UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT

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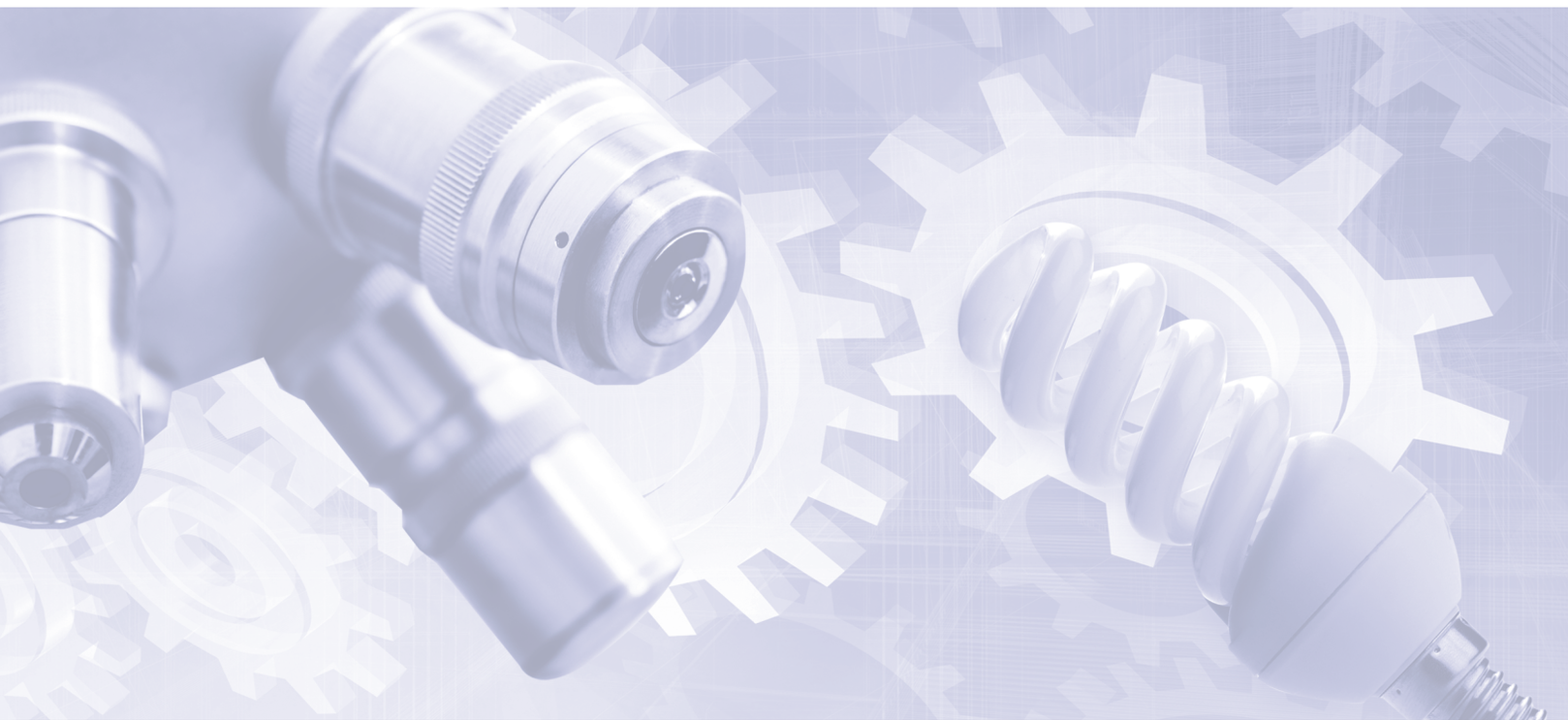
Science, Technology & Innovation Policy Review

Dominican Republic



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Explanatory note

Unless otherwise indicated, "US$" and "dollars" refer to United States dollars. "Pesos" refers to Dominican pesos, except where otherwise indicated. Because amounts are sometimes rounded off, partial data and percentages presented in tables do not always add up to the same total.

Document translated into English by Mr. Charles Akin

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PREFACE

The goal of the science, technology and innovation policy reviews prepared by UNCTAD is to contribute to the development of national capacities in this field in order that national science, technology and innovation (STI) plans and programmes effectively contribute to development strategies and improve the competitiveness of the productive sectors in a global economy in which knowledge is an increasingly important factor. Thus, STI measures will promote growth, lead to a productive diversification strategy and contribute to the creation of better-paid jobs, higher levels of welfare and poverty alleviation.

This review is intended to be a tool for learning and reflection, not a rating mechanism but an analytical instrument that examines a set of proposals from an external and neutral viewpoint. This document has three fundamental goals: first, to offer the Government and Dominican society an up-dated diagnosis of the effectiveness of STI policies, programmes and instruments; second, to facilitate the strengthening of those policies and measures by integrating them into the national development process; and third, to contribute to improve technological capacity, encourage innovation and incorporate greater added value into production.

This review of science, technology and innovation policies of the Dominican Republic was made in response to a request of the Government of the Dominican Republic and has received the support of the Ministry for Higher Education, Science and Technology. The review was prepared by a team of experts under the direction of Anne Miroux, Director of the UNCTAD Division on Technology and Logistics and under the direct supervision of Mongi Hamdi, Head of the Science, Technology and ICT Branch. The following members of the UNCTAD Secretariat contributed to this document: Ángel González Sanz, Lea Masin and Marta Pérez Cusó. The team of experts also included Sebastián Rovira of the Economic Commission for Latin America and the Caribbean (ECLAC) and the consultants Juana Kuramoto, Doroteo Rodríguez and José Luís Solleiro. During visits to the Dominican Republic, the team held near 100 interviews and meetings with representatives of governmental agencies, research institutes, universities, trade unions, chambers of commerce, businesses and non-governmental organizations. On 15 September 2011, a national workshop was held at Santo Domingo with the participation of more than 80 experts and national actors in the field of science, technology and innovation (STI). An initial draft of this document was presented during that workshop, permitting the taking into account of a large variety of comments and suggestions.

This review would not have been possible without the cooperation of the Ministry for Higher Education, Science and Technology, in particular that of Minister Mtra. Ligia Amada Melo de Cardona and the Vice-Minister for Science and Technology, Dr. Diógenes Aybar, and his team whom the UNCTAD Secretariat warmly thanks for their commitment to the project's success. Gratitude is also extended to all participants in the national workshop and to the persons and entities, too numerous to be listed, that generously gave their time and ideas. Naturally, the assessments, opinions and conclusions expressed in this document are attributable exclusively to the UNCTAD secretariat.

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ABBREVIATIONS

ADOZONA	National Council of Export Free Trade Zones
AI-RD	Industrial Association of the Dominican Republic
ARAPF	Association of Representatives, Agents and Pharmaceutical Producers
CAF	Corporacion Andina de Fomento
CEDAF	Centre for Agriculture, Livestock and Forestry Development
CEDIMAT	Center for Diagnosis, Advanced Medicine and Telemedicine
CEI-RD	Export and Investment Centre of the Dominican Republic
CIDT	Council for Innovation and Technological Development
CNC	National Competitiveness Council
CNE	National Energy Commission
CODOPYME	Dominican Confederation of Small and Medium Enterprises
CONIAF	National Agricultural and Forestry Research Council
DIA	Department for Agriculture and Livestock Research
DIGENOR	General Management of Norms and Quality System
DINISA	National Management of Research in Health
DR-CAFTA	Dominican Republic-Central America Free Trade Agreement
ECLAC	Economic Commission for Latin America and the Caribbean
FACV	School for Agronomy and Veterinary Sciences
FDA	Food and Drug Administration
FDI	Foreign Direct Investment
FONDEC	Competitiveness Fund
FONDOCYT	National Fund for Innovation and Scientific and Technological Development
GDP	Gross Domestic Product
GMO	Genetically modified organisms
GIZ	German Cooperation Agency
IADB	Inter-American Development Bank
ICT	Information and communication technologies
IDIAF	Dominican Institute for Agricultural and Forestry Research
IGC	Global Competitiveness Index
IIBI	Institute for Innovation in Biotechnology and Industry
INDOTEC	Dominican Institute for Industrial Technology
INFADOMI	Industrias Farmacéuticas Dominicanas, Inc.
INFOTEP	Institute for Technical Vocational Training
INTEC	Technological Institute of Santo Domingo
ITLA	Las Américas Technological Institute
kboe	Kilo barrel oil equivalent
LAVACEN	Central Veterinary Laboratory
MESCYT	Ministry for Higher Education, Science and Technology
MIC	Ministry for Industry and Trade
NIS	National Innovation System
NGO	Non-governmental organization
OECD	Organization for Economic Cooperation and Development
ONAPI	National Office for Industrial Property
PECYT+I	Science, Technology and Innovation Strategic Plan
PRO-INCUBE	National Programme for Incubation of Companies
PROMIPYME	National Council for the Promotion and Support to Micro, Small and Medium-sized Enterprises
PUCMM	Pontifica Universidad Católica Madre y Maestra

R&D	Research and development
RICYT	Ibero-American and Inter-American Network on Science and Technology Indicators
SCI	Science Citation Index
SEA	State Secretariat for Agriculture
SEIC	State Secretariat for Industry and Trade
SESCYT	Secretariat for Higher Education, Science and Technology
SESPAS	Secretariat of State for Public Health and Social Assistance
SIDOCAL	Dominican Quality System
SINIAF	National System for Agricultural and Forestry Research
SME	Small and medium enterprise
SNESCYT	National System for Higher Education, Science and Technology
SNIDT	National System for Innovation and Technological Development
STI	Science, technology and innovation
TFP	Total factor productivity
TRIPS	Trade-related aspects of intellectual property rights
UASD	Autonomous University of Santo Domingo
UNCTAD	United Nations Conference on Trade and Development
USAID	United States Agency for International Development
WHO	World Health Organization
WTO	World Trade Organization

I

General background of science, technology and innovation in the Dominican economy

Experience indicates that investment in the capacity to create, spread, adopt and adapt knowledge is a determining factor in ensuring long-term economic growth and development. Higher productivity is the main channel through which productive innovation promotes economic growth, creates employment with better levels of remuneration, reduces poverty on a sustainable basis and raises general living standards.

The creation and spread of knowledge is carried out by various public and private agents, businesses, universities, research institutes and public institutions. The extent to which these actors are capable of creating and spreading knowledge depends not only on their individual capacities but also on the existence and effectiveness of a broad system that includes creators, disseminators, intermediaries and users of knowledge, the institutional framework in which those agents interact in answer to a set of incentives and the quality of the material and non-material infrastructure relevant for knowledge and innovation activities.

This first chapter of the Science, Technology and Innovation Policy Review of the Dominican Republic presents general information on the economic and social context that determines the Dominican Republic's specific needs for knowledge. This chapter also describes the existing capacity to satisfy those needs.

The Dominican Republic is a middle-income country located in the eastern two thirds of the island of Hispaniola in the Caribbean. With a population of 10 million persons, it is, after Mexico and Cuba, the third largest economy in Central America and the Caribbean.

The country has made considerable economic and social progress during the past two decades. In 15 years, real GDP per capita has doubled, the infant mortality rate (children less than five years of age) has been reduced by half and life expectancy at birth has been extended by three and half years.[1,2,3] In education, school enrolment has continued to increase and gross participation in secondary education has increased 20 percentage points in a decade.[4]

Despite these significant achievements, the economy has a number of less-satisfactory aspects. In particular, economic and social progress has been affected by periods of economic crisis that have exposed the fragility of the Dominican economy to external shocks, such as the rise in oil prices, and internal weaknesses for competing at the international level based on a model of low labour costs. Furthermore, the country faces important social challenges (high levels of economic and social inequality and a fragile environment), which limit the gains of economic progress.

Sections A, B and C describe in detail the context and the recent economic and social evolution of the Dominican Republic. Section D presents a general panorama of science, technology and innovation based on available STI indicators.

A. EVOLUTION OF THE DOMINICAN ECONOMY

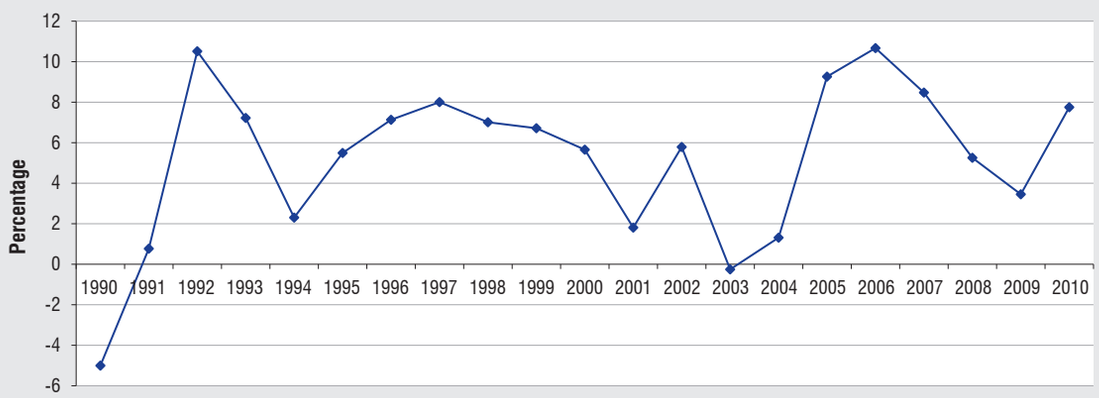
The Dominican economy has grown at an average rate of 5.5 per cent since 1992 (UNCTADstat 2011).[5] That average growth includes times of strong expansion along with periods of crisis, which in general were linked to international economic trends, especially those of the United States, petroleum costs and demand in the tourist sector. The worldwide economic and financial crisis of 2008–2009 led to a sharp drop in exports, tourist demand and remittances, which together resulted in significant deceleration and growth rates half as low as those recorded at the time of maximum growth in 2006. Later evolution has been more favourable, recording growth of nearly 8 per cent in 2010 in a context of stability of the other macroeconomic variables.

From the point of view of quality, and as in other Latin American countries, the economic growth difference observed between advanced and developing countries is explained primarily in terms of a chronic deficit in productivity growth (IADB 2010). In 2007, the total factor productivity (TFP) of the Dominican Republic was only 60 per cent of that of the United States. Despite that significant deficit in productivity, it should be noted that contrary to the case of most of the countries in Latin America and the Caribbean, the TFP in the Dominican Republic did not decrease in 1987–2007 compared with that of the United States.[6]

1. Main productive sectors

The Dominican Republic has made remarkable progress since the 1980s in transforming and diversifying its economy, thus allowing it to evolve

Figure I.1. Growth of real GDP (Dominican Republic),1990–2010 (percentage)



Source: UNCTAD, based on UNCTADstat.

Table I. 1. Main economic indicators

	1990	1995	2000	2005	2010
Population (millions)	7.2	7.9	8.6	9.3	9.9
GDP at current prices and exchange rate (millions of dollars)	9,385	15,520	23,655	33,542	51,570
GDP per capita at current prices and exchange rate (millions of dollars)	1,304	1,960	2,753	3,621	5,195
Growth of real GDP (%)	-5%	5%	6%	9%	8%
Inflation as a factor of GDP (%)	50%	9%	7%	3%	5%
Sectoral GDP					
Agriculture, value added (% of GDP)	13%	10%	7%	7%	6%
Industry, value added (% of GDP)	31%	36%	36%	32%	27%
Manufacturing, value added (% of GDP)	18%	26%	26%	23%	22%
Services, etc., value added (% of GDP)	55%	54%	57%	60%	67%
Exports of goods (millions of dollars)	735	3,780	5,737	6,145	6,598
Exports of services (millions of dollars)	1,097	1,951	3,228	3,935	5,091
Imports of goods (millions of dollars)	3,006	5,170	9,479	9,869	15,299
Imports of services (millions of dollars)	440	966	1,.373	1,478	2,137
Exports of goods and services (% of GDP)	34%	36%	37%	30%	19%
Imports of goods and services (% of GDP)	44%	39%	46%	36%	26%
Gross capital formation (% of GDP)	25%	18%	23%	17%	15%
Net Direct Foreign Investment	133	414	953	1,123	1,626
Human Development Index (value)	0.58	0.61	0.64	0.66	0.69

Source: UNCTAD, based on UNCTADstat, World Development Indicators (2011) and Human Development Indices (2011) (http://hdr.undp.org/en/statistics).

from an economy that exported a limited number of agricultural products (sugar, coffee and tobacco) and minerals (ferronickel, gold and silver) to an export economy based on the activity of free trade zones (primarily textile manufacturing) and tourism (table I.1 and figure I.4). Services now account for more than half of total production, industry accounts for one quarter and agriculture for less than one tenth (table I.2).

Table I.2. Main productive sectors, 2000 and 2010 (percentage of GDP)

	2000	2010
Agriculture and livestock	8.5	7.5
Industry	34.3	25.8
Local manufacturing	22.0	18.8
Manufacturing in free trade zones	5.4	2.4
Services	46.8	53.8
Communications	4.6	17.3
Taxes on production	10.5	12.8
Gross Domestic Product	100.0	100.0

Source: Central Bank of the Dominican Republic (2011).

