in Latin America show that national expenditure on R&D has remained low and, although there has been a rise in the number of scientific publications, the knowledge has not translated into innovations, patenting is low and productivity has declined (RICYT indicators and Lemarchand (2010)).

[36] See Mullin Consulting Ltd. and Associates, 2002 p.25.

[37] OECD/IDB (2007).

[38] Idem.

[39] Dependent on its own resources generated from income for its services.

[40] INDECOPI's standardization and metrology function needs to be reviewed in detail, but snippets of information that emerged during a number of interviews suggest that this is also an area to which not enough attention has been paid.

[41] There is still no national quality system.

[42] Despite the fact, for example, that the presidency of the FINCYT Governing Board represents CONCYTEC.

[43] In the systemic sense.

[44] The latter is linked to the former because comes under the responsibility of CONCYTEC.

[45] They also represent a huge waste of efforts and resources.

[46] On the contrary, such initiatives have been tried since the mid-80s, and most of them have ended in failure. These instruments, which form part of the evolution of regional economic thinking, nowadays are much more fruitful under the modern concept of regional innovation, which only requires more planning and almost no investment.

[47] In a scientific research – technological development – innovation sequence. It also implies the idea that the mere training of scientists and support for research in academic circles or public institutions will lead, in the medium term, to innovation.

[48] Although indirect financing, not yet explored by Peru, such as tax incentives for R&D and innovation can be applied horizontally or vertically, i.e. of general application or targeted at certain areas (by size of company or sector, for example).

[49] Without being able to generalize, for lack of specific hard information.

[50] Through questionnaires, interviews or similar means of collecting perceptions and information.

[51] Arrow, 1962; Nelson, 1959.

[52] Although it is likely that this was not what originally motivated them.

[53] Which can be defined as the relationship between the improvement obtained from the implementation of an innovation and a specific expenditure on R&D incurred to achieve it. Alternatively, as the relationship between the time required to achieve a specific improvement and the cumulative efforts made to obtain the improvement. Cf. Nordhaus, 1969.

[54] See, for example, Boekholt *et al.* 2001.

[55] They are merely the transfer to an intermediate level of the systemic approaches were have been using in this analysis.

[56] For example, Chile, Uruguay or Finland do not have a ministry of science, technology and innovation, but a ministerial office or council with ministerial representation for innovation which coordinate STI policies with funds or executing agencies. Although their institutional organization is different, these countries have in common that their STI policy is distributed and coordinated, not concentrated. See also European Commission (2002).

[57] This list is not exhaustive.

[58] Although not necessarily chaired at this level for all the Council's activities.

[59] The list is not exhaustive.

[60] The OECD family of Frascati Manuals, for example, or the UNESCO standards.

III

The information and communication technologies sector

The role of the information and communication technologies (ICTs) in economic and productive progress goes far beyond its contribution as a productive sector. As a general-purpose technology, investment in ICT contributes to productivity gains, both labour and multifactorial, in other economic sectors. Companies which adopt these technologies have opportunities to improve their productive processes, reduce costs, develop new products, reach new markets and increase their competitiveness. ICT can also encourage better public management. Thus, the development of an ICT sector capable of providing affordable and good quality goods and services can create an environment conducive to the adoption of ICT by companies, individuals and organizations, and offers the opportunity of greater increases in productivity.

The ICT sector is defined as those industries whose products (goods and services) are intended to perform or allow the processing of information and its communication by electronic means, including visual transmission and presentation. The sector includes the ICT manufacturing industries, ICT services industries (ICT publications, telecommunications, information technology and computer services, web gateways and data processing, and repair of computers and communications equipment) and ICT commercial industries (wholesale supply of computers and electronic equipment)[1].

A. INFORMATION AND COMMUNICATION TECHNOLOGIES: PERU IN THE INTERNATIONAL CONTEXT

ICTs have increasingly penetrated all areas of society. Between 2001 and 2007, global spending on ICTs rose at an annual rate of 7.5%. In 2007, the global market stood at 3.43 billion dollars, including telecommunications services which accounted for 57% of the total, hardware with 14% software 9%, and computer services 21%. The bulk of the ICT market is in the developed countries, especially the United States (30% of the global ICT market in 2007), the European Union and Japan (OECD 2008). Among the developing countries, the principal markets are in certain Latin American countries (Brazil, Mexico) and Asia (China, India, Korea, Taiwan, Hong Kong).

The expansion of ICT has also been reflected in the significant increase in the percentage of the labour force which can be characterized as information workers in various countries in recent decades (Table 1). The share has increased substantially in all the countries of Latin America, but is still far behind the most developed countries (the average in Europe is 50%, North America 48%) and the Asian countries (where the average is 31%).

As regards investment in information technology, the countries of Latin America invest an average of 2.1% of GDP in these technologies[2], also well below the 4% allocated by the developed countries (Table 2).

Both from the point of view of employment generation and investment, the indicators show Peru slightly below the modest Latin American averages. The percentage of information workers in the current decade reached 23 per cent of the country's total labour force which, although a significant increase compared with the sixties, is lower than other Latin American countries. Much the same can be said of the investment in information technologies, which was 1.77% of GDP in 2006, below the regional average of 2.1% for the same year.

At global level, the software and computer services sector (SCS) is one of the ICT segments which has experienced the greatest growth in recent years and which offers developing countries the best opportunities for insertion. While software production is concentrated in developed countries, there are some developing countries which have achieved significant penetration of international markets. India has been one of the most successful in terms of volume. Income from the SCS sector in India in 2010 reached 63,700 million dollars (of which 77% was exports chiefly destined for the United States and the United Kingdom), rising from 1.2% of GDP in 1998 to an estimated 6.1% in 2010. This industry generates some two million direct jobs in the country[3].

In turn, in recent years, and closely linked to the spread of ICT, there has been an expansion of a combination of activities known under the generic heading of "information technology enabled services" which provide a variety of distance services which previously required geographical proximity (accountancy, human resources management, purchasing management, computer maintenance, etc.). Transnational companies are increasingly installing or contracting offshore centres with the objective of procuring these

Table 1. Percentage of the labour force considered as information workers[(1)] in Latin America

	Decade from 1960		Decade from 2000	
	Percentage	Year	Percentage	Year
Argentina	21	1960	29	2006
Brazil	12	1960	26	2004
Chile	15	1960	31	2005
Colombia	14	1975	27	2000
Ecuador	7	1962	25	2006
El Salvador	6	1961	26	2006
Guatemala	6	1964	...	...
Mexico	11	1960	25	2006
Panama	14	1960	28	2006
Peru	9	1961	23	2001
Uruguay	21	1963	33	2006
Bolivarian Republic of Venezuela	14	1961	21	2002
Average	**12**	**...**	**27**	**...**

Katz considers information workers as all those working in sectors 1, 2 and 3 of the ILO International Standard Classification of Occupations (ISCO).
Source: Katz (2009).

Table 2. Investment in information technologies (IT), 2006

Country	GDP at current prices ($ millions)	Investment in IT ($ millions)	Investment in IT (percentage of GDP)
Argentina	214,241	4,113	1.92
Brazil	1,067,472	33,305	3.12
Chile	145,843	2,523	1.73
Colombia	153,405	3,466	2.26
Costa Rica	22,229	355	1.60
Mexico	839,182	9,650	1.15
Peru	92,416	1,635	1.77
Bolivarian Republic of Venezuela	181,862	1,964	1.08
Latin America	**2,716,650**	**5,701**	**2.10**

Source: Katz (2009).

services for themselves, basically in the pursuit of cost savings but also to access human resources and diversify their operations geographically. Just as in the case of SCS, some developing countries, China and India in particular, have been positioning themselves as attractive locations for the provision of these services.

These activities form part of the new "knowledge-based economy" and share some common characteristics; (i) all have greater export growth rates than sectors in the "old economy"; (ii) they tend to pay higher wages and generate more employment, and of higher skills levels, than the economy on average; (iii) depending on the development of their capacity for innovation and training of human capital, they generate positive spin-offs for the rest of the economy; (iv) productivity in them grows rapidly and there are possibilities of "late" entry (as shown by the experience of some of the countries mentioned above) as these are sectors which have not yet reached maturity from a technological point of view (ECLAC, 2008). From the perspective of developing countries, these are activities which can contribute to a development strategy and international insertion which is not solely based on the relative abundance of natural resources or cheap labour.

B. DIAGNOSTIC OF THE NATIONAL ICT SYSTEM OF INNOVATION

1. Production function

1.1. Infrastructure

The telecommunications infrastructure in Peru has been extended and modernized since the mid-nineties. The liberalization, privatization and regulation of this market have succeeded in attracting high levels of investment (3,800 million dollars, i.e. 22% of the total stock of foreign investment in Peru (EIU, 2010)). In 2009, there were 87.5 mobile phone lines per 100 inhabitants (OSIPTEL[4]). However, the country had only 10.5 fixed telephone lines per 100 inhabitants (OSIPTEL).

This investment has chiefly benefited the inhabitants of Lima and, to a lesser extent, the rest of the country. Various public and private programmes (prepayment schemes for fixed and mobile telephones, development of competition through mobile phone and broadband licences, and subsidies for the installation of public telephone booths in remote areas) have been put in place to encourage the development of telephone and Internet services in Peru. Nevertheless, one of the critical points for the development of ICT is the extension of broadband, especially to rural areas

1.2. Accessibility and use of ICT

As well as the level of development of ICT infrastructure, it is important to know the accessibility and use of these technologies by individuals, companies and organizations.

With regard to ICT use and access, Peru lags behind the more advanced countries of the region (Table 3), especially with respect to indicators of households with access to a computer, the Internet or a mobile phone. It should be highlighted that 70% of Internet users do so exclusively through public booths (Table 6). The costs of a computer is still high for the majority of Peruvians (EIU, 2009), but it is hoped that the lowering of tariffs imposed with the new trade agreements will facilitate the acquisition of computers.

Broadband access is important for the development of Internet services. Broadband allows access to a greater quantity of data, faster and more cheaply and thus a wider and more sophisticated range of supply and demand for Internet services (e.g. multimedia services). In Peru, the number of broadband subscribers is still limited (725,000 in 2008) i.e. a penetration of 2.5%. It should be pointed out, however, that 80% of household Internet subscriptions are for broadband (EIU, 2009).

There are marked differences between metropolitan Lima and the rest of the country, or between urban and rural areas, both in household access to ICT goods and services (Table 4) and in Internet use (Table 5).

Table 3. Internet users (millions and penetration) and households with ICT access in Latin America

Country	Millions of users, 2008	Internet users (% population), 2008	Households with access to a PC		Households with Internet access		Households with mobile phone access	
			Year	%	Year	%	Year	%
Argentina[(1)]	20.00	50.32	2001	21.9	2001	10.0	2001	21.3
Brazil	50.00*	25.93*	2008	30.9	2008	23.6	2008	75.7
Chile	6.97*	41.57*	2006	33.1	2006	19.2	2006	83.8
Colombia	17.12	35.46	2008	22.8	2008	12.6	2008	83.8
Costa Rica	1.35	29.75	2008	33.9	2008	14.6	2008	68.1
Mexico	22.34	21.01	2008	25.7	2008	13.5	2008	61.0
Peru	**7.46**	**26.42**	**2008**	**16.2**	**2008**	**7.3**	**2008**	**56.7**
Bolivarian Republic of Venezuela	7.17	25.90	2007	14.6	2007	5.7	2007	43.4

** Estimated.*

(1) Argentina: estimate based on 2001 (latest available household survey data).

Source: OSILAC-ECLAC, UNCTAD (2009b) based on International Telecommunication Union data and national sources.

Table 4. Households with access to a computer/Internet and/or telephone, by geographical location, 2008 (percentage of total households)

	Access to a computer	Internet access	Access to fixed telephone	Access to mobile phone
Total	**16.5**	**8.0**	**29.5**	**56.7**
Metropolitan Lima	29.7	18.6	59.7	75.6
Rest of the country	11.3	3.6	16.8	48.7

Source: INEI (2009a).

Table 5. Internet users, by geographical location, 2008 (percentage of total population aged 6 years and over)

Total	**28.5**
Metropolitan Lima	44.7
Rest of the country	21.7
Area de residence	
Urban	39.2
Rural	8.0

Source: CNC (2009).

As regards the use of this type of technology, only 4.5 per cent of Internet users do so for banking transactions. Likewise, few Peruvian Internet users (3.4%) interact with state organizations and public authorities via the Internet (Table 6). This suggests to us that there is great potential for developing ICT not only in terms of its use by a larger number of people but also in the use of a wider range of Internet services by existing users.

A study carried out in 2007 by the National Institute of Statistics and Information Technology (INEI, 2009b) addressed the question of the use of ICT by businesses. The study is based on a survey carried out among large enterprises[5] and a high percentage of the entities which replied belong to the services sector[6] (which generally use ICT more extensively and intensively). Thus, the conclusions of that study cannot be extrapolated to other Peruvian enterprises nor do they represent ICT use and access by Peruvian businesses.

It is worth highlighting the wide use of fixed telephones (97%) and mobile phones (86%), and a wide access to computers (95%) and Internet (93%) among the surveyed companies. The development of local area networks is also quite widespread (77% of companies have teams, computers and/or systems which share resources). 60 per cent of the enterprises have a website. However, only 35% of the enterprises have an Intranet, and only 13% extend these services to their suppliers through an Extranet (Figure 1).

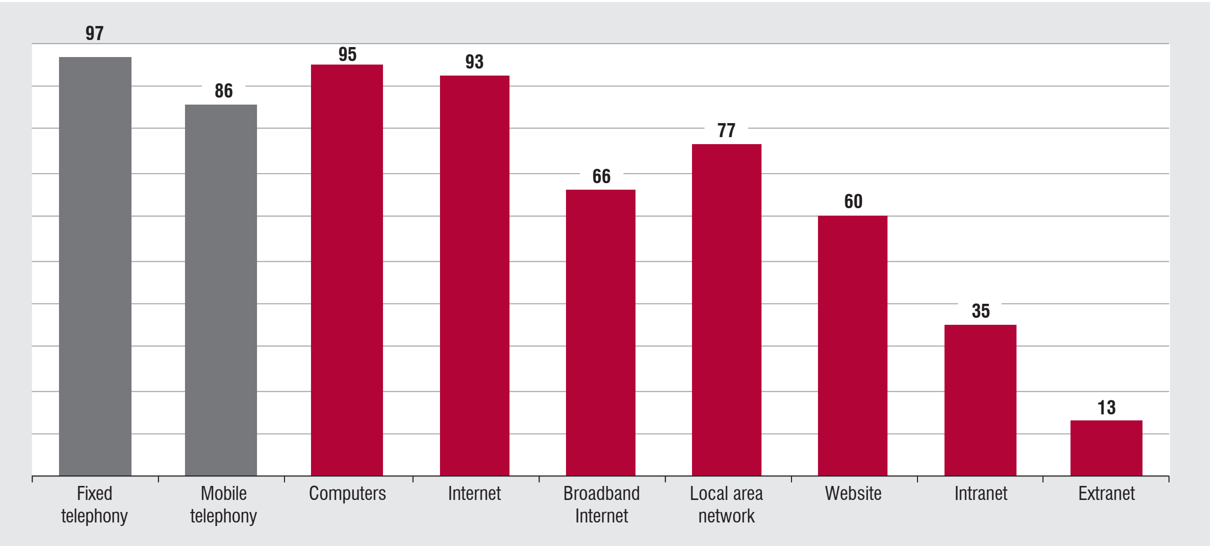
Enterprises with Internet access use it chiefly for communication and to search for products and services with percentages of 88% and 85% respectively. They also make significant use of electronic banking (77% of enterprises) and half of the large enterprises analysed interact with government organizations or public authorities via the Internet. 39.5% of the enterprises receive orders or make sales via the Internet compared with over 45% who place orders or purchase on line (Figure 2).

Table 6. Internet users, by place of use and type of activity, 2008 (percentage of total Internet users)

Place of use		Type of Internet activity	
Home	21.1	Obtain information	84.6
Work	12.5	Communicate	75.1
Educational establishment	6.3	Banking transactions	4.5
Public booth	71.0	Formal education	8.8
Other	3.3	Transactions with state organizations and public authorities	3.4
...	...	Leisure activities	44.8

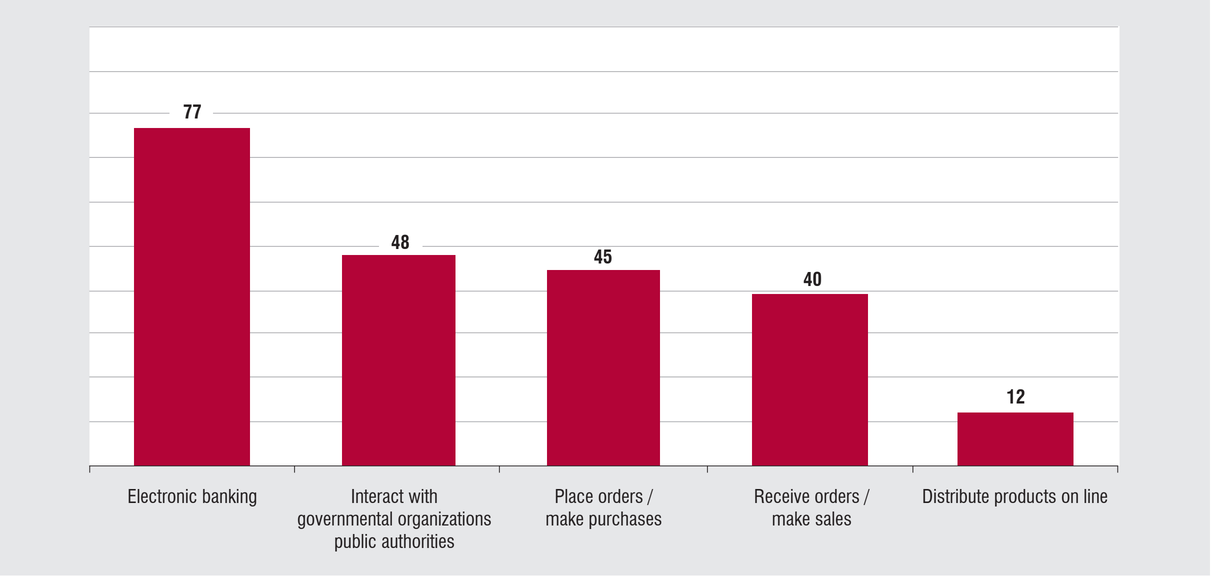
Source: INEI (2009a).

Figure 1. ICT access by large Peruvian enterprises (percentage of enterprises surveyed), July 2006 - June 2007



Source: INEI (2009b).

Figure 2. Internet use by large Peruvian enterprises (percentage of enterprises surveyed), July 2006 - June 2007



Source: INEI (2009b).

It is important to remember, however, that there is no information available on the behaviour of micro, small and medium-sized enterprises and that the Peruvian population as a whole shows a diametrically opposed scenario. Only 26% of the population uses the Internet and of these, only 4.5% carry out banking transactions and 3.5% interact with the public administration (Table 6).

In this regard, it will be necessary to have data on ICT use and access by MSMEs and the informal sector. It is worth mentioning that the collection of data on the informal sector is particularly difficult as, by definition, such economic actors do not appear on business registries. In some countries, this information is collected through a combination of household surveys and surveys of small business and self-employed workers, which include questions on ICT use and access. The Partnership on Measuring ICT for Development[7] can provide guidance and support in this area.

1.3. Companies

The Peruvian economy, as discussed below, does not, *a priori*, offer exceptionally favourable conditions for turning itself into a major player in the provision of ICT-related goods and services. However, it does have a certain number of companies with some experience which have managed to prosper in these areas. Moreover, as we will show, despite the intense competition seen in international markets, the international evidence suggests that there are no insuperable barriers to late entrants to the ICT services sector.

The question, therefore, is not whether Peru should or should not enter the "new knowledge-based economy" but rather, how. That would mean identifying those sectors that offer more opportunities and, consequently, formulating appropriate strategies for penetrating these sectors on the most advantageous terms possible.

a) Telecommunications

The telecommunications sector in Peru is well developed and composed of foreign companies, notable among them being the Telefónica Group. The development of the telecommunications sector missed the opportunity to stimulate a local telecommunications industry. With the opening of the market, operators did not require services from local industry as the equipment and associated software was acquired from their international suppliers. Faced with the urgency of developing the infrastructure, not only were telecommunications service providers transferred into the country but also their subcontractors (Sánchez Tarnawiecki, 2003). However, small and medium-sized Peruvian companies operate in long-distance and cable television (Table 7).

b) The ICT manufacturing sector

According to data from the international consultancy IDC[8], during 2008, 760,731 computers, desktops and laptops, were sold in Peru for 534 million dollars. While Hewlett-Packard, which has 26.2% of the market, is the leader in sales, domestic brands have only 8.5%. However, the most relevant fact is that 43.5% of sales were made by informal assemblers[9].

In general, despite progress in sales of hardware and, more generally, in ICT manufacturing, the sector accounts for a very small amount of total Peruvian manufactured goods, especially if we consider the new definition of ICT used by the OECD, which does not include the manufacture of cables (Table 8).

c) The ICT services sector

Parallel to the development of hardware sales, the software and computer services industry has made considerable advances. Peru's software industry can be characterized as a young industry which has developed over the last 15 years. There are already some 300 companies, the vast majority national. It should be noted that although the major global software companies sell their services in Peru, none of them develop software in the country. Out of the total number of software companies, 63% are microenterprises, 27% small, 6% medium-sized and only 4% are large companies. In 2008, sales in the sector rose by 7% to total 160 million dollars (Cuore, 2008). The large companies were responsible for 48% of sales in 2008, while medium-sized companies accounted for 15%, small companies 18% and microenterprises, 20%. Approximately 10% of total sales that year, some 16 million dollars, were exports. The chief export destination was the United States (53%) followed the countries of the Andean Community (27%). It should be emphasized that only 15% of the companies in the sector export their products (Cuore CRR 2008, CreaSoftware 2008). Other studies (Table 9) show similar volumes, although with higher rates of growth.

The share of this sector in GDP is still much lower than in other countries in the region. Table 10 shows a comparison of the aggregated software and BPO industries.

With regard to employment, companies in the sector generate between 5,500 and 6,000 highly skilled direct jobs and some 9,000 indirect jobs (through services such as sales of computers, installation, cabling, etc.). The average monthly wage of technical staff in the sector varies significantly depending on the enterprise size (Table 11).

Currently, one of the limitations faced by this sector is that the ICT industry in Peru is growing with full employment, and as a consequence, it is difficult to obtain specialist staff.

As regards the type of products offered by Peruvian companies in the computer services sector, crosscutting solutions (ERP type[10]) and vertical solutions for specific markets (construction, health, etc.) predominate, as well as the provision of services for the development of customised programmes, maintenance and systems integration[11].

Table 7. The principal telecommunications companies in Peru

Company	Principal service	Income 2008 (Millions US$)	Start-up of operations	Principal shareholder	Country
Telefónica del Perú S.A.	Fixed telephony	1,282	1994	Telefónica Group	Spain
Telefónica Móviles S.A.	Mobile telephony	1,131	1999	Telefónica Group	Spain
América Móvil Perú S.A.C.	Mobile telephony	742	2005	Carso Group	Mexico
Nextel del Perú S.A	Mobile telephony	239	1998	NII Holdings	United States of America
Telefónica Multimedia S.A.C.	Cable TV	161	1993	Telefónica Group	Spain
Telmex Perú S.A.	Fixed telephony	109	2004	Carso Group	Mexico
Americatel Perú S.A.	Long distance	39	2002	Entel Chile	Chile
Impsat Perú S.A.	Broadband	31	2000	Global Crossing	United States of America
DirecTV	Subscription TV	21	2005	DirecTV Group	United States of America
Gilat To Home Perú S.A.	Rural telephony	20	1999	Gilat Satellite Networks	Israel
IDT Perú S.R.L	Long distance	19	2000	IDT Corporation	United States of America
Terra Networks Perú S.A	Broadband	11	1999	Telefónica Group	Spain
Star Global Com S.A.	Cable TV	5.4	2003	n.a.	Peru
Gamacom S.A.C.	Long distance	5.3	2001	n.a.	Peru
Sitel S.A.	Long distance	4.5	2006	Romero Group	Peru
Convergia Perú S.A.	Long distance	4.3	2001	Future Electronics	Canada
TE.SA.M.	Satellite solutions	4.0	2000	n.a.	Peru
Rural Telecom S.A.C.	Rural telephony	3.4	2001	n.a.	Peru
BT LATAM Perú S.A.C	Fixed telephony	2.9	1998	British Telecom	United Kingdom
CATV Systems EIRL	Cable TV	2.7	2000	n.a.	Peru

Source: ICEX (2009).

Table 8. The ICT manufacturing sector (in millions of dollars), 2005-2007

	Brazil	Chile		Peru		
	2005	2005	2006	2005	2006	2007
Office, accounting and computing machinery	8,898	1,172	1,612	21	22	27
Insulated wire and cable	5,841	7,684	195,081	512	1,003	1,338
Electronic valves and tubes and other electronic components	4,065	1,731	1,033	7	12	15
Television and radio transmitters and apparatus for line telephony and line telegraphy	21,839	...	...	16	27	33
Television and radio receivers, sound or video recording or reproducing apparatus, and associated goods	9,774	...	...	34	59	73
Instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process equipment	...	40,813	39,997	...	...	...
Industrial process equipment	...	...	...	...	...	...
Total ICT manufacture, according to 2002 definition of the OECD	**50,418**	**51,399**	**237,724**	**589**	**1,122**	**1,486**
Total ICT manufacture, as % of total manufacturing industry, according to 2002 definition of the OECD	**4.45%**	**0.11%**	**0.45%**	**0.45%**	**0.75%**	**0.94%**
Total ICT manufacture, according to 2007 definition of the OECD	**44,577**	**2,903**	**2,645**	**78**	**119**	**148**
Total ICT manufacture, as % of total manufacturing industry, according to 2007 definition of the OECD	**3.94%**	**0.01%**	**0.00%**	**0.06%**	**0.08%**	**0.09%**

Source: UNCTAD based on INDStat data.

Note: The 2007 OECD definition excludes “Insulated wire and cable”, “Instruments and appliances for measuring”, and “Industrial process equipment”.

Table 9. Telecommunications, software and computer services industry and BPO, Peru, 2005-2009

	Sales 2005 (millions of dollars)	Sales 2009 (millions of dollars)	Average annual variation	Exports (millions of dollars)	Jobs (thousands)
Telecommunications	2,111	3,872	16	...	...
Software and computer services	95	167	15	16.4	4.4
BPO	24	106	45	48.1	23.2

Source: Adecso et al (2009) according to ICEX (2009).

Table 10. International comparison of the software, computer services and BPO industry

Country	Size 2008 (Millions of dollars)	Industry as % of GDP	Exports as % of sales	Jobs (Thousands)
Peru (2009)	**272**	**0.2**	**23.7**	**27.6**
Brazil	13,000	0.8	10.2	1,700.0 (2009)
Mexico	6,700	0.6	47.1	226.3 (2006)
Chile	4,033 (2007)	2.5	20.9 (2007)	20.0
Argentina	2,276	0.7	22.0	51.0
Colombia	1,139	0.5	13.5	73.0
Costa Rica	880 (2007)	3.3 (2007)	72.7 (2007)	25.5 (2007)

Source: Adecso et al (2009) according to ICEX (2009).

Demand for domestic software is led by financial and commercial firms and public bodies[12]. Domestic companies specialize in applications for specific needs and services, as they cannot compete in basic software and highly standardized commercial software. Local companies also have difficulty in competing in more complex tendering processes.

Despite the embryonic character of the Peruvian SIS industry, there are some interesting examples of successful businesses. Cosapidata/Cosapisoft, GMD, Novatronic, (bespoke solutions consultancy), Polysistemas (services), Lolimsa (health software – see Box 1), S10 (solutions for the construction industry), Persystems and Hacksoft (antivirus) are examples of Peruvian companies which have developed and consolidated themselves in the country. Box 2 provides additional information on a particular subsector of software companies, companies which offer free and open source software and associated services.

Another limitation is the low level of formal development of companies in the sector with regard to international certification and quality control[13]. Although a number of initiatives have been developed in this connection (see below the CITE Software programmes, the project for decentralization of quality of software competitiveness, PACIS), some have not proved sustainable and in the case of others, there is little information about their impact. It will be important to review these efforts in order to strengthen them and achieve institutional and financial sustainability. It is essential to strengthen access to the necessary financing so that companies, especially the smaller ones, can afford a service which is relatively expensive. State institutions could progressively introduce the requirement for CMMI type certification of all software suppliers, as a way of encouraging companies to obtain such certification.

Founded in 2000, the Peruvian Association of Software Producers (APESOFT) is the principal business association in the sector. Its objective is to join forces to improve the productivity of its members and increase exports of Peruvian computer programmes. One of the important areas for the development of a competitive ICT sector is the development of quality

Table 11. Average monthly wage (in dollars), Peru, 2007

Enterprise size	Project manager	Analyst	Programmer
Large	2,214	1,629	1,193
Medium-sized	1,582	1,197	799
Small	1,348	958	654
Microenterprise	1,139	793	555

Source: CreaSoftware Programme, Peru.

standards. APESOFT has concluded some agreements with higher education institutions to develop training programmes for the industry (see CreaSoftware Peru programme, Programme of support for competitiveness in the software industry and the Project for the decentralization of quality for competitive software).

The following is an examination of the information technology enabled services sector and the content sector, as they complement the development of the ICT industry and can contribute to the country's economic development.

d) Information technology enabled services (ITES)

Various types of information technology enabled services can be distinguished:

- front office services (call centres and customer service centres),
- back office (data capture, human resources, payroll, finance and accounting, purchasing, transcription), and
- outsourcing of knowledge-intensive activities (financial analysis, data mining, engineering, research and development, insurance processing, architectural design, distance learning and publishing services, medical diagnoses, journalism).[17]

It should be emphasized that the skills required by the different types of service vary from basic training (data capture and some call centres) to high levels of knowledge (design, medical diagnosis, financial analysis, R&D). Likewise, the international outsourcing markets for these services are at different stages of maturity. The most established market is the international outsourcing of computer services. Customer services, finance, infrastructure management, human resources and knowledge services are expanding. However legal and procurement services are still at an embryonic stage (UNCTAD 2009b).

The turnover of the broadest combination of ITES confirms Peru's tiny role in this market, even in Latin America (Table 12).

Peruvian exports and imports of ITES have both increased by 8% a year since 2000, but its share of total exports of services has not changed (Table 13).

In Peru, the call centre segment, in particular, has been developed and these have benefited from

Box 1. Lolimsa – Peruvian innovation in software

Formed in 1987, Lolimsa is a Peruvian company specializing in the development of information technologies for the health sector. Its principal activity is the development of hospital and pharmaceutical management software. Lolimsa covers 90% of the domestic market in the health software segment and domestic sales amount to a million dollars. Although various attempts at internationalization (distributors, own offices and franchises) were not always successful, the company has managed to install its technological solutions in over 2,000 customers in nine Latin American countries, with average sales of 250,000 dollars per country.

Lolimsa has recently entered the bioengineering area and has developed a digital audiometer and first aid software. CLEO 1000, developed by Lolimsa, is the first digital audiometer built by a Peruvian company. Unlike conventional audiometers, CLEO 1000 has a greater percentage of software in its construction (30% hardware and 70% software) which makes it more precise, dynamic and efficient. The total investment in the project was 538,000 dollars, of which 215,000 dollars came from FINCYT. Currently, the company is also developing a spirometer.

Lolimsa estimates that piracy causes them annual losses of some 250,000 dollars. Companies in the sector are always competing at international level, including in national tendering.

The company has CMMI certification at level three and one of its objectives is to obtain CMMI certification level 5. The cost of certification is the chief obstacle. The company is collaborating with several Peruvian universities, offering grants in bioengineering to students at the UNI and UNMSM.

Lolimsa's managing director is convinced of the potential of Peruvian software companies provided that they specialize in a particular segment (health, mining, etc.). In this regard, a multi-disciplinary training (e.g. in bioinformatics) is essential. The company has a team of 42 systems and biomedical engineers and faces string competition for skilled human resources. Demand outstrips supply and the remuneration offered by large companies in the sector is high.

In his opinion, public procurement still has a very important role to play in the development of this sector in Peru. The automation of the public administration is driving demand for software development

Fuente: Entrevista con el Gerente general de Lolimsa, www.lolimsa.com.pe

Box 2. Free and open source software in Peru

The importance of free and open source software (software whose source code is open) lies in the opportunities that it offers to develop skilled human resources (access to the source code is essential to the learning process), develop software adapted to local needs and facilitate access to this technology while respecting intellectual property rights (UNCTAD 2003)[14] .