Since the end of the 1990s, agriculture (primarily sugar for export and plantains and rice for domestic consumption) has been diversified towards non-traditional crops (tropical fruit, vegetables and flowers), and a more modern and efficient form of agro-industry has been introduced (EIU, 2008). Nonetheless, the importance of the agricultural sector, whose growth has been slowed down by reductions in Customs duties because of the Free Trade Agreement between the Dominican Republic, Central America and the United States (DR-CAFTA) and other economic and environmental causes, has decreased in the overall Dominican economy. Chapter III presents an analysis of the agricultural and agro-industry sector, proposing options for increasing productivity in that sector through a more efficient framework for innovation.

Local manufacturing (food processing, non-exportable and light manufacturing) represents three quarters of total industrial activity (EIU 2008).[7] The importance of manufacturing in free trade zones in the GDP (the main source of foreign currency until 2009 (figure I.4) and an important source of employment) dropped by half between 2000 and 2010 for several reasons, including the crisis in the world market, growing competition of Central American and Asian countries and an increase of transportation costs and Customs duties (EIU, 2008). As a consequence, the contribution of this sector to the labour market has decreased substantially since 2000 (table I.3, EIU 2008).

Table I.3. Creation of employment, October 2000 and October 2010

	October 2000		October 2010	
	Employed population	(%)	Employed population	(%)
Agriculture (including mining and quarries)	**460,967**	**15.6**	**537,890**	**14.6**
Manufacturing industry	**505,032**	**17.1**	**389,577**	**10.6**
Services	**1,981,095**	**67.0**	**2,746,047**	**75.0**
Electricity, gas and water	27,725	0.9	37,943	1.0
Construction	174,627	5.9	237,717	6.5
Wholesale and retail trade	617,110	20.9	771,591	21.0
Hotels, bares and restaurants	148,371	5.0	216,614	5.9
Transportation and communications	184,496	6.3	284,592	7.7
Financing and insurance	58,231	2.0	93,236	2.5
Public administration and defence	135,853	4.6	184,964	5.0
Other services	634,682	21.5	919,390	25.0
Total	**2,947,094**	**100.0**	**3,673,514**	**100.0**

Source: Central Bank of the Dominican Republic (2011).

Among services, the communications sector, powered by the expansion of mobile phones, has been the most dynamic. The participation of that sector in GDP increased four fold over ten years, reaching 17.3 per cent in 2010 (table I.2). In absolute terms, tourism represents the main activity in the service sector. Tourism is the country's main source of foreign currency and an important source of employment (figure I.4 and table I.3). The Dominican Republic competes in the tourist market with an offer of mass beach tourism with relatively low levels of expenditure per visitor characterized by an offer of all-inclusive hotels that frequently have very few linkages with the domestic economy.

2. Export sector

Trade

The export performance of Latin America and the Caribbean during the 1990s was outstanding. The Dominican Republic, together with Costa Rica and El Salvador, was one of the 15 most dynamic exporting countries in the world, with growth rates of more than 15 per cent (IADB 2001). Like other Caribbean countries in which tourism is a main source of foreign currency, the Dominican Republic has a structural trade deficit (tables I.4 and I.5). Its main exports include textiles (although their importance has decreased), medical instruments, fruit and sugar (table I.4). The Dominican Republic's main trading partner is the United States. Other important export markets are Haiti and Europe, especially Belgium, the Netherlands and the United Kingdom.

The Dominican Republic's main imports are machinery, transportation equipment, petroleum, gas and textile products (table I.5). An increase in the cost of imports (primarily the cost of petroleum and gas) has resulted in a current account deficit since 2005 (table I.1).

A policy of commercial openness, including the entry into force of the DR-CAFTA in 2007 and the signing of

Table I.4. Main exports, Dominican Republic, 2000–2010 (millions of dollars and percentage)

		2000		2005		2010	
SITC	**Total products exported**	**5,737**	**100**	**6,283**	**100**	**6,598**	**100**
0	**Food and live animals**	**402**	**7**	**496**	**8**	**1,088**	**16**
05	Vegetables and fruit	171	3	217	3	423	6
06	Sugars, sugar preparations and honey	106	2	95	2	182	3
1	**Beverages and tobacco**	**327**	**6**	**387**	**6**	**536**	**8**
11	Beverages	30	1	67	1	160	2
12	Tobacco and tobacco manufactures	296	5	318	5	373	6
5	**Chemicals and related products, n.e.s.**	**90**	**2**	**173**	**3**	**361**	**5**
6	**Manufactured goods classified chiefly by material**	**389**	**7**	**776**	**12**	**1,023**	**15**
65	Textile yarn, fabrics, made-up articles, n.e.s., and related products	58	1	114	2	458	7
67	Iron and steel	250	4	453	7	285	4
7	**Machinery and transport equipment**	**496**	**9**	**895**	**14**	**616**	**9**
8	**Miscellaneous manufactured articles**	**3,813**	**66**	**3,221**	**51**	**2,274**	**34**
84	Articles of apparel and clothing accessories	2,844	50	2,053	33	769	12
87	Professional, scientific and controlling instruments and apparatus, n.e.s.	438	8	541	9	724	11
9	**Commodities and transactions not classified elsewhere in the SITC**	**162**	**3**	**232**	**4**	**326**	**5**

Notes: Only the main exports are broken down. The total of the various categories is not 100 per cent.
SITC: Standard International Trade Classification
Source: UNCTAD, based on UNCTADstat.

economic association agreements with the European Union and the Caribbean Community (CARICOM) in 2008, has not translated into robust expansion of Dominican exports of goods, reflecting internal weaknesses for competing in the international market.

A competitive export sector, which, in addition to generating income and foreign currency, contributes to stimulate technological modernization of the productive sectors, can be the motor of medium and long-term development. Export and import activity can generate positive externalities by facilitating the adoption of new technologies and the acquisition of new productive capacities that then expand beyond one business and the sector in question and can stimulate demand for better services (for example, transportation and financial services), setting off a virtuous circle of technological improvement and increased productivity, income and demand.

Figure I.2 shows the evolution of the technological content of Dominican exports between 1995 and 2010. The growth of high technological and knowledge-intensive manufacturing (primarily medical instruments and equipment) stands out. In 2010, those exports represented 26 per cent of the total value of exports. On the other hand, labour-intensive exports or resource-based exports (primarily textile products) have decreased and their importance among total exports has contracted considerably, although they still represent approximately 40 per cent of total exports. Despite the contraction of the total value of exports in 2010 (linked to the global economic crisis), there has been a positive trend of economic restructuring towards products with greater added value.

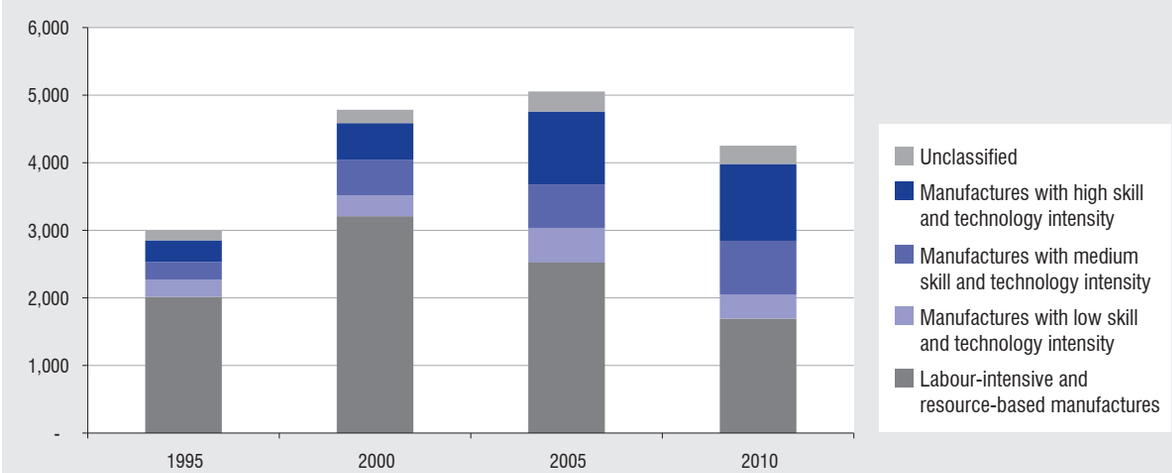
Another important indication of the type and level of industrial activity as well as of the level of technological development of the industrial sector and the country as a whole is the import of capital goods. Imports of capital goods by the Dominican Republic tripled during 1997–2010. The percentage of capital goods in total imports has, however, remained constant at around 17 per cent, not because of stagnation in the import of capital goods but because of a large increase in the share of fuel among total imports as a result of the rising price of gas and oil.

Foreign direct investment (FDI)

Since 1995, the Dominican Republic, along with Costa Rica and Panama, has been one of the main recipients of FDI in Central America and the Caribbean after Mexico (figure I.3).

Traditionally, FDI, attracted primarily by the advantages of localization, the relative size of the domestic market (compared to the rest of the Central American and Caribbean region) and a favourable investment climate, has focused on free trade zones (primarily textile production). Over the past decade, however, FDI has diversified and expanded to include additional sectors, such as mining, tourism, real estate, off-site business services and medical equipment (ECLAC 2011).

Figure I.2. Technological content of Dominican exports, 1995-2010



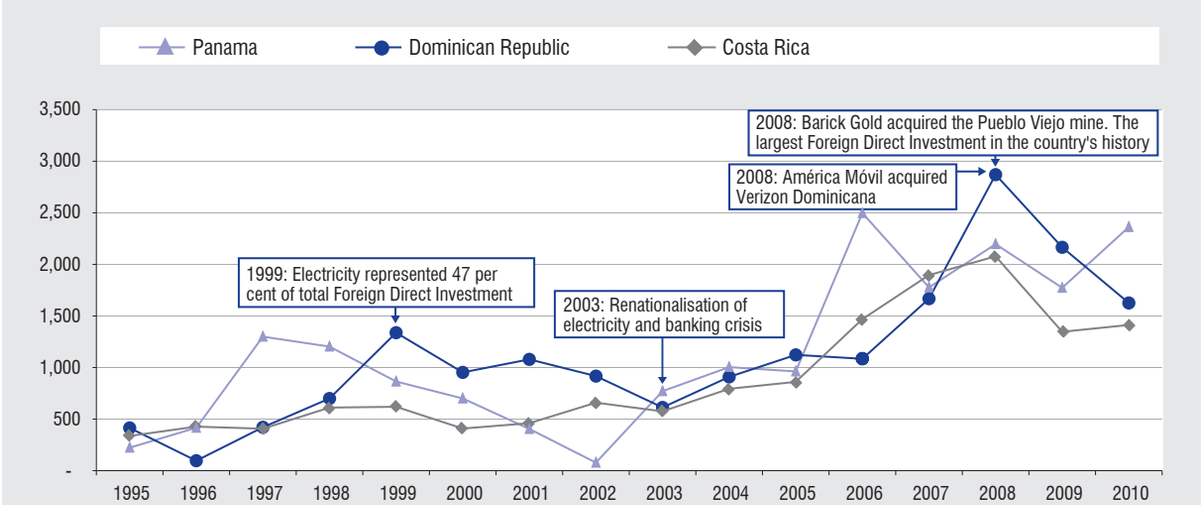
Source: UNCTAD, based on UNCTADstat.

Table I.5. Main imports, Dominican Republic, 2000–2010 (millions of dollars and percentage)

		2000		2005		2010	
SITC	**Total imported products**	**9,479**	**100**	**9,862**	**100**	**15,163**	**100**
7	**Machinery and transport equipment**	**2,473**	**26**	**2,411**	**24**	**3,517**	**23**
78	Road vehicles (including air-cushion vehicles)	701	7	883	9	968	6
77	Electrical machinery, apparatus and appliances, n.e.s., and electrical parts thereof (including non-electrical counterparts, n.e.s., of electrical household-type equipment)	484	5	585	6	738	5
3	**Mineral fuels, lubricants and related materials**	**1,527**	**16**	**1,309**	**13**	**3,298**	**22**
33	Petroleum, petroleum products and related materials	1,465	15	1,103	11	2,596	17
34	Gas, natural and manufactured	59	1	157	2	591	4
6	**Manufactured goods classified chiefly by material**	**1,518**	**16**	**2,312**	**23**	**2,725**	**18**
65	Textile yarn, fabrics, made-up articles, n.e.s., and related products	553	6	780	8	757	5
67	Iron and steel	178	2	554	6	620	4
0	**Food and live animals**	**699**	**7**	**831**	**8**	**1,572**	**10**
04	Cereals and cereal preparations	215	2	269	3	511	3
5	**Chemicals and related products, n.e.s.**	**540**	**6**	**928**	**9**	**1,520**	**10**
8	**Miscellaneous manufactured articles**	**2,092**	**22**	**1,398**	**14**	**1,444**	**10**

Notes: Only the main exports are broken down. The total of the various categories is not 100 per cent.
SITC: Standard International Trade Classification
Source: UNCTAD, based on UNCTADstat.

Figure I.3. Foreign direct investment, Costa Rica, the Dominican Republic and Panama, 1995–2010 (millions of dollars)



Source: UNCTAD, based on UNCTAD (2009) and ECLAC (2011).

That investment has permitted the development of key infrastructure (for example, telecommunications), the generation of employment and the diversification of the economy, which, as pointed out earlier, has evolved from being based on basic agricultural products to having a broader range of exports and a greater participation of services.

However, a recent UNCTAD study (2009) shows that the links between domestic companies and FDI are weak and that there are opportunities for obtaining greater benefits from FDI. The attraction of FDI to activities with greater value added that promote better training (and better remuneration) of workers and the promotion of higher levels of competitiveness and complementarity with the domestic industry and services are two of the areas that could stimulate productive innovation and lead to greater economic and social benefits. Through its National Competitiveness Plan and institutions, in particular the National Competitiveness Council, the Government has addressed these challenges and placed greater emphasis on the role of FDI as a stimulus for the competitiveness of domestic industries.

Remittances to families

In addition to the productive sectors, another important source of foreign currency is remittances by the approximately one million Dominicans residing abroad, although that source of income has recently decreased because of the effects of the global economic crisis (figure I.4) (EIU 2008).

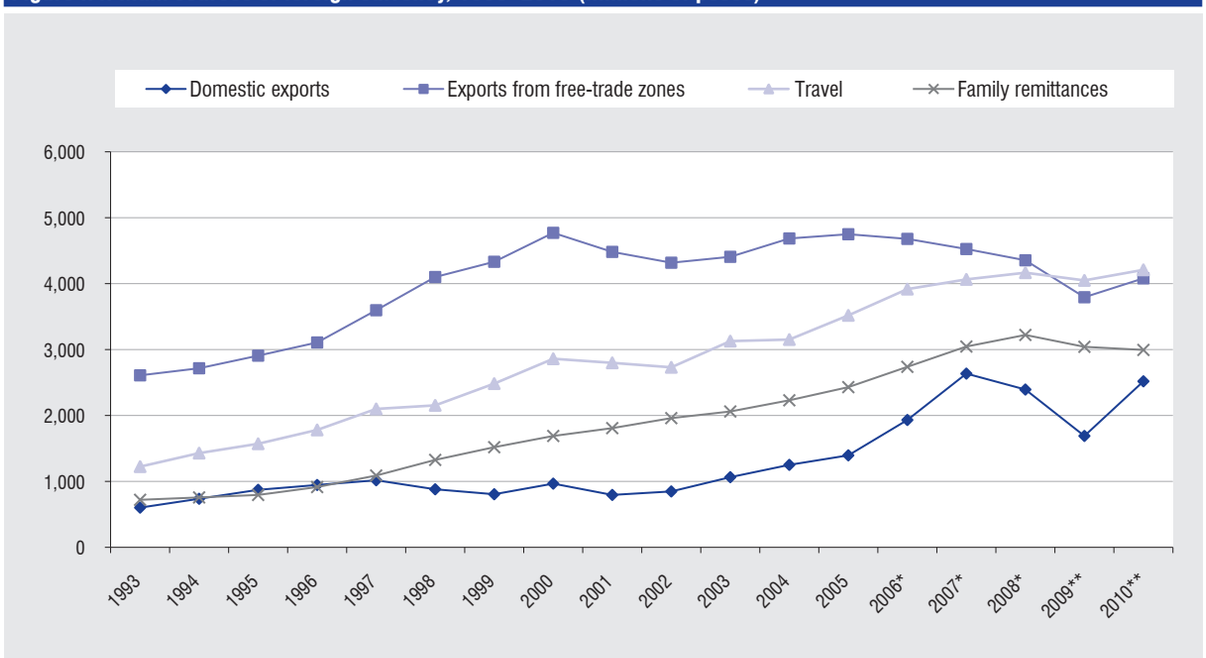
B. INFRASTRUCTURE AND BUSINESS ENVIRONMENT

Infrastructure

Adequate infrastructure is a prerequisite to be able incorporate new technologies into productive processes. That includes aspects such as the availability of sufficient and reliable electricity (for example, making possible the operation of machinery), modern communication networks (essential for the adoption of management techniques based on information and communication technologies) and adequate transportation systems (required, for example, for introducing value chain management innovations or for compliance with high quality standards in the handling and transportation of agricultural products).

As for transportation, the Dominican Republic has a well-developed infrastructure of roads, ports and air services. There are seven international airports, with Las Américas Airport in Santo Domingo as the main

Figure I.4. Main sources of foreign currency, 1993–2010 (millions of pesos)



Source: UNCTAD, based on data of the Central Bank of the Dominican Republic, 2011.

airport. At the end of the 1990s, the road infrastructure development programme improved urban roads and the main intercity roads. Port installations are adequate for shipping cargo, although there are still bottlenecks in Customs procedures (EIU 2008). As for the railway infrastructure, there is only one urban rail line (underground) in Santo Domingo.