The main business of free and open source software is in added value services which can be provided with the software, such as training, certification, adaptation, installation and maintenance. However, opportunities in this field are not confined to provision of services to the local market, they extend to opportunities in the international market. Very important companies in the sector are increasingly relying on open code software and have launched versions of their products or parts of their products in open source on to the market: Google, Sun, IBM, Oracle, and even Microsoft itself, among others.

Currently, there are 207 professionals and 84 companies registered in the Peruvian Free Software Association (APESOL). Half of these companies export free and open source software services[15].

Government policies on promotion of ICT and procurement of hardware and software have a direct influence on the development of this sector. In this regard, the Peruvian Government has issued various regulations to promote the use of legal software and offer the same terms for the purchase of free and open source software. Both initiatives favour the development of the software services sector.

Supreme Decree No. 013-2003 establishes the measures to guarantee the legality of the acquisition of software programmes in government departments and agencies and, in 2004, a Software Administration Guide was produced (RM 073-2004-PCM).

Act No. 28612 (2005) establishes the measures which allow the public administration to contract software licences and computer services on terms of impartiality, technological viability, free competition and fair and equal treatment of suppliers.

The capacity of free and open source software companies is limited and is at a disadvantage because of the lack of institutional capacities in application of the legislation[16], the lack of incentives to enforce it, the limited capacity of procurement staff and the heavy administrative burden of procurement processes, the large percentage of exclusive software already installed and the capacity of exclusive software companies, due to the greater number of people trained on and familiar with exclusive software and the lack of teaching of free and open source software development in universities.

Source. UNCTAD (2003), ONGEI (2007).

certain support measures (see section B.4). Some businesses related to the export of translation services, engineering and architectural design, accountancy services and laboratory analysis are also making an appearance (ICEX 2009).

e) The content and information media sector

A supply of relevant up-to-date and dynamic content, in the local language, is an incentive to use ICTs and, consequently, the development of ICT content is an important element in the adoption of these technologies.

The content and information media sector includes publishing of books, newspapers and other publishing activities; motion pictures, video and television programme activities, sound recording and music publishing activities, radio and television programming and broadcasting activities, and other information services activities (e.g. news agencies)[18]. Although not included in this formal definition, the sector often includes the electronic games industry and the mobile phone and web content sector and independent audio-visual production.

While all these industries provide content for ICT services, when talking about the ICT sector in a developing country such as Peru, the chief value remains, not in publishing or cinematographic services, but in the availability of a range of contents more closely related to ICT and directly relevant to the country's economic and social development. This refers to the availability of relevant and dynamic content which facilitates information and educational activities and market development. Of these, content for training activities, information services for businessmen, investors and market operators, or content with local marketing potential (e.g. content for mobile phones) stand out.

In Peru, the content industry (Box 3) does not appear to be sufficiently developed to be able to contribute to the development of the ICT sector. The launch of a support programme for the sector would be desirable. Among other things, consideration could be given to the development of public policies which promote the development of domestic content industries (e.g. production of digital content) and measures to combat piracy. In order to be able to design and revise support strategies for the sector, it will be necessary to collect information on a systematic basis and carry out studies of the industry, in particular the emerging areas and those directly related to the productive development of the ICT sector (e.g. content for mobile phones and the web or the electronic games industry). At the same time, it will be essential to have a space for discussion and work with the academic sector to be in a position to satisfy future training needs.

1.4. Financing via the market

In general, large private companies do not finance technological research, as they obtain the services externally, while suppliers only sell technology and equipment developed in other countries.

Some companies are investing in R&D (e.g. Lolimsa, Box 1), although their investment potential is limited by difficulties in accessing sources of financing, especially the lack of venture capital.

The problem of lack of access to financing by soft-

Table 12. Exports of information technology enabled services in Latin America (in millions of current dollars at current exchange rates), 2008

	Argentina	Brazil	Chile	Costa Rica	Mexico	Peru
Information technology enabled services	5,387	17,603	2,508	1,407	2,873	692

Source: UNCTAD based on COMTRADE data.

Table 13. Trade in information technology enabled services (in millions of dollars at current prices and current exchange rate), Peru, 2000-2008

		2000	2005	2008	CAGR (%) 2000-08
Imports	**Information technology enabled services**	**886**	**933**	**1,700**	**8**
	Information technology enabled services as % of total imports of services	*39%*	*30%*	*31%*	...
	Communications services	70	96	134	8
	Insurance services	150	233	374	12
	Financial services	16	20	88	24
	Computer and information services	...	...	167	...
	Royalties and licence fees	74	82	140	8
	Other business services	576	501	783	4
	Personal, cultural and recreational services	...	...	16	...
Exports	**Information technology enabled services**	**365**	**407**	**692**	**8**
	Information technology enabled services as % of total exports of services	*23%*	*18%*	*19%*	...
	Communications services	90	69	125	4
	Insurance services	113	118	227	9
	Financial services	12	6	47	18
	Computer and information services	...	...	18	...
	Royalties and licence fees	1	2	3	13
	Other business services	149	212	268	8
	Personal, cultural and recreational services	...	...	4	...

Source: UNCTAD based on COMTRADE data.
**Compound annual growth rate.*

ware development companies is well known. It is determined by factors such as the lack of sufficient physical assets as guarantee, the risk inherent in an innovation-based activity, and the reluctance of the financial system to become involved in this type of transaction. Financial institutions do not attach sufficient worth to the intangibles, which are the principal assets of these companies. Neither have specific mechanisms been developed in Peru for this type of company, such as exists in other countries: seed capital, business angels, contingent loans (for start-up companies) or venture capital (for companies with some experience in the market).

1.5. Knowledge disseminating organizations

A critical aspect for the development of the ICT sector is the availability of a sufficient quantity of adequately qualified human resources. The experience of various countries shows that when the development of the sector accelerates, the availability of human resources becomes a bottleneck. Companies start to compete among themselves for human resources, with a consequent increase in costs. Students, tempted by high wages, enter the industry before finishing their studies and training institutions of dubious quality proliferate.

In Peru, there has been a growing demand for human resources trained in telecommunications engineering, electronics, systems, information technology, computer sciences, etc. Peruvian universities, both public and private, have responded to this demand with increased provision of undergraduate courses as well as master's degrees and doctorates. For example, at the end of the 90s, courses in telecommunications engineering were created as a result of the privatization and expansion of this sector. Currently, the National University of Engineering, the Mayor de San Marcos National University and the Pontifical Catholic University of Peru offer master's courses in this area. Electronic systems engineering or information technology have a longer tradition. More recently, computer science courses have also been introduced in San Agustín de Arequipa University and the UNI. According to the National Population and Housing Censuses (INEI, 2007a), there are 27,000 information technology professionals in Peru. In 2006-2007, there are 17,306 students enrolled in systems engineering in Peru.

There is a great disparity in the quality of the training. There is no standardized curriculum, there is an enormous difference in the total number of credits or research necessary to complete a master's degree and the teaching capacity and equipment available varies from one university to another. Furthermore, just as in general education, there is no effective system of monitoring the quality of universities. There is no formal accreditation of courses. In this regard, mention should be made of a recent initiative, albeit of a

Box 3. The content industry in Peru

The Peruvian content industry is little developed and concentrated in Lima. There are no transnational groups of Peruvian origin nor does the local industry (TV, music or publishing) export its content. The film industry is very small (it makes 3 or 4 films a year). The Peruvian Cinematographic Act (Act 26370 of 1994) does not require screening quotas or the showing of Peruvian films. Independent television and film production is incipient.

The radio industry is widely distributed in terms of the number of broadcasters and geography. It has extensive coverage (84.4% of the population has a radio at home and 60% of Peruvians listen to it every day) and it plays an important communication role.

The television industry is made up of a small number of companies. Domestic production concentrates on the production of "soap operas", although this production accounts for only 16% of the soap operas broadcasted in Peru. The majority of cultural programmes are produced by the public channel (National Television of Peru). 67% of the population has television at home, 26% have pay-TV and 40% of cable connections are illegal. Digital television has not been developed and terrestrial digital television is starting to be introduced in 2010 in Lima and Callao. The Radio and Television Act of 2004 includes a minimum quota of domestic productions.

The press is conformed mainly by five national publishing groups. Only a quarter of magazines are national, and book publishing is heavily affected by illegal sales (16% of sales are illegal copies) and the low level of reading.

No data is available on the production of electronic games or mobile phone content or independent musical production.

Source: Castro (2008), Rey (2005).

voluntary character, by the Quality and Accreditation Institute for Engineering and Technology Careers (ICACIT) to accredit technical and university programmes in the fields of engineering, technology and computing. ICACIT is a not-for-profit association which promotes a culture of quality and provides training to educational institutions which wish to be accredited by ABET (the Accreditation Board for Engineering and Technology of the United States).

In addition, the educational provision is not commensurate with demand in the sector. There is a latent demand for workers with technical training and multidisciplinary and/or specialist training. In general, the educational institutions update their programmes in a reactive manner.

To prevent the emergence of this bottleneck, a crucial pillar is the development of a high-level training plan with the necessary financing to support a programme of grants for students, doctorate and post-doctorate training abroad and research projects in universities.

1.6. Knowledge generating organizations in the ICT sector

In Peru, there is limited research activity in the ICT sector concentrated in a handful of universities, sectoral research institutes and certain small domestically-owned companies. The causes of the limited research in the ICT area can be found both in the academic and the entrepreneurial side.

Although there are some 25 master's degree courses in these areas (Sánchez Tarnawiecki, 2003), there is a lack of human resources and researchers trained at a high level (doctors of information technology). It is estimated that in 2008, only 5 doctors graduated in all the engineering fields, and in 2006-2007, only 6 doctors graduated (Guerra García, 2009).

The academic system in general pays scant recognition or remuneration for research activities. Opportunities to carry out research as a permanent activity are few. In general, master's courses do not have full time teachers, as they work simultaneously in different universities or companies. Part of the student body works in the entrepreneurial sector and students do not devote themselves full time to their studies. Private universities, which focus excessively in profitability, normally do not promote or adequately remunerate research despite having the necessary resources (Sánchez Tarnawiecki, 2003).

Furthermore, the demand of transnational companies for research projects or technological services of Peruvian S&T institutions is very low, as these activities have traditionally been concentrated in their countries of origin. University-company collaboration is also rare, even with domestic companies. Reasons include the various idiosyncrasies and administrative and management problems which make collaboration between universities and private companies difficult.

There is no official list of research groups in Peru, but the following should be highlighted:

The Centre for Information and Communications Technologies (CTIC) in the National University of Engineering, supported by the Korea International Cooperation Agency, is carrying out research in software design, nanosatellites and artificial intelligence. The centre has various ICT research projects and ICT laboratories linked to the productive sector.

The CONCYTEC Chair of Information and Communication Technologies (ICTs), which concentrates on software design, is based in the National University of San Agustín de Arequipa and is supported by the Regional Science, Technology and Technological Innovation Council, Global System & Consulting S.A.C. and Representaciones Internacionales S.A.C. The project is also sponsored by the Embassy of France and benefits from the active involvement of doctors from the French Institute for Research and Development (IRD)[19].

The purpose of the Chair is to make the Arequipa region one of the development poles of the software industry to meet local, regional and global requirements and to train the human talent required for the technology park project which is being promoted in the region.

The Chair is currently developing three projects:

- Intelligent Integrated Water Resource Management System (GIRH) for the Pacific Basins, Case study: Chili river Basin (Arequipa). Development of a model for optimizing the use of water resources in the Chili river Basin which will be extended in the future to the Pacific basins.
- Automated System for the Diagnosis of Intestinal Parasites using Digital Imaging. This system will facilitate the diagnosis in healthcare centres and remote areas where there are not experts, reducing costs and improving the accuracy of diagnoses.
- Intelligent Hybrid System for the Management of Small and Medium-Sized Supermarkets.

The National Institute for Research and Training in Telecommunications (INICTEL) was created in 1963 with the object of conducting research, training and carrying out studies and projects in the telecommunications field. INICTEL had its heyday when the country's telecommunications companies were state-owned and contributed to cover its budget. Following the privatization of the sector, the limited state financial support and the lack of capacity to offer its services to the private sector, the Institute suffered heavy losses of technical staff and equipment. In 2006, its responsibilities for training, studies, projects and research were transferred to the National University of Engineering.

There are several public research institutes which, to carry out their tasks, rely on ICT infrastructure and knowledge. Worthy of mention are the Geophysical Institute of Peru, SENASA and INIA in the agriculture sector, INGEMMET in the mining sector, IMARPE in the fisheries sector, IGN and SENAMHI, among others.

Despite these efforts, it should be noted that the national ICT agenda has focussed its activities on the development of ICT infrastructure and not R&D. The Telecommunications Investment Fund (FITEL) is dedicated to the development of infrastructure, in particular the expansion of broadband in rural areas and the use of this Fund for R&D activities in software are not possible. At the same time, other funds for financing innovation (e.g. FINCyT) limit the use of resources to pay the wages of professionals in the team to 10% (although it can pay consultants' fees). This makes it more difficult to participate in software development programmes where the principal cost is researchers' wages.

2. Management and financing function

The sources of financing for R&D activities in the ICT area, as in the case of research generally, are sparse. Although ICT have a prominent place in the priorities of the principal public funds for the financing of R&D, the total amount allocated is insufficient to develop a critical mass of ICT research.

The Science and Technology Programme (FINCyT) includes the ICT sector among its priorities. In three years, the programme[20] has financed a total of 17 innovation projects in companies for a total amount of 2,225,000 dollars, as well as research projects in universities and R&D centres for a total of 984,000 dollars. It has also financed 8 events, 4 fellowships for the CONCYTEC ICT Chair and a study on the behaviour of technological entrepreneurs in the ICT sector.

CONCYTEC has been supporting the development of innovative projects in the ICT sphere. See, for example, the CONCYTEC ICT Chair in the University of San Agustín de Arequipa.

International cooperation (IADB, French, Korean, European cooperation, etc.) has also contributed to research activities in ICT (e.g. grants for doctorates and expert consultancies) and the development of the ICT sector in general (e.g. conduct of studies) and/or collateral (by promoting information systems or databases for social areas). However, international cooperation is insufficient to develop a critical mass of ICT research and development.

3. Regulatory function

Peru has a wide range of legal instruments which promote the use of electronic and telematic media in Peruvian society, both in the public and the private sector (Box 4). The legal provisions relating to the public sector are intended to promote the adoption of electronic and telematic media in the activities of the Public Administration and also to promote the State's Internet presence (through gateways) to facilitate relations between government departments, and between them and citizens at the information stage of electronic government. Aspects related to ICTs, such as electronic commerce, intellectual property and domain names, etc., are included in international trade negotiations, such as the FTAA and FTAs negotiated with different countries.

One of the remaining subjects to be addressed is personal data protection, see Bill No. 4079/2009-PE. The adequate protection of personal data can be an incentive to invest the ITES sector (e.g. companies which provide accounting or payroll management services). It is also foreseeable that adjustments will need to be made to the regulation of telecommunications in order to meet the needs of broadband access, convergence of telecommunications and access in rural areas[21].

A major threat to the sector is piracy. Despite having a developed regulatory framework, piracy remains high. The Business Software Alliance (BSA) and the consultancy IDC (2010) estimate a piracy rate of 70% in Peru, with a commercial value of 124 million dollars. Other studies (Cuore, 2008) show that 24% of software companies interviewed had been victims of

Box 4. Peruvian legislation on information and communication technologies[1]

Domain names

- Supreme Resolution No.292-2001-RE and No. 548-2001-RE: Establish the Peruvian Scientific Network (RCP) responsible for the administration of Peruvian domains (.pe).

Computer crime

- Act 26612/1996: Industrial Espionage Act. Covers hacking into or interference with databases, computer systems or networks.
- Act 27309: Incorporates computer crime into the Criminal Code.
- Bill No. 2825-2000/CR on child pornography on the Internet.

Consumer protection

- Act 28493 2000: regulates the use of unsolicited commercial electronic mail (spam).

Combating piracy

- Legislative Decree 822: Copyright Act. Establishes copyright and related rights. Establishes provisions on administrative infringements of those rights.
- Act No. 28289: increases the minimum custodial sentence to 4 years for aggravated forms of copyright crimes. Amends Act 27595 and creates the Customs and Piracy Crimes Commission.
- Legislative Decree 823: Industrial Property Act.
- Legislative Decree 1092: Approves border measures to protect copyright.

Electronic signatures

- Act 27269 of 2000: Digital Signatures and Certificates Act. Authorizes the use of digital signatures in any public or private document.

-Supreme Decree 052-2008-PCM: New regulations in application of the Digital Signatures and Certificates Act.

Electronic transactions

- Act 27291: Amends the Civil Code allowing the conclusion of contracts using electronic means. It allows the use of such means in relations between the Administration and citizens.
- Act 27419: Amends article 163 of the Civil Procedures Code, and establishes the possibility of serving notices of certain resolutions via electronic media provided that they allow acknowledgement of receipt.
- Act 27444: General Administrative Procedures Act. Incorporates the possibility of serving notices of administrative decisions by electronic or other means which allow reliable confirmation of receipt by the recipient, provided that the recipient has expressly so requested.
- Supreme Decree No. 135-99, Tax Code, amended by Legislative Decree No. 953, authorizes the submission of declarations by electronic means.

Electronic archive

- Legislative Decree 681 as amended and Supreme Decree 009-92-JUS (Regulations): Regulate the use of microfilm and computer and electronic procedures for archiving documents and information.

Transparency and access to information

- Act 27806: On transparency and access to public information. Provides for the creation of gateways of government departments.

Electronic government

- Supreme Decree No. 94/2005 Establishes the National Office of Electronic Government and Information Technology
- Ministerial Resolution No. 274-2006-PCM: Approves the National Electronic Government Strategy
- Supreme Decree No. 048-2008-PCM: Approves the restructuring of CODESI.

Personal data protection

- Bill No. 04079/2009-PE: Proposes the Data Protection Act.

Telecommunications

- Single Consolidated Text of the Telecommunication Act DS 013-93-TCC as amended (Act No. 27010, 1998; Act No. 28737).
- Single Consolidated Text of the General Regulations of the Telecommunications Act, DS No. 020-2007-MTC.

(cont.)

Box 4. Peruvian legislation on information and communication technologies[1] (cont.)

Other initiatives to promote ICT use with the force of law are:

- Supreme Decree No. 066-2001-PCM: Approves the general policy lines to promote mass Internet access.
- Supreme Decree No. 060-2001-PCM: Creates the Peruvian State gateway for unified access to administrative services and procedures.
- Emergency Decree No. 077-2001: Creates the economic transparency gateway of the Ministry of Economy and Finance.
- Supreme Decree No. 018-2001-PCM: Sets out the public sector entities which must incorporate in their Single Text of Administrative Procedures (TUPA) procedures to facilitate access to information. It states that administrative procedures for access to information may include the use of electronic media.
- Supreme Decree No. 031-2002-PCM: Approves the general policy lines for the development of the Electronic System for Government Procurement and Contracting (SEACE).
- Ministerial Resolution No. 142-2004-PCM: Approves the SEACE guidelines which must be applied by entities subject to the application of Act No. 26850, Government Procurement and Contracting Act, as amended and supplemented.

Source: UNCTAD (2009a), CEPAL (2010b), Barrantes (2008).

[1] This list is not exhaustive.

piracy, and 70% of companies lost less than 10% of their income due to piracy. The need to put in place mechanisms which promote protection of intellectual property is evident, in order to be able to develop the sector and promote the use of ICT.

4. Foresight and design of plans, programmes and instruments function

The INEI regularly collects statistics on ICT access and use in households, and intermittently in companies. In addition, various studies have been conducted into the situation and potential of the ICT sector in Peru[22]; as well as to monitor and evaluate the development of electronic government[23].

Nevertheless, there are opportunities to collect statistical information on ICT use by businesses, especially among micro, small and medium-sized enterprises. It is also necessary to monitor and evaluate the impact of government policies and programmes implemented to develop the sector (e.g. the Peruvian Digital Agenda and other programmes which are described below), to conduct foresight studies, particularly in specific niche areas, and to continuously monitor and evaluate training and research capacities in the area.

Peru has a plan for the development of the information society, the Peruvian Digital Agenda. The plan was developed between 2003 and 2005 by the Multisectoral Commission for the Development of the Information Society (CODESI, see Box 5), under the Presidency of the Council of Ministers. The Agenda, the development of which was not included in the process of dialogue of the National Agreement (Saravia and Iriarte, 2007), was approved by Supreme Decree No. 031-2006-PCM in 2006. The Agenda contains the main lines, objectives and strategies for the development of communications infrastructure, human capacities, social programmes, production services sectors, electronic government and international relations.

CODESI is responsible for monitoring the implementation of the agenda. The last progress report on implementation of the Agenda dates from December 2007 (CODESI, 2007), but it does not include a report of the working group on *Development and applications of ICT in the services and production sectors.* The least satisfactory results were in the development and applications of ICT in social programmes (including R&D in ICT) and in the services and production sectors (CODESI, 2007). One of the difficulties in monitoring the application of the Peruvian Digital Agenda has been the lack of baseline and monitoring indicators against which progress can be evaluated. The Peruvian Digital Agenda is currently being revised by ONGEI.

Presented below are the principal policies and programmes for promotion of the ICT sector. In addition to these initiatives, there are other ICT-related policies and programmes which, more or less directly, promote ICT development. Worthy of mention is FITEL (for its impact on infrastructure development), the extensive work programme for the development of electronic government promoted by ONGEI, as well as various programmes in the educational area, such as the Huascarán project, the promotion of the use of laptops in rural schools or the development of the Peruvian academic network.

In 2007, a Bill for the Promotion of the Software Industry was presented to Congress. The Bill, which was in line with legislation in other countries of the region, such as Argentina, Chile and Colombia, envisaged a series of tax benefits for software companies for a period of six years, which could be renewed:

- up to 50% rebate on income tax for each year, subject to fulfilment of investment, R&D and export targets
- deduction of income tax on expenses of training personnel, up to double the amount invested
- depreciation of equipment and machinery used at 25% per annum

However, the Bill was not approved.

Despite the fact that there is no legal framework for the promotion of the software and computer services sector, in recent years, the Peruvian State has been taking a series of initiatives aimed at strengthening the sector. Among the most significant are the following:

CITE Software (Centre for Technological Innovation of Software)

CITE Software was created (Resolution No. 002-2007- Produce/DVI) with the object of promoting development and technological innovation in the Peruvian software industry. CITE Software provides technological services to companies in the software productive chain to strengthen its competitiveness and improve its productivity. CITE Software also promotes technological solutions for MSMEs in other sectors linked to the CITE network and the use of computer tools by such companies. In 2009, it had a budget of 86,000USD and provided 20 technological services (CITE 2010).

CITE Software is administered by APESOFT and provides the following services:

- Software test laboratory. Software verification and evaluation services aimed at companies that develop software systems and applications.
- Accreditation of software quality standards. It issues the Software Technical Formality Certificate, specially aimed at companies which supply software packages. This certificate will be applied to software companies participating in the PRODUCE project “Buy software from Peru”.
- Quality Centre. Specialized training courses for software companies and technical assistance in the implementation of quality systems such as ISO 9000 and ISO 12207.
- Discussion forums for technological solutions for MSMEs. Meeting point for suppliers and seekers of technological solutions.

CREASoftware Peru Programme

CREASoftware Peru arose as an initiative of the Commission for Promotion of Exports and Tourism of Peru (PROMPERU), through the Services Export Programme, based on a pilot scheme carried out in 2000. That was the same year which saw the creation of APESOFT with the object of promoting the domestic software industry, improving the competitiveness of its members and promoting exports of Peruvian computer programmes.

CREASoftware Peru is a group of Peruvian software development companies and providers of information technology services which generate high quality solutions. It is supported by PROMPERU (Ministry of Foreign Trade and Tourism) and APESOFT. Its mission is to stimulate the international competitiveness of the Peruvian software industry by strengthening its capacity to provide solutions to the major global markets. It has the following components:

- External Markets Programme for the Services Sector (PROMPERU – Services).
  - Foreign trade branches.
  - Participation in fairs and enterprise missions.
  - Support for expansion of the supply of exportable software.
- Support for the development of business plans
- ISO 9001:2000 Certification.

The Programme has achieved the following results:

- 16 companies internationalized
- 15 companies certified ISO 9001:2000
- Trade Promotion Office in Colombia
- 24 companies trained in exporting
- Stimulating the development of the software industry in the country’s region
- Integrated Software Industry Programme.
- Approval for the establishment of software companies in the Tacna Free Zone.

In addition to the public policies described, there are some private initiatives which are of interest for their scope and impact. The following are worthy of mention:

Programme to Support Competitiveness of the Software Industry (PACIS)

In 2004, it was noticed that the principal barrier faced by Peruvian software companies in accessing foreign markets was the growing demands in terms of quality and international certification. APESOFT, in collaboration with the Lima Chamber of Commerce, designed an ambitious programme of activities aimed at improving the sector's competitiveness. In 2004, they signed an agreement with the IADB for the implementation of PACIS. The agreement was implemented between 2004 and 2008, with a budget of one million dollars, with an IADB/FOMIN contribution of 60%.

The programme had three main components: quality, promotion of exportable products and development of the institutional framework. The quality component involved the training of software development companies in the methodology of the CMMI quality standard. As regards promotion of exportable products, prospective studies of international markets were carried out and efforts were made to promote Peru's image as a software producer country. The third component sought to establish a propitious framework for the development of the software sector, strengthen the level of association between companies and attempt to establish a regulatory framework of defined support. The chief beneficiaries of the programme were software SMEs and the most significant results were as follows:

- 90 companies and 10 consultants trained in CMMI by the European Software Institute.
- 9 companies certified (6 CMMI and 3 IT-MARK).
- Software test laboratory implemented.
- 5 local and Andean market studies carried out.
- 6 graduates in software engineering and management.
- First catalogue and CD of export companies.
- Bill on the promotion of the software industry.
- Institutional strengthening of APESOFT.

These results could have been the basis of a permanent support structure for the sector. However, there was a failure to achieve the institutional and financial sustainability which might have been able to give continuity to the initiative.

Project for the decentralization of quality for software competitiveness

This project was financed by the Andean Development Corporation (CAF). Its objective is to translate a culture of quality to the software companies located in the country's principal regions though the creation, dissemination and adoption of an adapted CMMI model. The project will be implemented in four stages: (i) adaptation stage; (ii) instilling a culture of quality; (iii) decentralization of professional training in CMMI; and (iv) implementation of the quality model in regional software companies.

The direct beneficiaries will be all the software production companies located in the country's principal provinces, estimated to be about 20. Of these, eight, as pilot companies, will receive training and technical assistance in operating the CMMI model level 2 adapted to the Peruvian situation. The training in software quality will also be provided to 75 information technology professionals connected with the regional universities. Finally, a consultancy programme on the new adapted CMMI model to be developed with this project will serve APESOFT as a model to be replicated in other SMEs in the sector.

A series of measures have also been developed to promote the call centre industry:

a) Exemption from General Sales Tax (IGV). Supreme Decree No. 25-2006-EF exempts the provision of call centre services to customers in other countries from payment of IGV (19% of the sales value), as they are considered exports of services.

b) Tacna Free Zone (ZofraTacna): created with the objective of providing tax incentives to companies which locate to Tacna. Call centre services were included in ZofraTacna in 2008. However, only one call centre company has been set up there (ICEX 2009).

In summary, there has been an attempt to launch initiatives in support of the ICT sector which have produced some results but which have not been consolidated[24]. Consequently, there are still important gaps to be able to develop a strong innovative ICT sector which contributes to the country's economic and social development. In particular, a programme for entrepreneurial development in ICT, an ICT research programme and a human resources training programme at university level in line with current and future demand in the sector are missing.

5. Cohesion and execution function

In Peru, there are several public institutions responsible for the design and implementation of programmes in the ICT area (see Box 5). In the sphere of telecommunication, the institutional framework is well developed and responsibilities are clearly identified (Barrantes, 2008). Likewise, in recent years, the institutional framework for the promotion of electronic government (ONGEI) and the use of ICT in the educational system (Directorate General of Educational Technologies) has been strengthened. However, it cannot be said that the current mechanisms contribute to the development of the ICT industry.

Among the principal institutional gaps, the lack of a space for effective interaction to discuss the needs of the private sector and adapt the educational provision in the ICT sphere needs to be highlighted. There is a lack of leadership on promoting the ICT industry, on providing significant and sustained support for innovative ICT products and services and on investing in R&D in this sector.

Box 5. Principal public institutions responsible for the design and execution of an ICT strategy.

ONGEI. National Office of Electronic Government and Information Technology (under the Presidency of the Council of Ministers) Established in 2007 (D. S. No. 063-2007-PCM) as a specialized body responsible for directing, as the oversight body, the National Information Technology System and implementing the national policy on electronic government and information technology.
CODESI. Multisectoral Commission for the Development of the Information Society (under the Presidency of the Council of Ministers), and consisting of the Minister of Production, the Minister of Education, the Minister of Transport and Communications (MTC). The Head of ONGEI acts as technical secretary.
Created in 2003 (Ministerial Resolution No.181-2003-PCM) with the objective of preparing a Plan for the Development of the Information Society in Peru.
In 2008 (Supreme Decree No. 048-2008-PCM) the restructuring of CODESI into a Permanent Multisectoral Commission was approved. CODESI participates in five working groups:
Working Group 1: Infrastructure for the development of the information society. Coordinated by the Vice Ministry of Communications (MTC)
Working Group 2: Development of human capacities, Coordinated by the Ministry of Education
Working Group 3: Development and applications of ICT in social programmes. Coordinated by CONCYTEC
Working Group 4: Development and applications of ICT in the services and production sectors. Coordinated by INDECOPI
Working Group 5: Electronic government. Coordinated by ONGEI

Ministry of Transport and Communications. According to the Single Consolidated Text, DS 013-94-MTC, the Ministry sets telecommunications policy, prepares and proposes regulations for approval, grants and revokes concessions, authorizations, permits and licences, administers the use of the spectrum and promotes the development of the telecommunications and computer services industries. In addition, since 2006, it has administered FITEL.
OSIPTEL. Supervisory Body of Private Investment in Telecommunications, independent and attached to the Presidency of the Council of Ministers. It is the regulatory body. Created in 1994 and regulated by the Framework Act of Regulatory Bodies and its Regulations, D.S. No. 008-2001-PCM.
FITEL. Telecommunication Investment fund (under the Ministry of Communications and Transport since 2006). Finances the expansion of telephony in rural areas.

Directorate General of Educational Technologies (under the Ministry of Education). Established in 2007 (No. 016-2007-ED), responsible for integrating ICT in the educational process.

Ministry of Foreign Trade and Tourism. Promotes the export of Peruvian software services and information technology enabled services.
Ministry of Production. Developed CITE Software.

Source: Barrantes (2008), www.ongei.gob.pe, www.codesi.gob.pe

C. CONCLUSIONS AND RECOMMENDATIONS

The level of development of innovative activities in the ICT sector shows limitations and problems similar to those that can be observed in many areas of the incipient and still weak system of innovation in Peru (Table 14).

Private activity is marked by a high level of informal enterprises (reflected in the limited take-up of international certification and scant quality control), its concentration on low added value activities and minimal links with research initiatives in universities and other academic institutions. Peruvian companies also face a lack of capitalization mechanisms and bottlenecks in the training of human resources.

In the public sphere, for its part, added to the lack of a legal framework to promote the software industry and generate adequate incentives for the development of the sector, is the obvious institutional weakness of support bodies for scientific, technological and innovative activities, a marked scarcity of resources, a notorious lack of promotion of the sector and also a lack of coordination between bodies which tends to fragment the available funds into a multiplicity of separate initiatives.

Thus, although some successful individual initiatives can be found, they are still a long way from forming a critical mass which would allow an autonomous development of the sector.

To reverse this situation, it is essential to have a strategic definition, at present non-existent, which would, firstly, involve the key actors (including the public and private sectors, universities and research institutions) and, secondly, orient and coordinate the policies, programmes and instruments targeting the sector. The construction of such a strategic vision must be consensual and must allow the sector to act transversally as a disseminator of innovation to the rest of the economy and society and support the transformation of Peruvian production.

At present, there is a demand for such services in the Peruvian economy and it can be envisaged that this will increase in the future. Given the current openness of the Peruvian economy, it will be important to focus the strategy on the development of the local industry, to allow it to respond to domestic demand and, eventually, export its services. Given present conditions (limited size of the industry, presence of

Table 14. Principal strengths, weaknesses, opportunities and threats in the ICT sector

STRENGTHS	WEAKNESSES
• A certain level of installed capacity and creativity in the local software industry. • There are specific success stories of Peruvian software. • Low cost of human resources. • Similar culture to target markets at regional level. • Developed legal framework. • Developed infrastructure, at least in the main economic centres.	• Bottlenecks in the training of human resources, especially at doctorate level and in free and open source software. • Extreme fragmentation and lack of scale within the industry. • Low level of investment in R&D in the sector. • Lack of links between universities and the private sector in R&D activities. • Lack of capitalization mechanisms. • Low level of formal development of international certification and quality control in the sector. • Lack of a planned strategy involving the public sector, industry agents and the academic world to develop the sector.
OPPORTUNITIES	**THREATS**
• Expanding domestic market (dynamism in access to and use of ICT). • Development of ICT infrastructure (expansion of geographical coverage and reduction in costs) • Free trade agreements: will require effective measures to tackle software piracy and counterfeiting. • Possibility of capturing new markets in countries of Latin America and North America.	• Limited use of Internet to carry out banking transactions and transactions with state and public authorities • High degree of informality of micro and small enterprises • International competition • High level of contraband, piracy and counterfeiting directly affect the software industry.