In the field of telecommunications, growth during the past decade in the Dominican Republic has surpassed the world average.[8] As in other countries of the region, mobile phone use has grown exponentially during the past ten years. The country has also experienced important growth in the number of Internet users, reaching a penetration rate of 40 users for every 100 inhabitants (table I.6). However, the number of narrow and broadband subscriptions is still low compared to other economies in the region, such as Costa Rica, Mexico, Panama and the main Caribbean economies (table I.6).

As for infrastructure, insufficient power service is, without a doubt, the main obstacle to growth in the Dominican Republic. Despite preferential conditions granted by Mexico and Venezuela for oil imports, the high cost and low quality of the power supply, particularly electricity, is a serious obstacle to business competitiveness, and subsidies to that sector are a serious burden on the Government's budget.[9] Efforts to alleviate that problem, including the development of hydroelectricity and promulgation of a law on renewable energy, have so far had unsatisfactory results. Chapter V presents a detailed analysis of this issue.

Business environment

Major evaluations of the national competitive environment rate competitiveness in the Dominican Republic at an intermediary level. Nonetheless, perceptions are that business competitiveness and ease for doing business in the country have recently deteriorated (figure I.5). The country lost 15 places in two years in the ranking of the Global Competitiveness Index (2011) and three places in one year in the ranking of Doing Business in 2012 (2011). The 2011–2012 Global Competitiveness Report indicates that the main obstacles to national competitiveness are a number of important institutional weaknesses (including favouritism in government decisions, problems of government efficiency, the safety and

Table I.6. Penetration of information and communication technologies, 2010

	Fixed telephone	Mobile phones	Internet users	Broadband subscribers
Antigua and Barbuda	47.05	184.72	80.00	17.25
Barbados	50.30	128.07	70.20	20.56
Costa Rica	31.80	65.14	36.50	6.19
Cuba	10.34	8.91	15.12	0.03
Dominican Republic	**10.17**	**89.58**	**39.53**	**3.64**
El Salvador	16.16	124.34	15.00	2.83
Guatemala	10.41	125.57	10.50	1.80
Honduras	8.81	125.06	11.09	1.00
Jamaica	9.60	113.22	26.10	4.26
Mexico	17.54	80.55	31.00	9.98
Nicaragua	4.46	65.14	10.00	0.82
Panama	15.73	184.72	42.75	7.84
Trinidad and Tobago	21.87	141.21	48.50	10.81

Source: UNCTAD (2011a).

credibility of the police, as well as the quality of education) plus the difficulty of supplying electricity, a low savings rate and a very low level of innovation (INCAE 2011).

C. HUMAN DEVELOPMENT

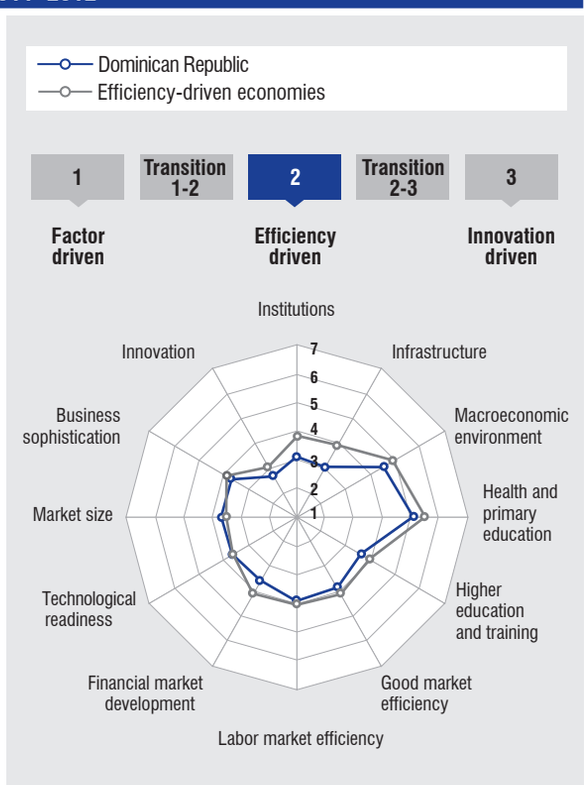
The Dominican Republic is classified among the countries with medium human development, according to the criteria of the Human Development Report prepared annually by the United Nations Development Programme. This position reflects several significant successes in human development. Between 1980 and 2011, life expectancy at birth increased by 10.5 years, the average number of years of school enrolment increased by 3.3 years and the number of years of expected school attendance increased by one year. Furthermore, the GDP per capita increased during that period by 127 per cent (table I.7). In 2011, the country was ranked 98th out of 187 countries. The Human Development Index (a broad definition of welfare based on three basic dimensions of human development: health, education and income) placed the Dominican Republic at the top of mid-range human development but behind the Latin American average (table I.7). Among that Index's three components, the country's relative better position in healthcare stands out (figure I.6).

Despite recent high economic growth rates, distribution of wealth has not improved (see UNDP 2005). The Human Development Index adjusted for inequality shows a loss of 25.9 per cent of human development in the country because of inequality. The handicap of inequality, considerable also in other Latin American countries, is slightly higher than that of other middle-income countries.[10]

The Human Development Report for the Dominican Republic (UNDP 2008) shows, using various measurements, inequality in the distribution of abilities and opportunities by province and within provinces as well as between groups and persons. The level of access to opportunities in the country does not correspond to the level of resources produced over decades.

Figure I.5. The competitiveness of the Dominican Republic, 2011–2012

Global competitiveness index (GCI)	Ranking	Points (from 1 to 7)
GCI 2011-2012 (out of 142 countries)	**110**	**3.7**
GCI 2010-2011 (out of 139 countries)	101	3.7
GCI 2009-2010 (out of 133 countries)	95	3.8
Basic requirements (40%)	**110**	**3,9**
Institutions	126	3.1
Infrastructure	106	3.0
Macroeconomic environment	96	4.4
Health and primary education	109	5.0
Efficiency enhancers (50%)	**93**	**3.7**
Higher education and training	99	3.6
Goods market efficiency	111	3.9
Labour market efficiency	104	4.0
Financial market development	103	3.6
Technological readiness	70	3.6
Market size	69	3.6
Innovation and sophistication factors (10%)	**109**	**3.1**
Business sophistication	89	3.7
Innovation	122	2.6



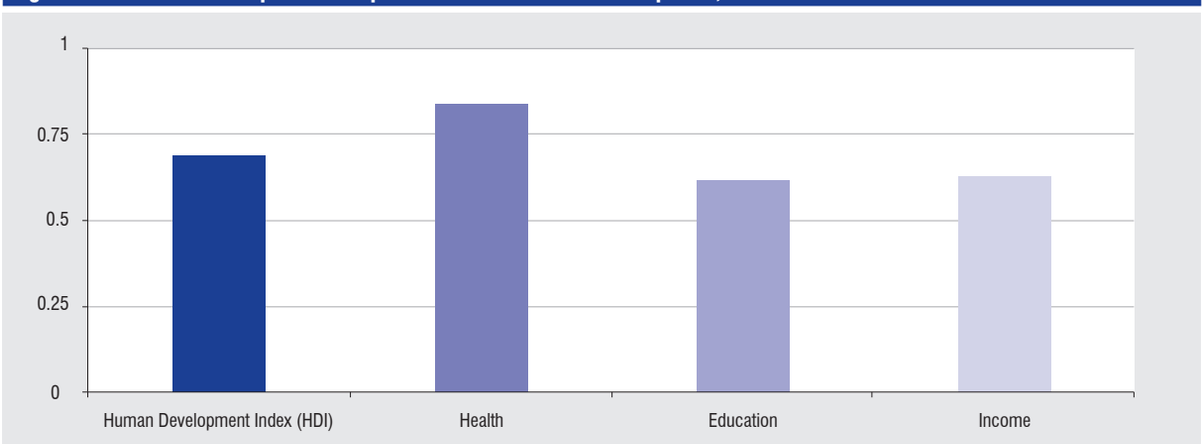
Source: Schwab (2011).

Table I.7. Human Development Index, Dominican Republic, 1980–2011

	Life expectancy at birth	Expected years of education	Mean years of schooling	GDP per capita (PPP dollars of 2005)	Human Development Index
1980	62.9	11.0	3.9	3,566	0.532
1990	67.6	11.3	5.0	3,594	0.577
2000	70.8	12.1	6.1	5,396	0.640
2005	72.0	11.9	6.7	5,850	0.658
2010	73.2	11.9	7.2	7,804	0.686
2011	73.4	11.9	7.2	8,087	0.689

Source: Human Development Indicators at www.undp.org (2011).

Figure I.6. Human development components in the Dominican Republic, 2011



Source: Human Development Indicators at www.undp.org (2011).

Education

An efficient system of innovation requires a critical mass of human capital with adequate scientific-technological knowledge. It requires persons specialized in exploring and selecting technologies that meet local needs, adapting them to local conditions and incorporating them into the national system of production as well as their efficient exploitation. Although some progress has been made, the education systems in Latin America and the Caribbean still have difficulty offering high-quality training, especially in the sciences and mathematics.[11] That results in a limited capacity for training future scientists and technicians and a decrease of scientific and mathematical literacy of the general population. Furthermore, the few scientists, researchers, technicians and even engineers in Latin America do not work primarily in the productive sector, and their concentration in public research institutions and universities does not seem to provide the stimulus necessary for other sectors.[12]

The number of higher education students in the Dominican Republic has risen 30 per cent in four years (2006–2009) (MESCYT 2011). The budget for higher education has also doubled in only four years, reaching 5,648.3 million pesos in 2009 (MESCYT 2011).

Despite advances in enrolment rates, the Dominican Republic is slightly behind in education in relation to Latin American averages, especially at the higher levels (table I.8). This can be explained by the lower level of national investment in education. In 2007, the Dominican Republic invested 2.2 per cent of GDP in education, in contrast to, for example, 6.3 per cent in Costa Rica or the 3.8 per cent invested by Panama (table I.8).

In line with the regional trend, higher education in the Dominican Republic has experienced considerable growth in absolute enrolment and the enrolment rates over the past two decades (table I.9). Nonetheless, the enrolment rate in third-level education (roughly 30 per cent) does not correspond with the level that could be expected, is below the Latin American average and is behind that of similar developing countries, such as Panama, which has an enrolment rate of 45 per cent (tables I.8 and I.9). In countries with a high level of economic development, enrolment rates are between 50 and 75 per cent. The Dominican Republic, with a rate of less than 30 per cent, is in the group of least-developed countries (MESCYT 2011).

There are weaknesses in the capacity of the Dominican education system to produce human capital in scientific and technological areas. In 2009, only one third of all students were enrolled in scientific, technological or engineering curricula (table 1.10). Studies in administration, education and legal areas dominate higher education. Furthermore, the proportion of students in the various areas of knowledge has remained constant during 2006–2009. The only observable differences are a reduction in the percentage of enrolment in the field of education and a greater percentage of enrolment in the humanities, engineering and architecture.

Furthermore, the training capacity at the post-graduate level, especially in scientific and technological areas, is still limited. In 2011, 9,399 students were enrolled in post-graduate studies, primarily in administration and education, and 4,765 post-graduate students received diplomas (MESCYT 2011). In that year, less than 15 per cent of the students enrolled in post-graduate studies were enrolled in scientific and technological areas (table I.10).

D. PERFORMANCE IN SCIENCE, TECHNOLOGY AND INNOVATION

STI indicators reflect the characteristics and evolution of the innovation processes in an economy. That information is of fundamental interest, both for public and private decision-makers and members of the scientific and technological communities. For the public sector, those indicators are the fundamental basis for the design, management and evaluation of STI policies and programmes. In the case of the private sector, the use of those indicators is key for defining competitive strategies that can be coordinated with the academic sector and government institutions.

Table I.8. Main education indicators, 2009

	Literacy rates[a]		Enrolment rates						Student/ teacher (primary)	Public expenditure on education	
				Primary		Secondary		Third-level			
	Adults (>15 years)	Youths (15-24 years)	Pre-school	Gross enrolment rate	Net enrolment rate	Gross enrolment rate	Net enrolment rate			As % of GDP[a, b]	As % of public expenditure[a, c]
Dominican Republic	88.2	95.8	38	110	90	79	63	33.3	25	2.2	11
Costa Rica	96.1	98.2	71	112	..	97	..	..	18	6.3	23.1
Panama	93.6	96.4	66	109	97	73	..	45	24	3.8	8.9
Promedio América Latina	*91.1*	*97*	*69*	*117*	*94*	*90*	*73*	*37*	*n/a*	*n/a*	*n/a*

[a] *Data for 2007 for the Dominican Republic.*
[b] *Data for 2008 for Panama.*
[c] *Data for 2004 for Panama (Estimates1) of the UNESCO Institute for Statistics.*
[d] *Data for 2004 for the Dominican Republic.*

Source: UNESCO Institute for Statistics.

Table I.9. Higher education enrolment and gross enrolment rates, 1990–2009

	Institutions of higher education	Absolute Enrolment	Population		Gross enrolment rates for higher education (%)
			Total	18-24	
1990	23	102,069	7,179,330	1,031,717	9.8
2000	31	245,056	8,553,739	1,141,547	21.5
2005	43	322,311	9,226,449	1,247,708	25.8
2009	43*	372,433	9,755,954	1,277,827	29.1

** This includes the 43 institutions of higher education for which statistical information is available.*
Source: MESCYT (2011).

Table I.10. Enrolment in higher education by area of knowledge, 2006–2009

	2006		2007		2008		2009		Post-graduate enrolment 2009	
	Total enrolment	%	Total enrolment	%	Total enrolment	%	Total enrolment	%	Total enrolment	%
Administration, economy, business and social sciences	86,911	30.3	94,035	30.3	106,446	30.2	111,843	30.0	6,031	64.2
Fine arts	5,952	2.1	6,386	2.1	7,708	2.2	7,383	2.0	-	0.0
Education	42,875	14.9	43,176	13.9	43,961	12.5	41,376	11.1	1,195	12.7
Legal sciences and policies	26,631	9.3	27,828	9.0	29,871	8.5	31,491	8.5	691	7.4
Humanities	27,598	9.6	31,446	10.1	37,853	10.8	40,028	10.8	140	1.5
Subtotal social sciences and humanities	**189,967**	**66.2**	**202,871**	**65.3**	**225,839**	**64.1**	**232,121**	**62.3**	**8,057**	**85.7**
Agriculture and livestock and veterinary sciences	2,576	0.9	2,460	0.8	2,991	0.9	3,466	0.9	91	1.0
Applied sciences	190	0.1	240	0.1	224	0.1	166	0.0	71	0.8
Basic sciences	431	0.2	501	0.2	668	0.2	786	0.2	58	0.6
Health sciences	36,374	12.7	39,187	12.6	43,010	12.2	46,990	12.6	709	7.5
Engineering and architecture	32,918	11.5	36,315	11.7	43,917	12.5	49,391	13.3	314	3.3
Information and communication technologies	19,407	6.8	22,199	7.2	25,956	7.4	26,823	7.2	82	0.9
Subtotal sciences, technology and engineering	**91,896**	**32.0**	**100,902**	**32.5**	**116,766**	**33.2**	**127,622**	**34.3**	**1,325**	**14.1**
Military	278	0.1	300	0.1	398	0.1	221	0.1	13	0.1
Not specified	4,825	1.7	6,509	2.1	9,166	2.6	12,469	3.4	4	0.0
Subtotal other	**5,103**	**1.8**	**6,809**	**2.2**	**9,564**	**2.7**	**12,690**	**3.4**	**2,447**	**0.2**

Source: UNCTAD based on data from MESCYT (2011).

STI evaluation requires a set of indicators capable of measuring not only inputs (human capital and financial resources) and the results of those activities (patents, publications, technological balance, etc.) but also the activities and processes of innovation and their impact, as well as the relationships between the various economic, political and scientific agents.

Based on the limited information available, this section offers a comparative analysis of the performance of the Dominican Republic in science, technology and innovation, taking into account inputs, results and innovation processes. It should be noted that the lack of systematically gathered information on STI, in particular concerning expenditure on R&D, is itself a serious shortcoming for the country.

1. Inputs

Research and development (R&D)

Investment in R&D is a determining factor for the successful acquisition of technology. Not only does R&D generate knowledge but it also expands the capacity to absorb new competencies and abilities necessary for finding, acquiring and adapting existing technology. A lack of R&D investment limits the absorption of foreign knowledge and the assimilation of new technologies.

Available estimates (which must be taken with caution given the difficulty of verifying them) indicate that R&D investment did not reach 0.25 per cent of GDP in 2004, which is a level of investment equivalent to half the Latin American average and is far below that of most developed countries.[13]

Currently, there is no accurate information on the country's expenditure on R&D as well as on who finances and manages that expenditure, which areas receive investment and the amount available per researcher. There is no accurate information on the number of researchers in the country and their dedication to research activities. This is a major weakness when designing a set of policies and programmes aimed at promoting innovation. The Ibero-American and Inter-American Network of Science and Technology Indicators (www.ricyt.org) has broad experience in promoting the gathering and use of STI indicators and could support future efforts to gather information on R&D investment and other data on STI in the country systematically.

2. Results

The indicators commonly used for measuring results in science and technology are scientific publications (bibliometric indicators) and patents (as well as utility models and trademarks). These are easy-to-gather indicators, but they present several limitations.

Bibliometric indicators refer exclusively to articles published in journals that are indexed and do not rank the relative importance of those publications. Nonetheless, these indicators can be very useful for identifying the main areas of a community's scientific knowledge, as well as its degree of cooperation with other countries.

Patents reflect only part of the science and technology activity of a country or institution. There is a great deal of scientific production and innovation that does not necessarily result in a patent. Certain minor adaptations, which play an especially important role in developing countries, can provide major results that are not necessarily patented.

Bibliometric indicators

The volume of Dominican publications reflects the limited scientific research and production with an international scope, especially when compared with other Latin American countries, both in absolute terms (figure I.7) as well as in relative terms (figure I.8). Furthermore, the data indicate difficulties to increase the number of publications.

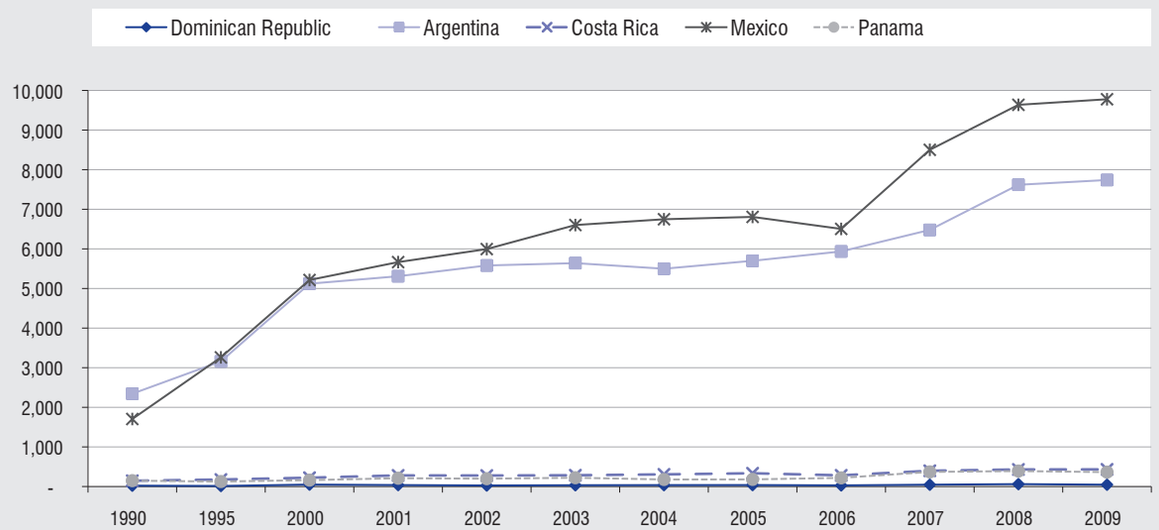
Patent indicators

There is no up-to-date information on the number of patents requested and granted, although available information seems to indicate little interest or capacity to patent and a high foreign participation in patent applications (figure I.9).[14]

Technology balance of payments

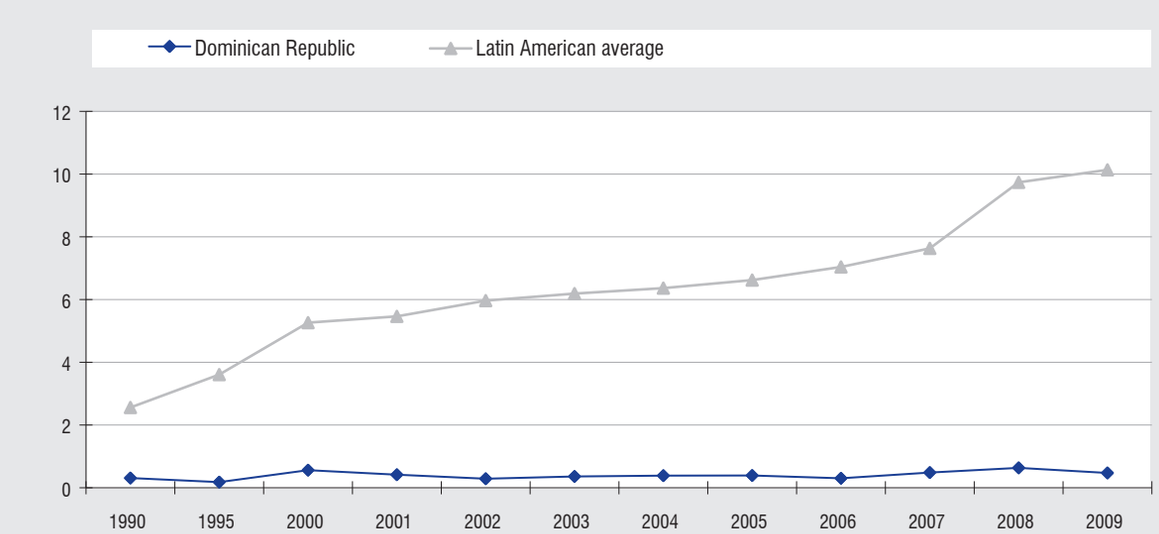
A country's technology balance of payments measures "the importance of a country's income from exports of technical know-how and services while indicating a country's competitive position in the international knowledge market".[15] The technology balance of payments includes, on the one hand, revenue from the sale of national technology abroad and, on the other, payment for the acquisition of external technology. In order to facilitate international comparisons and given that there are no sources of information sufficiently broken down at the levels required

Figure I.7. Publications in the Science Citation Index (SCI) in selected Latin American countries, 1990–2009



Source: RICYT.

Figure I.8. Publications in SCI per 100,000 inhabitants in the Dominican Republic and the Latin America average, 1990–2009

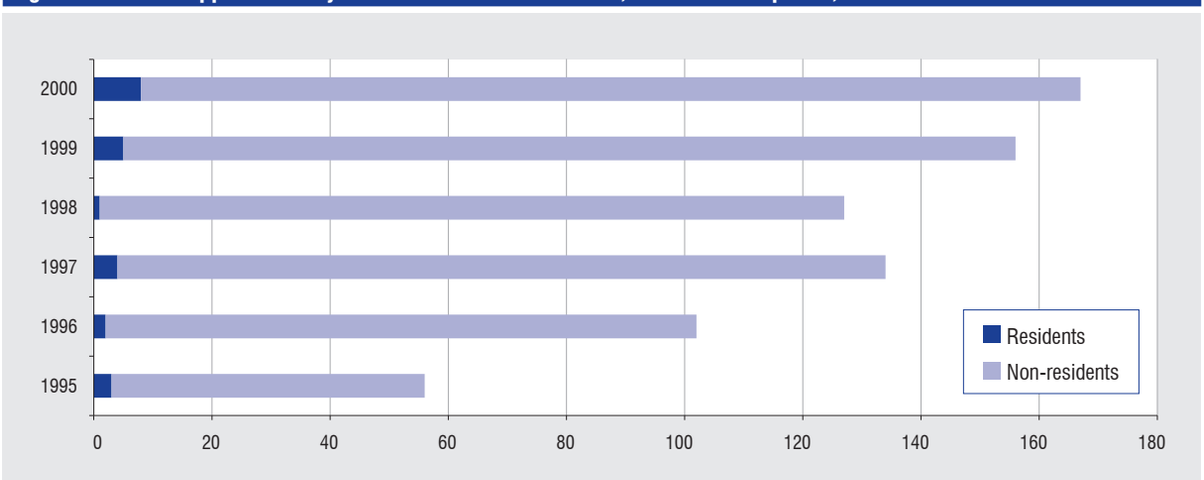


Source: RICYT.

by the technology balance of payments proposed in the Santiago Manual (RICYT 2007), this analysis is made only on the basis of royalties and licensing fees.

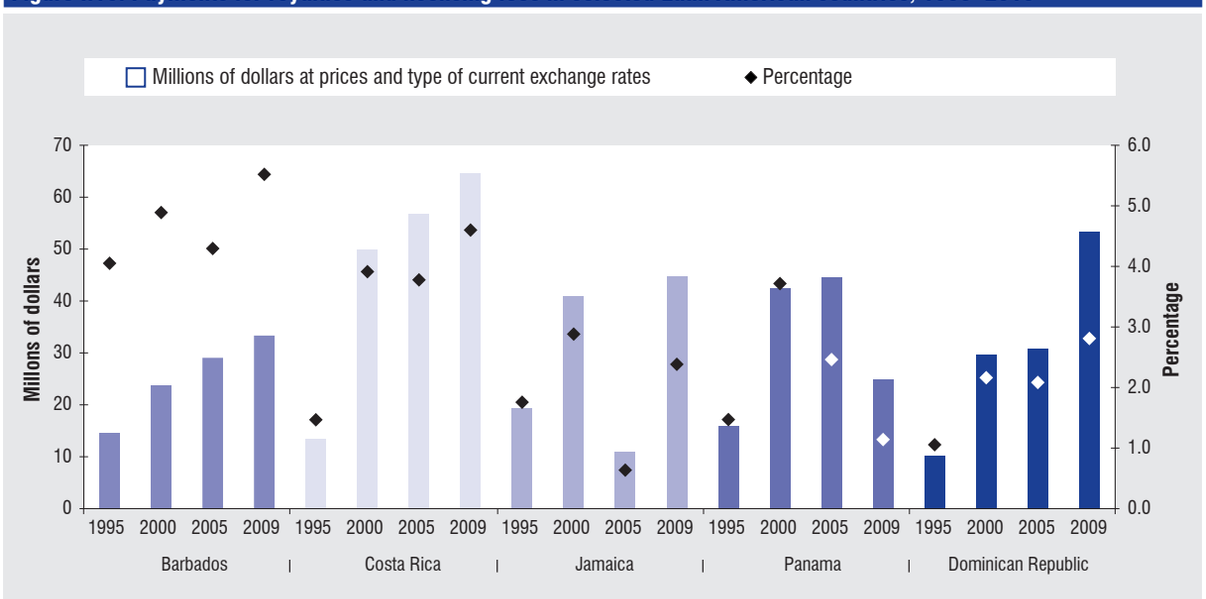
For the Dominican Republic, there are no data on revenues from royalties and licensing fees, although we know that the countries of the region pay much more than what they receive for royalties and licensing fees. Data on payments for this concept show relatively low amounts in absolute and relative terms, although a positive trend is growing (figure I.10). In 2009,

Figure I.9. Patent applications by residents and non-residents, Dominican Republic, 1995–2000



Source: UNCTAD, based on data from RICYT.

Figure I.10. Payments for royalties and licensing fees in selected Latin American countries, 1995–2010



Source: UNCTAD, based on data from UNCTADstat.

the Dominican Republic paid 53.4 millions of dollars for royalties and licensing fees, which represented 2.8 per cent of total payments for services.

3. Innovation activities and their impact

One important step made by the Government to facilitate the preparation and evaluation of science, technology and innovation policies has been the elaboration of two national surveys on innovation.[16] The information revealed by these surveys gives a better picture of the innovation activities carried out by Dominican companies and how that occurs and expands. It is important that decision-makers in the public sector as well as the business and academic

sectors learn about the surveys' results and use them in taking decisions.

The 2010 Innovation Review gathered information on innovation activities in two sectors: the business sector and the academic and scientific sector (institutions of higher education and research centres). Two separate surveys were carried out.

The innovation survey carried out in the productive sector used a stratified sample (by sectors, geographic areas and size) of companies with more than 10 workers in the agriculture and livestock, mining, manufacturing, construction, hotel, communications, health services, electricity, water, gas and other professional and social service sectors.

The results of that survey show that there is a considerable number of companies that innovate in products (55 per cent) and processes (73 per cent) and that those innovations are usually of an imitative nature, incremental and not radical. More than 80 per cent of the companies that innovate in processes or products declared that the innovations introduced were new for that company but not for its geographical market. The survey also shows that companies rarely cooperate with other institutions or companies in innovating. There is a notable absence of cooperation with universities. Finally, an identifiable trait of innovative companies is the significant influence that the level of managers' training has on the intensity of the innovative activity.

Estimates based on the survey responses indicate a low level of private R&D investment. Financing for innovation usually comes from the business itself (more than 88 per cent of the companies used their own resources). The role of venture capital or angel investors and the direct support of government entities to finance innovation for companies is very limited. Box I.1 presents several noteworthy aspects of the innovative activity of the business sector learned from the 2010 Innovation Survey.

The survey carried out in institutions of higher education and technological research centres could not cover the entire academic and scientific universe.[17] Nonetheless, taking into account that the entities that replied represent a significant part of all these institutions, several of the main traits that characterize innovative activity in the academic and scientific sectors can be extracted.

First of all, there is a limited amount of human, material and financial resources spent on innovative activities in general and research in particular. For example, the total number of persons reporting to be working in research is 450. It is indicative that in 2009 the investment reported in innovation activities was approximately 24 millions of dollars, and the expenditure on R&D activities made by institutions themselves was not more than 3 millions of dollars.[18] Secondly, just as occurs in the productive sector, innovative activities in the academic and scientific sectors are usually incremental and the main source of innovation is the acquisition of machinery, equipment, specialized hardware and software. Finally, it was noted that a large part of innovative activity is carried out in an isolated manner.

Consequently, the results of efforts to innovate by academic and technological institutions are still limited in terms of patents and licenses, scientific publications, commercial success or creation of technology-based companies. For example, in 2009 the revenue created by innovation through contracts with companies was approximately 2.5 millions of dollars. In that year, revenue from the sale of intellectual assets was approximately 600,000 dollars. During 2007–2009, no institution reported establishing a spin off.

E. CONCLUSIONS

The brief description of the context and status of science, technology and innovation in the Dominican Republic made in this first chapter points out some of the country's opportunities and weaknesses.

On the one hand, there have been opportunities for economic growth in the productive diversification that has been taking place in the Dominican Republic during the past two decades. Such opportunities could be strengthened through increased productive linkages and the transformation of enclave economies (textiles, package tourism) into productive processes with better linkages and cooperation among businesses and sectors.

There are specific areas of high added value in which the country has found niches of opportunity (for example in the manufacturing of medical equipment) and that should continue to be exploited and expanded. The development of productive capacities in high

Box I.1. Innovation in the business sector: Results of the 2010 Innovation Survey, Dominican Republic

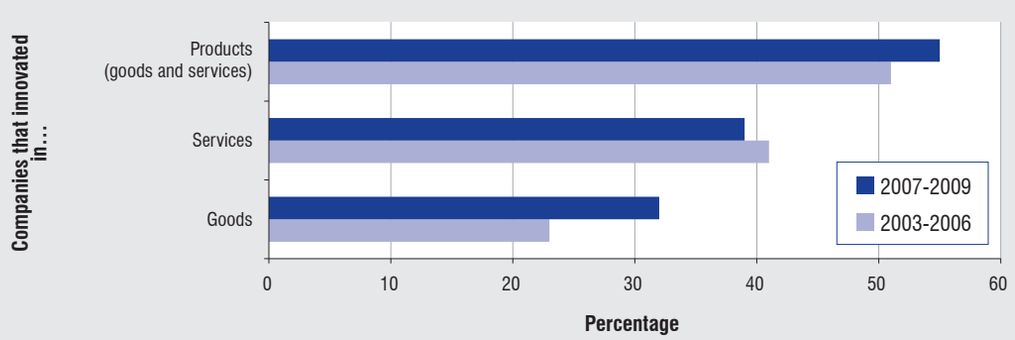
This box offers a more detailed analysis of business innovation activities based on the information collected from the second innovation survey made in the Dominican Republic (2010).

Technical information
Reference period: 2007–2009
Survey sample: 6,895 companies[19]
Planned sample: 639 companies
Actual sample: 506 companies
Location: 41% based in Santo Domingo, 22% based in Santiago
International dimension: 90% produce for the domestic market, 10% are exporters
Beginning of operations: 51% between 1982 and 1999, 32% during 2000–2009

Results
The 2010 Innovation Survey found that 55 per cent of the companies introduced product innovation (either in goods or services (figure 1.11)), contrasting with 51 per cent reported in a previous survey[20], and that 73 per cent introduced some form of process innovation in comparison with 67 per cent (figure 1.12). These results are rather high in comparison to the percentages reported in other countries[21], which could indicate the use of a broader definition of innovation.

Product innovation: There is a higher tendency to innovate by products in the telecommunication (66 per cent) and manufacturing (61 per cent) sectors compared to other sectors, especially the agriculture and livestock sector where only 37 per cent of the companies introduced some form of product innovation. Companies located in Santo Domingo and Santiago also showed a greater tendency to innovate in products, with a difference of 8.5 percentage points.

Figure I.11. Innovation in products in the Dominican Republic, 2003–2009



Process innovation: Inventory control, the use of information and financial administration continue to be the processes that are most frequently innovated (figure I.12).

As for **organizational innovations**, important percentages of companies introduced changes in organizing the workplace (57 per cent), the company (57 per cent) and the company's image (56 per cent).

As for **market innovations**, between 51 and 67 per cent of the companies introduced marketing innovations in each of four areas (product, distribution channels, price and promotion).

Degree of novelty: A substantial part of the companies that innovate in products and processes (more than 82 per cent) declared that their innovations were new for the company but not for the market. Less than 5 per cent of the companies that innovated in products and processes developed a new product for the global market (figure I.13).

(Cont.)

Box I.1. Innovation in the business sector: Results of the 2010 Innovation Survey, Dominican Republic (Cont.)