Source: Based on final report of CODESI working group 4 and information gathered during the review.

large international players), the best option will be to concentrate on specific niches in the market where companies can be competitive. Efforts must focus on the gradual formation of a specialized industry targeting those niche markets, articulated with the country's major productive or research sectors. To that end, it will be necessary to carry out a foresight study. As there are already a number of large companies able to offer a wide range of services, it will be important to focus efforts on strengthening small and medium-sized enterprises in order to create a broader base.

The high degree of informality of the economy and the still limited use of ICT services also represent a threat to the development of the sector. In this regard, it will be important to understand the barriers faced by SMEs to access and use such services, in order to promote their adoption and utilization.

Based on this analysis, presented below are a set of recommendations intended to achieve five objectives:
(1) Development of a strategic vision for the sector
(2) Provision of human resources training
(3) Development of research capacity
(4) Strengthening of entrepreneurial development
(5) Improvement of capacities to design policies and programmes

Recommendations

1) Develop a national vision and strategy for the development of the ICT sector.

- Strengthen the productive aspects of the Peruvian Digital Agenda, by promoting greater concern among the actors involved (including ONGEI and CODESI) and identifying a set of priority actions to develop the ICT sector and its contribution to the development of the information society in Peru.
- Establish a National Programme for the Development of ICT which includes the development of a human resources training plan, promotion of ICT research, a set of measures to develop greater sophistication among entrepreneurs, and strengthen foresight exercises and information gathering in the sector, as well as monitoring and evaluation of capacities, policies and programmes.

2) Establish a human resources training plan in the ICT sphere. This plan must foster the development of a comprehensive high-level, multi-disciplinary and specialized education based on an evaluation of the existing educational offer and the needs of the sector over the next 5-10 years. The plan must include the necessary financing for a programme of student grants and teacher training, doctorate and post-doctorate training in Peru and abroad, as well as for university research projects. The plan must also include support for the accreditation of training programmes in the area and promotion of technical training.

3) Strengthen the promotion of ICT research in universities and companies, in particular in the identified niches.

- Continue the support provided by competitive funds, adapting them so that they can respond to the demand for R&D in this sector.
- Explore other research funding options (permanent fund for innovation in ICT, development of venture capital, guarantee fund, fiscal measures).
- More generally, support research activities by establishing the profession of researcher as a career path and strengthening the supply and quality of postgraduate training programmes.

4) Establish a set of measures to **develop greater entrepreneurial sophistication in the sector**, in which Peruvian companies can undertake larger-scale projects, compete at international level and offer specialized added value services:

- Stimulate international certification by facilitating financing to allow smaller companies obtain certification and by progressively incorporating in state institutions the requirement for certification of software suppliers.
- Progressively redirect support instruments (e.g. competitive funds) towards activities in areas with greater added value, promoting specialization in niche fields.
- Consider the development of other measures which can facilitate financing of the sector (permanent fund for innovation in ICT, development of venture capital, guarantee fund, fiscal measures).
- Promote entrepreneurial development in other ICT-related sectors and which complement its development, such as the IT-enabled services sector and the content industry.
- Move forward in the implementation of the Government's digital strategy by creating demand for new complex solutions for Peruvian software companies. Analyse the principal barriers to the participation of local companies in this market and generate appropriate competitive conditions to allow local companies to enter that market.

- Foster collaborative projects of increasing complexity between universities, companies and public research institutes.
- Promote the creation of university spin-offs through incubators.
- Establish a set of actions to promote the adoption of ICTs by SMEs.

5) Strengthen foresight studies and the gathering of information on the sector as well as the monitoring and evaluation of capacities, policies and programmes.

In particular, it is recommended to:

- Undertake a foresight study on the ICT sector. This study should identify the niches with the greatest added value and potential for Peruvian companies and those on which public efforts should be focussed.
- Carry out a study on the content industry in Peru, concentrating on areas directly related to the productive development of the ICT sector.
- Systematically monitor and evaluate the impact of policies and programmes in support of the sector.
- Monitor ICT access and use by small and medium-sized enterprises.

NOTES

1 OECD definition 2006-07.

2 Including hardware, software and communications equipment.

3 Figures from NASSCOM, Chamber of Commerce for the IT sector of India.

4 See www.osiptel.gob.pe

5 Large enterprises which operate in the travel industry, agroindustry, commerce, services, private educational institutions, construction, hotel services, oil, fisheries, manufacturing, electrical services, transport and communications, private universities, restaurants and other services.

6 Over 80% of the enterprises which participated belong to the services sector. Agroindustry (1.8%), Oil (0.9%) manufacturing (13.9%) and fisheries (2.3%) accounted for 18.9% of the participation in the survey.

7 See measuring-ict.unctad.org/

8 See Limanche, 2009.

9 See also IDC data.

10 It is calculated that 60% of Peruvian software companies are dedicated to development of accounting and management applications (generically known as ERP systems).

11 APESOFT data.

12 53% of the surveyed companies sold software or services to State institutions, according to the PROMPEX and APESOFT report.

13 According to Lolimsa's managing director, there are only 4 companies in Peru (LOLIMSA, GMD, Cosapi and Banco de Crédito) which have CMMI certification level 3. See http://www.casamerica.es/opinion-y-analisis-de-prensa/zona-andina/claves-para-fortalecer-la-industria-de-software-en-el-peru

14 UNCTAD (2003) E-Commerce and Development Report 2003.

15 Apesol estimate.

16 Supreme Decree No. 013-2003 initially set 31 March 2005 as the deadline for listing software which did not have the respective licence and eliminating it. That deadline was postponed on several occasions (No. 037-2005-PCM, No. 02-2007-PCM, No. 053-2008-PCM, No. 077-2008-PCM) and the deadline is now 31 December 2011.

17 See UNCTAD (2009b).

18 OECD definition 2006-07.

19 The Chair has six researchers and seven scholarship students studying for doctor of computer sciences.

20 FINCYT (2010) Management report July 2007=March 2010, 1 April 2010.

21 For a discussion of the regulatory implications of technological convergence, see Barrantes (2008).

22 See Sánchez Tarnawiecki (2003), ONGEI (2009) or the Study on the IT and BPO services industry undertaken by PromPerú in 2009.

23 See ONGEI (2009).

24 It should be noted that information on resources allocated to several of the above programmes, their duration and current situation is not available.

IV

Biotechnology

A. INTRODUCTION[1]

Biotechnology, meaning "any technological application that uses biological systems and living organisms or derivatives thereof to make or modify products or processes for specific use"[2], is a technological platform which serves as a base for an enormous diversity of specific technologies with a practical use in productive activities.

In its widest definition, biotechnology encompasses many traditional instruments and methods such as tissue cultivation commonly used in agriculture, food production and health. In its narrowest definition, so-called modern biotechnology, it comprises more sophisticated genetic engineering techniques, such as DNA manipulation, combining or cloning of plants and animals.

Biotechnology offers numerous opportunities in the field of human and animal health, agriculture, the environment and industry. Its application can offer increased productivity in agriculture, new diagnostic methods for diseases, vaccines, drugs and treatments, industrial tools or the development of biofuels (see box 1).

The application of biotechnology has a direct impact on many of Peru's core activities (e.g. agriculture, livestock, fisheries, forestry, mining, the food and pharmaceutical industries) which will be felt, either positively or negatively, both in productivity and Peru's integration in the global economy.

Furthermore, Peru's biodiversity provides genetic riches which are of great importance to biotechnology. The development of modern biotechnological capacities could allow Peru to exploit its competitive advantage in the abundance and diversity of natural resources by integrating its many traditional primary activities into more complex value chains.

Biotechnology covers a wide range of activities characterized by a high degree of interaction between the scientific, technical and production aspects. While

Box 1. Applications of biotechnology – some examples.

Biotechnology and livestock

Applications:
- Identification of strains to allow guiding the process of natural selection and cross-breeding
- Cloning of animals
- Modification of the genetic profile of animals by changing the conformation or production quality of a particular derivative
- Procreation techniques

Benefits:
- Improving the "natural" selection process by shortening time spans in the process
- Targeting certain attributes of the animals (and/or subsequent products)
- New products and/or uses of "natural" but modified products
- Inducing an animal organism to produce certain chemical compounds pre-existing in nature (replacing others deriving from the chemical industry)

Biotechnology and agriculture

Applications:
- In vitro reproduction of seedlings free of all disease. After isolating an example which it is wished to be multiplied, micropropagation allows the plant to be reproduced in the laboratory. It is extensively applied to the production of seedlings for tobacco, trees for cellulose paste, fruit trees and, in general, crops which are produced initially in nurseries and then planted out individually.
- Identification of genes and sequences responsible for the final content of seeds and/or behaviour in relation to specific external events (climates, attractive/repellent to insects, salinity of soils, etc.).
- Transgenics. After identifying and isolating one or more genes of other species, they are added to the existing variety and a new plant is obtained. These genes may change the plant's behaviour but keep its desirable final content unaltered or modify the final content.

Biotechnology in the food industry

Applications:
- Biological organisms added to dairy products

(cont.)

Box 1. Applications of biotechnology – some examples (cont.)

- Blended yeasts and leavenings used in the production of wine, cheese and yoghurt
- Preservatives and dyes used in meat and dried fruit.

Benefits:

- Improvements on current processes without altering the end product (with impacts on costs as it allows better control of biological reactions)
- Generation of new end products which offer desirable qualities from a nutritional point of view

Gene therapies, medicines and other inputs for human health

Applications and benefits:

- Development of drugs derived not from chemical synthesis but from living organisms
- Modification of bacteria can make the development of conventional drugs more efficient
- Knowledge of the genetic map of persons allows "dysfunctional" genes to be identified in order to cure the disease by other means
- The development of stem cell-based gene therapies (which may subsequently be reproduced to "regenerate" certain organs)

The most significant advances on the field of medicines involve about ten products generated by blending techniques. Genetic insulin, eritropoyetina, various retroviral drugs for treatment of AIDS and the production of certain cancer drugs

Biomass as a source of industrial raw material

Applications:

- Biotechnology can be used to generate raw materials from which a wide range of industrial by-products are derived. Initially, a combination of natural chemical components, which may be vegetable materials or animal waste, are introduced into a fermenter (biomass). In this cultivation mix a series of controlled chemical reactions occur, using genetically modified organisms, which produce precursors of industrial inputs. From then on, the traditional processes used in the chemical and petrochemical industries are used.

Benefits:

- Production of biodegradable PVC from ground maize stalks and leaves; extraction of biofuels from lignin from wood chips and other developments.

Source: Adapted from Bisang et al. (publication pending).

there is a series of techniques common to all the applications, there is another series of technologies with a specific use, the development of which is confined to companies or institutions. Furthermore, local features (e.g. soils and climate) require local adaptations. The complexity of these developments has led to the division of activities, at the level of both research and product development and marketing. This segmentation requires multiple exchanges, challenges previous knowledge and opens up new markets.

On the other hand, biotechnology is applied in sectors which are already developed in which the marketing of biotechnological products enhances the importance of some complementary assets such as brands, existing contractual relations or the logistics of distribution. These characteristics lead to two contrasting organizational models: the first formed by mega companies with highly integrated technology and production, and the second by segmented activities in a framework of more decentralized productive chains.

The combination of productive activities linked to biotechnology is still in the early stages of maturation. This is reflected in the difficulties still encountered in the adequate definition and protection of property rights, the design of regulatory and institutional frameworks and the appropriate organization of markets for these goods and services. (Bisang et al., 2009).

As a result, the development of biotechnology in Peru will depend not only on its research capacities in this area but also on the combination of research capacity in other areas (e.g. biology, chemistry, plant development) and on the existing set of institutions (CONCYTEC, universities and research institutions, etc.) and on the systems of interaction between producers, government departments and research and development institutions which are key elements in the adoption, adaptation and development of the regulatory framework and the market for goods and services related to biotechnology.

Biotechnology and its impact on national development

Given the magnitude of its transforming impact, it is necessary to consider the role of biotechnology and how it relates to the development desired for Peru. From the perspective of a national economic and social development policy, it is essential to take three factors into account:

1)Biotechnology is only one element among many to promote improvements in health, agriculture or the environment. To foster development and reduce poverty in Peru, biotechnology must complement fundamental strategies such as the development of basic health and education systems or strategies to improve the production and marketing of agricultural products by small producers.

2) The advances on modern biotechnology have as yet had little impact for the great majority of people living in poverty, especially among small agricultural and livestock farmers in rural areas (FAO 2010). The private sector is developing products in the most profitable areas but not necessarily those most relevant to people living in poverty (e.g. commercial crops versus staple crops for small producers). Similarly, the pharmaceutical sector does not have incentives to research into forgotten diseases and the high cost of new medical techniques and drugs can exacerbate inequalities in the national health system.

3) Biotechnology can yield results only if it is accompanied by other institutional and socioeconomic factors and capacities which go beyond technology as such. A fair and competitive commercial system, the capacity of small producers to assimilate technology and proper development of the basic health and sanitation system are fundamental requirements if technological progress is to contribute to national development.

Box 2 suggests some considerations in ensuring that biotechnology contributes to the national development and poverty reduction policy.

B. GLOBAL OVERVIEW[3] AND A LATIN AMERICAN EXPERIENCE (BRAZIL)

The advance of modern biotechnology and its consequent application in the business world is characterized by a marked asymmetry between a limited number of countries where these phenomena are originally developed and the remaining countries, as well as the emergence and consolidation of large corporations which lead the process at a global level.

In 2008, some 5,000 biotechnology companies were counted worldwide, with an estimated turnover of some 90,000 million dollars (Table 1). Although this is an approximation, given the blurring of the edges

Box 2. Biotechnology policies and programmes which contribute to national development: some recommendations

- Develop a national vision and strategy for biotechnology which supports national development and complements other fundamental efforts.
- Consider the cost and relative impact of modern technology on the principal public health concerns and the activities of small agricultural and livestock farmers.
- Promote public participation, including representatives of the main disadvantaged groups, in the process of drawing up national policy on biotechnology.
- Carry out surveys to identify the biotechnological techniques and methods most relevant to various groups of small producers.
- Promote research and development in the principal endemic diseases and in the sectors, products and techniques which have the greatest potential impact on small producers which attract limited interest from private investors.
- Facilitate access to intellectual property, by developing policies and capacities for the management of intellectual property in public research institutions so as to allow the exploitation of intellectual property and promote the spread of knowledge and products to small producers.
- Strengthen the public health system in rural areas as well as agrarian extension and technology transfer services to small agricultural and livestock farmers.
- Monitor and evaluate the impact of biotechnology policies and programmes on small agricultural and livestock farmers, and other groups living in poverty.

Source: FAO (2010), WHO (2002).

Table 1. Overview of biotechnology companies in the world (millions of dollars and quantity), 2008

	World	United States	Europe	Canada	Asia-Pacific
Company data					
Income	89,648	66,127	16,515	2,041	4,965
R&D Expenditure	31,745	25,270	5,171	703	601
Profits	-1,443	417	-702	-1,143	-14
R&D / Income	35%	38%	31%	34%	12%
Number of employees	200,760	128,200	49,060	7,970	15,530
Number of companies					
Public companies	776	371	178	72	155
Public and private companies	4,717	1,754	1,836	358	769

Source: Ernst & Young (2009).

of biotechnology, the figure is sufficiently significant to show the dynamism of a sector which did not exist a decade ago.

The United States is the leader in these technologies, especially with respect to pharmaceutical and seed companies. Following far behind are the European countries (France, Switzerland and Germany). Canada and the Asian countries have a smaller share and its activities are confined to a few sectors and companies. The share of state-owned companies is minimal and the bulk of them are spin-offs of science and technology institutions which find in this legal format a way of capturing the technological profit formerly generated by the scientific bodies.

The levels of turnover achieved are the result of rapid and sustained growth in intensive exploitation of research and development (R&D). The levels of investment in R&D are astonishing. For example, in the United States it represents up to 35% of turnover. It should be mentioned that the economic crisis, in particular the evaporation of sources of funding, has affected the sector in all the regions.

The generation of employment in these activities, on the other hand, is not especially impressive compared with the levels of turnover. It is estimated that in 2008 there were just over 200,000 people employed in the sector. Few jobs, but highly paid and highly skilled seem to be the hallmark of the activity. Thus, the multiplier effects of this "industry of knowledge-based industries" are associated more with the possibility of lower costs, higher quality and/or the introduction of new products in downstream activities in the productive chain rather than the direct generation of employment.

Although still far behind the leading countries, several Latin American countries have already begun to develop industries related to agricultural and environmental biotechnology, and are developing important innovations in animal and human health. Among the most advanced Latin American countries in this sector, Brazil, Argentina, Mexico and Chile deserve mention. It should be noted that in all these countries, the elaboration of strategic plans driven by the State has been essential to promote the development of biotechnology.

For example, the experience of Brazil (Box 3) shows that an early bold and decisive wager on the sector (both in terms of building research capacity and marketing transgenic products), as well as political will to promote biotechnology as an integral part and priority of the national development strategy, to include the development of biotechnological products which meet national social demands and to address the legislative obstacles were essential in promoting its development. Nevertheless, Brazil, like many other countries, is still faced with many difficulties, especially the development of the private sector, to ensure the economic and social return on biotechnology.

Box 3. Brazil's wager on biotechnology

In recent years, Brazil has stood out for the development of postgraduate education and research in biotechnology. In 2008, Brazil had over 30 postgraduate biotechnology programmes across a broad range of areas, with 790 research groups and 6,844 researchers (including 3,899 doctors). The increase in research capacity was reflected in results both in terms of patents and publications. The United States Patent and Trademark Office (USPTO) granted 33 patents in biotechnology to Brazilian patent applicants (2000-2007) and in 2007, Brazilian scientific institutions published 1,137 articles on biotechnology, almost four times as many as those in Argentina.

Brazil also excels in the marketing of genetically improved crops. In 2009, Brazil became the second largest producer of GM crops (21.4 million hectares planted or 15% of the global market). The expansion in the commercialisation of GMOs took place despite the fact that the strong opposition from some sections of civil society put a brake in its policy of liberation of GMOs and the legal framework. Support at the highest political level through incentive measures and explicit policies was crucial at several moments. However, all the genetically improved crops were developed by multinational companies. Brazil, like all the other Latin American countries, has not transferred any technology of its own on a commercial basis.

Since 2007, Brazil has had a National Biotechnology Policy and a National Biotechnology Committee which coordinates and implements that policy and ensures its harmonization with other national policies. The National Biotechnology Policy identifies strategic objectives (those with greatest market potential), priorities (of national strategic interest/with a high social impact) and leading edge technology in the four sectoral areas (human health, agriculture and livestock, industry and environment). Biotechnology is also one of the priority areas of the Industrial, Technological and Foreign Trade Policy (2004) and the Industrial Development Policy (2008). This priority is reflected in the various instruments of government finance.

The Brazilian Government actively and explicitly financed biotechnology research from an early stage. For example, the Sao Paulo Research Foundation (FAPESP) bet in the late 1990s on research in biotechnology, investing 12 million dollars in sequencing the genetic code of the pathogen Xylella Fastidiosa. The accumulated tools and experience later served in research in sugar cane through two companies: Allelyx (the first major agro-biotechnology company formed in 2002) and CanaVialis (a company expert in the conventional cultivation of sugar cane). Monsanto bought both companies in 2008 for 290 million dollars.

Since 2001, there has been a sectoral fund for biotechnology and, during the period 2000-2007, over 290 million dollars of sectoral and other funds were allocated to some 1800 projects in the field of biotechnology. Despite the size of the funds allocated, their wide dispersion (apart from some exceptions in the health sphere) hampered a more substantial impetus. Other instruments such as the policy of using public purchasing power in the health sphere (2008) and encouraging the development of venture capital also promote the financing of R&D in biotechnology.

Brazil participates in the principal international conventions (in the areas of trade, biodiversity, biosafety and intellectual property) which affect the development of biotechnology. At national level, it has a law on industrial property (1996), a law on plant varieties (1997) and a law on biosafety (2005) which was amended in 2007. The National Biosafety Council (CNBS) and the National Biosafety Technical Committee (CTNBio) are responsible for the approval of GMO and derivatives. CTNBio (established in 1995)) is concerned with the technical approval of the use, cultivation and commercialisation of GMOs. Its decisions have often been contested in the courts. The CNBS assists the President of the Republic in the formulation and implementation of national biosafety policy and evaluates the socioeconomic implications and national interests related to the approval of the use of GMO for commercial use.

The private biotechnology sector has also experienced a remarkable development although it is still at an early stage. In 2006, the sector employed 462 biotechnology professionals and 554 technicians. In 2008, there were 71 companies dedicated to biotechnology in Brazil, highly concentrated in the states of Sao Paulo and Minas de Gerais. 75% of these companies are micro or small enterprises. A third are embryonic and a large number only recently formed. The level of patenting by these companies is still quite low.

The small number of patents registered by Brazilians and by companies, the incipient collection of companies and their limited interaction with universities and research centres, the lack of complementary policies to support R&D in biotechnology (such as support for certification and quality, internationalization of companies and management of intellectual property) are some of the current constraints on the biotechnology sector

Source: Biotecsur (2008a, b, c), Ceballos Rios (2006), Fundaçao Biominas (2007), ISAAA (2009); Ministry of Science and Technology of Brazil, MOITI (2008), Nature (2010), OECD (2009a), http://www.grupobiotecnologia.com.ar/verarticulo.asp?id=24.

C. ANALYSIS OF THE SYSTEM OF INNOVATION IN BIOTECHNOLOGY IN PERU

1. Production function

Peru is regarded as one of the countries with the greatest biodiversity in the world (CONAM, 2008). This abundance and diversity of genetic material gives the country a considerable comparative advantage in the development of biotechnology, although this advantage is only potential. Exploiting it depends primarily on the country's capacity to put in practice policies for the conservation and sustainable development of this diversity. Secondly, as indicated above, the development and application of this technology requires mastering a broad spectrum of other aspects of the research, production, marketing and logistics chain.

Bearing these considerations in mind, strictly speaking, one cannot talk about the existence of a biotechnology sector in Peru. What does exist is an important base of natural resources, a certain degree of research and development capacity in the area and a set of traditional sectors which are actual or potential users of biotechnological innovations: agriculture, livestock farming, fish-farming, mining, the food industry and health, among others.

In these sectors there are a few that use biotechnology, such as breweries and dairy producers involved in traditional biotechnology. There are also some companies in the agricultural sector (cultivation of vegetable fibres) and a few relating to human health (diagnostic, vaccines) which make use of biotechnology. But in practically all the cases, the level of biotechnological innovation and investment in R&D by these companies is very low.

Investment in biotechnology in Peru is very limited in comparison with other countries in the region. Although there are no complete figures on investment in biotechnology in Peru, an estimate of investment in agricultural and livestock biotechnology (Falck et al., 2009) shows that, in absolute and relative terms, Peru invested much less than other countries in the region (Table 2).

1.1. Infrastructure

The physical infrastructure, in terms of space in universities and institutions is sufficient for the development of a biotechnology programme. However, as pointed out in a report prepared in 2004 (INCAGRO 2008[4]), there are shortcomings concerning equipment in these facilities (see Box 5).

This report also highlighted the existence of a number of well-equipped research laboratories. For example, special mention should be made of the laboratory in the Peruvian Cayetano Heredia University (UPCH) twinned with the one in which Peruvian researcher and promoter of this initiative, Dr. Carlos Bustamante, Professor of the Berkeley University (United States) works. In this twinned laboratory, UPCH carries out advanced research in molecular biology and biophysics and will participate in research with Berkeley University. The laboratory is equipped with cutting edge technology, such as an atomic force microscope and a microscope with optical pincers, the first in Latin America. Initial research includes the study of an enzyme to detect new antibiotics against a variety of tuberculosis which is resistant to existing medicines.

Mention should also be made of the current project to establish a National Centre of Agricultural and Forestry Biotechnology which is being implemented by the Institute for Agrarian Innovation (INIA) (Box 4).

Table 2. Investment in agricultural and livestock biotechnology in Peru and selected countries, 2005

	Peru	Argentina	Brazil	Chile	Mexico
Total investment (millions USD)	**0.93**	**8.2**	**68.8**	**3.31**	**24.7**
Private sector (millions USD)	0.17	3.4	13.7	0.26	24.7
Public sector (millions USD)	0.76	4.8	55.0	3.04	n.a.
Investment per billion GDP (USD thousands per billion GDP)	**17**	**31**	**111**	**41**	**42**

Source: Falck et al. 2009.
Approximate values based on surveys of the principal organizations in each country.
n.a.: not available.

Box 4. National Centre of Agricultural and Forestry Biotechnology (CNBAF)

The CNBAF is envisaged as the nucleus of R&D in applied biotechnology to solve problems in agriculture, livestock farming and forestry, by developing new varieties and their accelerated propagation, creating livestock breeds with outstanding characteristics, finding solutions to combat abiotic and biotic stresses which affect crops and animals, developing transgenic plants and animals where necessary, creating means for studying and determining the presence of useful genes in genomes of plants, animals and microorganisms of economic interest and various applications related to other activities inherent in its function.

The functions of the CNBAF are:

- Developing in association with producers, industry and biotechnology research institutions, research activities and services for the application of the biotechnology generated, including the necessary training and technology transfer.
- Leading, coordinating and executing research, technological development and commercial applications of biotechnology in the INIA's experimental agrarian stations and in other institutions belonging to the National System of Agrarian Innovation.
- Developing biotechnology and promoting its use as a useful tool for the conservation, characterization, improvement, sustainable exploitation and profitable utilization of agricultural, livestock and forestry resources and the production of seeds and breeding stock.
- Fostering the development and implementation of basic and applied research in animal and plant biotechnology.

The project is in the implementation phase and is being coordinated with the Inter-American Institute for Cooperation in Agriculture (IICA).

Source: Vivanco W. (2009) El INIA y el Centro Nacional de Biotecnología Agropecuaria y Forestal. First National Biotechnology Conference. May 2009, Lima

The first phase of this initiative (two million dollars) is intended to provide the INIA with the capacity to serve as the responsible authority for control of GMOs (it is funding equipment to detect GMOs) and to carry out feasibility studies for the Centre. The second phase, in which it is hoped to obtain 30 million US dollars from foreign financing sources, will develop the Centre to allow it to provide services to universities and other institutions in the sector.

1.2. Companies

As mentioned above, there is no private biotechnology sector in Peru. There are some companies which use biotechnology in its traditional forms but the level of biotechnological innovation and investment in R&D in these companies is very low. For example, in 2005, private investment in biotechnology was estimated at just 170,000 US dollars (Falck et al., 2009). Moreover, the number of techniques used in the private sector in the sphere of agricultural biotechnology is much more limited than in the public sector, although they are concentrated in modern methods (see Table 3).

Box 5 shows an isolated example of a Peruvian company in the pharmaceuticals field which is introducing innovations based on natural products. The example enshrines three defining points in the context of innovation in Peru:

a) entrepreneurial investment in R&D is isolated and feeble,

b) competitive funds have facilitated R&D activities and universities-company collaboration, but have not been enough to generate a critical mass of research which would revolutionize the sector, and

c) there is limited experience of exploiting intellectual property although there is greater awareness of opportunities in this sphere.

1.3. Knowledge generating organizations

Peru has some R&D capacity in biotechnology and limited capacity for commercialising this research.

Peru's scientific output in biotechnology is scant, even in comparison with other countries in the region. In 2008, the three leading countries in biotechnology in Latin America (Brazil, Mexico and Argentina) produced 1405, 400 and 295 publications respectively, while in the same year Peru had only 33 publications on the same subject (OEI-CAEU 2009, see Figure 1).

In addition, the data for biotechnology patents published by WIPO for the period 2000-2008 confirm this evidence, showing a total of 8 patents registered for Peru, well below the 200 patents of Brazil and Argentina (OEI-CAEU, 2009).

Biotechnological research in Peru takes place mainly in the agricultural and livestock area (Roca 2003, Falck-Zepeda et al. 2009), notably in conservation and characterization of phytogenetic resources in roots and tubers, medicinal plants, fruit, vegetable, leguminous and ornamental plants. Other research groups work in the biopharmaceutical, industrial, environmental and biofertilizers and nutraceutics fields.

In the agriculture and livestock fields, the principal products in which biotechnology is applied are roots and tubers (potatoes) (36%), micro and other organisms (yeasts and fungi) (19%) and other animals, camelids, aquatic animals and other species (10%) (Falck-Zepeda et al. 2009).

In Peru, traditional biotechnology predominates. For example, although in the agricultural and livestock sector a large number of biotechnological methods are used comparable with other countries in the region, 75% of the methods used are traditional (Falck-Zepeda et al. 2009). The use of traditional methods of tissue cultivation stands out (see Table 3).

Research into transgenics is very limited. Currently a research project to develop a papaya resistant to the annular spot virus is being carried out by the INIA.

Box 5. Hersil S.A. – Peruvian innovation in functional natural products

Hersil is a Peruvian laboratory which carries out innovative work in the development of functional and nutraceutical foods based on Peru's biodiversity. With a national sales volume of some 35 million dollars and a 2.4% share of the domestic market, Hersil cannot compete in the development of new pharmaceutical products (which require high levels of investment) and has focused its R&D activity on the development of functional and nutraceutical (natural) products.

Its principal fields of activity are the manufacture of pharmaceutical products (85% of turnover), production of pharmaceutical products as a service for others (10% of turnover) and production of natural products, i.e. development of products based on plants native to Peru (at most 2% of turnover). Hersil carries on R&D activities in this third business line. This innovation work is carried out thanks to innovation funds which allow the conduct of pre-clinical and clinical studies and through two joint ventures (with the Schuler family and the La Molina National Agrarian University). The products developed (*) include gelatinized maca and tablets, cat's claw and development of hercampuri, dragon's blood, chanca piedra and pasuchaca.

Hersil has 627 workers, of whom 6 work in R&D. This team of six people is chiefly dedicated to quality control and supervision of processes and only to a lesser extent to R&D activities as such where resources are insufficient. The R&D budget is estimated at approximately 100,000 dollars a year for the last three years and comes mainly from foreign sources (competitive project funds). Hersil has invested some 200,000 US dollars in local universities to finance research into medicinal plants, especially validation of their active principles. The income obtained did not even cover the investment in the research.

The company has various items of state-of-the-art equipment for identifying the active principles but they are not exclusively for use with natural products. The company does not engage in technological foresight activities and essentially invests in low risk products. The first innovative experiment (gelatinized maca) was not patented and has suffered from domestic competition by poor quality products. Currently, Hersil has filed a patent application for its product, Warmi, which is based on plants native to Peru for treatment of the menopause).

Due to the unfair competition in the domestic market and a limited awareness on the part of Peruvian consumers of pharmaceutical products, Hersil has targeted the sale of its natural products towards export markets. Although there is a trade association for natural products (the Peruvian Institute for Natural Products), there is currently no consolidated support for the sector.

The predominance of the pharmaceutical industry, the limited technical capacity to identify new compounds, the lack of a legal framework (regulations, technical standards) for nutritional supplements, and the absence of a critical mass of innovative companies in the sector are some of the factors which limit the national capacity to carry out exploratory studies and develop new commercial products based on Peru's biodiversity.

Source: Gallástegui et al. (2009), interview October 2009, www.hersil.com.pe

(*) Note: some of the attributed effects include: Maca (Lepidium meyenii Walpers): reduction of menopausal symptoms, energizer; cat's claw (Uncaria tomentosa): inmunostimulant, anti-inflammatory and cytostatic (delays the growth and development of tumour cells); Hercampuri (Gentianella alborosea): collagen, choleretic, hypocholesterolemic and diuretic; dragon's blood (Croton lechleri): coagulant and antiseptic; Chancapiedra (Phyllanthus niruri): antispasmodic; Pasuchaca (Geranium deilsianum Knuth): hypoglycemiant. For further details, see: www.hersil.com.pe

Some of the principal lines of research in biotechnology found in Peru are described below.