Figure I.12. Innovation in processes, Dominican Republic, 2003–2009

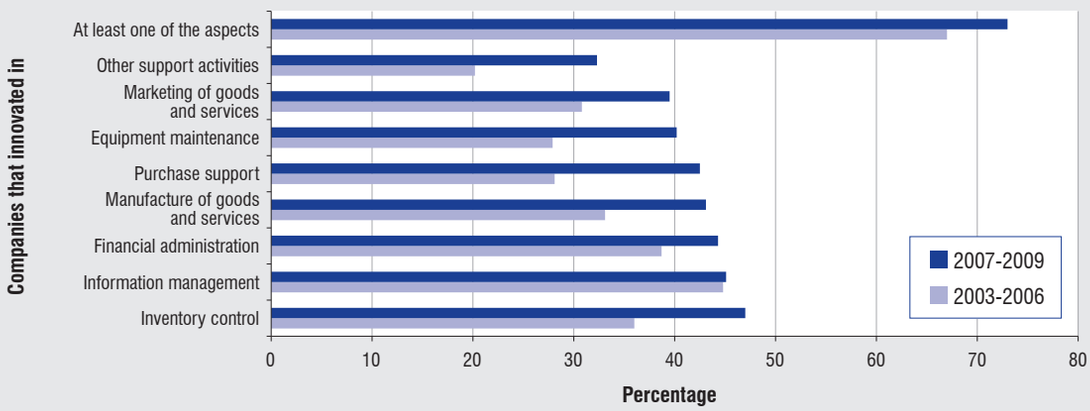
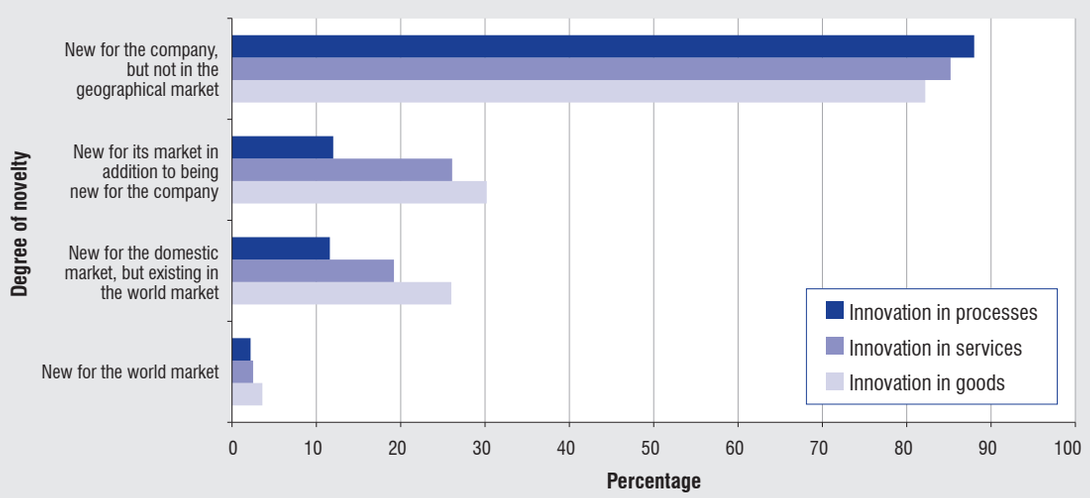


Figure I.13. The novelty of innovation activities, Dominican Republic, 2007–2009



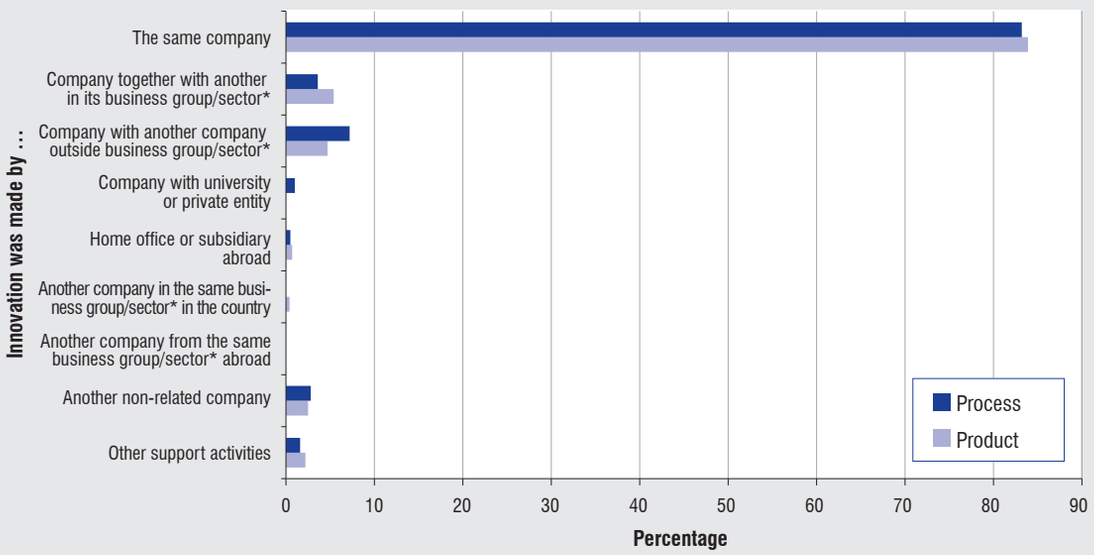
Limited collaboration in innovative activities: There was a strong trend (more than 80 per cent) to innovate, both in products as well as in processes, independently without cooperating with other entities. In the case of innovation in products, there was an exception in the case of large companies, which introduced one third of the innovations of products in collaboration with other companies, primarily of the same business group. In addition, the survey shows that the collaboration with universities is practically zero (figure I.14).[22]

The importance of training: There is a clear positive relation between a manager's or company director's education and the innovative activity of that company. For example, 53 per cent of the companies whose managers had post-graduate education innovated in products compared to 17 per cent of those companies whose manager had no secondary education.

(Cont.)

Box I.1. Innovation in the business sector: Results of the 2010 Innovation Survey, Dominican Republic (Cont.)

Figure I.14. Collaboration in innovative activities, Dominican Republic, 2007–2009



The role of competition: Linkages with foreign markets, in which the main business clients (consumers or companies) are located abroad, did not have a substantial impact on business innovations. Companies without competition showed significantly lower rates of product innovation (40 per cent) than those facing competition (ranging between 52 and 64 per cent).

Main innovation activities: As in most countries of the region, innovation is focused on the acquisition of machinery and equipment. About 59 per cent of companies report acquisition of computer equipment and programmes. About 54 per cent acquired capital goods, and 52 per cent trained their employees. Something that is worth noting is that 36 per cent of the companies reported having carried out research and development (R&D) activities. However, most of that 36 per cent had not allocated a budget for that activity. When that data is corrected using only companies that allocated a budget for this activity, the percentage of companies that carried out R&D activities is only 7 per cent (Guzmán et al, 2011).

Sources of financing: Eighty-eight per cent of the companies finance their innovation projects themselves. Twenty-two per cent declared having had recourse to the national bank. The role of risk capital or angel investors and the direct support of government entities for financing business innovation is very limited (figure I.15).

Sources of information: A total of 76.5 per cent of the companies reported that they highly valued domestic and foreign consultants' ideas. They also valued ideas from suppliers (54 per cent), foreign companies that were neither a client nor a supplier (53 per cent), other Dominican companies (52 per cent) and from clients (43 per cent). Ideas from universities were also highly appreciated by companies that innovate (61 per cent).

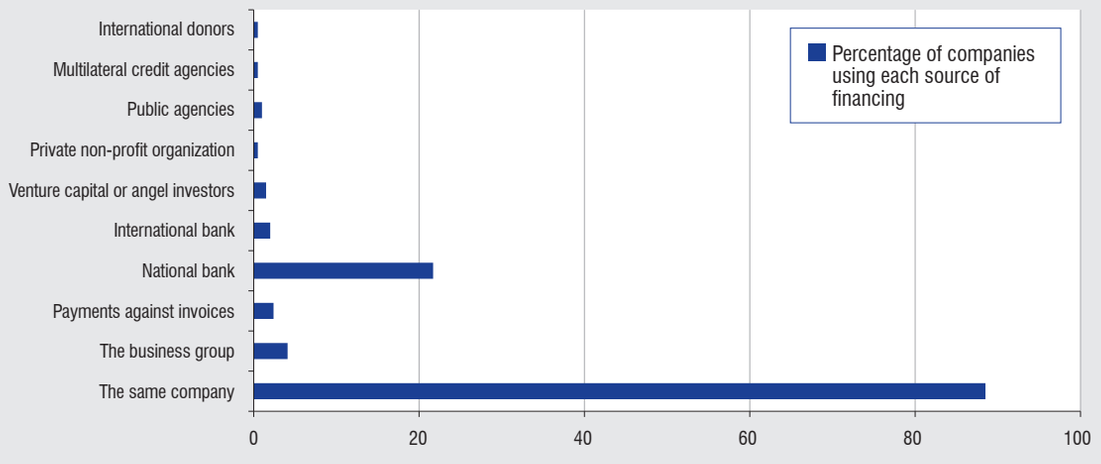
Impediments to innovation: Forty per cent of the companies mentioned the high cost of introducing new products or changing processes. Thirty-five per cent indicated that the investment payback period is very long, and 34 per cent reported a lack of financial resources for innovation.

Source: UNCTAD, based on Guzmán et al, 2011.[23]

(Cont.)

Box I.1. Innovation in the business sector: Results of the 2010 Innovation Survey, Dominican Republic (Cont.)

Figure I.15. Sources of financing of innovation, Dominican Republic, 2007–2009



added value areas will require greater investment in education, especially at the undergraduate and post-graduate levels as well as greater investment in and recognition of research activities.

On the other hand, as shown by available data, including patents, it will also be very important to promote capacities for ensuring that the knowledge created can be transferred and used in productive activities.

Finally, to be able to design and evaluate STI policies in the country, the collection of basic information currently unavailable, primarily information concerning investment made in R&D, would be essential to design effective policies.

Various components of the national innovation system in the Dominican Republic and the relationship that exists between them are examined in more detail in the following chapters of this report. Chapter II analyses the composition and functioning of the Dominican innovation system. Chapters III, IV and V present a more detailed diagnosis of innovation systems in three key sectors of the Dominican economy: agriculture and agro-industry, health and the energy sector. In each case, there is an attempt to combine the analysis with the formulation of recommendations for implementing a process of gradual transformation of the Dominican economy into a knowledge-based economy.

NOTES

[1] Real GDP per capita increased from 2,179 dollars in 1995 to 4,759 dollars in 2010 (based on data from UNCTADstat).

[2] The infant mortality rate (less than five years of age) for every 1000 persons dropped from 50.1 in 1995 to 26.5 in 2010 (based on World Development Indicators, World Bank, 2011).

[3] Life expectancy at birth increased from 69.3 years in 1994 to 73 years in 2009 (based on World Development Indicators, World Bank, 2011).

[4] The gross enrolment rate in secondary education increased from 58 in 2000 to 76.8 in 2009 (based on World Development Indicators, World Bank, 2011).

[5] Average growth of real GDP between 1992 and 2010, based on estimates of UNCTADstat (2011).

[6] Total factor productivity (TFP) is a standard indicator for measuring the efficiency with which an economy transforms its accumulated factors of production into output (IADB, 2010).

[7] EIU (2008).

[8] In the database of the International Telecommunications Union (ITU) available at www.itu.int/ITU-D/ict/definitions/regions/index.html.

[9] See, for example, Doing Business in 2012 (2011).

[10] The 2011 Human Development Index adjusted for inequality shows that the average loss of human development from inequality is 26.1 per cent for Latin America and the Caribbean and 23.7 per cent for middle-income countries (UNDP 2011).

[10] The OECD-sponsored programme for International Student Assessment (PISA) test, as noted in IADB publication.

[12] IADB 2010.

[13] See Navarro (2009).

[14] Including data available on patents requested for the period 1995—2000 and the results of the 2010 National Innovation Survey, in which only 29 out of more than 500 companies interviewed had registered patents.

[15] Santiago Manual (RICYT, 2007).

[16] 2003-2005 Innovation Survey and the 2007-2009 Innovation Survey.

[17] This survey sample was based on information from the 2009 Social Security Treasury (TSS) survey and was expanded to include companies suggested by the National Office of Statistics and the telephone directory (Guzmán et al, 2011).

[18] The Pareto Consulting Group conducted an innovation survey reporting the innovation activities carried out by 484 companies with six or more workers from 2003 to 2006 .

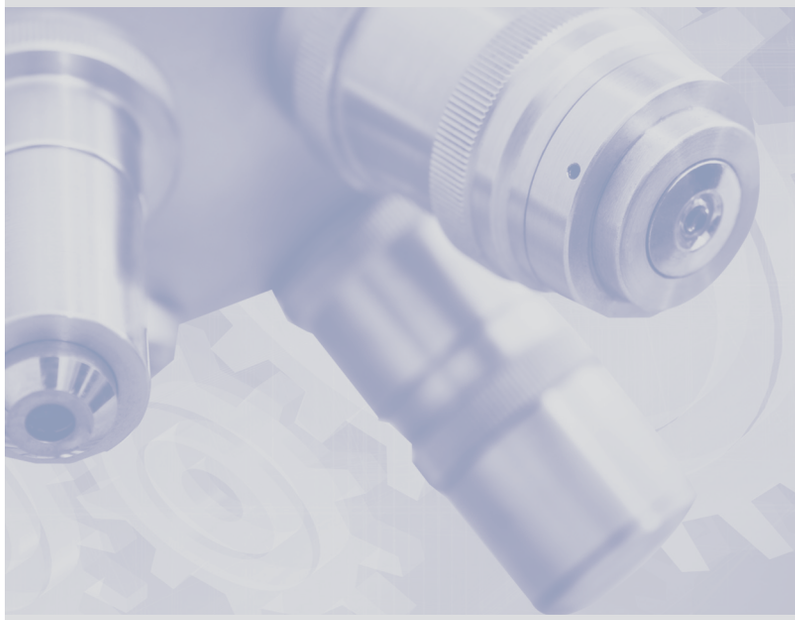
[19] For example, the results of the 2007–2008 Innovation Survey in Chile indicate that only 25 per cent of the companies introduced some form of innovation (i.e. product, process, marketing and management).

[20] This detail is not broken down by innovation in processes.

[21] Grupo Consultoría Pareto (unpublished) National Innovation Survey 2010. ENI II 2010. Ministry for Higher Education, Science and Technology. Draft of March 2011.

[22] The questionnaire was filled in by 19 universities (which represent more than 80 per cent of the Dominican Republic's student population) and by four out of nine technological research centres that were approached.

[23] It should be noted that not all institutions reported their expenditures on innovation activities and these tables can be an underestimation. For example, the total amount of funds available for R&D reported for that same year were 11.5 millions of dollars.



II

The national innovation system

The science, technology and innovation policy of the Dominican Republic is based on two concepts widely used in the context of economic growth strategies: an innovation system and industrial clusters. Both concepts have been adopted by many countries for orienting their efforts to make their economies more dynamic through increased competitiveness. Like in many other countries, these concepts are applied in the Dominican Republic only in a very basic manner, leaving aside several crucial elements that can make a big difference when measuring results.

A. CONCEPTUAL NOTES

1. Innovation systems

This report was prepared using a conceptual framework based on the systemic notion of innovation that in recent decades has become the most useful tool for understanding the differences in the technological progress rates experienced by countries and regions and, therefore, differences in their economic results.

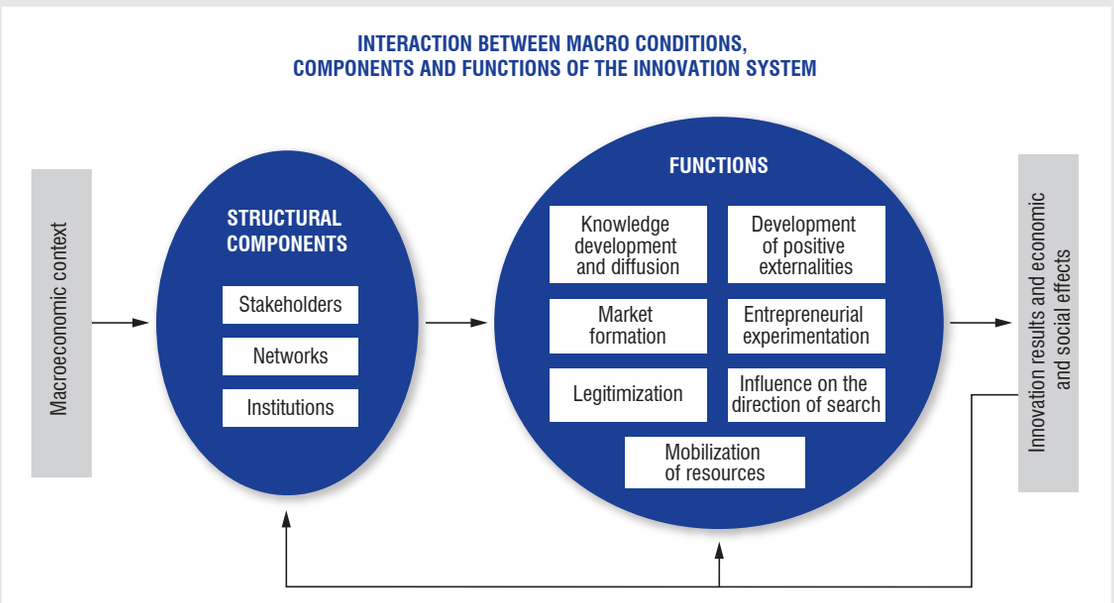
The literature developed after the work of Freeman (1987, 1988), Lundvall (1985, 1992) and Nelson (1993) gives many definitions of the concept of a national innovation system. The basic concept is that the degree of innovation observed in a national economy is strongly related to effectiveness of the system in which the actors involved in the production, spread and application of knowledge (companies, research centres, universities, public agencies) interact among themselves and nurture a process of learning and accumulation of explicit and tacit knowledge that enables innovation. Given that those interactions take place both through market mechanisms and outside the market, policies used to promote innovation should take into account the problems created by market and systemic failures (including institutional shortcomings, network effects, regulatory problems, coordination issues and blockages caused by previous decisions or dependency paths) that can hinder innovation.

A national innovation system is defined as the various government and business institutions that make up the scientific and technological apparatus and the way in which each of these agents interacts to create, spread and use knowledge. It is a question of institutions in the broadest sense; in other words, the norms, practices and incentives that occur in these processes. That means that they include the market's existing incentives, competencies and shortcomings (Patel and Pavitt 1994).

As mentioned earlier, an innovation system is composed of organizations and institutions that interact to create, spread and use knowledge. It is important to identify not only which organizations and institutions make up the system but also the functions that they fulfil and how these functions are carried out within the framework of a series of connections that condition whether the goals of creating, spreading and using of knowledge are reached or not. Various authors have written about this issue, proposing several functions, but in this document seven specific functions have been selected that incorporate most considerations (see figure II.1). These include the following.

- *Knowledge development and diffusion* is the main function of an innovation system. It also captures the scope and depth of the system's knowledge base and how knowledge is spread and modified within the system.
- *Influence on the direction of search* is the function dealing with incentives used to ensure the participation of the various actors in the system, but also the influence of certain mechanisms on that system; for example, how long-term visions and priorities are established. That not only depends on the orientation of public policy but also on the actors' perceptions, which in the end respond to incentives in accordance with their visions.
- *Resource mobilization* is key because introduction of innovation has a cost and requires an effort by all the actors involved. The resources necessary for this type of initiative include human capital in specific fields of science and technology as well as a trained labour force and entrepreneurs with management and financial capacities. Financial capital is also required in the form of venture or seed capital and public and private resources for financing innovation activities. Furthermore, complementary resources, such as specific physical and technological infra-structure that permit supporting science, technology and innovation activities are required.
- *Market formation* is highly important for risk activities such as innovation. An entrepreneur will invest in developing new technologies if the market risk for his product or service decreases. Initiatives that lead to institutional changes in markets are of great importance. For example, markets do not usually develop until technical norms or standards have

Figure II.1. Interaction between macro conditions, components and functions of the innovation system



Source: UNCTAD, based on Bergek et al. (2007).

been established that guide consumers about a product's or service's merits or guide suppliers about the type of inputs that should be offered in order for the new product to be sold.

- *Legitimization* is obtaining social acceptance of science and technological developments and being considered appropriate to established institutions. For example, until transgenic products gain legitimacy among consumers and various interest groups, it will be difficult to form wide and large markets for this type of product. In other words, there must be better acceptance of science and technological development.
- *Entrepreneurial experimentation* is a corner stone in economies with a more dynamic innovative activity. Not by chance, private research and development represents more than 70 per cent of R&D in developed economies. This experimentation is not only restricted to product and process innovations but also to the search for new forms of organization or markets, as is well described in the Oslo Manual.
- *Development of positive externalities* concerns the promotion of processes that spread technology and the development of network economies that create specialized markets and information spillovers that can be used by the productive agents and institutions participating in the system. Thus, the costs associated with innovation are reduced, and a greater number of agents can adopt new technology.

It is important to mention that several of the functions mentioned above have an influence on other functions. Thus, the development of positive externalities contributes to entrepreneurial experimentation, resource mobilization, influence on the direction of search and market formation.

Although the proposal by Hekkert and Suurs (2007) as well as that of most authors focuses on a sector or a certain technology, it can be translated to a national scale. These authors suggest that when analysing an innovation system what is important is to monitor the dynamics with which its structure accommodates itself to a specific desirable behaviour. In other words, actors must carry out their functions well in order to achieve a desired operation standard.

Finally, it should be taken into account that for effective implementation of the seven functions mentioned above there must be trained human resources and adequate management systems in the institutions that form part of the innovation system.

2. The concept of cluster

The concepts of innovation system and cluster are interrelated and, given the competitiveness of various productive sectors, several basic concepts about clusters and their relationship with innovation are presented in the following paragraphs.

The term cluster refers to an agglomeration of agents concentrated around related productive activities that establish relationships of cooperation and joint action for achieving collective efficiency, innovating and raising the quality of a product or service, and/or that concentrate in a geographical area (Porter 1990 and 1998; Schmitz 1999). Given that companies and knowledge organizations that are present in a single area form in principle an innovation system (to the extent that they systematically interact), innovation systems and clusters can coexist. In certain circumstances, the innovation system can in fact embrace one or more clusters. However, it should be noted that a cluster will not necessarily be an integral part of the innovation system of the area where it functions.

Although the agglomeration of agents has almost immediate effects on the generation of external economies, evidence in many countries shows that after a period of initial growth there is a tendency to stagnate or break up over time. That creates subsistence agglomerations that do not successfully develop completely and that do not fulfil the expectations of converting into clusters that are motors of regional development.

The three main attributes of a cluster are joint activities, the existence of collective efficiency and constant innovation. Authors such as Schmitz (1999) stress the function of joint action and cooperation for raising the level of collective efficiency in dynamic clusters, especially during times of crisis. Cooperation among companies occurs in two dimensions: vertically between suppliers and clients and horizontally between companies involved in the same activity in the value chain that defines the cluster and can involve joint activities by two or more companies (see table II.1). However, cooperation among companies tends to be selective because of the heterogeneity of the companies making up a cluster. For cooperation to be favourable, companies must need what the rest of the cooperating companies offer and vice versa. Likewise, vertical cooperation is more common than horizontal cooperation because clusters are usually exposed to international competition and that requires changes in the entire value chain. On the other hand, joint multilateral action is expressed primarily through affiliation of companies in associations of peers.

Table II.1. Types of cooperation among companies

	Bilateral	Multilateral
Horizontal	Sharing equipment by two companies that produce the same product	Sectoral association
Vertical	Producer and client improve their components	Alliance throughout the value chain

Source: Schmitz 1999.

In reality, collective efficiency is a result of the agglomeration that crystallizes in various types of external economies. These can occur as a greater division of labour and specialization, the availability of suppliers and sellers or the emergence of suppliers of specialized services and of trained labour.

Finally, a cluster's dynamics is based on constant innovation. Successful clusters are those that constantly strive to improve all associated activities and contribute to the generation of new business and greater specialization that result in better efficiency and productivity levels.

If those conditions do not occur, Altenburg and Meyer (1999) suggest that agglomerations end up forming subsistence clusters of micro and small companies that sell low-quality products for the local market where market barriers are low. There are two other types of clusters: (a) those formed by companies of differentiated large-scale production that arose on the basis of import substitution and that serve the domestic market and (b) those formed around transnational companies that take place in more complex technological activities. The policies required for promoting these distinct types of clusters are described in table II.2.

The upgrading of subsistence clusters requires support measures for individual SMEs, the promotion of cooperation among companies based primarily on the creation of confidence and the benefits of joint action. The policies necessary for promoting the creation of clusters of large-scale production companies are those dealing with improvement of the

business climate, stimulation of cooperation among companies, provision of information and consulting services, provision of training services and creation of technological infrastructure that has technological institutions that support research and development within the cluster. Finally, the policies necessary for stimulating clusters of transnational companies imply the attraction of additional foreign direct investment for consolidating the local productive system, developing local suppliers in order to establish a local productive system and transferring technology to local companies to promote spillover that raises the competitiveness of the entire cluster.

Table II.2. Policies for promoting and improving several types of clusters

Type of cluster	Recommended policies
Survival	• SMEs promotion • Support for collective action • Identification of bottlenecks in the chain or agglomeration • Implementation of pilot projects
Differentiated mass production	• Improvement of the business climate • Stimulating inter-firm cooperation • Provision of training services • Creation of technological infrastructure
Based on transnational companies	• Attraction of additional foreign direct investment • Supplier development by providing them the same benefits as to foreign investor • Transfer of technology to local companies

Source: Altenburg and Meyer (1999).

B. ACTORS IN THE INNOVATION SYSTEM

After defining several basic concepts used in this chapter, this section reviews the different stakeholders of the national innovation system of the Dominican Republic, grouped in the following categories: government, private sector, academic sector and international cooperation.

1. Government

The institutions and norms of the science, technology and innovation system. As in many countries of Latin America, scientific and technological activities have occured sporadically long before regulations were established or specific policies drafted. In 1962, the National Planning and Coordination Board was created as an advisory body to the Executive Branch of Government. Development strategies implicitly incorporated aspects of science and technology through the National Development Council. In 1972, professionals associated in Pro-Education and Cultural Action (APEC) made efforts to diagnose the situation in order to begin planning the scientific and technological development of the Dominican Republic. Later in 1974, the Science and Technology Unit (UNICYT) was created in the office of the president to promote and formulate activities. In 1981, with financing from the United Nations, the project "Building national capacity for planning science and technology" was implemented. Finally in 1983, the National Science and Technology Council (CONACITE) was created (Bodden 1991).

All of that reflects the efforts made to create a public institution to deal with issues of science and technology. As Bodden (1991) pointed out, several of those efforts failed because they did not assign sufficient budget resources for these new entities to begin to function. On the other hand, in none of these efforts is there a trace of the private sector as an important actor in science and technology. The private sector is seen as a recipient of the results of research made in academic and public research institutions. The vision is that of a linear innovation system.

Recently, as can be seen in legislation and existing norms, the systemic approach to innovation has been adopted. However, the implementation of activities seems to be more in line with a linear system, than with one in which there are multiple connections, the participation of the private sector in research remains limited and innovation is rarely promoted by government-sponsored programmes.

As mentioned above, efforts began in the 1960s to create institutions responsible for science and technology activities. However, it was with the promulgation of the law on higher education, science and technology (Law No. 139-01) in 2001 that the National System for Higher Education, Science and Technology (SNESCYT) was established, formed by "institutions that fulfil functions of higher education, such as the creation, incorporation and financing of education", as well as the National Council for Higher Education, Science and Technology which regulates, controls and supervises that system's components (Guzmán 2008).

This council, chaired by the Secretary of State for Higher Education, Science and Technology, has 21 members from the executive branch, universities, public agencies involved in science and technology activities, the education sector and a representative of the private sector.[1]

SNESCYT has four basic goals: (a) promotion, coordination and provision of higher education, (b) creation and incorporation of knowledge, innovation and invention, (c) intermediation and coordination of the institutions that form part of this system and (d) financing for higher education, science and technology.

It is stricking in this law that despite breaking down the goals of science, technology and innovation, there is no direct reference to the competitiveness of Dominican companies as the main axis of "the needs and goals for the social and economic development of Dominican society".

Mullin Consulting Inc. (2003) criticizes the fact that Law No. 139-01 stipulates that the science and technology institutions that form the SNESCYT must not be for profit, which excludes companies as well as the emphasis that the law places on the normative and regulatory functions of SESCYT.

In 2004, the President of the Dominican Republic issued Decree No. 1374-04, which stresses the importance of adopting a national competitiveness plan for raising the country's competitive capacity through improvement of the business climate, support for business partnerships, promotion of the development of small and medium enterprises and implementation of promotion policies for increasing traditional and non-traditional exports and foreign direct investment.

That decree also created the National Competitiveness Council, an organization responsible for developing and implementing, together with the public and private sectors, the national competitiveness plan.

The *law on competitiveness and industrial innovation* (Law No. 392-07) of 2007 seeks to promote renovation and industrial innovation through a strategy of industrial districts and parks and ties with international markets. That law provides tax exemptions for companies, freeing them from the obligation to collect income taxes from physical persons or foreign legal entities that "provide professional services related to the development of products, materials and production processes, research and development of technology, training of staff, research, innovation, training and protection of the environment, as well as all types of consultant services and technical advice" (article 47). Likewise, that law establishes a five-year transitional regime so that companies may request accelerated depreciation of the equipment, machinery and technology that they acquire and deduction of up to 50 per cent of the net taxable income of the previous year's fiscal exercise for acquisition of equipment, machinery and technology (article 50).

Although this law makes progress in offering clear incentives for renovation of equipment and machinery, it makes little progress in promoting the creation and local adaptation of technology. Article 49 mentions briefly a form of linkage between companies and academic centres through training programmes and promotion of a culture of innovation (Guzmán 2008).

Three years after the adoption of the law, several of the persons interviewed during the field work for this review stated that the law has not fulfilled its purpose. Furthermore, declarations of the executive director of the National Competitiveness Council stress that it is important to change the composition of PRO-INDUSTRIA's Board of Directors and the way the institution functions.[2]

Also in 2007, the president of the Dominican Republic signed Decree No. 109-07, creating the National System for Innovation and Technological Development (SNIDT) "to coordinate the functioning of the network of institutions (academic, public, private and foreign) and public policy for promoting innovation and applied technological development…" (article 1). Likewise, article 2 of that decree creates the Council for Innovation and Technological Development (CIDT), which acts as the governing body of this innovation system. The Council is chaired by SESCYT[3] and is composed of the Export and Investments Centre (CEI-RD), seven members from the public sector, four members from the private sector and two members from the academic sector. CIDT prepares incentives and support mechanisms for innovation in traditional sectors of the economy and boosts sectors of high technology or knowledge-intensive.

That decree states that the three pillars of that system are the Institute for Innovation and Technological Development, the network of incubators and the technological parks. However, according to the 2010 Innovation Survey, the structure of that system

is fragile, and several of its components are still not fully functioning.[4] "The development of technological parks as a place for the development of prototypes, polishing ideas before creating companies and taking them to the real market" is still very limited. In addition, the Institute for Technological Development and the Fund for Financing Technological Innovation, institutions that are provided for in Decree 109-07 are not yet operating (Guzman et al, 2011).

One important instrument that has been created for supporting policy in this sector is the Strategic Plan for Science, Technology and Innovation 2008–2018 (PECYT+I). The plan's goals are to: (a) strengthen the STI institutional framework by building capacity in the public sector; (b) design research, development and innovation programmes for improving the quality of the goods and services produced in the system; (c) continue to train human resources for STI; and (d) disseminate notions of science and technology as a means of social cohesion (Guzman et al, 2011).

2. Institutions involved in policy design

As has been pointed out in the previous section, the following institutions are involved in the design of science, technology and innovation policy.

The Ministry for Higher Education, Science and Technology (MESCYT) was created as the Secretariat for Higher Education, Science and Technology (SESCYT) and then became a ministry following changes brought into effect by the new Constitution adopted on 26 January 2010.

MESCYT is the main authority of the SNESCYT and coordinates actions with the various entities that define policy, such as the CNC and CIDT. As can be seen from figure II.2, MESCYT has five vice-ministries: higher education, finances, administration, science and technology and international relations.

The vice-ministries of higher education and science and technology define public policy related to these two issues. In the case of higher education, the vice-ministry promotes quality and excellence of education and for that purpose accredits universities because of the existing academic heterogeneity. Likewise, the specialities in the engineering curriculum are being revised to ensure compatibility with the training required by the private sector.

The vice-ministry for science and technology, in addition to drafting policies, is also responsible for implementing the FONDOCYT. This fund finances primarily basic and applied research at universities and research institutes. Companies can apply only through universities and research institutes. Another area in which it is working is in the creation of a system of science and technology indicators, although that is still in the preliminary phase. Likewise, a national programme of entrepreneurship is being implemented.

The National Competitiveness Council (CNC) was created in 2004 in order to develop and implement the National Competitiveness Plan. The CNC is financed with a loan from the Inter-American Development Bank (IADB) of 9.4 millions of dollars and with a national counterpart contribution of 4.1 millions of dollars. The implementation period of this loan is seven years (2003–2010). Later, the CNC obtained financing from UNDP in the amount of 200,000 dollars.