Public research institutes

Added to the lack of a specific programme to promote and develop biotechnology is the fact that the state research centres responsible for the exploitation of genetic resources (INIA, IMARPE, IIAP, INS) are faced with the constraints imposed by their meagre budgets. This is despite the fact that they have competent staff and carry out some well directed initiatives. The following can be mentioned by way of example:

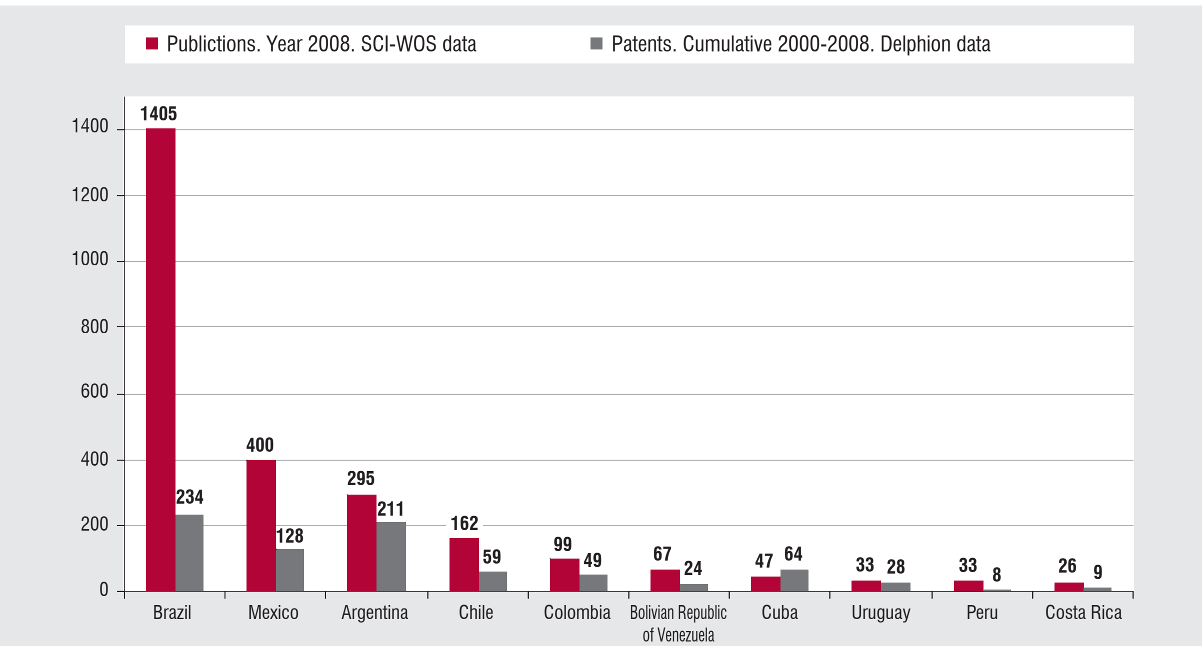
- INIA: characterization of alpaca herds with microsatellites, development of papaya resistant to the annular spot virus, creation of the National Centre of Agricultural and Forestry Biotechnology (see Box 4).
- IIAP: sexing of paiche; population studies of Amazonian fish.
- IMARPE: germplasm bank of aquatic organisms, study of the genetic structure of scallop beds (Argopecten purpuratus).
- National Institute of Neoplasic Diseases: molecular diagnosis of the virus associated with cervical cancer.

Universities

Outside the sphere of public research institutes, there are a number of groups and research projects which are worth highlighting:

- Peruvian Cayetano Heredia University: The Potato Genome Sequencing Consortium, resistance to parasites in alpacas, protection against infectious diseases of alpacas, vaccines, characterization of alpaca herds, search for genes and markers, white spot in prawns, shrimp population.
- La Molina National Agrarian University: transfer of embryos, molecular study of native plant genetic resources, protoplast fusion and transformation, nitrogen fixing bacteria and biofertilizers, biotechnology of enzymes produced by fungi (cellulases, xylanases, pectinases and peroxidases).
- Mayor de San Marcos National University: camelid diseases, population and evolutionary studies, generation of genetic markers to evaluate the biodiversity of marine resources, bioconversion of agroindustrial wastes and fermentation production of biopesticides.
- San Martín de Porres University: Alpaca genome project, generation of genetic markers to evaluate the biodiversity of marine resources.
- Federico Villarreal National University: fish nutrition, markers in scallops.
- San Antonio Abad del Cusco National University: isolation of native edible fungi, fungal biocides and fermentation processes with immobilized cells.
- Catholic University of Santa María, Arequipa: bioremediation, cyclodextrines and production of sweeteners.

Figure 1. Biotechnology publications and patents, Latin American and Caribbean countries, 2000- 2008



Source: OEI-CAEU, 2009.

Table 3. Number of biotechnological methods used in total (and by the private sector)*, 2006-2007

	Peru	Argentina	Brazil	Chile
Cultivation of cells and tissues	70	29 (3)	78	46 (4)
Molecular marker techniques	48 (1)	40 (3)	60	19
Diagnostic techniques	22 (2)	45 (20)	79	24 (5)
Total traditional biotechnology	**140 (3)**	**114 (26)**	**217**	**89 (9)**
DNA combination techniques	16 (2)	38 (8)	35	31
Genetic transformation techniques	9	44 (11)	36	20
Functional and structural genome techniques	22 (4)	21 (7)	...	17
Total modern biotechnology	**47 (6)**	**103 (26)**	**71**	**68**
Other/information not available	11 (3)	22 (5)	...	23 (1)
Total	**198 (12)**	**239 (57)**	**288**	**180 (19)**

Source: Falck-Zepeda et al. (2009).

**= the number of techniques used by the private sector is in brackets.*

- National University of Piura: ex situ soil bioremediation; biopesticides.
- Ricardo Palma University: in vitro conservation of medicinal and aromatic plants, micropropagation and molecular characterization.

There are also interesting developments in biomining. In particular, UPCH is participating in international projects with academic institutions of other countries in the region and in Europe on biolixiviation and bisorption. There are also some mining operations in Peru where biomining is used, for example biooxidation of gold in Tamboraque, biolixiviation of copper in Tintaya, Cerro Verde, Toquepala, and marshlands in Orcopampa and Antamina.

Also worthy of mention is the CONCYTEC Chair of Animal Biotechnology, for the development of a biotechnological platform based on DNA microadjustments to extract value from animals and plants of economic importance (especially alpaca and maca). The Chair the result of a cooperation agreement between UPCH and Hersil S.A. It has three chief researchers, two masters scholarships and a doctorate scholarship.

Despite these interesting advances and isolated initiatives, it cannot be said that Peru will have the research capacity required to promote the sustained development of biotechnology in the next few years.

In this respect, it is worth citing the report "Baseline for the implementation of the National Agroindustrial Biotechnology Programme in Peru" prepared by Gutiérrez Correa and Estrada Jiménez, and published by INCAGRO in 2008 (see Box 6). Although the report was produced in 2004, many of its conclusions remain valid.

1.4. Knowledge disseminating organisations

With regard to the academic education in the field of biotechnology, there are only two faculties which offer degree courses in biotechnology (the Mayor de San Marcos National University and the Catholic University of Santa Maria de Arequipa). In the other universities, biotechnology is taught as part of the biology or genetics courses. At postgraduate level, there is a master's degree in the National University of Trujillo (Master of Agroindustrial and Environmental Technology) and in Del Santa National University, and a doctorate in the La Molina National Agrarian University (Doctorate in Biological Sciences and Engineering). These programmes, albeit the result of praiseworthy efforts, are very recent and lack international accreditation.

The number of graduates with doctorates in Peru (see Table 4) is extremely low. The following table shows the pattern of doctorate students enrolled, leaving and graduating science and engineering. Although enrolment in the exact and natural sciences has grown significantly in the last few years, only 37 doctors graduated in the entire field, which as well as biology includes other disciplines which have nothing to do with biotechnology.

The Special Science Education Doctoral Programme is established within the framework of the National Strategic Plan on Science, Technology and Innovation for Competitiveness and Human Development to 2021 as a tool to achieve Specific Objective 3: quantitative and qualitative improvement of human capacities in science, technology and innovation, with emphasis on excellence in postgraduate education and specialist technical training.

Box 6. Biotechnology research in Peru. Report "Baseline for the implementation of the National Agroindustrial Biotechnology Programme in Peru"

The following are some of the key findings of the report "Baseline for the implementation of the National Agroindustrial Biotechnology Programme in Peru" prepared by Gutiérrez Correa and Estrada Jiménez, and published by INCAGRO in 2008.

1. The existing infrastructure (buildings, useable area, etc.) in the institutions evaluated is sufficient for the development of a biotechnology programme. This is not the case of the number of specialists available at the moment. Services and working facilities, including basic services, are inadequate. The shortfall is even greater when it comes to telephone and Internet access.
2. The equipment in the majority of the institutions is basic and is, on average, at least five to ten years old and requires urgent replacement and repair, apart from a few exceptions in the area of molecular biology. If we consider the potential of our biological diversity and our most urgent agricultural problems, which can be tackled using biotechnological alternatives, the available equipment is insufficient. As to the rest, it must be reported that there are well equipped laboratories but with staff of a low academic level, while others are very poorly equipped but have highly qualified staff.
3. There is a deficit of qualified staff in the majority of institutions and advanced training programmes. Less than 50% of the laboratories are headed by postgraduates, while the creative and innovative capacity of the rest to suggest lines of greater competitiveness is very limited.
4. The majority of institutions involved in biotechnology are in the academic sector, as there are no agreements or contracts with the productive sector (with the exception of the Microbiology and Biotechnology Laboratory of the La Molina National Agrarian University) [...] The publication results in indexed journals is almost nil (except for the International Potato Centre, the Private Cayetano Heredia University and the Microbiology and Biotechnology Laboratory of the La Molina National Agrarian University) probably due to the lack of academically sound results or the lack of "education and culture" to write up and publish results.
5. The most frequently developed lines of research are the cultivation of plant tissues for the production of seeds and the characterization of genetic resources. No work was found on cultivation of plant tissues in relation to the transformation or production of metabolites (except the work of the Microbiology and Biotechnology Laboratory of the La Molina National Agrarian University on microorganisms) or molecular biology related to assisted improvement or genetic engineering. However, staff and infrastructure exist in the Private Cayetano Heredia University and also in bioinformatics.
6. Several institutions stated that they work with molecular and genetic engineering techniques in plants, but in reality only the International Potato Centre has a systemic approach to the process. [...] In general, the work is essentially related to the characterization of genetic resources.
7. Investment in biotechnology is scant or almost nil. Cooperation relations are primarily based on the supply of genetic material or training which does not translate into the return of qualified staff. This situation, combined with the lack of knowledge of current legislation, is a high risk for our genetic resources and the nation's intellectual property rights.
8. There is no national biotechnology programme nor institutional plans. The activities take place on the basis of individual initiatives and projects.

Source: Gutiérrez Correa M. and Estrada Jiménez, R. (2004).

To achieve this objective, it is necessary to take certain measures so as to raise doctoral standards, give priority to education at doctorate level in science and technology and monitor institutions and doctors graduating from them[5]. These measures, however, are only being implemented in a fragmentary manner as individual initiatives of certain institutions such as CONCYTEC and FINCyT.

2. Regulatory function

The need to carry out multiple exchanges to be able to develop biotechnological products means that the protection and management of intellectual property are particularly important tools for the development of biotechnology.

Peru has a range of provisions to protect intellectual property relating to biotechnology (see Box 7). Discoveries, biological processes, plants and breeds of animals are not patentable, and there is evidence that genes are not patentable (Falck et al., 2009). On the other hand, varieties of plants and microorganisms can be protected. However, there is widespread uncertainty about what is patentable and what is not. Greater development of biotechnology in Peru would require clarification and ample dissemination of the scope of the legal framework and the development of the capacity of INDECOPI, the competent authority for granting patents and plant breeder's rights certificates, in this area where it currently only has one expert.

The limited capacities for managing intellectual property and the absence of intellectual property policies in research institutions and universities should also be highlighted. For example, the INIA, the principal centre for agricultural technology transfer, does not have an intellectual property policy covering the development of its biotechnology research activities (Ferro et al., 2010).

One highly important factor for the development of biotechnology is regulation of biosafety. It is necessary to have a credible biosafety system which bases its decision on scientific knowledge of the risks and how to manage them. The Cartagena Protocol on Biosafety (CPB) is an international legislative framework which allows the development and application of modern biotechnology, reconciling the interests of international trade and the need to protect human health and the environment. Implementation of the CPB requires:

- Establishment of a national biosafety framework (NBF).
- Development of risk assessment, management and communication capacities.
- Research to identify the possible impacts of modified living organisms (MLO) in tropical conditions.
- Development of the Biosafety Clearing-House (BCH) to provide assistance to the Parties on the application of its provisions and to facilitate the exchange of information and experience concerning MLOs.

In Peru, some progress has been made in the implementation of the national biosafety framework. Act 27104 on Prevention of Risks derived from the Use of Biotechnology (approved in 1999 with regulations issued in 2002 (Supreme Decree No. 108-2002-PCM)) regulate safety in the use of modern biotechnology following the requirements of the Convention on Biological Diversity and the Cartagena Protocol. However, despite the fact that the Act was passed 10 years ago, it has not been possible to implement it up to now because the sectoral regulations in agriculture (whose competent authority is the INIA), health (DIGESA) and

Table 4. Doctorate students enrolled, leaving and graduating in science and engineering, 2004 – 2008

Area	Status	2004	2005	2006	2007	2008
Social sciences and humanities	Enrolled	119	172	363	275	327
	Completed	0	0	12	0	24
	Graduates	2	1	5	2	4
Exact and natural sciences	Enrolled	35	26	320	71	360
	Completed	0	1	0	31	108
	Graduates	0	1	0	16	37
Health sciences and psychology	Enrolled	102	193	345	144	349
	Completed	0	8	52	36	18
	Graduates	3	0	3	18	33
Engineering	Enrolled	9	14	69	57	70
	Completed	0	0	0	3	0
	Graduates	0	0	0	3	5
Agricultural, veterinary and similar	Enrolled	0	0	0	5	7
	Completed	0	0	0	0	0
	Graduates	0	0	0	0	0

Source: Guerra García, R., (2009), Study of Peru: "Los programas de apoyo a la formación de postgrado en ciencias e ingeniería".

water resources (Vice-Ministry of Fisheries) have not yet been approved[6].

In Peru, public opinion is extremely sensitive to biosafety and the use of GMOs. In recent years, various draft legislations relating to the regulation of modern biotechnology have been put forward, from labelling specifying GMO content to a moratorium or total prohibition of the use of GMO (MINAM, 2009b). Added to these diverse opinions is the lack of a national biotechnology policy and a concerted vision by the Government of the role that biotechnology should play in Peru. This lethargy and uncertainty has meant that investment and innovation in biotechnology in the country has been constrained by the absence of official procedures and regulations.

Furthermore, although the BCF has already been set up in the Ministry of the Environment and there has been a national biosafety policy since 2009, the principal supervisory bodies do not at present have the specific infrastructure nor sufficient staff to fulfil their safety functions (MINAM, 2009a). Technical and research capacity in biosafety needs to be strengthened if Peru is to be able to meet the objective of having a feasible, effective, transparent and excellent national biosafety framework by 2011, compatible with national development policies and its international obligations.

3. Management and financing function

Key among the instruments to promote biotechnology in Peru is direct funding of R&D. Although there is no specific fund for biotechnology research, research projects have been financed through the various general funds (FONDECyT, FINCyT) or sectoral funds. The disadvantage of these funds, as promoters of biotechnology, is that they do not have funding lines for long-term projects. It should be noted, moreover, that FINCyT does not include health in its financing priorities.

Many of the biotechnology projects could be implemented thanks to international cooperation. International cooperation is particularly important in Peru as it can complement national investment and promote the internationalization of the scientific community, thus allowing the spread of knowledge and the development of joint activities.

For international cooperation to be effective, it must be viewed from a strategic point of view, avoiding scattering of efforts and relying on larger scale programmes with partners who can reinforce and complement Peruvian capacities and objectives.

Box 7. Intellectual property and biotechnology in Peru.

Patents

- Member State of the World Trade Organization.
- Paris Convention for the Protection of Industrial Property, World Intellectual Property Organization (WIPO) (1995).
- Patent Cooperation Treaty (PCT), WIPO (2009).
- Decision 486 Common Intellectual Property Regime /Commission of the Andean Community (2000) and amendments (Decisions 632 and 689).

Plant varieties

- Decision 345 Common Provisions on the Protection of the Rights of Breeders of New Plant Varieties/ Commission of the Andean Community (1993).
- Supreme Decree No. 008-96-ITINCI – Regulations on the protection of the rights of breeders of new plant varieties.
- Act No. 28126 Sanctions for infringements of the rights of breeders of protected new plant varieties (2003).
- UPOV – Peru is not a member of the International Union for the Protection of New Varieties of Plants (UPOV) but the UPOV Council, by UPOV decision of 1991, has confirmed the conformity of Decision 3456 and the draft Supreme Decree which establishes the new Regulations on the protection of the rights of breeders of new plant varieties.

Microorganisms

- Budapest Treaty on the International Recognition of the Deposit of Microorganisms for the Purposes of Patent Procedure, WIPO (2009).

Access to genetic resources and protection of traditional knowledge

- Decision 391 of the Commission of the Cartagena Agreement, Common Regime on Access to Genetic Resources (1996).
- Act No. 27811, Regime on Protection of the Collective Knowledge of the Indigenous Peoples in relation to Biological Resources (2002) and amendments (Act No. 28187 and Legislative Decree No. 1029).

Source: INDECOPI, UPOV.

The Intergovernmental Agreement on Science and Technology of 1980, which led to the creation of the Argentine-Brazil Biotechnology Centre (CABBIO) in 1986, is a good example of regional cooperation in science and technology which allowed working groups (official and private) in the two countries to link up in correlated productive projects.

By 2004 (Menvielle, 2004) CABBIO had facilitated the development of 86 bilateral projects on a wide variety of important subjects[7] as well as a genetic resource bank, a bilateral germplasm bank and a microbial stock bank. The Electronic Science and Technology Library was also created as a solution to the serious problem of access of Argentine researchers to international bibliography. Lastly, it should be highlighted that CABBIO also contributed to the training of a large number of specialists from throughout Latin America.

4. Foresight and design of plans, programmes and instruments function

In Peru, public interest in the development of biotechnology is quite recent and has still not led to a national strategy in this area.

As regards strategic plans, the National Strategic Plan on Science, Technology and Innovation for Competitiveness and Human Development 2006-2021 attaches crucial importance to biotechnology, establishes a National Biotechnology Programme and places emphasis on the industrial value of diversity and on making use of genetic resources (see Box 8)

More recently, under the 2006-2021 Plan, CONCYTEC prepared, for a more limited period, the National Plan of Science, Technology and Technological Innovation for Productive and Socially Sustainable Development 2009-2013. This plan defines biotechnology as one of the crosscutting areas of knowledge to be given priority, with the following action lines:

- Conservation of biological diversity.
- Application of methods to study the genome of species making up that biodiversity.
- Development of new highly productive plant, animal and hydrobiological varieties to meet the challenges of climate change and which require a reduced use of agrochemicals.
- Improvement of the quality of exportable agricultural products, wheat and fish.
- Genetic improvement of pathogen-free marine and freshwater species.
- Bioprospecting of active compounds.
- Bioremediation for decontamination of mining wastes, contaminated soils, sea, rivers, lakes and urban pollution, including research, development, pilot studies and measurement.
- Development of metabolic engineering and evolution studies for the design and construction of biorefineries.
- Development of biotechnology-based energy production systems.
- Production of vaccines.

However, these plans lack clear priorities in line with other productive and institutional priorities and they do not have resources and effective mechanisms for their implementation.

Another noteworthy initiative was the Bill on the Promotion of Modern Biotechnology, which declares the promotion of modern biotechnology to be “in the national interest”. Most importantly, it established incentives, primarily tax advantages, for companies that invest in R&D in modern biotechnology. The bill was approved by Congress in July 2006, but it was observed by the Government that it contained some incompatibilities with international agreements on intellectual property. Once the necessary corrections had been made to remove those inconsistencies, it was resubmitted in early 2007 for final approval. It was then sent back to the Committee where it remains while a final agreement on its fate has still not been reached.

A similar fate befell the National Biotechnology and Genetic Engineering Plan, an initiative of the State Consortium CEPLAN – PRODUCE – CONCYTEC the principal objectives of which were to define a stable and continuous national policy and develop a national biotechnology system to gather together and coordinate its institutions, stimulate investment and try to increase companies’ competitiveness. The Plan established strategies for the development of biotechnology based on the enterprise development, capacity building and international funding. However, this plan was not officially approved and has now been shelved.

Since May 2009, Peru has had a National Environment Policy (Supreme Decree No. 012-2009-MINAM) which provides guidance on the use of biotechnology. Its objectives include providing mechanisms for the responsible and safe use of biotechnology and products derived from it, and also ensuring protection of human health, the environment and biological diversity during the development, use and application of goods and services involving modern biotechnology in Peru. This policy offers some general guidelines on the use of biotechnology calling for responsible use.

There is also a draft National Environmental Action Plan 2010-2021 (February 2010) which includes two strategic objectives in the biosafety sphere: (1) to establish transgenic-free zones (under the responsibility of regional governments) and (2) control risks associated with modern biotechnology (under the overall responsibility of the Ministry of Agriculture and SENASA).

In short, there is a clear consensus in Peru on the importance of biosafety but not on biotechnology or the role that it needs to play in the country's development.

As regards foresight, mention should be made of a foresight study (requested by the INIA and now in progress) on biotechnology in the agricultural and forestry sector in Peru. The aim of this study is to ascertain the state of the art in biotechnology and set criteria for the allocation of resources.

Some important studies have also been carried out into research capacities in biotechnology in Peru[8], which, although not technological foresight studies, provide important inputs for the design of plans and programmes in support of the sector.

5. Cohesion and execution function

As mentioned above, in Peru there is no consensus on the role that biotechnology should play in the country's development. The lack of a national biotechnology agenda is holding back investment and development in the sector.

Given the high sensitivity of Peruvian society to biotechnology, it will be necessary to continue working with the various sectors of society, the private sector and the Government to reach a consensus on the role of biotechnology which includes the principal parties involved, among them the State. A conviction at the highest level of the importance to the country of developing biotechnology will be crucial in promoting serious and effective dialogue.

Box 8. Biotechnology in the National Strategic Plan on Science, Technology and Innovation for Competitiveness and Human Development 2006-2021

The National Strategic Plan on Science, Technology and Innovation for Competitiveness and Human Development 2006-2021 attaches crucial importance to biotechnology, establishes a National Biotechnology Programme and places emphasis on the industrial value of diversity and on making use of genetic resources. The Plan states the following:

"The life sciences and biotechnologies (cellular and molecular biology, genetic engineering, genomics) and bioinformatics, have a strategic importance in national development since they relate to five of the seven selected priority productive sectors and three of the four social sectors in the Plan.

In the agrarian and agroindustrial sector, there is the possibility of genetic improvement and phytosanitary protection of crops, adaptation of crops to abiotic stress (aridity, salinity, low temperatures), improvement of food quality and characterization and industrial exploitation of the native biodiversity. In the fishing and fisheries sector, these sciences allow genetic improvement, health and reproduction of hydrobiological species, as well as the characterization, conservation and improvement of the genetic pool of promising native species. In the forestry sector, tissue cultivation can be applied for the production of virus-free seeds and plants by micropropagation of genetically improved varieties and the quality of timber and fruit can be improved by genetic engineering.

In the human health sector, the life sciences and biotechnologies allow the development of diagnostic kits and vaccines for tropical and endemic diseases, xenotransplants, tissue cloning, gene therapy, production of drugs from native medicinal plants and the production of biological medicines from bacteria and other live organisms, among other applications. In the housing and environment sectors, biotechnology allows the development and application of biotreatment of urban and industrial wastes, and biotreatment and bioremediation for sustainable management of mineral-metallurgical residues"

Source: National Strategic Plan on Science, Technology and Innovation for Competitiveness and Human Development 2006-2021, Section III. Priority Areas. CONCYTEC, Lima, April 2006.

D. CONCLUSIONS AND RECOMMENDATIONS

Biotechnology is an industry growing at the global level, with a high market value, strong investment in R&D and great innovative dynamism.

An important element of innovation in biotechnology is biodiversity. Peru has a comparative advantage, as it is one of the countries in the world with the greatest biodiversity. However, it is a static advantage which has not so far been exploited.

The first aspect which needs to be considered is the lack of a policy framework which ensures continuity of action in the medium and long term. While there are general formulations on science, technology and innovation which assign an important role to biotechnology, these formulations have not been reflected, except for isolated cases, in specific plans and policies endowed with resources. A national biotechnology agenda needs to be developed linked to a national development strategy which sets priorities and which guides the allocation of public, private and academic resources.

The regulatory framework also needs to be completed, in particular by establishing sectoral regulations, so as to be able to move forward in the development of biotechnology activities.

Biotechnological development at public level in Peru is scant and much more so at private level. The existing research groups and the research projects in which they are engaged tend to be isolated efforts. There are also limitations on the transfer of this research.

The provision of academic education is weak, exacerbating the situation as there are insufficient qualified professionals to develop biotechnological innovations in Peru. The CONCYTEC Chair is an appropriate initiative but not on a large enough scale. It should be strengthened with more resources in order to support different research groups and education in the area. It should be complemented by programmes which improve the level and access of students to postgraduate education, promote doctoral and post-doctoral education abroad and the return of researchers to the country.

There is also a need to strengthen links between scientific research and the sectors which use biotechnology, in particular the primary sectors (agriculture, livestock, fisheries, forestry and mining) and industrial sectors (food, textiles). The specialized institutions INIA, IIAP, ITP, CITEs and project funding programmes should play a key role in strengthening those links.

Table 5. Principal strengths, weaknesses, opportunities and threats in the biotechnology sector in Peru.

STRENGTHS	WEAKNESSES
• Adequate basic infrastructure • Experience in biotechnology in agriculture and health • Developed legal framework for protection of intellectual property.	• Lack of a long-term vision and national biotechnology agenda • Limited scale of available financial resources • Scant biotechnological development, especially in the private sector • Limited postgraduate education • Limited links between research and the user sectors, and limited (capacity for) transfer and commercialisation of research • Lack of sectoral biosafety regulations • Limited capacity in management of intellectual property • Small impact of international cooperation • Obsolete equipment
OPPORTUNITIES	**THREATS**
• Peru's natural resources and biodiversity • Traditional sectors as potential users of biotechnological innovations • Positive experience of competitive funds • International and regional cooperation	• Appropriation of resources of Peruvian biodiversity by foreign companies • High sensitivity of public and political opinion in the biotechnology sphere

Recommendations

Based on this analysis, the following recommendations are proposed:

1) Define a clear and consistent policy and position with respect to biotechnology

- As a first step, it will be necessary to continue investing in dialogue and building a greater social consensus on the role of biotechnology in Peru.
- Develop a National Biotechnology Policy which offers a consensual strategic vision and includes the legal and regulatory aspects necessary to provide a stable framework for the development of biotechnology in the country[9].
- Based on the results of a foresight exercise in the various areas of biotechnology and broad dialogue, develop a National Biotechnology Programme which establishes a set of specific coordinated actions which can be evaluated; assign responsibilities for their execution; and establish the financial and human resources necessary to implement them.

2) Strengthen research and training capacities:

- Increase funding for research in priority areas
- Establish financing opportunities for longer-term projects and, in the case of FINCyT, open the competition to proposals in the health sphere.
- Facilitate the financing and acquisition of equipment for research laboratories.
- Promote international accreditation of masters degree and doctorate courses in biotechnology.

3) Complete the existing regulatory framework and strengthen capacities for its implementation and for managing intellectual property

- Give priority to the approval of the biosafety sectoral regulation in agriculture.
- Prepare the draft sectoral biosafety regulations on health and water resources.
- Strengthen the biosafety capacities of the competent sectoral bodies.
- Promote the development of an intellectual property policy in the principal public research institutes (e.g. INIA)
- Strengthen capacities for analysis and advice with respect to intellectual property in the field of biotechnology.

4) Stimulate transfer of knowledge and products and the commercialisation and economic development of the sector

- Facilitate the commercialisation of research by developing intellectual property policies in research institutes and universities
- Continue to promote financing of joint projects by universities and companies
- Promote the participation of key technology transfer organizations (CITES, INIA, NGOs, etc.) in research projects
- Establish a package of incentives for the creation and/or attraction of biotechnology companies

5) Strengthen international cooperation through strategic alliances with high level institutions in key sectors, both in research and infrastructure and biosafety processes.

NOTES

1 Based on Bisang et al. (2009).

2 Convention on Biological Diversity, 1992.

3 Based on Bisang et al. (2009) and Ernst & Young (2009).

4 Although the report was prepared in 2004, the comments received during interviews show that many of its conclusions remain valid.

5 See Gutiérrez Correa (2008).

6 Currently, the sectoral regulations in the agricultural sphere are at an advanced stage of public consultations.

7 For example: monoclonal antibodies, transgenic maize resistant to herbicides or pests, phenotypic studies of citrus canker to identify varieties of commercial interest, or industrial enzymes for the clarification of fruit juice. Progress has also been made in producing a triple vaccine, virus-free garlic and peneid crustaceans. Researchers from both countries developed a method of biolixiviation to conserve 100% of manganese and increase the recovery of silver from 30% to 60%.

8 See Roca (2003), Gutiérrez Correa and Estrada Jiménez (2004), Falck-Zepeda et al. (2009).

9 Reconsider, for example, the bill on promotion of modern biotechnology.

V

Nanotechnology

A. INTRODUCTION[1]

Nanotechnology[2] is the discipline concerned with the creation of functional materials, devices and systems by engineering matter at the atomic and molecular level. On this scale, unique phenomena appear, originating in the quantum nature of matter, which can be used for new applications. It is a highly interdisciplinary activity which involves, among others, physics, chemistry, biology, medicine and engineering.

Since the 1980s, nanotechnology has been developing rapidly thanks to the emergence of new capacities for observation and manipulation of matter at the level of atoms and molecules, the exponential growth of computational capacity, the development of new methods of theoretical calculus and advances in chemistry. This development has also been influenced by the vision of eminent scientists of the capacity of nanotechnology to produce a significant impact on society.

All this has led to the incorporation of nanotechnology as a key area the science, technology and innovation systems of the most industrialized countries, which are investing billions (increasing each year) in public and private research and development in this subject (see section B).

However, nanotechnology is not a well defined field of technological activity but a set of technologies which evolve at different speeds and which have different characteristics. Nanotechnology is a general purpose technology which has begun to bring about changes in various industrial sectors, including biomedical, pharmaceuticals, cosmetics, information technology, aeronautics, automobile, textiles, rubber, agriculture, food, construction, the chemical and materials industry, etc. There are already 500 products on the market which use nanotechnology: sun protection, cosmetics, food additives, pesticides, textiles, varnishes, coatings and membranes which are applied to household articles, electronic chips, sensors and diagnostic devices. This illustrative list, although not exhaustive, is constantly growing and producing incremental changes in existing markets, as well as the generation of new markets hard to imagine until now.

Furthermore, it is important to bear in mind the growing and accelerating convergence between nanotechnology, biotechnology, information technology and cognitive sciences (NBIC as they are known) which augurs changes which will drastically affect the human condition itself, its relation with nature and the social environment.

B. GLOBAL OVERVIEW AND THE LATIN AMERICAN EXPERIENCE

At global level, nanotechnology has experienced exponential growth. It is estimated that during 2007, global expenditure on R&D in nanotechnology reached 13,500 million dollars and 54% of the funds were invested by the private sector (BET, 2009). Table 1 shows investment in the last few years by the principal world leaders.

Nanotechnology, measured in scientific publications, doubled in volume at global level between 2000 and 2007, rising from 2.5% to 4.1% of total publications in the Science Citation Index (SCI) (OEI-CAEU, 2008).

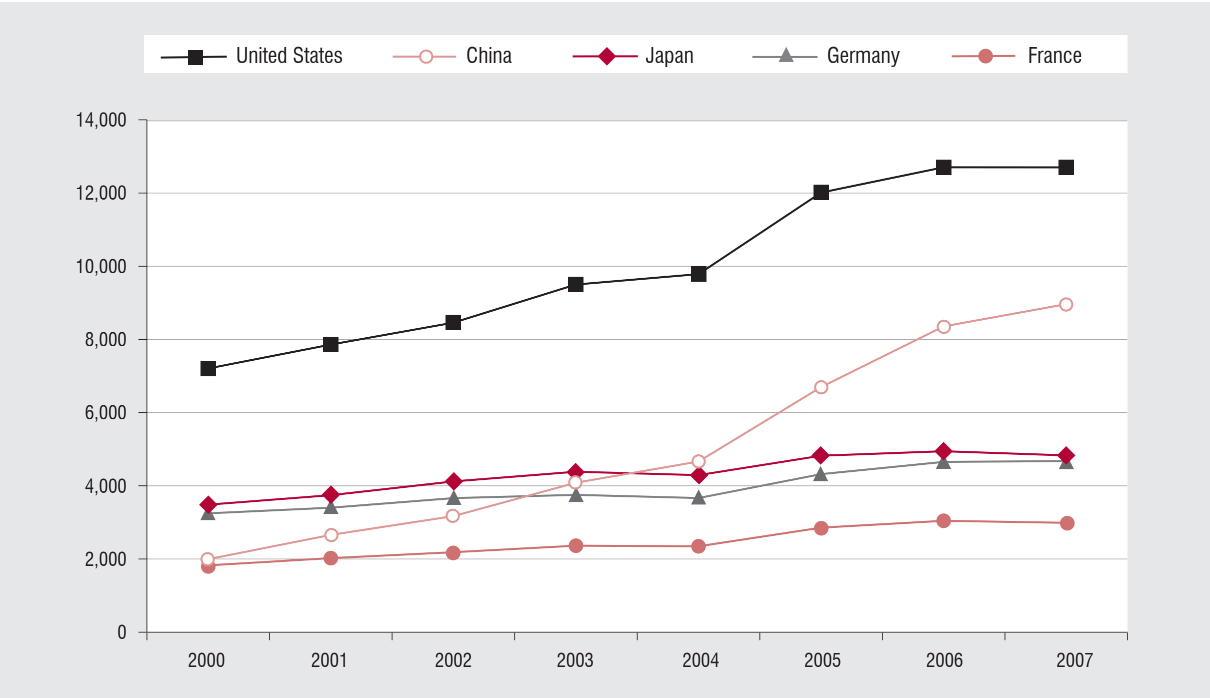
The United States, with 7,206 articles in 2000 and 12,701 in 2007, contributes almost 27% of the total over the period (Figure 1). In second place, in 2007, comes China, standing out especially for its growth, much higher than the other countries. It more than

Table 1. Public investment in R&D in nanotechnology (millions of dollars), 2005-2010

	2005	2006	2007	2008	2009	2010
United States	1,200	1,351	1,425	1,491	1,527	...
Japan	881	655	667	735	...	...
Germany	386	414	534	547	547	547
France	344	370	404	...	...	...
Republic of Korea	274	280	280	270	290	300

Note: Data for 2008-2010 are estimated.
Source: WPN Policy Questionnaire (2008) in OECD (2009).

Figure 1. Publications of the world's leading countries in nanotechnology, 2000-2007



Source: OEI-CAEU (2008).

quadrupled its output in the same period (from 1,995 to 8,964 publications registered), rising from the fourth place it occupied in 2000. Completing the list of the five most important countries in this field are Japan, Germany and France, which show modest growth (OEI-CAEU, 2008).

In Latin America, Brazil is the pioneer and current leader in scientific output and technological development in nanotechnology. Mexico and Argentina form a second block, while the other countries have much lower output (Figure 2). Based on the STI and the World of Science (WOS) database, while Brazil published over 5,254 articles during the period 2000-2007, Peru only published one hundredth of that (50 publications).

An analysis of publications in collaboration between researchers in the Ibero-American countries shows that regional knowledge networks have been formed in the field of nanotechnology, and these have progressively consolidated. In the networks (Figure 3) which have developed, two different patterns can be observed. One is that of the countries which have a direct nodal link to Spain (such as Argentina and Uruguay) and those which are directly linked to the United States (such as Brazil, Mexico, Bolivarian Republic of Venezuela and Peru). This phenomenon is relatively recent, as previously Spain served as the focal node for almost all the countries of Ibero-America.

Given the relatively small size of the scientific community and financial resources of the region, and especially Peru, only intensive regional and global collaboration can produce the critical mass necessary to provide R&D in nanotechnology with the necessary sustainability.

However, over and above the research capacities and strengthening it through collaboration networks, a key factor is the ability to take ownership of the results of that research, i.e., the rate at which it is translated into patents.

Nanotechnology, measured in terms of patents registered internationally through the Patent Cooperation Treaty (PCT) of the World Intellectual Property Organization (WIPO) showed a global growth of 183% between 2000 and 2007. During this period, 75,720 patents were registered. Latin America is the owner of only 0.3% of these patents. Figure 2 also shows the principal Latin American countries for inventors of nanotechnology patents.

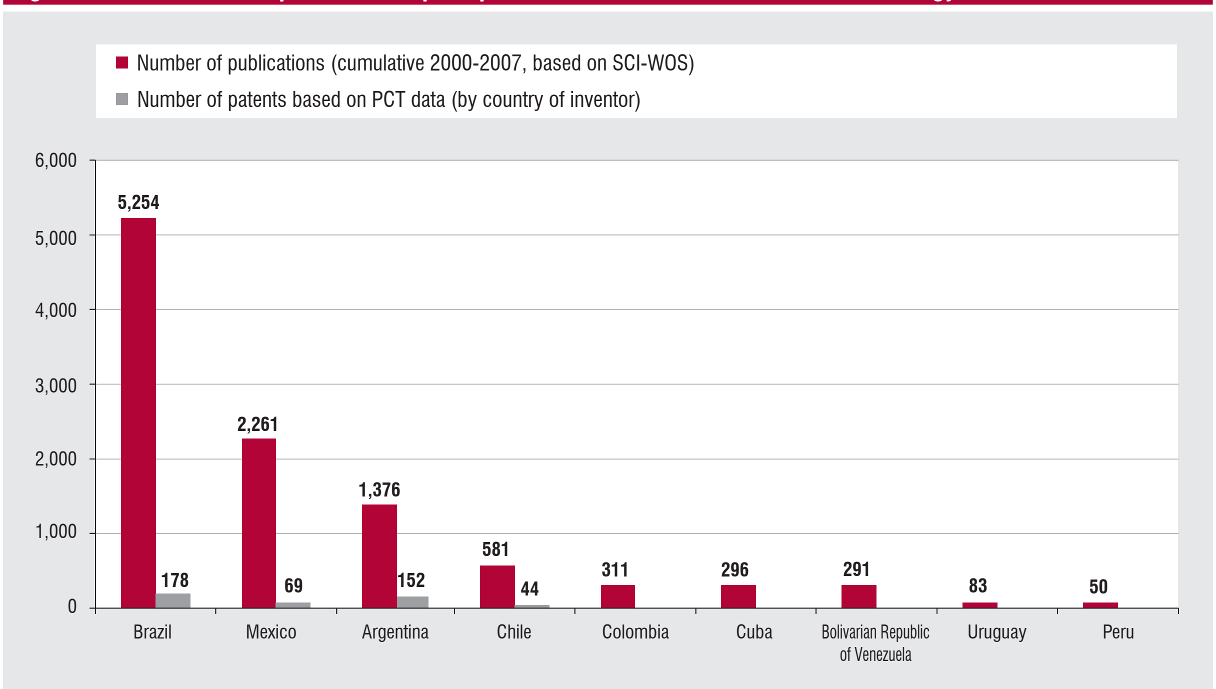
According to C. Aguirre et al (2007), among the significant applications of nanotechnology in the Andean countries during recent years, the following should be highlighted:

- Treatment and improvement of water. Nanosensors to detect pollutants and pathogens; nanomembranes and clays for desalination and removal of toxic compounds; nanomagnets to remove radioactive compounds.
- Diagnosis and control of diseases. Lab-on-a-chip; quantum dots for biodetection and bionanalysis; DNA testing and sequencing for human, veterinary and agricultural purposes; devices for the detection of pathogens; medical image amplifiers; optical and magnetic molecular labels.
- Transplant and repair of organs and tissues. Nanomaterials for transplant bandages and repair of organs and tissues; artificial blood; prosthetics including visual and auditive devices.
- Increased efficiency of electrical, chemical and mechanical equipment. Fullerenes as lubricants; molecular machines, devices and manufactures; nanomaterials for thermal and electrical insulation, reduction of friction and wear; molecular engineering of materials.
- Storage, production and conversion of energy. Solar and fuel cells; storage and conversion of hydrogen; self-healing humid membranes for storing energy; photonic applications and devices
- Improvement of the air. Devices for separating gases; nanocoatings for photocatalysis of air pollutants and reduction of fossil fuel emissions; nanosensors for toxic materials and leaks.
- Data storage and processing. Carbon nanotubes for electron transistors; DNA and optical memory, storage and processing; quantum pits and dots; spintronics; transistors with nanowires.
- Data transmission. Self-assembled nanowires and monolayers.
- Improvement of agriculture. Nanocapsules for the propagation of herbicides; slow-release water and nutrient systems; soil quality nanosensors; plant health nanosensors; biodegradable fertilizers and nanomagnets for soil decontamination.
- Drug transport systems. Nanocapsules; liposomes; dendrimers; buckyballs for delivering drugs and vaccines; slow and sustainable drug delivery systems.

Nevertheless, these countries have only taken the first steps.

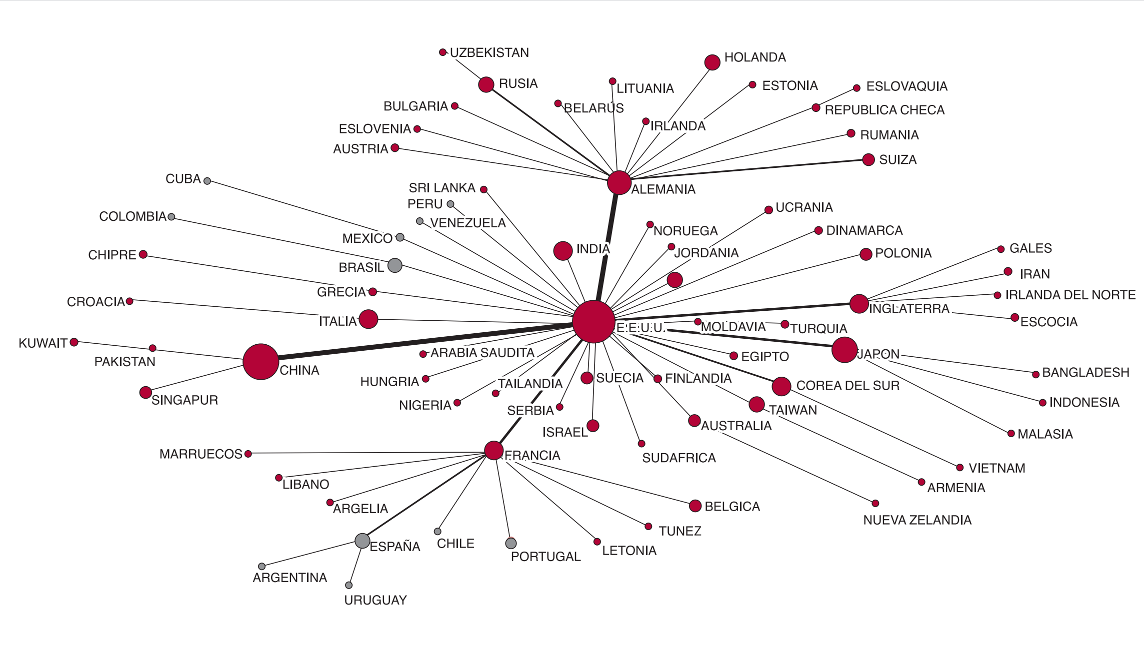
The principal countries of Latin America in the sphere of nanotechnology have implemented active policies,

Figure 2. Publications and patents of the principal Latin American countries in nanotechnology



Source: Based on OEI-CAEU (2008).

Figure 3. Network of countries with scientific output in nanotechnology, 2007



Source: OEI-CAEU, 2008.

forming institutions and ad hoc instruments in support of nanotechnology, such as the Brazilian Nanotechnology Initiative and the Argentine Nanotechnology Foundation. Annex E describes the experience of two Latin American countries (Argentina and Brazil) which have active policies and have achieved considerable development in nanotechnology.

C. DIAGNOSTIC OF THE SYSTEM OF INNOVATION IN NANOTECHNOLOGY IN PERU[3]

Peru still has a long way to go to catch up with the levels of nanotechnology development of its most advanced neighbours. At present, there is no system of innovation in nanotechnology in Peru. What follows is a description of the main threads. The analysis focuses on the aspects most relevant to the specific case of nanotechnology. However, the general assessments of the national system of innovation apply in the case of nanotechnology.

1. Production function

Nanotechnology is scantly developed in Peru, even in comparison with other countries in the region. As described below, current capacities are a very long way from forming a critical mass. In Peru, there are 25 researchers in nanotechnology, scattered among six universities and a research institute, and there are no companies which develop nanotechnology nor the necessary infrastructure.

1.1. Infrastructure

Peru has a basic infrastructure in terms of universities and laboratories working in nanotechnology. However, these laboratories do not have the necessary equipment. Part of the available equipment is obsolete and, above all, there is basic equipment which is still not available in Peru (e.g. X-ray photoelectron spectrometer, vibrating sample magnetometer, Raman spectrometer, among others) (Gutarra, 2010). There are no policies to facilitate the financing of such equipment[4].

1.2. Companies

In Peru, there are no companies which develop nanotechnology, but only a few companies which use nanotechnology (see example of I&T Electric in Box 1).

The example of I&T Electric shows that there are trained persons in Peru able to develop innovative products which incorporate nanotechnologies. This case also shows the significance of accreditation and certification and the current weaknesses in Peru in the certification of products and the cost involved.

In Peru, unlike the leading countries in the region (Brazil, Mexico and Argentina), applications designed to solve problems with a social impact (e.g. water quality) predominate, rather than the productive aspects of nanotechnology (Gutarra, 2010). Although it is difficult for the private sector to get involved in the development of nanotechnologies for social purposes, there are a large number of organizations which should participate actively in nanotechnological developments, such as non-governmental organizations (NGOs) or the CITEs. These organizations play a fundamental role in the formulation of demand for technology, communication of needs and as a vehicle for distribution. In addition, they play a role in evaluating the relevance of modern technology compared with other traditional technologies. For example, ITDG Soluciones Prácticas is an NGO involved in the exploration of technological options to solve social problems and which has explored the opportunities that nanotechnology may offer to improve water quality.

To enhance the productive aspects of nanotechnology, four fundamental tools need to be considered, as shown by the examples of Argentina and Brazil: 1) incentives for applied research in the academic world; 2) support for the development of laboratory infrastructure to international standards; 3) development of venture capital; and 4) the promotion of spin-offs from research. The first two tools can be considered from the outset, while the development of venture capital for nanotechnology and the promotion of spin-offs in this area will only make sense once better research capacities have been developed.

1.3. Knowledge generating organizations

Peru has a series of groups which, in different disciplines (chemistry, physics, biology, engineering), undertake research in nanotechnology (Box 2). In all, there are 13 research groups or laboratories with projects in the nanotechnology field. Outstanding among them are a number of groups engaged in developing applications of nanotechnology to water and sanitation problems[5]. In recent years, groups have been formed which are experimenting with techniques of improving water quality in those areas of Peru where basic water supplies are inadequate. A successful outcome to these experiments would be very important in a country where six and a half million people (25% of the total population) do not have drinking water and another 11 million do not have sanitation services (Gutarra 2010).

An example of the initiatives to treat water with techniques derived from nanotechnology, in which Peru is involved, is the Chemical Activity Unit of the CNEA in Argentina which, since 2002, has been studying

Box 1. Companies which use nanotechnology – the case of I&T Electric S.A.C.

I&T Electric is a company dedicated to the design and manufacture, maintenance and repair of low, medium and high tension equipment, including the production of transformers and sensors incorporating nanotechnology. It is an innovating company, 100% Peruvian owned, which develops its own products. I&T Electric experienced geometric growth in sales following certification of its equipment.

The certification process has often been difficult due to the lack of accredited laboratories in Peru and the high cost of certification in foreign laboratories.

The need to certify its products led it to develop two laboratories: an Accelerated Ageing Laboratory (to test the useful life of products) and, more recently, a High Tension Impulse Laboratory (to test the anti-lightning insulation of products). The accreditation of these laboratories allows/will allow certification of the quality of the products developed. This certification is an international requirement, essential in order to be able to export. The laboratories also serve to optimize product design.

The company has not applied for any patent for the products that it has developed.

Source: Interview with Ing. Wilber Aragonés R., partner in I&T Electric, www.itesa.com.pe/

the application of certain techniques to make water in rural areas drinkable. This project is being carried out in collaboration with Brazil, Chile, Mexico and Trinidad and Tobago. The specific objectives of the programme include training of human resources and sharing of information as well as increasing scientific and technological knowledge. Essentially, three technologies were proposed: solar disinfection of water, removal of arsenic by solar oxidation and heterogeneous solar photocatalysis with TiO2.

Some of the mechanisms for water treatment which incorporate nanotechnology are:
- Nanofiltration membranes.
- Attapulgite clay and zeolite
- Nanocatalysts and magnetic nanoparticles
- Nanosensors for the detection of pollutants

1.4. Knowledge disseminating organizations

No detailed report is available on training in nanotechnology provided in Peru. Logically, the chief organizations for disseminating knowledge are the universities which carry out research in this field. Although specific seminars are arranged on nanotechnology in Peru, there is considerable interest in pursuing postgraduate studies abroad (Gutarra, 2010). The limited number and quality of doctorate courses in the science and technology field in Peru should also be borne in mind (see chapters II and IV). In this regard, instruments to promote exchange of researchers, the promotion of research fellowships abroad and incentives for subsequent return are highly important (see CONCYTEC Chairs in Nanomaterials).

2. Regulatory function

Nanotechnology may present potential risks, in particular relating to the environment and health, such as the unregulated emission of designer nanoparticles during the development, manufacture, incorporation, use and elimination of products.

The leading countries in this field have already begun to debate the implications of nanotechnology and, although there is no specific regulation in this field (in part due to the multiplicity of technologies involved), voluntary measures have been developed (e.g. the Code of Conduct promoted by the European Commission (2008) or voluntary notification schemes). Efforts are also being made to develop capacities to assess and manage risks derived from nanotechnology. National regulations have been reviewed to assess to what extent they are appropriate for the nanotechnology sphere (e.g. evaluating the relevance of environmental protection or food and drugs legislation to the products and processes involving the use of nanotechnology) (Framing Nano, 2009). In Argentina, there is a project for the creation of a Code of Ethics for Nanotechnology Research based on the European Union recommendations (BET, 2009).

At present, there is no specific regulatory function for nanotechnology in Peru, which is to some extent not surprising given the low level of development. However, when the time comes, it will be necessary to create spaces where the potential risks of nanotechnology and the most effective preventive measures can be researched, debated and communicated. Although it is not yet a major concern for Peruvian society, unlike GMOs, questions are already being asked about the uncontrolled circulation in Peru of products (e.g. foods, cosmetics and beauty products) which incorporate nanotechnology.

3. Management and financing problem

Public funding of nanotechnology is extremely scarce and dispersed. Although competitive funds have functioned well in promoting specific research, the scale of these funds is insufficient to develop this sector in Peru.

In addition, it should be borne in mind that the development of nanotechnology research and applications with a social objective will essentially require public investment. Although financing through international cooperation, in terms or fellowships or donations of equipment, is an area which should still be explored, it will never be enough. In any case, it will be important to maintain a certain degree of independence in order to ensure that the collaboration is consistent with the country's national objectives[6].

4. Foresight and design of plans, programmes and instruments function

The National Science and Technology Plan for Competitiveness and Human Development 2006-2021 includes the manipulation and design of nanomaterials as a thematic pillar within the Materials Programme, whose lines of action include:

Box 2. Principal research groups in nanotechnology in Peru

1. Pontifical Catholic University of Peru

Extractive Metallurgy Laboratory, Department of Engineering
Team: 2 researchers with doctorates, 1 researcher with masters degree, 1 postgraduate student, undregraduates, graduate researcher (B.Sc./ Eng.)
Lines of research:
a) Nanomaterials: Metallic nanoparticles
b) Metallurgy: Electrochemistry applied to materials

Research Laboratory No. 4, Dept. of Science, Chemistry Section

Team: 1 researcher with doctorate, 1 researcher with masters degree, 5 postgraduate students, undergraduates, 4 graduate researchers (B.Sc./ Eng.)

Lines of research:
a) Absorbent materials (clays, activated carbons)
b) Treatment of industrial water
c) Retention of heavy metals in mining effluents

The university is taking part in the research project on treatment systems for removal of arsenic, boron and iron from bodies of water for agricultural and agro-industrial purposes, financed from FINCyT resources.

2. Peruvian Cayetano Heredia University

Bioinformatics and Computational Biology Unit, Faculty of Sciences and Philosophy
This unit carries out research into molecular modelling using computational methods.
Lines of research:
a) DNA biophysics and its relation with molecular evolution
b) Mechanism of resistance to pyrazinamide in Mycobacterium tuberculosis
c) Design of fusion multiepitope vaccines for taenia solium and the influenza A virus.
d) Haemoglobin alosterisms (dimeric level)
e) Repotentiation of bacterial RNA polymerase inhibitors
f) Rifaximin.

3. National University of Engineering

Thin Film Laboratory, Faculty of Science
Team: 2 researchers with doctorate, 2 researchers with masters degree, 2 postgraduate students, 4 undergraduates, 2 graduate researchers (B.Sc./ Eng.)
Lines of research:
a) Photoelectrochemical cells
b) Synthesis and characterization of nanoparticles
c) Heterogeneous photocatalysis with TiO2 and ZnO nanoparticles.
They carried out research into the treatment of water using commercial TiO2 nanoparticles (Degussa P25) and obtained by the same group by hydrothermal methods. They characterized the photocatalyst structures and evaluated their quantum efficiency using standardized light sources. They also implemented a system of solar capture using glass tubes coated internally with TiO2 nanoparticles. It was successfully tested in a district of Cuzco.

Nanostructured Materials Group, Faculty of Science
Team: 2 researchers with doctorate, researchers with masters degree, 1 postgraduate student, 4 undergraduates, graduate researchers (B.Sc./ Eng.)
This group is working on obtaining or modifying porous materials, monocaps of organic molecules for biosensors and manufacture of thin film for the study of magnetoresistance.
Lines of research:
a) Porous silicon
b) Clay filters
c) Magnetoresistance
d) Biosensors
e) Scanning probe microscopes (SPMs)
f) Decontamination of textile effluents and waters polluted with pesticides
This group carried out tests on elimination of pollutants from water, combining in a single reactor absorption by activated clays and then photocatalytic decomposition with TiO2. Good results were obtained using this process in eliminating azo dyes in textiles effluents and pesticides.

(cont.)

Box 2. Principal research groups in nanotechnology in Peru (cont.)

Sputtering Laboratory, Faculty of Science

Lines of research:

This laboratory manufactures thin coatings with various characteristics. The term "sputtering" (sometimes referred to as cathode pulverization) refers to a method of making metallic, ceramic or dielectric coatings using a plasma discharge in a vacuum chamber. By this method, the laboratory has obtained very hard ceramic films on the surfaces of cutting tools, in order to extend their useful life. Among applications of nanotechnology, they have deposited silver nanoparticles on a dielectric matrix to study the resonance of surface plasmons. These materials have enormous potential for use in biosensors. The sputtering method is very versatile. It allows thin film to be obtained from a few nanometres thickness up to several micrometres. This has enabled the group to manufacture thin dielectric film for optical interference filters, and electrodes for rechargeable micro-batteries with Li+ as the cation of charge and vanadium oxide as the matrix.

Laboratory of Chemistry of Materials Applied to the Environment, Faculty of Science

Team: 1 researcher with doctorate, researchers with masters degree, 1 postgraduate student, 2 undergraduates, graduate researchers (B.Sc./ Eng.)

Develops and characterizes catalysts for the decontamination of volatile organic compounds (VOCs). It uses aluminium and iron oxide bases. It is currently working on applications of pillared clays as a base for catalysts for the decontamination of industrial effluents and in the manufacture of membranes.

Modelling and Multiscale Simulation Group, Faculty of Mechanical Engineering

It studies biological systems using computational methods. It studies the interaction of proteins and their functioning, in order to discover the mechanisms behind certain diseases. The ultimate objective of this study will be the prevention of various diseases such as cancer, cardiac and neuronal disorders, among others. Four of its members are following courses of postgraduate study in nanoscience in North American Universities.

Lines of research:

a) Mechanical properties of proteins.
b) The cancer eliminator, p53
c) Mechanical and micro-structural properties of synthetic bones.

4. Mayor de San Marcos National University

Institute of Physical Sciences, Faculty of Physical Sciences

Team: 7 researchers with doctorate, 4 researchers with masters degree, 5 postgraduate students, 10 undergraduates, 10 graduate researchers (B.Sc./ Eng.)

Comprises the nanomaterials laboratory, the X-ray diffraction and Mössbauer spectroscopy laboratory and the soil analysis laboratory.

Lines of research:

a) Hydroxyapatite synthesis. Hydroxyapatite (HAP) is a phosphate of calcium, Ca10(PO4)6 (OH)2 with physical and chemical properties similar to bone tissue.
b) Synthesis of soft magnetic materials.

Institute of Chemical Sciences and Chemical Engineering, Faculty of Chemical Sciences and Chemical Engineering

Lines of research:

Reduction of sulphur content present in oil by the application of nanoparticulate compounds of molybdenum.

5. Peruvian Nuclear Energy Institute

Research and Development Department

Team: 3 researchers with doctorate, 1 researcher with masters degree, 3 postgraduate students, 1 undergraduate, 1 graduate researcher

Lines of research:

Computational simulation

6. San Agustín de Arequipa National University

Chemical Research Laboratory, Faculty of Natural and Formal Sciences. School of Chemistry

Team: 20 researchers with doctorate, 10 researchers with masters degree, 1 postgraduate student, 5 undergraduates, 7 graduate researchers (B.Sc./ Eng.)

(cont.)

Box 2. Principal research groups in nanotechnology in Peru (cont.)

Lines of research:
a) Environmental pollution
b) New materials
c) Natural resources (photochemistry)
Research projects:
- Coagulation and flocculation of the waters of the Chili River
- Absorbents applied to minimize heavy metals in the decontamination of residual waters from the textiles industry and tanneries.
- Preparation of catalysts by the sol-gel method.
- Monitoring at 15 points of NO2 pollutants in the air in the city of Arequipa using passive tubes.

7. National University of Trujillo

Materials Physics Laboratory, Thin Film and Nanostructures Section, Faculty of Physical Sciences and Mathematics
Team: 1 researcher with doctorate, 1 researcher with masters degree, 1 postgraduate student, 2 undergraduates, 1 graduate researcher (B.Sc./ Eng.)
This laboratory develops materials with applications in nanoelectrics. To obtain thin films, it uses the spray-pyrolysis method.
Lines of research:
a) Thin films based on ZnO.
b) Diluted magnetic semiconductors
c) ZnO:Co nanoparticles de

Ceramic Materials Laboratory, Faculty of Engineering
Team: 2 researchers with doctorate, 2 researchers with masters degree, 3 postgraduate students, 4 undergraduates, 2 graduate researchers (B.Sc./ Eng.)
This laboratory manufactures ceramic materials for construction and characterizes their mechanical properties. Currently it is engaged in a project that manufactures clay filters for the decontamination of gases using ceramic materials.
Lines of research:
a) Development of ceramic gas filters

Source: Gutarra (2010).

- Development of metallic, ceramic, magnetic nanomaterials, semiconductors or superconductors
- Growth of monocaps of molecules
- Development of nanocapsules and nanocarriers
- Design and construction of small scale transductors.
- Computational methods for the design of nanostructures

National Plan of Science, Technology and Technological Innovation for Sustainable Productive and Social Development 2009-2013 (a medium-term plan within the framework of the plan 2006-2010) includes nanotechnology as a priority cross-cutting area, associated with the materials technologies. The lines of action in this area comprise:

- Research and development in nanoparticles and nanostructured materials, controlled release of drugs and fertilizers, rendering water drinkable and improving fuel quality.
- Characterization of the physical properties of nanostructured metal alloys.
- Research and development in biosensors with applications in biomedicine, agriculture and environmental control.
- Application of computational methods for the study of nanostructures.
- Development of metallic, ceramic, magnetic nanomaterials, semiconductors or superconductors.

These general plans have not been translated into concrete objectives and budgets. In this regard, it would be important for the Plan to focus more its priorities to be able to make some tangible progress in the coming years.

In this context, one of the most tangible public initiatives in support of the development of nanotechnology was the creation of the CONCYTEC Nanomaterials Chair, under a cooperation agreement between the National University of Engineering and the Hyperthermia company signed in July 2009.

The project which gave rise to the Chair is the production of silver, zinc and iron oxide nanoparticles for water purification. The objective of the Chair is the development of nanomaterials which will be used in the decontamination of water. The project comprises two stages. The first develops appropriate conditions for the manufacture of the silver, zinc and iron oxide nanoparticles and their influence on their size and distribution. In the second stage, tests will be carried out to evaluate the efficiency of the materials developed in decontaminating water. The first evaluations will be aimed at the disinfection of water polluted with Escherichia coli (E-coli).

As well as this general objective, the CONCYTEC Chair seeks to achieve the following results:

- Strengthening training of human resources in nanotechnology by making grants for doctorates.
- Contributing to the exploitation of Peruvian minerals through the technological content that can be added by converting them into nanomaterials with a variety of applications.

The main limitation of the CONCYTEC Chair is the scarcity of resources allocated. It receives 20,000 dollars a year from CONCYTEC.

In addition to the CONCYTEC Chair, as indicated above, FINCyT is financing the research project on treatment systems for removal of arsenic, boron and iron from bodies of water for agricultural and agro-industrial purposes which is being carried out at the Pontifical Catholic University of Peru and the project on reduction of sulphur content present in oil by the application of nanoparticulate compounds of molybdenum at the Mayor de San Marcos National University.

For its part, the IPEN project “Manufacture and characterization of nanotextured membranes for environmental applications” is being funded by PROCYT (CONCYTEC).

In Peru, there have not been any foresight studies in nanotechnology. However, mention should be made of the work to inventory current capacities in the area of nanotechnology and its application in the area of water and sanitation (CONCYTEC and Soluciones Prácticas-ITDG, 2010). The study catalogues current capacities in nanotechnology and related areas and offers some guidelines.

5. Cohesion and execution function

Peru does not have any Nanotechnology Commission, Agenda or National Plan to guide, to provide direction, establish priorities and help include nanotechnology in the strategic aspects of national development.

The level of activity in this area does not justify a formal commission or a national agenda. Nevertheless, if the aim is to encourage the development of capacities in nanotechnology, it will be necessary to have a working group which can be a national focal point for nanotechnology and which can guide the first steps in establishing the foundations for the development of these capacities (for example, by promoting the establishment of a national nanotechnology programme).

D. CONCLUSIONS AND RECOMMENDATIONS

Although there is evidence of growing interest in nanotechnology, activity in this sphere in the country is still very limited, even in comparison with other countries of the region. The number of researchers, who are concentrated in just a few universities and research institutions, is still small and the number of productive applications even less.

Moreover, with regard to the availability of space and equipment to develop research in nanotechnology, much of the equipment is very old, while much of the basic equipment required is not available in the country.

In addition, there are shortcomings in terms of training of researchers, both with respect to quantity and quality.

Recommendations

Given that current capacities (research, equipment and financing) in Peru in the sphere of nanotechnology are sparse, it is recommended that efforts should be focussed on one or two specific areas (e.g. nanomaterials and nanostructured filters and membranes for water treatment).

As it is a field of research where specialised capacities and the availability of equipment are critical, and given the relatively small size of the Peruvian scientific community and the resources at its disposal, it is especially important to promote cooperation at both regional and global level, without which it will be impossible to achieve the critical mass necessary to endow R&D in nanotechnology with the necessary sustainability.

Equally important is strengthening the links between the academic world and actual or potential users of nanotechnology, whether they are private companies or the public sector itself. However, such links are especially weak in Peru in general, and even more so in the relatively new field of nanotechnology.

Peru is faced with two main challenges in the field of nanotechnology. One is to strengthen research capacities in areas regarded as strategic (materials) or whose development is so far embryonic in the country (sanitation and environmental applications), through the training of highly qualified human resources, laboratory equipment and support for collaboration projects with centres of excellence in this field.

The other, which is crucial, is to promote links between the private sector and the State as clients for possible solutions to productive and/or social problems which incorporate nanotechnology. To this end, it is necessary to strengthen existing instruments, such as the CONCYTEC Chair and the competitive funds, and, possibly, incorporate materials nanotechnology as an area of specific interest for the work of some of the CITEs.

At a later stage, a line of action which should be pursued, and which addresses both sides of the problem (the academic world and companies) will be to promote the creation of science-based companies from research groups. Here, there are several possible variants, from direct involvement of members of a research group to licensing or linking of researchers with entrepreneurs.

Based on this analysis, the following recommendations are suggested:

1) Establish a working group, formed of the principal national actors in nanotechnology (including representatives of the chief ministries involved, researchers, universities, companies, NGOs, etc.) **with the objective of steering the establishment of a National Nanotechnology Programme.**

Table 2. Principal strengths, weaknesses, opportunities and threats in the nanotechnology sector in Peru.