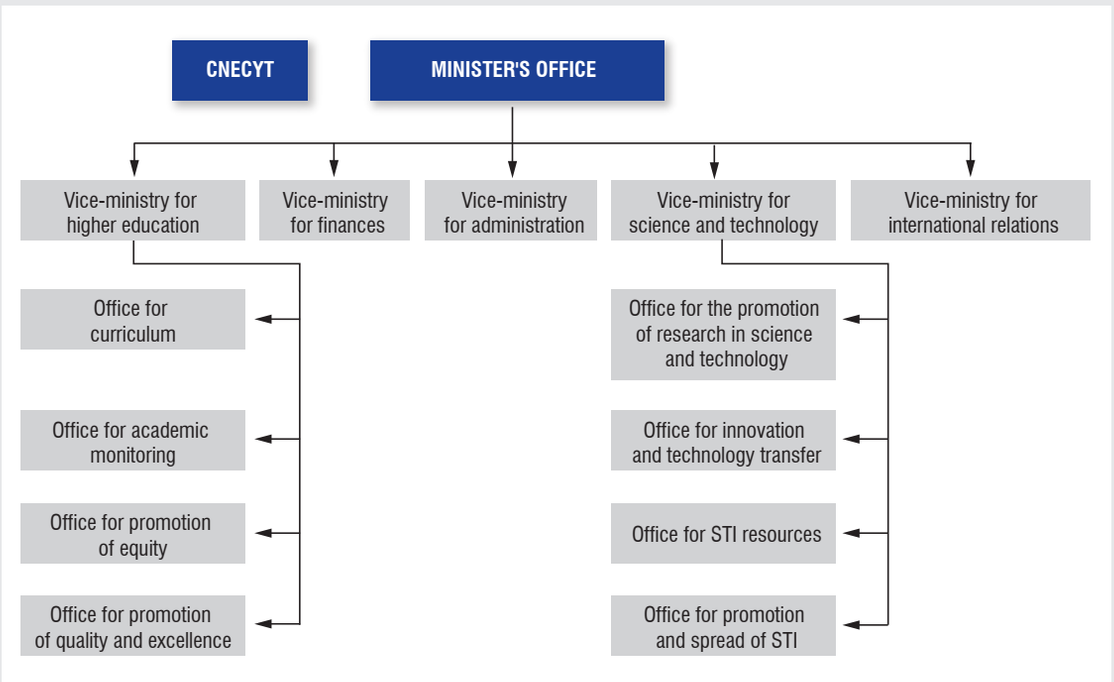
It is an agency that promotes cooperation between the public and private sectors for implementing projects in six areas: (a) industries, SMEs and free trade zones; (b) agro-industry, (c) improvement of the business climate; (d) commercial and logistical infrastructure; (e) sustainable and cultural tourism; and (f) innovation, entrepreneurship and training.

CNC has played a fundamental role in creating and building clusters in several sectors. For example, its support has been decisive for the creation of ClusterSoft, which is composed of 30 companies, six universities and seven public sector entities. Likewise, other clusters are being assisted, namely that of cacao producers, producers of moulded plastic products and cosmetics through technical assistance projects and training.

Likewise, the CNC has promoted a series of studies and policy reforms aimed at increasing the competitiveness of Dominican companies. For example, it has provided support to the General Office for Norms and Quality System (DIGENOR) for preparing a draft law on the Dominican quality system (SIDOCAL).

CNC manages the competitiveness fund (FONDEC), which is a shared fund for co-financing projects for increasing competitiveness at the national and sectoral levels, as well as initiatives for the development of clusters. Between September 2004 and December 2007, FONDEC financed 68 projects for a total of 9.4 millions of dollars.

Figure II.2. Simplified organizational chart of MESCYT



3. Regulatory institutions

The General Office for Norms and Quality System (DIGENOR) is the main regulatory entity concerned with science, technology and innovation. As part of the Ministry for Industry and Commerce, it provides several quality certification services, but its capacities are limited. The International Organization for Standardization (ISO) has designated DIGENOR as a "correspondent member", which is the status of a member that has no fully developed activities in standardization (Navarro 2009).

The director general of DIGENOR has pointed out its weaknesses, whose impact is made clear by the fact that the Dominican Republic is among the 15 countries with the highest number of devolutions of shipments from the United States because of low quality standards and problems with the packaging of agricultural and industrial products (Diario Digidal RD 2010).

In order to strengthen its capacity, DIGENOR has signed an agreement with the Spanish Association for Standardisation and Certification (AENOR). Through that convention, DIGENOR will receive requests for certification and will transfer them to the AENOR offices in the Dominican Republic for processing. AENOR functions as the accrediting agency and DIGENOR acts as the official authorized agency. Likewise, the convention establishes a training course for DIGENOR staff offered by AENOR International (DominicanosHoy.com 2010).

DIGENOR is currently preparing draft legislation on the Dominican quality system with the support of CNC.

The National Office for Industrial Property (ONAPI) is responsible for the administration of legislation in the field of industrial property aimed at developing and protecting industrial property in the Dominican Republic. It was created in 2000 and is attached to the Ministry for Industry and Commerce. It administers the granting, maintenance and enforcement of the registration of various types of industrial property (patents for invention, utility models, registration of industrial designs and trademarks).

ONAPI applies ISO 9000, which required the revision of its processes and has made it more efficient. This institution has been working to make the administration of disputes over copyrights more efficient, to train and incorporate trained personal for the processing patent requests and to provide technical assistance to inventors (Lugo undated).

With the signing of the Free Trade Treaty with the United States, the Dominican Republic has assumed a series of obligations concerning intellectual property, which has required ratification of international agreements and more effective protection of trademarks, patents and copyrights (Rivera 2005).

4. Institutions carrying out technological activities

The following are the main institutions implementing scientific and technological activities in the public sector.

The Centre for Development and Industrial Competitiveness (PRO-INDUSTRIA) is a decentralized public agency of the Ministry for Industry and Commerce. Its predecessor was the Industrial Development Corporation (CFI), which was created in 1962 to promote industrial development in the Dominican Republic.

Its goal is to ensure the competitive development of the domestic manufacturing industry, proposing policies and programmes for support that stimulate industrial renovation and innovation through the promotion of industrial zones, industrial parks and ties to international markets.

Among its functions are those of approving the creation of industrial parks and the establishment of companies in those parks as well as approving all support programmes and services to industry, projects and programmes for financing, competitive bids for industrial innovation and other business projects.

Its main projects are divided into three programmes: (a) industrial zones of which the Santo Domingo Oeste Industrial District and the San Cristóbal Industrial District stand out, (b) industrial parks, including the creation of La Canela Industrial Park in Santiago de los Caballeros and (c) the national programme for business incubation (PRO-INCUBE). This programme has around 200 projects of which 35 have been incubated and 17 continue to function. PRO-INCUBE has a budget of only 300,000 pesos (approximately 8,000 dollars) and, therefore, is trying to raise funds through a network of angel investors with the support of IADB, CAF and MESCYT. These funds would serve to finance projects using basic technology with a scheme of 50-per cent co-financing.

The National Council for the Promotion and Support of Micro, Small and Medium Enterprises (PROMIPYME) is an administrative dependency of the Ministry for Industry and Commerce. That programme was created in 1997, and since 2010 it is the authority dealing with SMEs, although it still is not legally established. It provides financing and technical assistance for strengthening these industrial segments. The PROMIPYME budget is 2,000 million pesos (about 54 millions of dollars) in investments and has about 20,000 clients.

PROMIPYMES has the following functions: provision of credit at low interest rates, training in industrial areas and services (trade). It works in depressed areas to prevent migration and provides micro-credit for promoting business registration. The credits that PROMIPYME grants cover working capital, the purchase of equipment and goods. The loans are for 3,000 to 3 million pesos (approximately 90,000 dollars), and loan periods vary from three months to three years. In addition, it has created a programme for micro companies, PRODEMICRO, which gives loans from 3,000 to 50,000 pesos through NGOs (but it is not a second tier programme, the NGOs simply help to identify potential beneficiaries).

In general, PROMIPYME is a support programme for micro companies and apparently has evolved into a programme for alleviating poverty rather than a programme that meets the needs of micro and small companies.

The National Council for Agrarian and Forestry Research (CONIAF) is a decentralized institution of the Dominican Government, which strengthens, stimulates and orients the national system for the development and transfer of agricultural and forestry technology. It offers financing through a research fund, promoting the development of scientific and technological capacity in public and private institutions. It finances a maximum of 3 million pesos (approximately 81,000 dollars) for a maximum of two years. Since its creation in 2000, 116 research projects have been financed through public bidding for a total of nearly 102 million pesos.[5] Its focus is (a) food security, (b) agro-exports and markets, (c) sustainable management of natural resources and (d) rural development and poverty.

5. Public research institutes

The Dominican Institute for Agricultural and Forestry Research (IDIAF) is the main institute for public research. This institute was created in 1985, but began to function only in 2000 following a recommendation of the International Service for National Agricultural Research (ISNAR). Its mission is to ensure food security in the country and promote the competitiveness of the Dominican agro-industry.

The research carried out by IDIAF is based on the priorities defined by the Government through CNA–CONIAF, the strategic institutional plan and the identified of demand of interest groups in the sector. Annual operational plans are prepared, which are approved by technical committees and by the board of directors. Later, each individual IDIAF researcher prepares a plan of action.

IDIAF also provides services for transferring technology through information centres located in various parts of the country and publications and audiovisual materials. It offers direct training in its experimental stations. It has a network of research centres, laboratories and stations distributed throughout the entire country.

The Institute for Innovation in Biotechnology and Industry (IIBI) was created in 2005 to carry out scientific research, technological transfer and innovation, as well as to provide technical consultancy services in areas relevant to national development in order to contribute to improving the level of competitiveness. The predecessor of the IIBI is the Dominican Institute for Industrial Technology (INDOTEC).

IIBI offers technological services in the form of technical assistance and testing in its laboratories for microbiology, chemical testing, physical testing, sewage, mineralogy, fuels, chromatography, wood, textiles, and biomedicine. IIBI also offers services for product development. It has developed a line of cosmetic products based on local raw materials and it has added value to agricultural products in the form of dehydrated fruit, nectars and juices, and green banana flour, among others.

IIBI acts as an environmental consultant registered with the Ministry for the Environment and Natural Resources. IIBI provides services to companies for compliance with environmental regulations, carrying out environmental measurements, such as measurement of atmospheric gases and particles and chimney particles, and preparing environmental studies including environmental impact studies and environmental management plans.

IIBI also carries out applied research in various aspects of biotechnology, including industrial, plant, medical, pharmaceutical and environmental research.

6. The private sector

The Dominican Confederation of Small and Medium Enterprises (CODOPYME) estimates that there are approximately 365,000 micro, small and medium-sized companies in the Dominican Republic.[6] They contribute close to one million jobs at the national level and 27 per cent of GDP (PUCMM undated). These data are only indicative because they include informal companies for which there is no official information.

Free trade zones and industrial parks. The law on competitiveness and industrial innovation considers industrial parks to be the most efficient instruments for promoting development and industrial integration, achieving greater competitiveness, attracting foreign direct investment and promoting technological transfer.

According to the National Council of Export Free Trade Zones (ADOZONA), there were 48 free trade zones operating in the Dominican Republic in 2008, with the oldest being La Romana, which dates from 1961, and the most recent which is Multiparques, created in 2007. Out of the 48 free trade zones, 21 are private, 18 are public and three fall within the category of industrial parks with mixed administration.

Despite these positive results, the strategy of free trade zones seems to have limitations as a development strategy. Sánchez-Ancochea (2006) reports that it is difficult for free trade zones to be a motor for economic development because they are based on relations of dependence with other countries, especially the United States, and concern industries with low added value. They do not necessarily contribute to the accumulation of human capital and do not necessarily integrate with the local industry.

In 2004, 50 per cent of the companies located in free trade zones of the Dominican Republic were clothing and textile industries (Tejada Holguín & Asociados 2007). With the end of the Multifibre Arrangement (MFA) in 2005, these companies lost their competitiveness in relation to Asian producers and, as a result, several companies closed, which substantially reduced employment. In 2008, textile

companies made up 27 per cent of the total number of industries in free trade zones.

The interrelation between companies located in free trade zones and the rest of the productive sector has been and continues to be rather limited. Textile companies located in free trade zones usually assembled clothing creating little added value. In 2003, only 10 companies in free trade zones bought inputs from local suppliers, while 241 companies imported from North American companies. Currently, the provision of inputs by local companies has improved, but there are restrictions because of a lack of local suppliers and a lack of reliable power supply (Sánchez-Ancochea 2006).

Diversification towards sectors of greater added value has been rather timid. In 1998, at the initiative of President Fernández, the Parque Cibernético in Santo Domingo was created to promote foreign investment in information technology and telecommunication companies. However, in 2003 only three companies that created 32 jobs were attracted, while 70 per cent of the installations remained unoccupied. According to ADOZONA, there were eight companies established in the Parque Cibernético in 2008, where occupation was 75 per cent of capacity and exports are only 1.5 millions of dollars.

According to interviews with various officials of ClusterSoft, Parque Cibernético and the Technological Institute of the Andes (ITLA) the main obstacle is a lack of trained human resources in this sector.

Associations and employers associations. The main industrial association is the Industrial Association of the Dominican Republic (AIRD). It was created in 1962 and has played a major role in the country's industrialization, assisting the creation of new industries.

The main services it provides to its members are access to privileged information about domestic and international issues related to production, business and the economy in general, plus information concerning legislative reforms, regulatory norms and regulations. It also provides permanent consultant services and training.

Currently, AIRD is carrying out the industrial innovation programme "Competing on Speed and Flexibility" financed by IADB. This programme seeks to encourage and improve the competitiveness of the Dominican industrial export sector, promoting the organizational model of clusters. Three sectors have been selected: cacao and chocolate products, cosmetics and plastics (packaging and moulded products).

Clusters. As mentioned earlier, the Dominican Government is betting on a scheme of industrial clusters for promoting activities and competitiveness in the productive sector. The formation of clusters in several economic sectors is being promoted with the help of several multilateral and bilateral organizations.

In the agricultural sector, USAID has been supporting the creation of various clusters related to agro-exports through a project of diversification of the rural economy.[7] This project has the following goals: to facilitate access to markets, obtain certification of organic products and improve post-harvest production.

In the field of information technologies, ClusterSoft is a group of 30 private companies, six universities and seven public sector institutions. This association operates within the strategy of the Dominican Government to attract foreign investment to this sector. A strategic plan with four aspects has been proposed for this sector: promotion and attraction of investment, human resources development, international certification of companies and promotion of research and development.

As mentioned above, three clusters are supported by the industrial innovation project "Competing in Rapidity and Flexibility" financed by IADB. The cacao cluster, in which four exporters of cacao and chocolate products out of the 25 that exist in the Dominican Republic are associated. These companies are linked to the 35,000 producers of cacao. Among this cluster's main needs are renovation of plants, productive training, generational replacement of producers, combating several pests and diseases and drought-related problems.

Members of the plastic cluster produce packaging and moulded articles. There are approximately 300 companies in this sector, of which 30 are registered in this cluster and participate in the project. As part of this project, contacts have been made with similar producers in Colombia.

The cosmetic cluster is formed by companies that produce primarily hair care products. There are around 150 small producers, many of whom are informal. A total of 58 of these producers are registered in this cluster.

7. Universities and technological institutes

Universities. Higher education in the Dominican Republic has had a unique development. The first university in the Americas was founded in the Dominican Republic in 1538 with the name Santo Tomás de Aquino, which later became the Autonomous University of Santo Domingo (UASD). The offer of higher education expanded through the creation of the Católica Madre y Maestra University in 1962, the National Pedro Henríquez Ureña University in 1967 and the Institute for Higher Studies in 1968 (becoming the APEC University in 1985).

This expansion of the educational supply responded to the need created by the expansion of demand for higher education that was straining the capacity of UASD. As can be seen in table II.3, there were 1,987 university students in 1950, and a decade later that had practically doubled to 3,729 students. Since then, the university population and the number of universities have been steadily increasing, reaching 43 universities and 372,433 university students in 2009. A clearer picture may be found in the level of enrolment rate: in 1950 university enrolment was 0.6 per cent of the population between 18 and 24 years of age, while in 2009 the enrolment rate reached 29.1 per cent of the same population group.

According to Grupo Consultoría Pareto (2007), the expansion of university studies occurred in three phases or waves. The first occurred up to 1968 and was characterized by the creation of private universities with good equipment and whose fees were relatively high for the average income of Dominican families. The second phase occurred during the 1970s when 10 additional universities were created. The third phase occurred during the following decade when 12 universities were created. Later, 17 more universities were created, bringing the total number of universities to 43.

There are currently 45 universities in the Dominican Republic. This sustained growth of higher education is due, on the one hand, to pressure of social mobility among the urban middle class and working classes resulting from expansion of activity in the public and private sectors during the 1960s and 1970s (Grupo Consultoría Pareto 2007) and, on the other hand, from growth of privately sponsored universities, given the Government's low investment in higher education.

As the result of this expansion, there is a highly heterogeneous higher education offer because each university has sought to serve specific market niches (for example the regional market, low-income population, part-time students). Because of poor supervision by the educational authorities, this heterogeneity has led to a low quality of institutions. The private sector complains that the profile of university graduates does not satisfy their needs and that they have to invest substantially in training in order to have the required qualified employees.

Table II.3. Total university enrolment and gross enrolment rate, 1950–2009

Year	Number of Institutions of Higher Education	Enrolment	Population		Gross enrolment (%)
			Total	18-24	
1950	1	1,987	2,135,900	307,777	0.6
1960	1	3,729	3,047,100	390,253	1.0
1970	4	20,602	4,009,500	499,383	4.1
1985	19	123,748	6,416,289	958,739	12.9
1993	28	108,335	7,293,390	1,079,013	10.0
2002	39	286,134	8,562,541	1,112,118	25.7
2003	38	298,092	8,819,000	1,199,961	24.8
2004	44	313,427	8,960,000	1,227,642	25.5
2005	43	322,311	9,100,000	1,247,708	25.8
2009	43*	372,433	9,755,954	1,277,827	29.1

Source: MESCYT, 2011.

To respond to this situation, MESCYT began in 2005 a process of institutional evaluation to improve the quality of higher education. This evaluation process is provided for in the law on higher education, science and technology and must be repeated every five years. According to MESCYT, in 2009 31 out of 45 universities carry out a self-evaluation and 29 were evaluated externally (MESCYT, 2011).[8] Towards October 2010, the universities Eugenio María de Hostos (UNIRHEMOS) and the Experimental Félix Adams (UNEFA) were closed. Likewise, enrolment of new students was prohibited in the National Evangelic University (UNEV) and the Dominican University of Dentistry (UOD) for a six months and one year, respectively (Cosas Novas 2010).