STRENGTHS	WEAKNESSES
• Some research experience • A degree of basic infrastructure capacity	• Limited research capacity • Limited amount of financial resources available • Obsolete and/or insufficient equipment • Little nanotechnology development, especially in the private sector • Few opportunities for training in nanotechnology at national level • Lack of links between the academic sector and private companies or other users. • Lack of a national nanotechnology agenda which sets priorities
OPPORTUNITIES	**THREATS**
• Potential for developing products with a social impact • Positive experience of competitive funds • International and regional collaboration	• Development of the sector requires a high level of investment • Highly interdisciplinary sector, requires close collaboration between experts in different fields • Limited capacities for assessing risks of nanotechnology • Lagging far behind other countries in the region • General weakness of the national system of innovation: - Limited quality of education in science and technology - Limited involvement of the private sector in general - Scarce financial resources - Weakness of infrastructure - Limited university-enterprise links - Lack of priority for science, technology and innovation in the country

2) Carry out **a foresight study and consultation process** with the various key actors, including potential international partners, in order **to identify one or more national nanotechnology research networks** (e.g. nanomaterials and nanostructured filters and membranes for water treatment) and two or three niches with the greatest potential.

3) Establish a five-year **National Nanotechnology Programme** to support the development of the nanotechnology network(s) and the niches identified in the foresight study and the consultation process. The national nanotechnology programme will include:

- Development of the nanotechnology network(s) and financing of research activities in the niches identified
- Financial support for laboratory facilities and equipment
- Development of one or two international cooperation programmes
- Support for the development of high-level training and research through the CONCYTEC Chairs
- Training of researchers abroad and facilitation of their return
- An information campaign on nanotechnology aimed at Peruvian entrepreneurs
- A series of activities to strengthen links with potential users and client organizations, private companies and others
- Identification of financial resources to achieve the objectives (a minimum of 250,000 dollars[7] annually during the first five years will be necessary).

At a later stage, consider:

1) Consolidating the working group in a **National Nanotechnology Commission**. Once a certain degree of development and support has been reached, the creation of a more consolidated space able to lead and advice on the development of nanotechnology in Peru can be considered.

2) Expanding the number of networks, projects and financial resources.

3) Developing a human resources training plan in the field of nanotechnology.

4) Developing practical applications, spin-offs and patents derived from research. Consideration should be given to instruments that promote the transfer of technology, strengthen the management of intellectual property and develop venture capital for nanotechnology projects.

5) Creating a forum (e.g. in the National Nanotechnology Commission) **to research, debate and provide advice on the safety and regulation of nanotechnology**.

NOTES

[1] See OEI (2008).

[2] Although a distinction is sometimes made between the terms nanoscience and nanotechnology, this report uses the term nanotechnology to cover both the concept of nanoscience and that of nanotechnology.

[3] The Government of Peru requested an analysis of this sector given the potential that nanotechnology offers as a general purpose technology.

[4] Opinion collected during interviews with researchers in the field of nanotechnology.

[5] The Study "Estado de Situación de la Nanotecnología en el Perú" (Gutarra, 2009), which examines the potential for developing a multidisciplinary nanotechnology team dedicated to water and sanitation work, provides a description of the principal laboratories and groups with nanotechnology projects.

[6] See Delgado Ramos (2007) for a critique of the dependency of some Latin American countries on foreign financing of nanotechnology.

[7] Estimate based on the need to invest at least 100,000 dollars per year for each research network and to finance equipment and training and promotion activities. In comparison, Brazil invested some one million dollars annually during the first five years (2001-1005) to create four nanotechnology networks.

VI

Conclusions and key recommendations

A. DIAGNOSTIC OF THE PERUVIAN NATIONAL SYSTEM OF INNOVATION

Innovation capacity in Peru is extremely weak. R&D investment levels are extremely low (even by the standards of the region). The university system, and education in general, is in crisis. Private investment in R&D is almost nil. There are no links between research activities and the productive sector. Most serious of all, the theme of science, technology and innovation is still not a priority for the State.

There is an urgent need to build capacities in science, technology and innovation to enable Peru to use knowledge to serve economic activities and the wellbeing of its citizens. The country's sustained development in the medium and long term largely depends on it.

Low level of public and private investment in research. Although there are no objective up-to-date data on public and private investment in research and development, the information and opinions gathered confirm a low level of investment in R&D in Peru in relative and absolute terms compared with the leading countries in the region. This financial constraint is a major factor, but not the only one, in explaining the limitations of Peru's national system of innovation discussed below.

Poor educational performance at all levels, as a result of inadequate investment in education, excessive commercialization of education provision, predominance of short-term considerations both on the supply and demand side and inadequate control of educational provision and institutions. Other major barriers are the limited orientation towards scientific and technological disciplines and insufficient provision of doctoral courses. In addition, several regulatory shortcomings, which limit the recruitment of staff or more flexible use of the mining canon, hamper the development of research projects in universities. The lack of links between the scientific and business communities should also be highlighted, together with the fact that educational provision does not meet the needs of the productive sector.

Scant private participation in research and development. The majority of Peruvian companies are concentrated in activities with little added value, there is a lack of readiness and opportunity to take on risk and low demand for technology and productive knowledge. Moreover, Peru suffers from a fairly unsophisticated financial market and a lack of credit for innovative activities, in particular in terms of venture capital.

Absence of a critical mass of research. In addition to the low level of private participation in R&D, there are difficulties in generating knowledge through public research institutes and universities. The public research institutes suffer from a lack of funding, little generational renewal of their research teams, lack of formal recognition of the profession of researcher and limited cooperation between research bodies. The universities, as well as these limitations, face a lack of differentiation between the education and research functions, the flight of talent and limited control of the quality of education and research. As a result, Peruvian scientific productivity is among the lowest in Latin America.

Incomplete research and development infrastructure. Although there is a basic infrastructure of research institutes and universities, the equipment and accreditation of research laboratories is insufficient. Peru also needs to consolidate enterprise incubators, in particular in order to be able to form technology-based companies, and develop the conditions necessary to ensure that projects that emerge from technology parks are successful. The lack of an efficient national quality system, for example, and the lack of international recognition of laboratories, seriously affect Peruvian companies innovative and export activities.

A regulatory framework that is developed but largely ineffective and often contradictory. On the one hand, bureaucratic procedures have a considerable effect on the performance of the system of innovation. On the other, the legal commitment to promotion of competitiveness and innovation is not matched by an effective allocation of resources for R&D, there is duplication of organizations and functions, and problems with the hierarchical position of CONCYTEC. There is no effective control of quality of education and research and there are various legal obstacles to the use of the scarce economic resources. Peru has a well developed legal framework for intellectual property but there is insufficient capacity to manage and profit from intellectual property.

Lack of leadership in science, technology and innovation. Lack of belief in the importance of STI for economic development and the need to integrate economic and

STI policies. Lack of any real commitment at the highest level to articulate consistent policy systems.

A disjointed national system of innovation incapable of setting priorities and creating synergies. Dispersal and duplication of functions and a marked lack of foresight and monitoring and evaluation activities.

Limited exploitation of the broad range of policy instruments to support STI. Broad promotion of scientific and technological supply through direct financing but lack of systemic financing instruments (venture capital and guarantee funds) and indirect financing (fiscal incentives for R&D), and lack of focus of instruments, in part due to lack of clear sectoral policies.

Nevertheless, Peru has some strengths and important initiatives on the basis of which its system of innovation can be developed.

There are **nuclei of capacity in science, technology and innovation**. The country has a small group of excellent universities, laboratories and some public research institutes. This group of universities with the greatest capacity for research is widely involved in international cooperation and carries out notable activities in cooperation with the productive sector, albeit biased towards technology transfer. The bibliometric study carried out shows research capacity in the biological sciences and health fields.

Positive experience of various instruments and initiatives for the promotion of science, technology and innovation. Special mention should be made of the STI funding programmes (e.g. FINCYT, FONDECYT), promotion of the decentralization of STI policy through regional STI councils, initiatives to repatriate and provide training to doctorate level through the CONCYTEC Chairs, and the efforts to transfer technology to SMEs through the CITEs. Although the results are still limited in scale, these initiatives and instruments are worth continuing and improving.

Peru also has many factors which can provide opportunities for the development of STI in the country. The country is in a situation of economic growth, it has achieved macroeconomic stability and foreign investors are expressing interest, which offers excellent conditions for access to sources of financing for STI. The commercial opening of the country can facilitate the increase in technological capacity, making it easier to buy capital goods, facilitating access to new technologies and creating natural incentives to entrepreneurial innovation which will allow Peruvian companies to compete. In addition, there are ample opportunities for international and regional cooperation which could be exploited for access to resources and capacity building.

At the same time, it is necessary to bear in mind the challenge posed by the great heterogeneity of Peruvian companies consisting of a broad informal sector with low productivity and a small modern sector. The productive structure lacks diversity and is concentrated in sectors involving intensive use and exploitation of natural resources. Faced with the increase in international competition, Peruvian companies, unless they develop their capacity to absorb technology, among other things, will have difficulty in competing. Lastly, there is the risk of speculation and volatility in the commodities markets and foreign investment

The following table presents a summary of the principal strengths and weaknesses of STI in Peru, together with the principal opportunities and threats which may affect their development.

Table 1. Principal strengths, weaknesses, opportunities and threats of the Peruvian national system of innovation

STRENGTHS	WEAKNESSES
• Basic infrastructure of research institutes and universities • Nuclei of STI capacities (group of excellent universities, university laboratories and certain pubic research institutes) • Certain research capacity and human resources in the biological sciences and health • Experience of STI financing programmes (competitive funds) • Efforts to disseminate technology in SMEs • Developed legal framework (intellectual property, legislation on ICT, etc.).	• Low levels of R&D investment • Education system weak at all levels • Limited professional orientation towards scientific and technological disciplines, imbalance between technical and professional careers • Lack of a critical mass of STI capacity • Absence of the private sector from STI issues • Disjointed national STI system • Institutional framework for promotion of STI complex with duplication of functions • Limited capacity for foresight exercises and technological intelligence • Difficulties in setting priorities for the allocation of resources • A degree of ignorance and lack of agreement on STI policies among decision-makers and economic agents • Non-existence of financial market instruments for STI (e.g., seed capital and venture capital)
OPPORTUNITIES	**THREATS**
• Macroeconomic stability, economic growth, foreign investment and access to sources of financing • Commercial openness: opportunities for increasing technological capacity (purchase of capital goods, access to new technologies, incentives for innovation) • International and regional collaboration on STI • Peruvian human capital abroad	• Great structural heterogeneity, with large informal sector with low productivity and small modern sector which can compete internationally. • Productive structure lacking in diversity and concentrated in sectors with intensive use and exploitation of natural resources • International competition: without greater capacity to absorb technology, among other things, Peruvian companies will have difficulties • Speculation and volatility in the commodities markets and foreign investment.

B. KEY RECOMMENDATIONS

The construction of a national system of innovation must address two fundamental dimensions: (i) policy (budgeting and planning, decision-making and monitoring); and (ii) economic and productive (articulation of economic agents as generators and disseminators of knowledge at regional and sectoral level. This requires a radical cultural change at all levels: in the highest Peruvian government circles and the political class, businessmen and investors, and in academic and educational circles.

The construction of the system will have to be based on Peru's existing capacities and opportunities, continuing those initiatives which have been successful but making greater efforts to set priorities.

Based on the diagnostic analysis, six sets of basic recommendations have been identified to stimulate the development of science, technology and innovation in Peru:

1) Establish an institutional framework as well as an organizational, human and financial structure capable of leading the development of science, technology and innovation in Peru.

Concentrate in two bodies, the functions of foresight, intelligence and strategic planning and evaluation of STI policies, on the one hand, and financing and execution of STI programmes, on the other.

These agencies must have the authority, leadership qualities and human and financial resources necessary to steer the development of science, technology and innovation in Peru. Their respective areas of competence and the relation between them should be clearly defined to avoid overlaps and institutional rivalries. It is also considered important that the location of both agencies in Peru's general institutional framework should ensure greater visibility of STI issues, with direct access to policymakers at the highest level to facilitate the incorporation of the scientific and technological dimension in the country's overall development vision.

In accordance with these basic principles, it is proposed to establish:

1) A *National Innovation Council* – an independent body, with participation of the various actors in the national system of innovation and linked to the Presidency of the Council of Ministers (PCM). The Council would be responsible for setting the main lines of science, technology and innovation policies and would also be responsible for foresight, intelligence, strategic planning and evaluation. For that purpose, it should be provided with its own human and financial resources. Ideally, *the National Innovation Council* should be chaired by the Prime Minister[1], and the Council would necessarily include the participation of the principal ministries and representatives of the universities, research institutes, the private sector and the proposed Peruvian Innovation Agency[2].
2) A *Peruvian Innovation Agency* – a body subordinate to the PCM, responsible for the financing and execution of STI programmes.

2) Design a mix of STI policies and programmes which, combined with economic policy, will strengthen general STI capacities in Peru and the development of STI in a selected number of strategic sectors and technologies.

Articulate and integrate STI policies in economic policy. Starting with a foresight exercise and a process of consultation with the various key actors, identify a limited number of priority subsectors and technologies of strategic importance for the Peruvian economy and society, in which active policies on strengthening technological capacity and innovation would focus.

The STI policies and instruments aimed at the development of these subsectors and strategic technologies should be accompanied by others of a more general character designed to establish the essential conditions for the development of STI in Peru, acting on both the supply and the demand side. In both cases, it is desirable to strengthen the involvement of the private sector in the development of STI in Peru (see recommendation 5).

Progressively and steadily increase the financing of STI activities, so that levels of investment in STI in Peru in the medium term reach at least the levels invested by the region's leading countries. Consider the establishment of incentives to promote private investment in STI. For example, consider the establishment of fiscal incentives for investing in R&D.

Also develop a science, technology and innovation system which allows the design, monitoring and evaluation of STI policies. For example, promote the elaboration of a national innovation survey, the systematic collection of STI data and the development of capacities to process and analyse this information.

3) Improve the management of STI programmes and policies. Improve the management of STI policies by developing short-term plans with concrete and measurable objectives, with clearly identified responsibilities and resources subject to a control system.

Place responsibility for the management of the STI financing programmes (FONDECYT, FINCyT, FIDECOM) under the proposed Peruvian Innovation Agency. Also consider the inclusion of other sectoral funds.

Relax the conditions attached to the funding resources from the mining canon, so that it can be used in research, innovation and advanced capacity building activities in the area of STI with a broader remit, in accordance with the particular needs of regional research groups.

4) Invest in the development of Peruvian human capital.

Strengthen quality of education at all levels, increasing investment in education and improving systems of evaluation and control of education.

Ensure quality of teaching and research in Peruvian universities, reviewing the model of certification and quality control of the university system and, in particular, the mechanisms for authorization of the creation of universities in Peru.

Establish the profession of researcher as a career path with effective mechanisms for regular evaluation, promote the renewal of the body of researchers, facilitate the financing of research activities and increase the quality of postgraduate training programmes.

Promote education in scientific and technological fields, starting in primary and secondary education.

Drive information and awareness raising campaigns to encourage the development among the general public of a more science-oriented culture and greater awareness among economic, social and political operators of the importance of science, technology and innovation in achieving the country's development goals, including improved living standards.

Promote programmes which facilitate the contribution of Peruvian scientists, researchers and engineers abroad in achieving national STI policy objectives, through (a) programmes which facilitate their reintegration in the Peruvian labour market in universities or the private sector, (b) other ways of participating in the country's scientific and technological activities which do not involve the permanent return of participants (for example, as advisers, network facilitators or occasional trainers).

5) Promote the participation of the private sector in science, technology and innovation.

Develop a set of programmes and actions which promote innovation in the private sector. These could include:

- Reducing the cost of innovation, in particular removing administrative barriers or others which affect the acquisition of technology.
- Facilitating the development of the venture capital and seed capital sector in Peru and access to venture capital.
- Supporting the consolidation of business incubators, in particular the capacity to incubate technology-based companies.
- Facilitate public-private partnerships and co-financing through an appropriate regulatory framework,

Facilitate the articulation of the national system of innovation, including:

- Promoting collaboration and technology transfer between universities, research institutes and companies and, promoting the role of the university and research institutes both in technological development and scientific knowledge and its transfer and application to the productive sectors. For example, facilitating training in management of the intellectual property that their activity may generate, developing mechanisms for mobility between universities, research institutes and companies, or facilitating private investment in research carried out by universities and public research institutes.
- Stimulate multi-disciplinary programmes which combine the participation of several research institutes, universities and companies. For example, by considering the multi-disciplinary character as a positive factor in the grant of competitive funds.
- Promote the participation of the private sector in the design of STI policies. For example, consulting directly with entrepreneurs, and not only representatives of professional organizations, or facilitating their participation in the formulation of study plans in the education system.

6) Strengthen capacity relating to intellectual property and quality.

Develop institutional capacities in the private sector, universities and public research institutes relating to intellectual property, so that existing intellectual property instruments better fulfil their function of encouraging and facilitating the generation and commercialisation of technologies. Drive the development of intellectual property policies in public research institutes.

Establish an action programme which promotes and facilitates the application of quality systems in the productive system. This would allow a greater number of companies to penetrate the domestic and international market.

C. THE INFORMATION AND COMMUNICATION TECHNOLOGIES SECTOR. PRINCIPAL CONCLUSIONS AND RECOMMENDATIONS

Although a few cases of success in the ICT sector in Peru can be found, they are still far from forming a critical mass capable of allowing the autonomous development of the sector.

The sphere of private activity is marked by the high level of informal business (limited adoption of international certification and scant quality control), its concentration in activities with low added value, and scant links with research initiatives in universities and other academic institutions. Peruvian companies are also faced with the lack of capitalization mechanisms and bottlenecks on the training of human resources.

In the public sphere, for its part, added to the lack of a legal framework to promote the software industry and generate adequate incentives for the development of the sector, is the obvious institutional weakness of support bodies for scientific, technological and innovative activities, a marked scarcity of resources, a notorious lack of promotion of the sector and also a lack of coordination between bodies which tends to fragment the available funds into a multiplicity of separate initiatives.

The following are five main recommendations to reverse the situation:

1) Develop a national vision and strategy for the development of the ICT sector.

- Strengthen the productive aspects of the Peruvian Digital Agenda, by promoting greater concern among the actors involved (including ONGEI and CODESI) and identifying a set of priority actions to develop the ICT sector and its contribution to the development of the information society in Peru.
- Establish a National Programme for the Development of ICT which includes the development of a human resources training plan, promotion of ICT research, a set of measures to develop greater sophistication among entrepreneurs, and strengthen foresight exercises and information gathering in the sector, as well as monitoring and evaluation of capacities, policies and programmes.

2) Establish a human resources training plan in the ICT sphere. This plan must foster the development of a comprehensive high-level, multi-disciplinary and specialized education based on an evaluation of the existing educational offer and the needs of the sector over the next 5-10 years. The plan must include the necessary financing for a programme of student grants and teacher training, doctorate and post-doctorate training in Peru and abroad, as well as for university research projects. The plan must also include support for the accreditation of training programmes in the area and promotion of technical training.

3) Strengthen the promotion of ICT research in universities and companies, in particular in the identified niches.

- Continue the support provided by competitive funds, adapting them so that they can respond to the demand for R&D in this sector.
- Explore other research funding options (permanent fund for innovation in ICT, development of venture capital, guarantee fund, fiscal measures).
- More generally, support research activities by establishing the profession of researcher as a career path and strengthening the supply and quality of postgraduate training programmes.

4) Establish a set of measures to **develop greater entrepreneurial sophistication in the sector**, in which Peruvian companies can undertake larger-scale projects, compete at international level and offer specialized added value services:

- Stimulate international certification by facilitating financing to allow smaller companies obtain certification and by progressively incorporating in state institutions the requirement for certification of software suppliers.
- Progressively redirect support instruments (e.g. competitive funds) towards activities in areas with greater added value, promoting specialization in niche fields.
- Consider the development of other measures which can facilitate financing of the sector (permanent fund

for innovation in ICT, development of venture capital, guarantee fund, fiscal measures).
- Promote entrepreneurial development in other ICT-related sectors and which complement its development, such as the IT-enabled services sector and the content industry.
- Move forward in the implementation of the Government's digital strategy by creating demand for new complex solutions for Peruvian software companies. Analyse the principal barriers to the participation of local companies in this market and generate appropriate competitive conditions to allow local companies to enter that market.
- Foster collaborative projects of increasing complexity between universities, companies and public research institutes.
- Promote the creation of university spin-offs through incubators.
- Establish a set of actions to promote the adoption of ICTs by SMEs.

5) Strengthen foresight studies and the gathering of information on the sector as well as the monitoring and evaluation of capacities, policies and programmes. In particular, it is recommended to:
- Undertake a foresight study on the ICT sector. This study should identify the niches with the greatest added value and potential for Peruvian companies and those on which public efforts should be focussed.
- Carry out a study on the content industry in Peru, concentrating on areas directly related to the productive development of the ICT sector.
- Systematically monitor and evaluate the impact of policies and programmes in support of the sector.
- Monitor ICT access and use by small and medium-sized enterprises.

D. BIOTECHNOLOGY. PRINCIPAL CONCLUSIONS AND RECOMMENDATIONS

In Peru, there is no consensus on the role that modern biotechnology should play in the country's development. The lack of a national biotechnology agenda which sets priorities and guides the allocation of public, private and academic resources acts as a brake on investment and development in the sector.

Peru's biodiversity is an advantage for innovation in biotechnology which has not been exploited up to now. There is little biotechnological development at public level in Peru and even less in the private sector. Research projects are isolated efforts and links between research and the user sectors are limited. The capacity for academic training is inadequate. The regulatory framework is developed but incomplete (sectoral regulations need to be established) and capacities in the management of intellectual property are limited.

As a result of this analysis, the following recommendations are offered:

1) Define a clear and consistent policy and position with respect to biotechnology
- As a first step, it will be necessary to continue investing in dialogue and building a greater social consensus on the role of biotechnology in Peru.
- Develop a National Biotechnology Policy which offers a consensual strategic vision and includes the legal and regulatory aspects necessary to provide a stable framework for the development of biotechnology in the country[3].
- Based on the results of a foresight exercise in the various areas of biotechnology and broad dialogue, develop a National Biotechnology Programme which establishes a set of specific coordinated actions which can be evaluated; assign responsibilities for their execution; and establish the financial and human resources necessary to implement them.

2) Strengthen research and training capacities:
- Increase funding for research in priority areas
- Establish financing opportunities for longer-term projects and, in the case of FINCyT, open the competition to proposals in the health sphere.
- Facilitate the financing and acquisition of equipment for research laboratories.
- Promote international accreditation of masters degree and doctorate courses in biotechnology.

3) Complete the existing regulatory framework and strengthen capacities for its implementation and for managing intellectual property
- Give priority to the approval of the biosafety sectoral regulation in agriculture.
- Prepare the draft sectoral biosafety regulations on health and water resources.
- Strengthen the biosafety capacities of the competent sectoral bodies.
- Promote the development of an intellectual property policy in the principal public research institutes (e.g. INIA)

- Strengthen capacities for analysis and advice with respect to intellectual property in the field of biotechnology.

4) Stimulate transfer of knowledge and products and the commercialisation and economic development of the sector
- Facilitate the commercialisation of research by developing intellectual property policies in research institutes and universities.
- Continue to promote financing of joint projects by universities and companies.
- Promote the participation of key technology transfer organizations (CITES, INIA, NGOs, etc.) in research projects.
- Establish a package of incentives for the creation and/or attraction of biotechnology companies.

5) Strengthen international cooperation through strategic alliances with high level institutions in key sectors, both in research and infrastructure and biosafety processes.

E. NANOTECHNOLOGY. PRINCIPAL CONCLUSIONS AND RECOMMENDATIONS

Although there is evidence of a growing interest in nanotechnology, activity in this sphere in the country is still very limited, even in comparison with other countries in the region.

Current capacities (research, equipment and financing) in Peru in the sphere of nanotechnology are scant. The number of researchers, who are concentrated in just a few universities and research institutions, is still small and productive applications even fewer. Much of the equipment is of considerable age and a number of basic equipment is not available in the country. There are shortcomings in terms of training of researchers, both in terms of quantity and quality.

As a result of this analysis, it is proposed, as a first stage:

1) Establish a working group, formed by the main national actors, **with the objective of steering the establishment of a National Nanotechnology Programme.**

2) Carry out a foresight study and a consultation process with the various key actors, including potential international partners, **in order to identify one or more national nanotechnology research networks** (e.g. nanomaterials and nanostructured filters and membranes for water treatment) as well as two or three niches with the greatest potential.

3) Establish a five-year National Nanotechnology Programme to support the development of the nanotechnology network(s) and the niches identified in the foresight study and the consultation process, which includes:
- Development of the nanotechnology network(s) and financing of research activities in the niches identified.
- Financial support for laboratory facilities and equipment.
- Development of one or two international cooperation programmes.
- Support for the development of high-level training and research through the CONCYTEC Chairs.
- Training of researchers abroad and facilitation of their return.
- An information campaign on nanotechnology aimed at Peruvian entrepreneurs.
- A series of activities which strengthen the links between potential users and client organizations, private companies and others.
- Identification of financial resources to achieve the objectives (a minimum of 250,000 dollars per year[4] during the first five years will be necessary).

At a later stage, consider:

1) Consolidating the working group in a **National Nanotechnology Commission** to lead and advice on the development of nanotechnology in Peru.

2) Expanding the number of networks, projects and financial resources.

3) Developing a human resources training plan in the field of nanotechnology.

4) Developing practical applications, spin-offs and patents derived from research. Consideration should be given to instruments to promote the transfer of technology, strengthen the management of intellectual property and develop venture capital for nanotechnology projects.

5) Creating a forum (e.g. in the National Nanotechnology Commission) **to research, debate and provide advice on the safety and regulation of nanotechnology.**

NOTES

[1] Not necessarily at this level for all the Council's activities.

[2] The list is not exhaustive.

[3] Reconsider, for example, the bill on promotion of modern biotechnology.

[4] Estimate based on the need to invest at least 100,000 dollars per year for each research network and to finance equipment and training and promotion activities. In comparison, Brazil invested some one million dollars annually during the first five years (2001-1005) to create four nanotechnology networks.

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Annexes

ANNEX A. DEVELOPMENT AND LIMITATIONS OF THE NATIONAL INNOVATION SYSTEMS APPROACH

The notion of systems in the literature on technological innovation

The origin of the notion of systems associated with innovation studies can be found in the evolution of the concept of innovation itself. These early associations between notions of systems and innovation, which began in the 70s in the work of various academics around Christopher Freeman and the *Science Policy Research Unit* (SPRU)[1], conceived them as *a non-linear process which involves the coordinated participation of a wide range of actors.*

The subsequent use of these concepts, through the late eighties and early nineties, is found in three seminal works which introduce the idea of national innovation systems.[2] It involved extending the idea of networks of agents in the innovation process to include the role played by institutions[3]. However, these *original interpretations* did not lead to a unified notion of a national innovation system,[4] probably because the main proponents come from different research traditions, in which the common denominator was affinity with the ideas of the economist Joseph Schumpeter.

The principal objective of these original interpretations of national innovation systems was to explain national patterns of economic development by analysing interactions between actors and institutions involved in innovation networks. Linked to this primary objective there was an implicit, and at times explicit, orientation towards the design of innovation policies.[5]

Despite their policy orientation, none of the original interpretations included a practical version of the innovation systems approach. This was essentially developed by the OECD, which adopted the notion in the early nineties (David and Foray 1994; OECD 1992). There followed what we may call the *generalized interpretation* approach, which means that specific national systems can be adequately described by listing the principal components (agents and institutions) involved in innovation processes and studying their most significant interactions. Starting from an analysis of how these interactions shape successful innovation systems, "best practice" is identified and the fundamental components are derived. These then serve as a guide to institutional and organizational learning in the international sphere. This generalized interpretation, refined in various reports and studies[6], is the one usually employed in studies of innovation systems.

The current interpretation of innovation systems is not wholly consistent with the systems approach. For example, the objectives of the approaches are different. The original interpretation of national innovation systems is aimed at identifying differences in the innovative performance of different countries, especially how different national institutions influence the success of innovation systems. In contrast, systems theory is based on the identification of factors, functions, behaviours, etc., which are similar[7] across different areas. This means that systems of all kinds operate according to the same basic principles, thus ideally it should be possible to deduce the principles applicable to particular systems from those which are more general[8].

Furthermore, the innovation systems approach was fundamentally based on a traditional definition of systems as entities composed of elements and interactions and does not address aspects concerning the hierarchical structure of systems, the treatment of the environment and analysis of the processes which occur within the system[9]. The theory of open systems replaced this traditional notion with one in which a system is distinguished from its environment (Checkland 1981; Luhmann 1995; von Bertalanffy 1968). It introduced two pairs of ideas which form the basis of systems thinking: emergence and hierarchy and communication and control. In other words, new systems emerge from the interaction between subsystems, while at the same time the different hierarchies between the whole and its components allow differentiation with respect to the environment. These interactions require different means of communication whose function is control of the system in its tendency towards stabilization.

The application of the framework of innovation systems presents some paradoxes. One of them is the dual use of the concept of innovation system. On the one hand, it is a reference framework to *explain the reality*. On the other, it is used as a normative posture where the framework becomes a *model of how it should be organized in reality*. Thus, instead of being a faithful representation of the observed reality, it becomes one which is filtered through a predetermined structure.

In short, the idea of innovation systems can only be generalized as an analytical framework which assumes the need for articulation or interactions between economic agents, but it does not provide the basis for dealing systematically with these agents. In other words, it does not explain how they are organized hierarchically to form emerging systems of increasing complexity.

Consequently, the studies done in this context frequently describe supposed subsystems whose interactions constitute national innovation systems. However, they do not provide details which would allow an evaluation of whether the agents actually constitute such subsystems, for example, an industrial subsystem or a research subsystem which is sufficiently mature and developed. In other words, it is generally assumed that these subsystems are given and it is only necessary to consider the development of institutions, entities, policy instruments, etc (through learning/replication of international experience) which favour the interrelation of those subsystems. Naturally, this perspective works quite well in countries which, for historical reasons, actually have such subsystems. However, it will be futile in countries where such subsystems do not exist or are still in a process of maturation or consolidation.

ANNEX B. REGIONAL INNOVATION SYSTEMS (RIS)

The concept of regional innovation systems has grown in importance among academics and decision-makers since the late nineties. The approach has received considerable attention as a promising analytical framework for increasing understanding of the phenomena of innovation in regional economies (Cooke 2001; Cooke 2005). Its popularity is closely related to the emergence of industrial hubs and conglomerates which can be identified in regions, and also the surge in government innovation policies in which the region is considered as the most appropriate level to promote and generate sustainable knowledge and innovation-based economies.

There are no generally accepted definitions of the concept of regional innovation systems, but it is usually taken to mean an interactive combination of public and private interests and formal organizations and institutions operating in accordance with organizational and institutional rules and relations that lead to the generation, use and dissemination of knowledge (Doloreux 2004; Doloreux and Parto 2005). The fundamental argument is that this combination of actors produces systemic effects which stimulate companies within the regions to develop specific forms of capital derived from social relations, rules, values and interactions within the community, which in turn strengthen innovative capacities and competition.

The origin of the concept is based on two main bodies of theory: (1) the literature of innovation systems and (2) the regional studies whose approach is to explain the socio-institutional environment within which innovation emerges (Malmberg, 1997). From a regional perspective, innovation is a localized phenomenon in a local setting, and not a universal process.

The concept of regional innovation systems has emerged in various countries at times when government policies sought to focus on the promotion of local processes of knowledge generation to ensure the competitiveness of the regions. The chief justification in framing specific policies within regional systems is based on the greater ability to concentrate on the development of capacities to improve companies' performance and improve the business environment. From this point of view, it is of considerable importance to promote interactions between various actors who should have good reason to interact, such as between companies, universities and research centres, or between emerging and other more developed companies (Cooke, 2001). In the light of this, policy strategies may also be oriented to the development of local comparative advantages, linked to the specific resources of the regions.

ANNEX C. STUDY OF PERUVIAN SCIENTIFIC OUTPUT, 2003–2009

C.1. Note on methodology

The purpose of this brief bibliometric study is to help identify the strongest areas of research in Peru, in order to guide decisions on STI priorities. The study measures the "international visibility" and other attributes of the publications to which Peruvian researchers contributed from 2003 to 2009[10]. This international visibility is determined on the basis of the publication in indexed journals, i.e. journals whose bibliographies and references cited in each of their articles are systematically recorded in databases of recognized standing[11]. This study used data from Thomson Reuters' ISI[12] Web of Knowledge, the most internationally recognized provider of this type of service.

For the study, all publications of articles in journals[13] in which an author registered as resident in Peru participated were collected. Once the bibliographic lists had been cleaned up, the following data fields were used for the study: name of author, title of article, address of author, address of principal author, institution in which the research was carried out, thematic category (assigned by the ISI), key words assigned by the authors, key words assigned by the ISI and number of citations received by the article (at the date of collection of the data).

The various fields were processed to identify: the number of articles by thematic category, differentiating the institution and country of residence of the principal author; the *impact* of the articles by thematic category and institution, differentiating the author's country of residence; research subjects in which there is the greatest scientific output; and the collaboration networks established with other countries for research purposes.

For the research themes and patterns, various analytical methods were used. Networks were constructed so as to identify the groups of research concepts and thematic categories which occurred most frequently and their relations. Statistical processes were used to establish comparisons between articles in which the principal author is based in Peru and those where he is based abroad. For this analysis, the chosen variables were: number of publications and their impact by thematic category/country and Peruvian institutions.

Impact is defined as the number of citations divided by the number of publications. In this study, it corresponds to the number of citations received by articles in each thematic category and each country, divided by the total number of publications in that category and country during the given period. This indicator provides an approximation of the quality of the articles by relating articles which scientific communities consider useful for their work (based on the number of citations) to the total volume of published articles.

C.2. Interpretation of networks

Some of the figures used in bibliometric studies involve networks which refer to various types of relationships. The networks are formed of nodes and connectors (relationships). In the example of Figure A. 1, the countries are the nodes and the lines which link them, the relationships.

Depending on the type of analysis, it is important to differentiate three aspects of the networks: the frequency of appearance of each node (number in the rectangle next to the country's name); the frequency with which each node is paired with another (frequency of pairs, represented by the number in the circle on the connector); and the number of relationships which each node has with the others, or connectivity (the number of lines flowing from each node).

Thus, in the example, the node for Peru has a frequency of 3,446 nodes, in this case, authors of articles; a frequency of pairs of 1,467 with the United States, representing the number of times a Peruvian or a US citizen appears as co-author of an article; and a connectivity of 4, indicating co-authorship relationships with four other countries. The example in Figure A.1 is a very simplified network, as it employs thresholds of these factors to eliminate their complexity, make them easier to understand and extract the most significant conclusions.[14]

C.3. Brief description of the results

The total number of publications found in the database during the period 2003-2009 came to 3,663 articles, for which the breakdown between principal authors based in Peru and abroad was 1,304 and 2,359 respectively. Figures A.2 and A.3 show the distribution

Figure A.1. Example of network of authors in articles

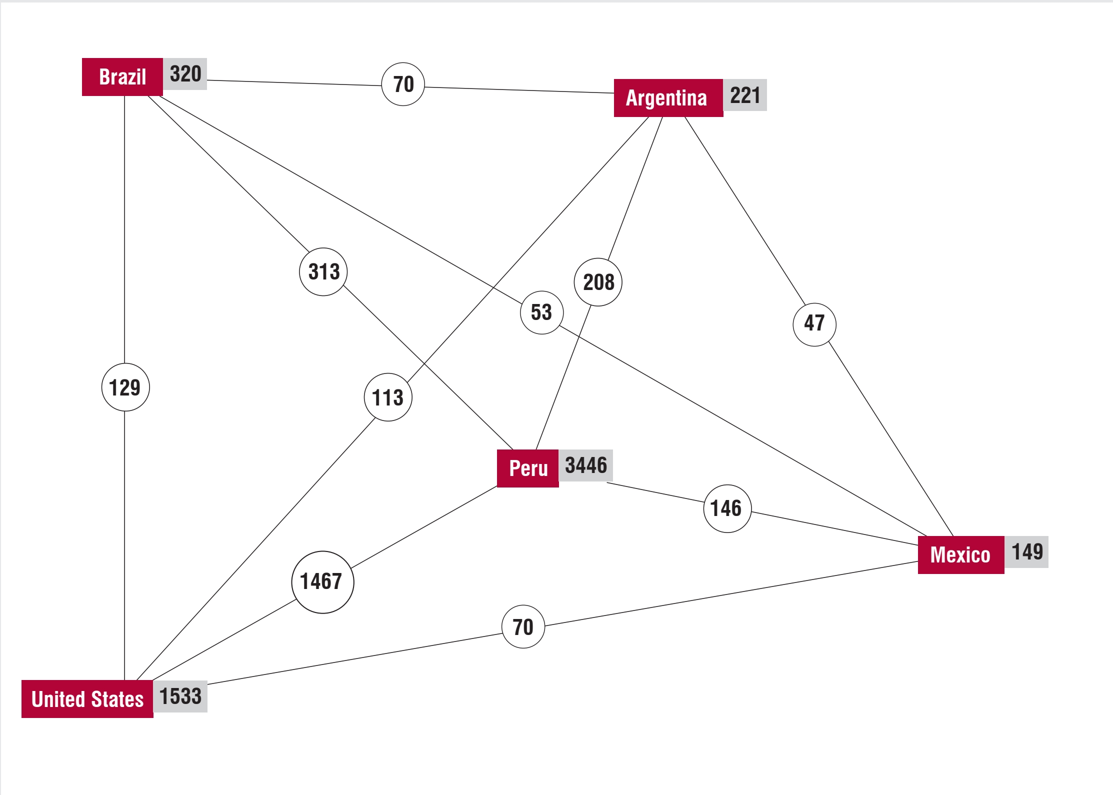
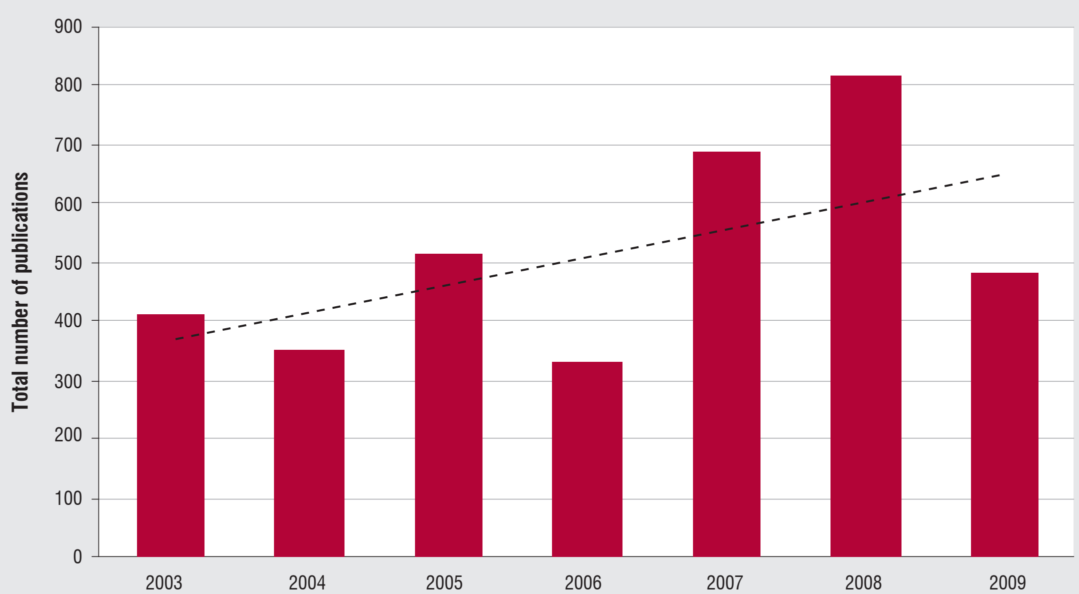


Figure A.2. Distribution of total number of publications, 2003–2009



of publications by year and country of residence. As can be seen, the output is generally irregular, although the trend is upward. However, it can also be seen that this upward trend is a reflection of foreign output.

Figures A.4 and A.5 show both Peru's principal research partners and the collaboration networks established between them. The chief collaborators of Peruvian researchers are found mainly in the United States (34%) Brazil (7%), Spain (6%), England (6%) and Argentina (5%)[15]. It also shows that, in this collaboration network centred in Peru, the basic relationship is with the United States, almost five times higher than the next highest. It also shows a high level of collaboration with the other countries (threshold of connectivity = 18).

As regards the patterns of research, Figure A.6 shows the three major areas in which research is most intensive. In first place and highly important, human medicine, with emphasis of infectious diseases (tuberculosis and HIV). In second place, ecology, dominated by the generation of dynamic models of conservation of biodiversity in the forests. Finally, a third area on zoo technology, although ultimately focussed on human medicine, aimed at the study of porcine cysticercosis and neuro-cysticercosis.

For the analysis of thematic categories, a slightly more complex network was used (to provide more information). The analysis of the thematic categories shows six important categories: health (with interactions with various areas), plant sciences, environmental sciences, physics, food sciences and technologies, and surgery (also part of the health area) (Figure A.7). The health area is generally dominated by public, environmental and occupational health, with strong emphasis on tropical medicine and infectious diseases (including immunology and microbiology). To a large extent, the immunology studies also have links with zoology,

Figure A.3 Distribution of number of publications by origin of principal author, 2003–2009

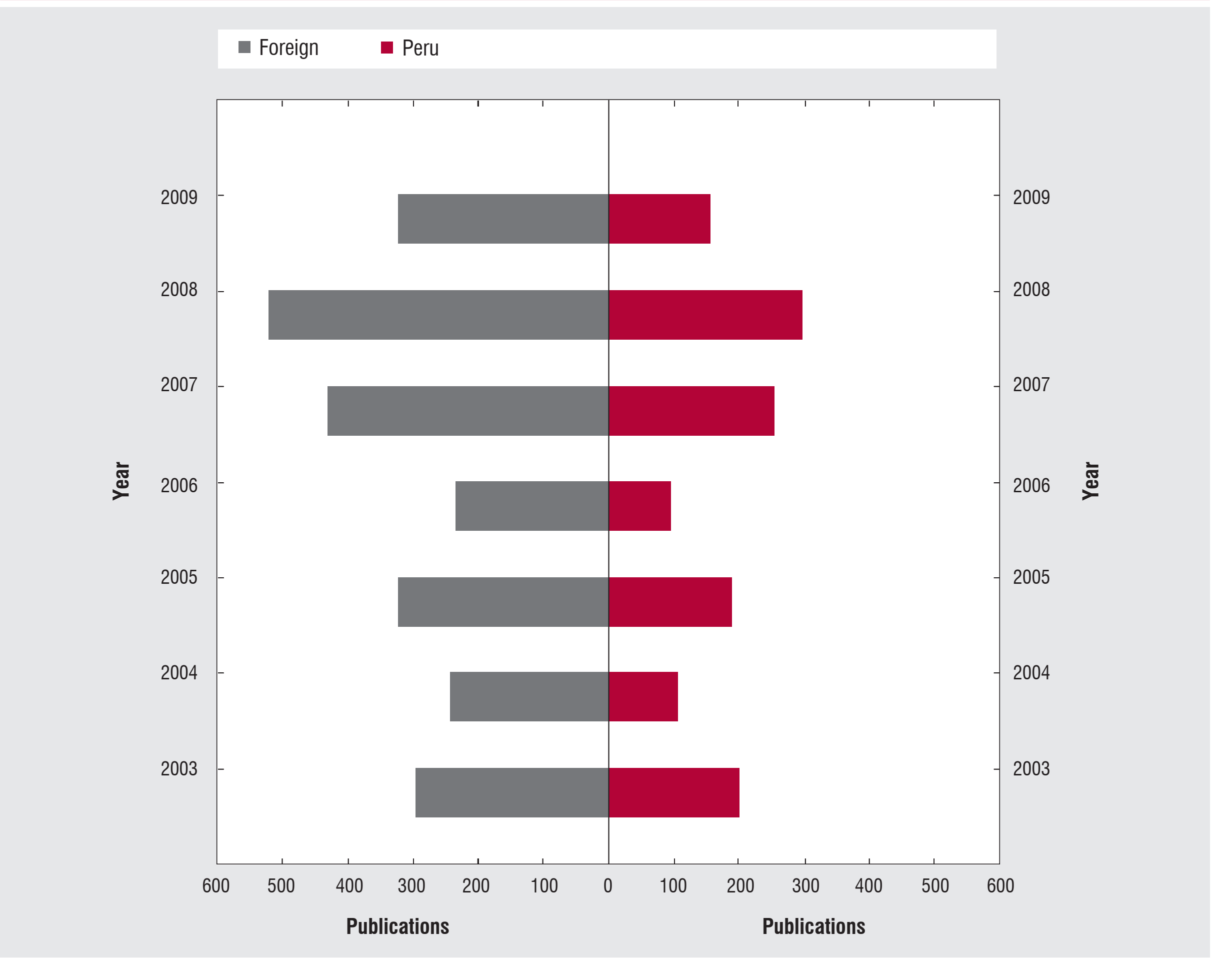


Figure A.4. Matrix of collaboration between authors by country of residence

	Peru	United States	Brazil	Spain	England	Argentina	Francie	Germany	Canada	Belgium	Chile	Mexico	Italy	Switzerland	Colombia	Ecuador	Bolivarian Republic of Venezuela	Plurinational State of Bolivia	Netherlands	Sweden	Australia	Japan	India
Peru	3446	1467	313	265	262	208	197	196	169	155	147	146	123	105	97	95	87	85	73	65	45	52	52
United States	1467	1533	129	52	140	113	71	57	71	43	54	70	49	55	51	62	47	41	28	25	34	26	32
Brazil	313	129	320	24	46	70	34	23	29	11	39	53	23	27	43	30	38	19	13	17	16	9	10
Spain	265	52	24	380	26	34	28	24	22	10	28	30	27	8	17	7	13	7	12	15	16	10	6
England	262	140	46	26	277	34	24	19	22	17	23	18	23	32	20	25	23	18	13	10	19	10	22
Argentina	208	113	70	34	34	221	17	12	25	15	48	47	16	20	29	27	35	12	7	8	8	5	13
France	197	71	34	28	24	17	201	19	12	18	16	16	28	17	14	14	9	14	8	7	12	8	11
Germany	196	57	23	24	19	12	19	197	11	20	15	8	25	10	11	17	8	10	7	7	6	7	5
Canada	169	71	29	22	22	25	12	11	177	9	14	20	18	22	13	11	6	9	4	12	14	5	6
Belgium	155	43	11	10	17	15	18	20	9	156	8	9	9	15	4	2	5	8	11	3	10	6	5
Chile	147	54	39	28	23	48	16	15	14	8	152	27	13	10	25	13	16	8	6	3	8	4	6
Mexico	146	70	53	30	18	47	16	8	20	9	27	149	14	10	37	12	29	7	7	10	13	8	12
Italy	123	49	23	27	23	16	28	25	18	9	13	14	142	16	10	6	6	13	7	14	16	8	9
Switzerland	105	55	27	8	32	20	17	10	22	15	10	10	16	107	8	12	1	4	7	13	11	8	17
Colombia	97	51	43	17	20	29	14	11	13	4	25	37	10	8	99	19	29	16	7	7	6	2	5
Ecuador	95	62	30	7	25	27	14	17	11	2	13	12	6	12	19	96	23	28	10	6	2	…	…
Bolivarian Republic of Venezuela	87	47	38	13	23	35	9	8	6	5	16	29	6	1	29	23	87	15	3	…	1	…	5
Plurinational State of Bolivia	85	41	19	7	18	12	14	10	9	8	8	7	13	4	16	28	15	85	7	7	1	1	…
Netherlands	73	28	13	12	13	7	8	7	4	11	6	7	7	7	7	10	3	7	79	1	6	4	4
Sweden	65	25	17	15	10	8	7	7	12	3	3	10	14	13	7	6	…	7	1	66	10	3	5
Japan	52	26	9	10	10	5	8	7	5	6	4	8	8	8	2	…	…	1	4	3	5	54	7
India	52	32	10	6	22	13	11	5	6	5	6	12	9	17	5	…	5	…	4	5	8	7	52

Figure A.5 Network of collaboration between authors by country of residence

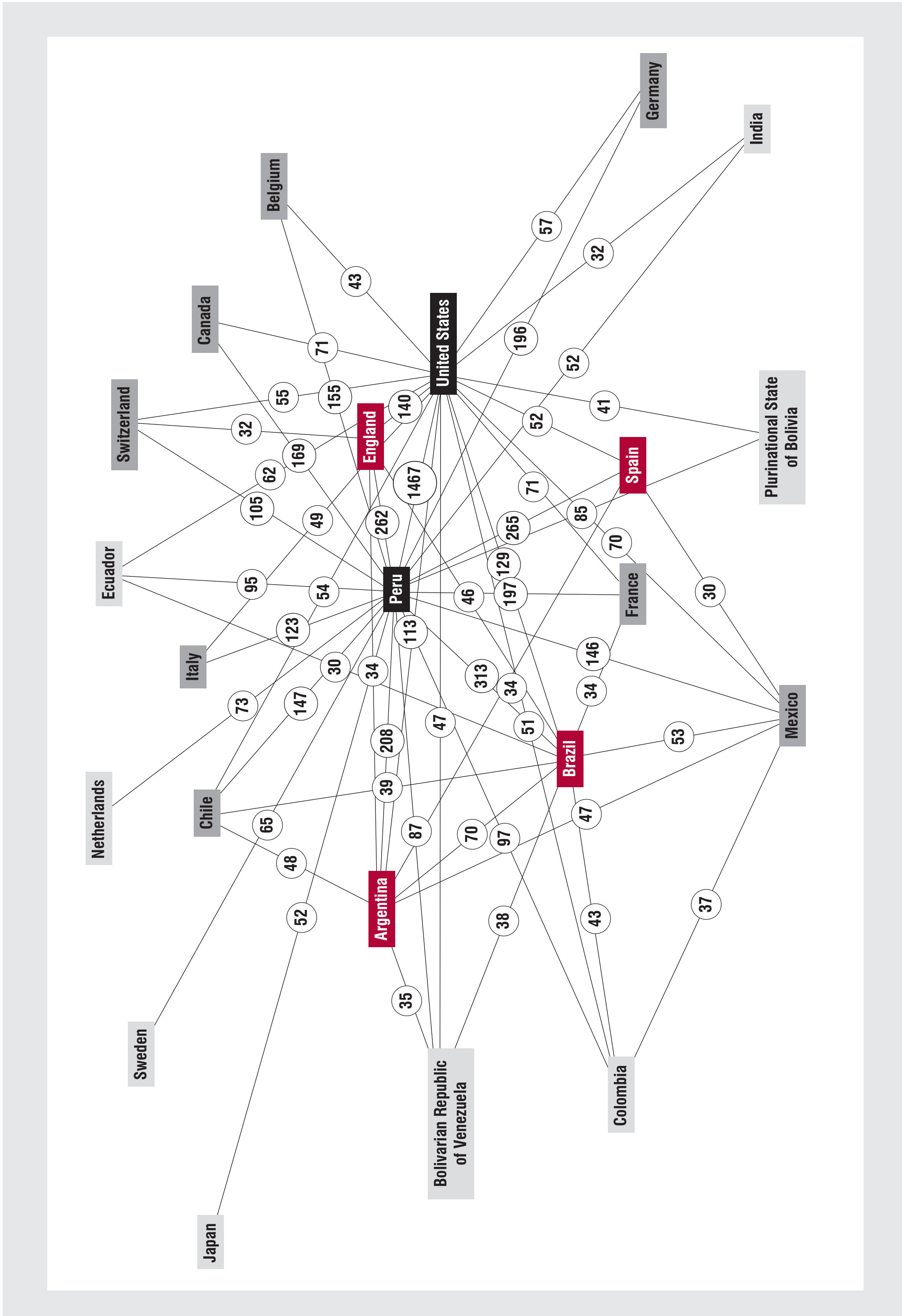
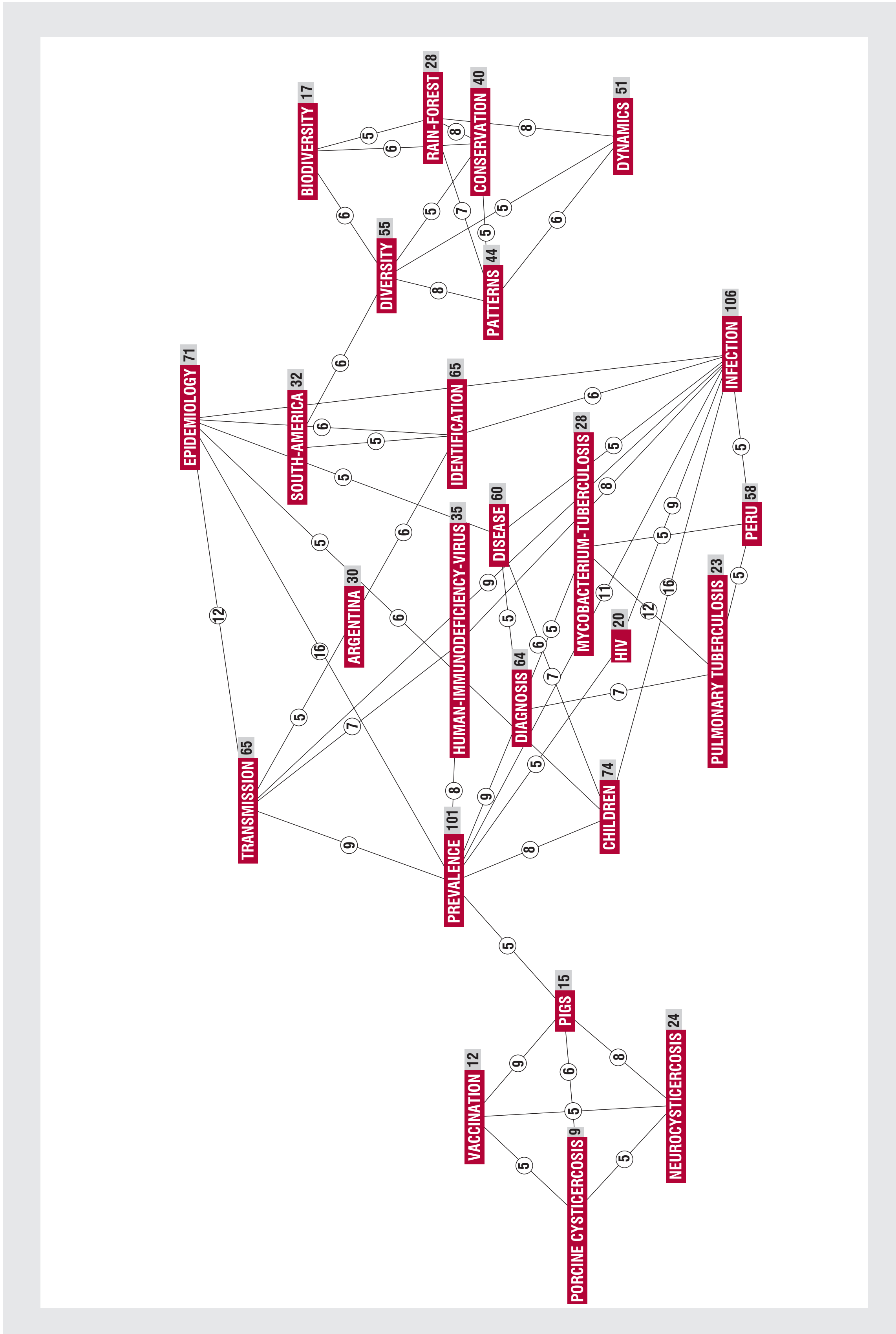


Figure A.6 Patterns of research based on co-occurrence of key words, considering the total number of articles



Note: the key words used are those assigned by the ISI.

Figure A.7. Research patterns based on the thematic categories with the highest number of publications, total number of articles considered

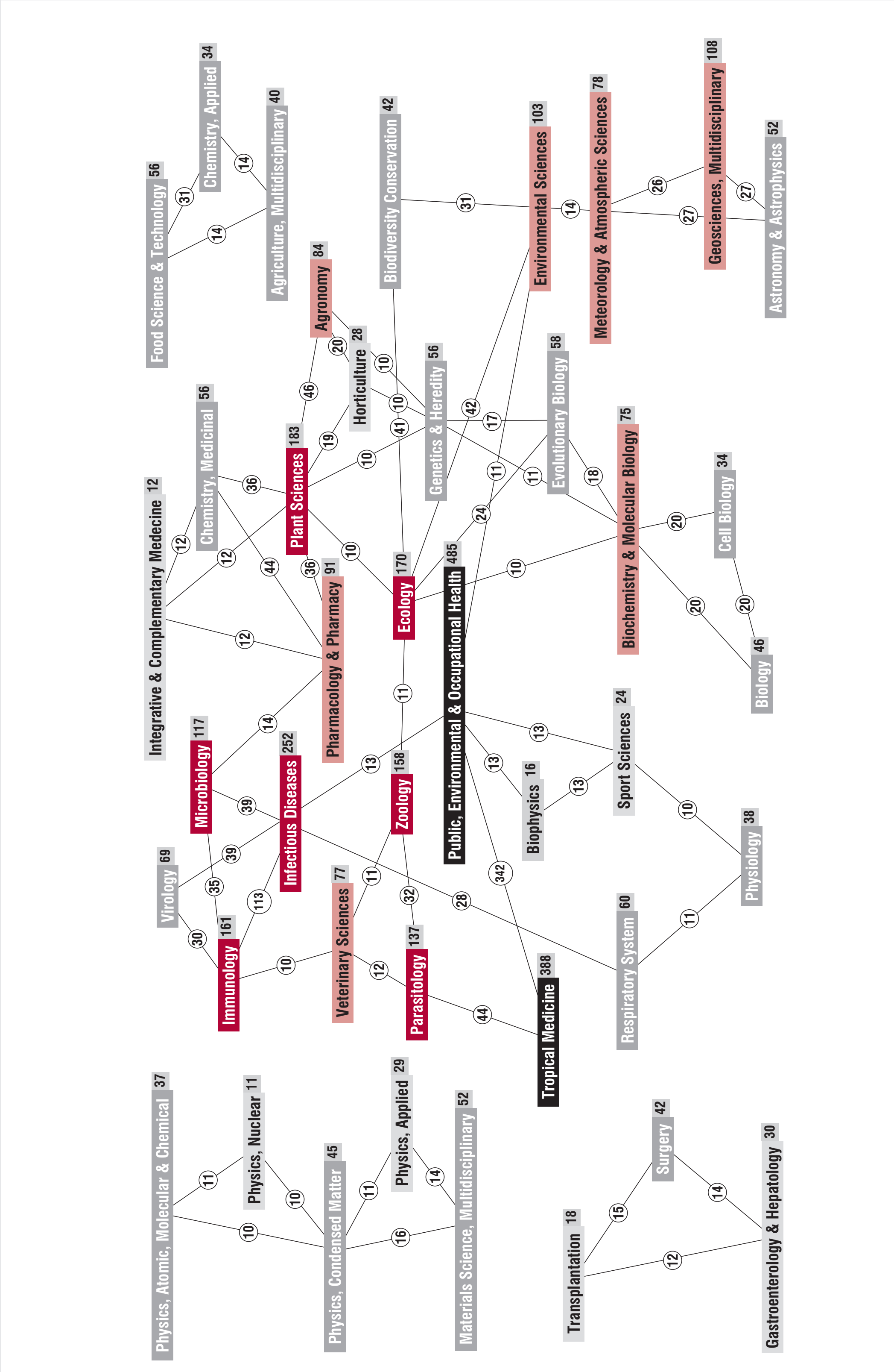
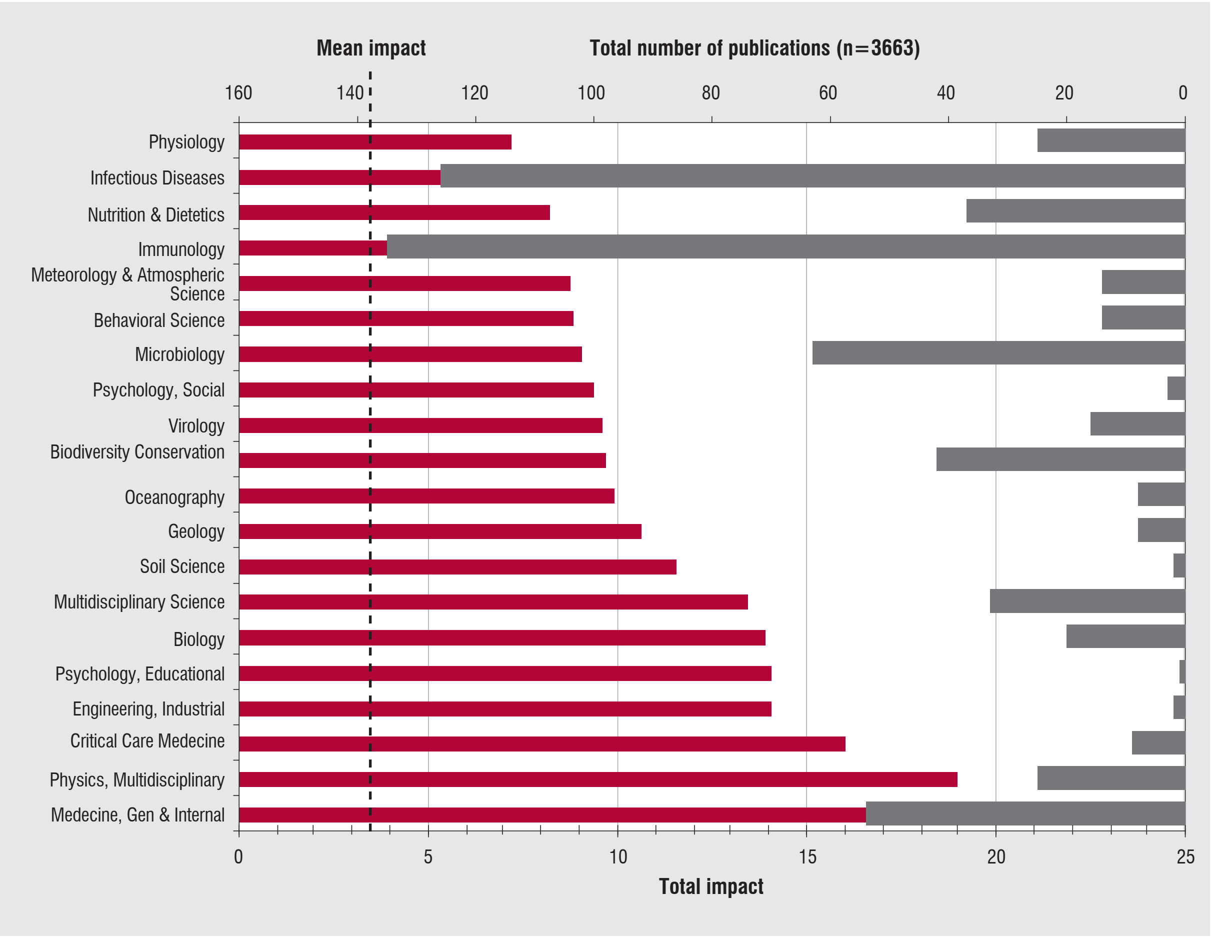


Figure A.8. The 20 categories with the greatest impact and number of publications (total categories = 186)



the veterinary sciences and parasitology.

In the area of plant sciences, relations can be seen with pharmacology and medicinal chemistry, as well as agronomy, biochemistry and molecular biology. In the environmental sciences, the earth sciences, meteorology and atmospheric sciences are best represented. The foregoing, in turn, relate to ecology, astronomy and astrophysics, and conservation of biodiversity.

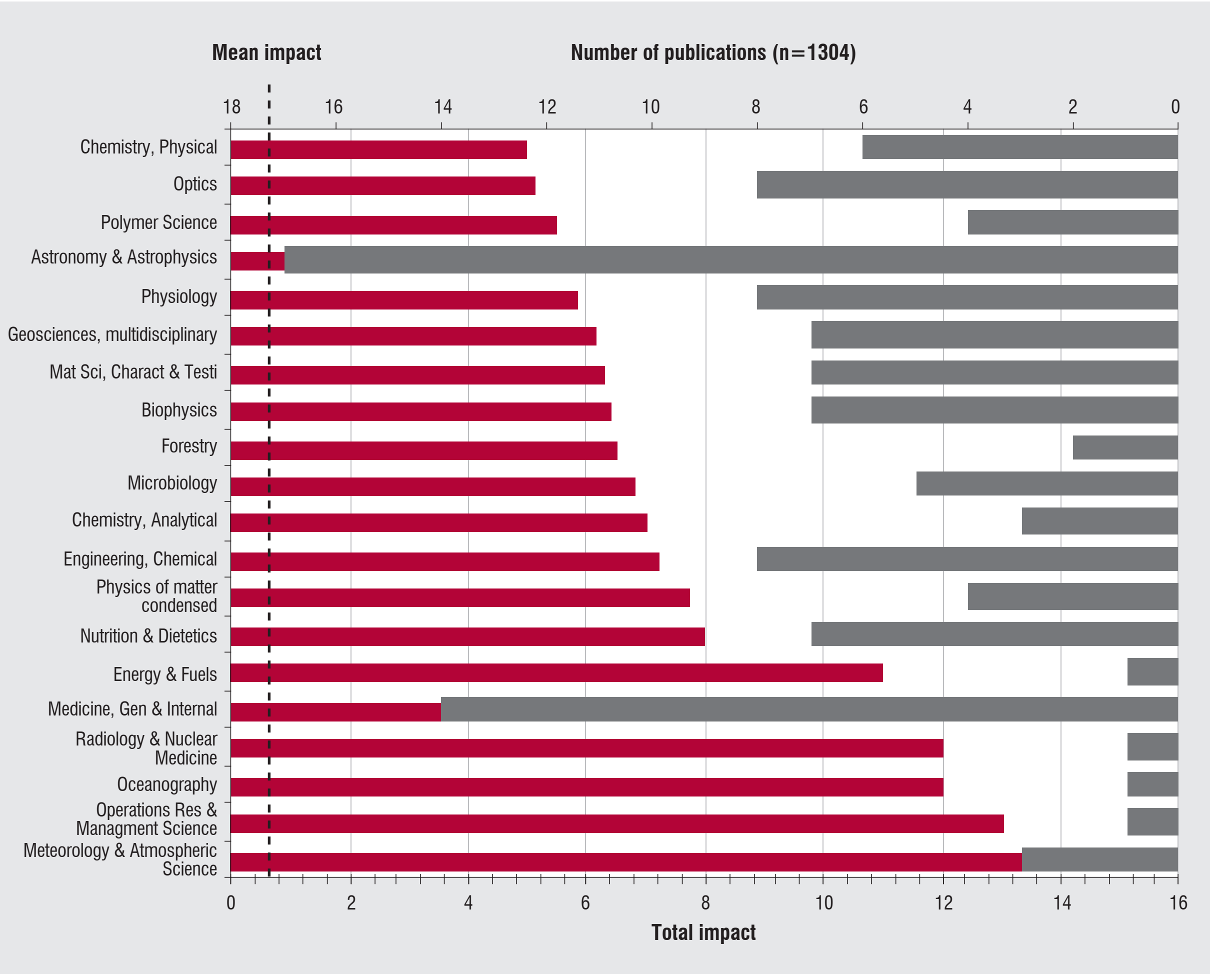
As regards physics, the greatest intensity of research occurs in materials science, condensed matter physics and atomic, molecular and chemical physics. For its part, food science and technology has an important link with applied chemistry. Finally, surgery is related chiefly to gastroenterology and hepatology and transplants.

The observed research patterns reflect the volume of research and the thematic areas of greatest interest. However, to get an idea of the international visibility of this research, it is useful also to consider its impact on scientific communities. Figures A.8 and A.9 compare the number of articles and their impact by thematic category both for total publications and those in which the principal author is based in Peru.

Taking into account all the publications (Figure A.8), it is evident that the areas of greatest impact are general and internal medicine, multidisciplinary physics and critical care medicine. However, the 20 themes included in the graph shows areas of research with impacts at least twice the average of the total output. It should also be noted that the areas of immunology, infectious diseases and microbiology have a large output and good impact.

On the other hand, Figure A.9 shows the areas where Peruvian scientific output is strongest, notably meteorology and atmospheric sciences, operations research and administrative sciences, oceanography and nuclear medicine and radiology, as areas of high

Figure A.9. The 20 categories with the greatest impact and number of publications when the principal author is based in Peru (total categories = 186)



impact, although with very low output. Likewise, general and internal medicine and astronomy and astrophysics show a high scientific output and high levels of impact.

Figure A.10 shows the 20 Peruvian organizations whose publications have the greatest impact and output. With respect to output, the Peruvian Cayetano Heredia University and the Mayor de San Marcos National University stand out, although it should be pointed out that the output of the former is over twice that of the latter. As regards impact, the National Institute of Neurological Sciences, the Nutritional Research Institute and the National University of Engineering stand out. However, the 20 organizations are well above the average impact of publications whose principal author is based in Peru.

However, to visualize the dimensions of these research strengths and put them in context, Figure A.11 shows Peru's position in relation to the countries where it has research partners. It is clear that, while a high percentage of the articles have a principal author who is a researcher resident in Peru, the impact of their work is well below the average for the total sample of articles. To expand on this, the results of the scientific output are described below.

Figure A.12 shows a general "map" of the output, in which the further to the right a country is placed, the greater its output. This map is based on a new sample of data on publications composed of all the articles published from 2003 to 2009 with an address in the countries identified as Peru's principal research partners. In this case, the databases for the sciences, social sciences and arts and humanities were used. As complete and reliable statistics on national expenditure in research and development are not available, per capita GDP was used[16].

The results clearly show the low productivity of the Latin American countries, with the exception of Brazil, which is the only one above the mean for the sample of countries (dotted lines).

Figure A.10. The 20 Peruvian organizations with the greatest impact and number of publications (publications in which the principal author is based in Peru)

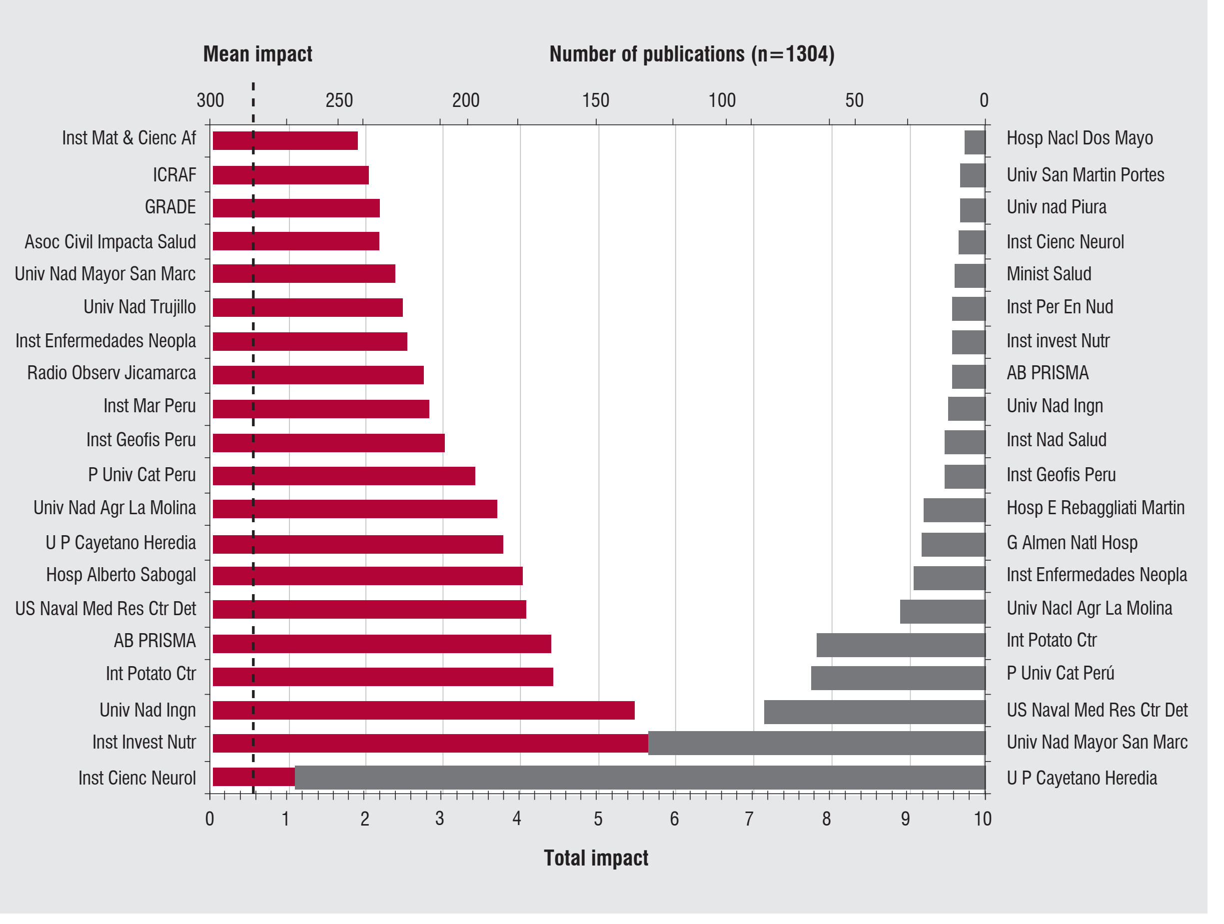


Figure A.11. The 32 countries with the greatest impact and number of publications by country of residence of the principal author (total countries: 68)

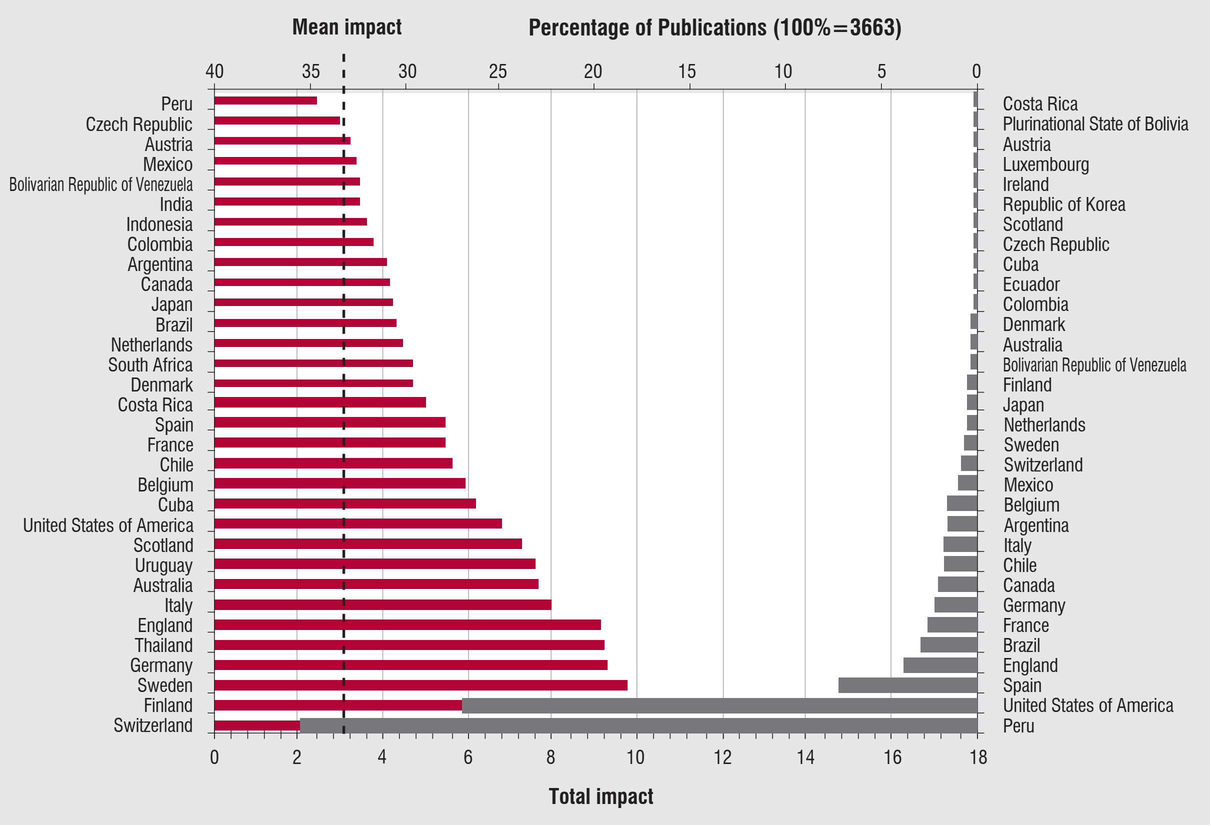
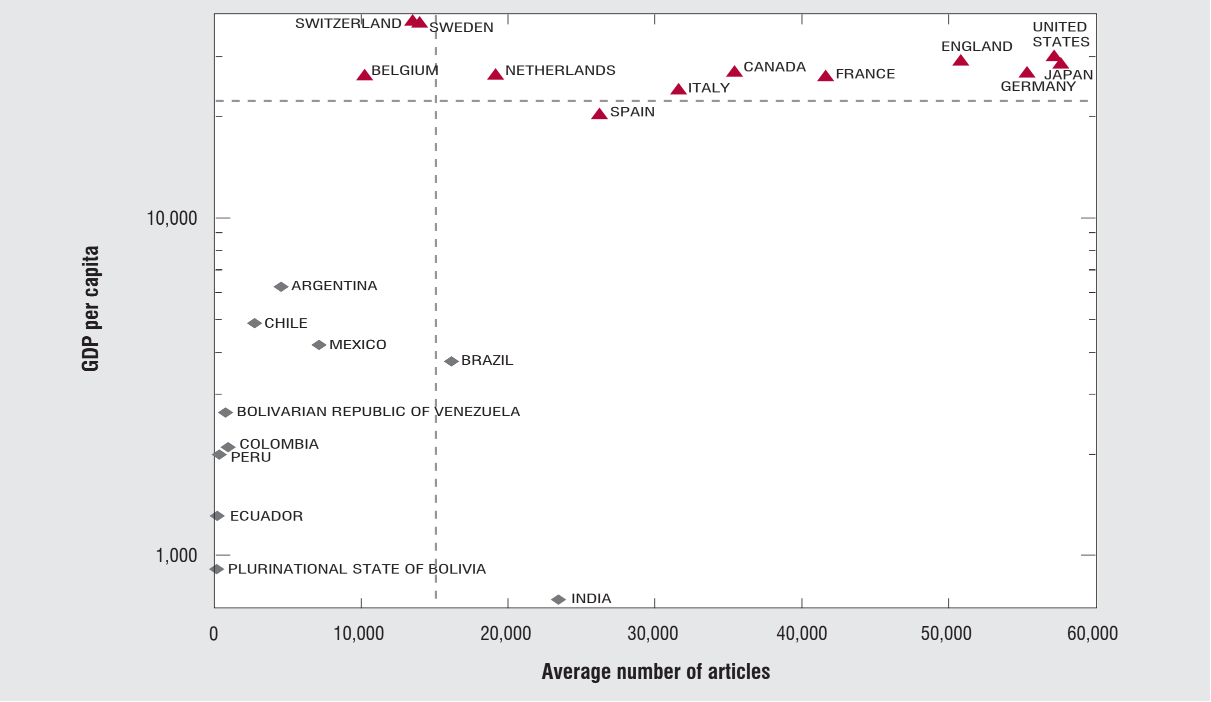


Figure A.12. Average articles to average GDP per capita (constant dollars 1990), 2003–2009



Note: GDP per capita in logarithmic scale.

ANNEX D. NATIONAL POLICIES ON STI

D.1. Policies under the National Agreement on STI

EIGHTEENTH POLICY OF THE STATE: Pursuit of competitiveness, productivity and formalization of economic activity

We undertake to increase the country's competitiveness with the object of achieving sustained economic growth which generates quality jobs and successfully integrates Peru in the global economy. The improvement of all forms of enterprise, including micro and small enterprises requires the efforts of society as a whole and especially entrepreneurs, workers and the State, to promote access to a good education, a favourable and stable political and legal environment for private investment as well as public and private management. We further undertake to promote and bring about the formalization of economic activities and relations at all levels.

With this objective, the State will: (a) consolidate an efficient, positive, transparent, modern and decentralized administration; (b) guarantee a legal framework which promotes formalization and competitiveness of economic activity; (c) procure effective and constant simplification of the administration and eliminate barriers to access to and exit from the market; (d) provide adequate infrastructure; (e) promote greater competition in markets for goods and services, and capital and financial markets; (f) pursue a tax policy which does not burden investment, employment and exports; (g) promote the added value of goods and services and increase exports, especially non-traditional ones; (h) guarantee access to economic information; (i) promote research, creation, adaptation and transfer of technology and science; (j) facilitate the training of management and the workforce; and (k) build a culture of competitiveness and entrepreneurial commitment to national objectives.

TWENTIETH POLICY OF THE STATE: Development of science and technology

We undertake to strengthen the country's capacity to generate and use scientific and technological knowledge, to develop human resources and improve the management of natural resources and the competitiveness of companies. We also undertake to increase research activities, monitor the results obtained and evaluate them properly and thoroughly. We also undertake to allocate greater public resources through public merit-based competitions leading to the selection of the best researchers and projects and to protect intellectual property.

With this objective, the State will: (a) allocate greater resources, apply tax regulations and promote other means of financing human capacity building, scientific research, improved research infrastructure and technological innovation; (b) create mechanisms which raise the level of scientific research and technological development in universities, research institutes and companies; (c) procure the training of highly skilled workers in the productive sectors which are the most promising for the national economy; (d) develop national and regional programmes with a productive, social and environmental impact; and (e) promote among the general public, especially young people and children, creativity, the experimental method, critical and logical reasoning as well as a love of nature and society through the communication media.

D.2. STI-related policy lines in the National Strategic Development Plan proposed by CEPLAN

PLAN PERU 21 National Strategic Development Plan – Draft for discussion, CEPLAN March 2010

STRATEGIC PILLAR 4: ECONOMY, COMPETITIVENESS AND EMPLOYMENT

A. NATIONAL OBJECTIVE: A competitive economy with high employment and productivity

B. POLICY LINES

Productive structure

1. Promote the articulation of exporting companies with input, capital goods and service industries, with a view to developing related activities with a high technological level and added value.
2. Stimulate investment in local and regional, public and private, logistical and productive infrastructure, including irrigation infrastructure, and converting inter-oceanic routes into longitudinal and transversal economic corridors.
3. Promote production, local enterprise development and employment, stimulating the development of transforming industries based on sectors of exportable products.

4. Strengthen domestic industries which serve the domestic market and promote their participation in international markets.
5. Stimulate mining exploration and operation with a focus on social and environmental responsibility.
6. Collaborate with mining companies on the industrial transformation of their output to increase its added value preferably at the mine site.
7. Support research and development for applications of production of light alloys for microelectronics and robotics.
8. Promote the development of tourism and restaurant services and related activities.
9. Promote the development of the tertiary sector or solidarity economy (productive chains, strategic partnerships, subcontracting) to convert peasant farming into commercial agriculture and MSEs into formal SMEs .
10. Facilitate the access of all types of enterprise, especially MSMEs, to financial markets on an equal footing, and promote entrepreneurial development in the management of productive family businesses in urban and rural areas.
11. Regulate and supervise monopolies to prevent abuse of dominant position.
12. Support the development of local management capacities, and access to information, technology transfer and credit.
13. Transform state university vocational training to achieve international standards of quality and competitiveness and bring it into line with the modernization of production.
14. Maintain permanent mechanisms for dialogue and coordination between different public sector bodies and between the public and private sectors, to define strategic development themes and instruments to improve and consolidate the competitiveness of the productive sector.

Competitiveness and integration in global markets

1. Promote international agreements for the diversification of our export markets in a framework of reciprocity, and take advantage of the benefits of trade agreements and treaties with the United States, the European Union, APEC, the Andean Community (CAN) and MERCOSUR.
2. Stimulate competitive exportable production with high added value, encourage the establishment of a logistics and information chain for competitive foreign trade, support the formation of export consortia of SMSEs, and promote public-private partnerships for investment in foreign trade infrastructure.
3. Stimulate exports of ecological products to increase their share of the value of exports.
4. Promote the use of information technologies as a way of reducing costs, expanding markets and improving competitiveness.
5. Stimulate physical, trade and economic integration with Brazil

Innovation and technology

1. Promote scientific and technological research that is reflected in innovation based on Peru's development priorities and its competitive insertion in the global economy.
2. Facilitate closing the gaps in scientific and technological knowledge with the industrialized countries.
3. Ensure an environment of competitiveness, meritocracy and good research practices in universities and state research centres.
4. Promote the profession of scientific and technological researcher as a career which revalues its role and orients it to the production of scientific and technological knowledge and innovation to attain international standards.
5. Promote, in the National System of Science, Technology and Technological Innovation, efficient, highly professional and developed management based on principles of international competitiveness, public ethics, intersectoral coordination and broad participation, which is both informed, transparent in its actions and technologically developed at all levels.
6. Ensure that the National System of Science, Technology and Technological Innovation becomes a positive factor in the development of national competitiveness.
7. Promote closer collaboration between university research centres and public research institutions and companies, to carry out research projects directly linked to the needs of economic growth.
8. Foster the development of science, technology and innovation activities at national, department and local level, and the generation of small and medium-sized technology-based enterprises, giving priority to technology poles.
9. Foster the building of a national scientific and technological culture to stimulate creativity, scientific research, technological development and to encourage the socialization and ownership of science, technology and innovation with a view to becoming part of the knowledge society.
10. Promote the creation, modernization and constant updating of the country's research and develop-

ment infrastructure, especially the establishment of science and technology parks and innovation technopoles.

11. Promote public and private shared responsibility for the financing of science, technology and innovation activities at national and regional level.
12. Stimulate the establishment of an inclusive and decentralized national science, technology and innovation information system.
13. Strengthen the mechanisms to guarantee intellectual property rights and the defence of traditional knowledge.

Specific objective 4: Innovation, technological development and the application of scientific knowledge constantly contribute to the development of productive and environmentally sustainable activities.

a. Indicators and targets

b. Strategic actions

- Establish a single National Science and Technology Fund.
- Implement new financing methods and instruments for science and technology (research and development funds, prioritization of projects, etc.).
- Identify medium and high technology subsectors in which there are comparative or competitive advantages and develop them.
- Implement measures to increase domestic and foreign private investment in medium and high technology sectors.
- Establish incentives to encourage careers in science and engineering and specialization at undergraduate and postgraduate level.
- Create prizes, honours and tax incentives to stimulate the development of science and technology projects.
- Establish research priorities by scientific fields in accordance with the country's needs, and allocate public funding for projects in subjects of the highest priority.
- Create the career of researcher in order to involve scientific and technological researchers in proven output in publications and patents.
- Establish a programme for the repatriation of Peruvian talent from abroad.
- Create a national scientific and technological research centre for the development of priority sectors, both to carry out basic research activities and support medium and high-technology sectors of industry.

a. Indicators and targets

N°	Indicator	Indicator formula	Information source	Base line	Trend	Meta 2021
11	Ratio of professionals in engineering, science, medicine, biology and similar to the total	Number of professionals in engineering, science, medicine, biology / Total professionals and technicians	INEI	(2007) 22,9 %	s. i.	30%
12	Annual number of new patents	Number of patent applications by residents per year	INDECOPI	40	s. i.	100
13	Rate of investment in research, science and technology	Investment in research/GDP	MEF	0,15%	s. i.	0,5%
14	Number of Peruvian articles published in indexed scientific journals	Number of Peruvian articles published in indexed scientific journals according to Science Database	Network of S&T indicators (www.ricyt.org)	600	s. i.	1500

D.3. National policies binding on national government agencies [SUPREME DECREE No. 027-2007-PCM]

Article 2.- National policies

7. EXTENSION OF TECHNOLOGY, ENVIRONMENT AND COMPETITIVENESS

7.1 Stimulate in each national government institution and promote in society the dissemination of basic research activities, applied research and technological innovation, establishing incentives for the participation of researchers in technology transfer activities in all the regions of the country.

7.2 Promote scientific, technological and technological innovation activities on a delegated and decentralized basis at national, regional and local level, collaborating with private institutions in the joint implementation of technological innovation programmes and projects.

7.3 Apply sectoral policies for the incorporation of basic irrigation technologies, improved cooking methods, suppression of smoke and installation of lavatories in homes away from kitchens, etc.

7.4 Support technological innovation in the productive sector, chiefly though projects involving entrepreneurs.

7.5 Provide institutional support to researchers, innovators and inventors, in particular young and talented people.

7.6 Promote and stimulate technological innovation programmes and projects.

7.7 Support national, regional and local strategies to prevent environmental pollution.

7.8 Implement measures to prevent environmental hazards and damage where necessary.

7.9 Promote the use of the cleanest technologies, methods, production processes and practices, marketing and final disposal.

7.10 Provide the necessary information for the proper functioning of markets and implement and adopt the necessary measures to improve the flow of information, in order that companies may identify business opportunities.

7.11 Training micro and small business owners through training programmes on intellectual property rights and contracting with the State.

The Ministry of Education is responsible for supervising compliance with these policies.

ANNEX E. NANOTECHNOLOGY IN LATIN AMERICA. THE EXAMPLES OF ARGENTINA AND BRAZIL.

Argentina[17]

In Argentina, in recent years, measures have been taken to promote activity in nanotechnology. The results have been positive and the outlook for the next few years seems to be following the same pattern. According to data from the Argentine Scientific and Technological Information Centre (CAICyT), in 2008, over 4% of the total number of Argentine scientific publications were on nanotechnology, compared with only 3% in 2003. According to data in the Statistical Bulletin of the Ministry of Science and Technology (MINCyT), between 2003 and 2008, the average annual rate of growth of scientific output in nanotechnology was 14% while for all Argentine publications, it was only 7%. Comparing output in 2008 with that of 2003, there is a marked rise, from 169 publications to 327. Although Argentina is still well behind the investment level of the leading powers on these technologies, it offers good prospects for future years if the current rate of growth of publications continues.

In 2005, the Argentine Nanotechnology Foundation (FAN) was founded (Decree 380/05) as a not-for-profit entity under private law, with the objective of promoting the development of the human and technical infrastructure, to compete internationally in the application of micro and nanotechnologies and increase the added value of domestic production. In addition, the Government announced an investment of 10 million dollars in this sector. The Foundation's chief activities comprise:

- Construction of clean design laboratories for the development of micro and nanotechnological devices of international quality.
- Education and training of human resources.
- Research into the development of micro and nanotechnological devices.
- Development of micro and nanotechnologies.
- Advice to public and private institutions on the development and production of micro and nanotechnological products.
- Development of markets for the entry of the domestic industry into domestic and international micro and nanotechnology markets.

The FAN's work is aimed at promoting applied research, with special emphasis on innovation. The FAN's legal form facilitates the financing of different projects on a venture capital basis. Contingent financing actions are proposed as well as support for strategic activities.

In 2007, the FAN came under the umbrella of the Ministry of Science, Technology and Productive Innovation (MINCyT). The priority objectives of the new ministry are the development of biotechnology, nanotechnology and ICT, with financial support from the World Bank

The FAN finances projects of companies or national public institutions which incorporate nanotechnologies in their products or services, while at the same time it supports and finances niche projects on a "case-by-case" basis. In 2006, it began granting lines of credit and from that year, 20 project ideas were received of which 10 were selected. Of the projects in the current portfolio, the majority are in the sphere of environment, space-satellite technology and medicine. Among the FAN's objectives for 2010 is the launch of an enterprise incubation project.

At present, there are four nanotechnology networks in Argentina, with 200 research scientists, the majority being researchers in the National Scientific and Technical Research Council (CONICET). Research in this area is cooperative and multicentric. The Balseiro Institute (Bariloche), the National Atomic Energy Commission (CNEA) and the University of Buenos Aires are key centres for the training of nano scientists. The four networks dedicated to nanotechnology in Argentina are:

1) Argentine Network for Nanoscience and Nanotechnology: nanostructured materials and nanosystems
2) Self-organization of bionanostructures for the transmission of molecular information in neuro biology and biological processes
3) Laboratory network for the design, simulation and manufacture of nano and micro devices, prototypes and sample nodes
4) Argentine Network for Nanoscience and Molecular, Supramolecular and Interface Nanotechnology.

Argentina is considered to be in a position to develop projects in the field of micro and nanotechnologies. Among the organizations which stand out for their capacities in this sphere, we find the CNEA, CONICET, the Faculty of Exact Sciences of the University of Buenos Aires, the University of La Plata and a Centre for the Development of Nanoscience and Nanotechnology. In addition, the National Institute of Industrial Technology has several R&D groups in related areas and the National Institute of Agricultural Technology has a specific interest in incorporating nanobiotechnology development activities.

In Argentina, there are some twenty national companies dedicated to development in this area. Four of them have created and financed the Interdisciplinary Centre for Nanoscience and Nanotechnology (CINN). Key among the fields in which CINN works is the synthesis and characterization of molecules and nanostructures, molecular self-assemblies and functionalized surfaces, manufacture and characterization of nano and micro-structured materials, theoretical and computational modelling at a nanoscale, and design of materials and devices. The Centre has a budget of around four million dollars over four years for instruments, industrial products and financing of a post-doctoral fellowship, as well as the repatriation of 12 young scientists and the completion of 60 doctorates.

One of the chief weaknesses of the development of nanotechnology in Argentina is the lack of funding for high technology undertakings, which affects the development of companies which export high technology products. In addition, there is a considerable gap between the natural sciences and engineering, and scientific training does not include enterprise development.

However, there are also many points in favour, such as the good basic research facilities in centres such as the CNEA or the Balseiro Institute, intensive participation and collaboration with scientists in other parts of the world and the return of many Argentinean scientists in recent years.

Brazil[18]

In 2001, Brazil launched the *Brazilian Nanotechnology Initiative*, which culminated in the *Programme for the Development of Nanotechnology and Nanoscience* of the Multiannual Plan 2004-2007 (2003) of the Ministry of Science and Technology (MCT).

The call for nanotechnology projects, *Llamado CNPq Nano n° 1/2001*, was the first action of the Brazilian State to stimulate the development of nanotechnology. The objectives of the call were, among other things, to promote the formation and consolidation of networks of basic and applied research in nanotechnology, organized as virtual centres of a multidisciplinary character and of national scope, through support for scientific research and/or technological development projects in the identified research fields (CNPq, 2001). Four nanotechnology research networks were formed, with an initial budget of some 1.75 million dollars. The call received 27 proposals and approved 12 of them. However, the National Scientific and Technological Development Council (CNPq) had been making investment in equipment since 1987.

As a result of the *Brazilian Nanotechnology Initiative*, four research networks were formed, which between 2002 and 2005 involved 300 researchers, 77 educational and research institutions and 13 companies. Over 1,000 scientific articles were published and over 90 patents were filed. Between 2001 and 2005, the four networks received a total of about 5.7 million dollars (MCT, 2006). These four cooperative research networks officially completed their activities in 2005.

Government action to promote nanotechnology research networks continued through the *Llamado MCT/CNPq n° 29/2005*, which led to the creation of ten networks (Brazil Nano Network Programme), with resources of 15 million dollars over four years (MCT, 2006). Its activities are centred on the acquisition of equipment, integration and implementation of appropriate infrastructure. Up to the first half of 2006, there were no concrete results such as products, processes, patents or services.

The Programme for the Development of Nanotechnology and Nanoscience of the Multiannual Plan 2004-2007 of the MCT was centred in the generation of patents, products and processes in this field. It provided support for basic research, and for strengthening existing networks and laboratory facilities.

The year 2005 saw the launch of the National Nanotechnology Programme (NNP) and the Argentine-Brazilian Nanoscience and Nanotechnology Centre (CABNN) was set up. The objectives of the NNP included: fulfilling strategic demand related to the development of nanoscience and nanotechnology, including development and management of the Nanoscience and Nanotechnology Development Programme, and support for networks of nanotechnology laboratories; promoting institutional research and development projects in the nanosciences, micro and nanotechnologies, and establishing micro and nanotechnology laboratories and networks. Other objectives of the CABNN include coordinating the formation of research groups and networks of Argentine and Brazilian companies through specific projects, and establishing a critical mass of human resources in an interdisciplinary area covering physics, chemistry, biology and engineering, with a view to implementing joint research projects.

NOTES

[1] Andersen 1994.

[2] See: Freeman, 1987; Lundvall, 1992a; Nelson, 1993.

[3] It is important to emphasize that the concept of institutions refers to the “rules of the game” in the national context, such as legislation, regulations, practices and customs, etc. and must not be confused with organizations.

[4] The classic reference in this respect is Edquist 1997; see also McKelvey 1991. Additionally, the recent work of the original proponents of the concept usually refer to differences between the different approaches (Freeman 1995, 2002; Lundvall et al., 2002; Nelson and Nelson, 2002).

[5] Dalum et al. 1992.

[6] OECD 1994, 1999, 2002a; Edquist et al. 1998; Soete and STRATA-ETAN Expert Group 2002.

[7] In a process which moves from perception to analogy and subsequently to isomorphism (Beer 1984).

[8] General Systems Theory (von Bertalanffy 1968).

[9] This is chiefly reflected in the (possibly insoluble) debate concerning the appropriate limits or boundaries of analysing innovation systems.

[10] January 2003 – second half of November 2009.

[11] The indexed journals must satisfy various criteria which ensure their quality and utility for scientific communities. There is always a slight skew and limitations when using these databases, as publications in English predominate. Nevertheless, they reflect the visibility in the most important media used by scientific communities to publish their research.

[12] Institute of Scientific Information.

[13] Only data bases for the sciences and social sciences were included.

[14] In this study, for example, Peru has co-authorships with 67 countries; a network with 68 nodes is so complex that it would be totally incomprehensible and conceal the most significant relationships.

[15] Percentages refer to the coauthorship taking into account only the countries in Figure 5.

[16] The sources of information used were: National Accounts Statistics database of main aggregates, United Nations Statistics Division, for economic information; and the U.S. Census Bureau, Population Division, for demographic information. To make certain adjustments in the case of the United Kingdom, as the information in publications refers to England as a country, data from the UK Government Office for National Statistics were used.

[17] See Malsch TechnoValuation, 2007.

[18] See Martins et al. (2006).