MESCYT has also begun a process of accrediting engineering degrees under a programme of renovation and updating of curricula in order to comply with international standards and current and future needs of the productive sector. This process is carried out with the support of IADB in a programme of regional public goods, in which the Dominican Republic, Jamaica and Panama participate (Hoy Digital 2010).

Medical schools have also gone through a process of accreditation. Out of a total of 10 schools, seven have been accredited for five years without reservations, which means that they comply with all required standards and have remedied any observations made during the evaluation. The three remaining schools have been accredited with a reservation (MESCYT, 2011).

As can be seen, higher education in the Dominican Republic, as in almost all countries of the region, has focused on training human resources and little attention has been given to academic research. This is reflected in the few resources that university institutions have spent on this activity. Grupo Consultoría Pareto (2007) shows that only 15 out of 43 universities have a research budget and that represents only between 0.01 and 1.74 per cent of university budgets. If we consider that academic research takes place primarily in universities, the results are not very encouraging. For example, there were only 61 articles by Dominican authors recorded in the Science Citation Index (SCI) in 2003, while there were 31,903 for Brazil, 9,637 for Mexico, 7,618 for Argentina, 673 for Peru and 238 for Bolivia. As will be noted further along, MESCYT is trying to provide incentives for academic research through FONDOCYT.

Technological institutes. The National Institute for Vocational Training (INFOTEP) is the main authority of the national vocational training system for productive work. Its board of directors is formed by representatives of the business, labour and government sectors. Its function is to train human resources, advise companies and regulate vocational training.

Vocational training is provided by INFOTEP through a network of affiliated centres and through the system's operational centres, more than 150 in all of the Dominican Republic. These centres currently provide training for careers accredited by INFOTEP. This system covers roughly 30 per cent of the country's demand for training.

INFOTEP is financed with 1 per cent of the monthly payroll of companies and 0.5 per cent of the annual bonus for workers. In addition, the Government subsidizes this institution with 25 million pesos.

Table II.4. Courses offered by type of instruction, 1984–2004

Type	Number of graduates
Complementary training	420,745
Permanent training	830,982
Licensing	428,476
Dual training	4,083
Training at a centre	1,304
Training of technicians	544
Occupational certification	597
Total	**1,686,731**

Source: Department for Research and Labour Market Statistics, INFOTEP, 2005.

As shown in table II.4, INFOTEP has trained more than 1.5 million persons in various types of courses since its creation in 1984. As can be seen, most of the training offered by INFOTEP is considered to be complementary training, certification of abilities and permanent training. This type of training consists in short and specific courses. As OECD (2008) points out, INFOTEP has been successful in providing short-term technical courses, however, the degrees that it grants do not lead to opportunities for additional education in the formal education system.

8. International cooperation

As in many developing countries, international cooperation organizations play an important role in the design and implementation of science, technology and innovation (STI) policies.

In the field of policies, various multilateral organizations, such as OECD and IADB, along with bilateral organizations such as USAID, have contributed consultants for carrying out studies for drafting STI policies or programmes. For example, OECD financed a report on education policies in the Dominican Republic, and USAID has financed several studies of emergent industries.

As for implementation, these organizations have financed specific programmes aimed at promoting STI policy instruments. For example, IADB is financing a programme to strengthen industry and support competitiveness in three clusters (plastics, cosmetics and cacao). Likewise, USAID is financing various projects for promoting the creation of agricultural clusters. The German Cooperation Agency (GIZ) is supporting a series of projects to improve management of natural resources, specifically in issues of desertification and deforestation.

Owing to duplication in various projects, at least in agriculture, donors have established an informal round table to share information about the projects they finance and their results.

C. LINKAGES AMONG THE VARIOUS ACTORS

One of the main problems perceived in most countries in which the concept of an innovation system has been adopted is the lack of linkages among many participants. Without these interactions, it is very difficult to create the virtuous circles required for knowledge to be created, adapted, spread and used in a specific region or industry, allowing, thereby, the innovation system to function efficiently.

This section will review the links established among the various actors in the Dominican innovation system. Special emphasis is given to linkages between the private sector and sectors generating knowledge (universities and research institutions), as well as to the initiatives that promote cooperation among various private sector actors, such as the promotion of clusters.

1. Bringing together the private sector and universities

The relationship between the private sector and universities is very weak and almost non-existent. That is because, on the one hand, universities focus on teaching and do not carry out academic research activities that would allow them to produce knowledge and, on the other hand, most Dominican companies have low technological capacities and do not usually request technological services. Only 15 per cent of the companies report having some type of cooperation in their innovation activities. Among them, 8 per cent report that cooperation with universities was favourable. 17 per cent indicate that they have cooperated in some way with a university and 9 per cent with public research institutions.[9]

Recently, several universities, especially private universities, report having a more fluid relationship with the private sector and have begun to offer services to individual companies or to companies participating in clusters. For example, the Higher Institute for Agriculture works with various productive chains providing research services and transferring technology. Likewise, it seeks to improve health and safety for producers although it does not have international accreditation.

UASD declares having a programme promoting linkages between universities and companies, but in practice that has not functioned. All has depended on individual researcher's interest. Despite that, it was reported that UASD has permitted researchers to receive additional compensation for their projects. Moreover, UASD implemented 16 measures in 2011 for expanding research, including equal pay for hours of research and for hours of teaching with students; economic incentives for researchers who have projects with external financing; study leave of the equivalent of 50 per cent of teaching duties for professors studying doctoral degrees; the creation in each university, campus, centre and university extension service of a set of research lines, programmes and topics based on society's identified needs; and the establishment of a patent and property rights policy (UASD, 2011).[10]

Clusters, such as ClusterSoft, link companies and universities together. In this specific case, the universities forming this cluster are UASD, UNIBE, UNPHU, UNAPEC, INTEC and the institutes INFOTEP and ITLA. While these educational institutions participate in this cluster in order to assist in the training

of human resources required in this sector, the academic interrelation with the companies over time can lead to advanced technological services.

Various universities have an interest in supporting entrepreneurship programmes. Moreover, MESCYT is working to promote a national entrepreneurship programme that involves students and professors in activities that can result in the creation of innovative companies. This programme is based on four pillars: the promotion of an entrepreneurial culture, the creation of university entrepreneurship and innovation centres, the strengthening of a network of business incubators, and a fund for entrepreneurship and business incubation.

In the first pillar, there has been intensive work on developing workshops and training seminars. Special attention has been placed on training instructors in entrepreneurship with the participation of experts from foreign universities, such as the Rochester Institute of Technology and Babson Collage in Boston. Work has also taken place to reform curricula to include issues of entrepreneurship and innovation in university programmes. Since 2009, two types of entrepreneurship competencies have been introduced at the university level: business ideas and business plans. In 2010, 120 proposals for technological projects were received from universities.

In the second pillar, seven university entrepreneurship centres have been created. These centres have received assistance from the Korean Advanced Institute of Science and Technology (KAIST).

In the third pillar, the Dominican Network of Business Incubators and Entrepreneurship (Dominican INCUBA) has been created. Furthermore, six directors of the incubators participated in an intensive entrepreneurship course at the Massachusetts Institute of Technology.

Finally, a seed capital fund of 1.2 million pesos has been created, and a prize of 100,000 pesos will be granted to the projects that win the entrepreneurship competitions. Prizes of 1.9 million pesos were awarded during 2009 and 2010. In 2011, the intention was to award 1.5 million pesos.

2. Bringing together the private sector and research and innovation institutions

This type of cooperation is also rather timid. Most public research institutions do not have the resources required for meeting companies' needs or their research does not meet companies' needs. For example, in the case of agriculture, IDIAF follows a policy of scientific and technological linkages, in the framework of which, 45 agreements were established with cooperation agencies and international research centres between 2004 and 2010. Agreements were also signed with 20 national and foreign universities (IDIAF, 2011).[11] IDIAF is also involved with the various clusters, and this collaboration with companies should be improved, because the companies consulted declared that IDIAF still does not have sufficient products that directly solve their problems. For example, citrus producers mention that they need to find a solution to the problem of a particular pest (*Diaforina citris*) and for that they require genetic engineering that IDIAF still cannot provide.

Perhaps the public institute that has most linkages with the private sector is IIBI. This institute offers a rather wide range of technological services and has good technological infrastructure. It has developed various products for companies that want to add value to typical Dominican products, including instant mangú flour and bottled mabi drink. Also, because there are several accredited laboratories, they can provide services to companies. IIBI has assisted several small companies to develop traditional agro-industry products that have been successful in the market.

3. Cluster initiatives

As already mentioned, one strategy included in the law on competitiveness is the promotion of clusters. Several multilateral organizations are assisting in the creation and strengthening of existing clusters. However, as mentioned earlier, the concept of cluster is being used in its most basic form. What is being promoted is an association of producers located in a specific area. However, there is no further work being done to promote the three fundamental elements of clusters: joint activities, collective efficiency and innovation.

That is what is clearly happening in the agricultural clusters. They are promoting certain crops in specific areas, in order to be able to provide a supply of products with export potential. Although farmers participate in an association, few joint actions have been carried out in each value chain (perhaps this is the form of industrial organization most adequate for identifying these associated producers and its related members). In the same way, there is little evidence of

clear activities aimed at raising collective efficiency and much less promotion of innovation. An example of this, is that in most of these chains there are still many bottlenecks in the production chain, specifically concerning quality and safety.

The law on competitiveness also mentions industrial areas and technological parks as competitiveness strategies. Activities have been restricted to the promulgation of a legal framework that promotes these industrial areas, but, except for the case of Parque Cibernético in Santo Domingo, little progress has been made in creating synergies for promoting innovation or transferring technology within these areas. Furthermore, through interviews, it seems clear that these areas are thought of as industrial enclaves and strategies have not been prepared for linking them with other Dominican companies.

D. GOVERNANCE OF SCIENCE, TECHNOLOGY AND INNOVATION

According to OECD (2005), governance refers to the systems and practices that Governments use to establish priorities and agendas, implement policies and obtain knowledge about their impact and effectiveness. Governance of innovation is knowledge intensive. A coherent and cross-cutting innovation policy requires organizing and using relevant knowledge in the decision-making process. There is a need to create and distribute knowledge that helps to develop a shared understanding among the various agencies dealing with innovation policy.

The design of the science, technology and innovation policy in the Dominican Republic corresponds to the Ministry for Higher Education, Science and Technology (MESCYT). However, given the nature of the functions of this ministry, its emphasis of action is on scientific and higher education policy. The object of these policies is to create scientific capacities that will produce and adapt knowledge that can later be applied to various productive and social activities in the country. The emphasis is on the development of the knowledge supply.

MESCYT has the President's support for improving higher education and financing science and technology activities. In fact, under its management the Parque Cibernético Santo Domingo was conceived as a measure for promoting the development of high technology industries in the country. Likewise, there is no interference in MESCYT's activities. Its mandate is clear, and its management structure gives it freedom of action over universities. Furthermore, in FONDOCYT it has a powerful policy instrument for encouraging research institutions outside its jurisdiction to carry out academic research.

In order to address demand issues, a policy framework of competitiveness has been prepared with the purpose of supporting companies through a strategy of building clusters and productive chains. The National Competitiveness Council (CNC) is the decentralized agency that applies that policy in the country. In contrast to MESCYT, this CNC is not at the ministerial level, and its field of action involves working with the private sector (companies). On the other hand, the scope of a competitiveness and innovation policy requires actions that fall within the work of the Ministry for Industry and Commerce, which requires a high degree of inter-institutional coordination and interaction with private actors, such as the main business associations.

The Dominican industrial sector is highly heterogeneous. As was mentioned earlier, approximately 90 per cent of the formal companies can be classified as micro and small companies while the companies that function in the free trade zones have greater technological capacities that allows them to compete in external markets. Although the strategy of free trade zones has been crucial for increasing exports and supporting economic growth, it also has created enclaves of productivity that have not been able to link with the rest of the Dominican productive sector. A competitiveness policy will have to achieve two goals. On the one hand, to raise the domestic technological frontier so that micro and small companies are able to increase their efficiency and productivity, thus establishing the basis for generating good employment and coordination with more advanced companies. On the other hand, this policy should try to raise the technological capacity of the more advanced companies in order for them to approach the international technological frontier, making them more competitive and capable of diversifying into more knowledge intensive sectors.

The CNC has opted for a strategy of building specific production clusters and chains. Given the low technological capacities of the companies they intend to support, it is necessary to have a range

of broader policy instruments that involve training, technical assistance, provision of credit, market information, improvement of the quality system, etc. and that will require very close coordination with the Ministry for Industry and Commerce and the Ministry for the Economy and Planning. Greater financing for programmes such as PROMIPYME or institutions such as PRO-INDUSTRIA is needed.

Financing STI is crucial for a country that invests approximately 0.25 per cent of its GDP in research and development, less than half of the Latin American average (Navarro 2009). The role of the Ministry for the Economy and Planning is crucial, and its relevance comparable to that of the ministries or institutions directly responsible for this policy, This same situation occurs in several countries in Latin America and it has been aggravated by the framework of austerity in which Governments usually operate. Thus, there is a conflict of interest in financing long-term programmes, such as those that support STI, competitiveness or industrial restructuring. Moreover, the lack of relevant information about this type of programmes and their results leads to the situation in which the Ministries for the Economy or Finance cannot take informed decisions in allocating the budget, which usually means that they opt not to finance these programmes.

Inter-institutional coordination must cover not only the activities of preparing and implementing policies but also the establishment of financial priorities. The only way to reach a budget compromise is through direct intervention of the President of the Republic, which although solves one problem also creates vulnerabilities as the institutional mechanisms of the Executive power are weakened.

E. NATIONAL SCIENCE, TECHNOLOGY AND INNOVATION POLICIES

As stated in section B.1, STI policy is defined by the law on higher education, science and technology (Law No. 139-01) and the law on competitiveness and industrial innovation (Law No. 392-07). These two laws define the institutional framework for this sector as well as the main activities of government entities for promoting STI activities. The basic guidelines for STI policy in the Dominican Republic are on the STI Strategic Plan and the strategies for economic growth based on the creation of clusters and industrial districts and on the promotion of free trade zones.

1. Strategic Plan for science, technology and Innovation 2008–2018

The main STI policy instrument that the Government of the Dominican Republic has used is the 2008–2018 Strategic Plan for Science, Technology and Innovation. This plan is based on the fundamental notion that knowledge creates public goods and positive externalities for society and the environment. It is based on the following basic principles.

- *Equity* through consideration of all social groups without distinction of gender, ethnicity and religion, among others;
- *Inclusion,* as it is intended to be a tool to facilitate social inclusion and poverty reduction;
- *Transparency* in assigning resources for drafting and implementing STI activities;
- *Participation* in the drafting of STI policy and the Strategic Plan;
- *Sustainability* as a consideration in all phases of preparation and implementation of this Plan, taking into account social, environmental and economic sustainability;
- *Welfare*, by ensuring that all the Plan's activities are aimed at providing the inter-generational well-being of Dominican society.

The Strategic Plan has four main components: the institutional and financial strengthening of the STI system, the development of a research and technological innovation programme, training of human resources for science and technology and the spread and social acceptance of science and technology. Table II.5 shows the Plan's components and its main activities.

As shown in table II.5, the Strategic Plan is highly ambitious and is designed to establish the institutional basis of the Dominican innovation system. It promotes behaviour changes so that its participants consider STI to be a central activity for generating wealth and social welfare.

In light of the functions carried out by the participants in the innovation system and that were presented at the beginning of this chapter, the various lines of action and activities proposed in this Strategic Plan cover those functions. The only point where there may be a vacuum is in market creation. The Plan

Table II.5. Components and activities of the Strategic STI Plan (2008–2018)

Strategic Goals	Líneas de Acción
Institutional and financial strengthening of the STI system	Revision and preparation of a new legal framework for STI Strengthening of STI inter-institutional and intrasectoral coordination and articulation capacities Strengthening of the National System for Innovation and Technological Development (SNIDT) Creation, reordering and implementation of the organizational structure of the National System for Science, Technology and Innovation Strengthening the National Science and Technology Information system Creation and improvement of STI infrastructure and equipment Building the capacity to finance the National System for Science, Technology and Innovation
Development of the research and technological innovation programme	Consolidation of basic research capacities Consolidation of research and development (R&D) capacities Consolidation of science and technology supply and of business innovation Promotion of university-business linkages Development of new knowledge-intensive sectors Building the incubation system and promotion of technology-based companies and businesses Creation of research and development networks
Training of human resources in science and technology	Strengthening the STI training structure Promotion of human resources training for the development of scientific, technological and innovative activities Development of the national programme for advanced training in science and technology Development of the programme of science and technology for business innovation and competitiveness Development of the mobility programme for scientific-technological staff Establishment of a national system of researchers
Dissemination and social adoption of science and technology	Promotion of the network for the dissemination and social adoption of science and technology Stimulate the national museum network to support the dissemination of science and technology Support efforts to consolidate the information society in the Dominican Republic Promotion of the science programme in schools Promotion of dialogue about knowledge for inclusion and development Young talent programmes for science and technology

contains no specific instruments for creating markets, such as a government procurement programme of intensive science and technology services, namely ICT services, that provides a very strong stimulus for software companies, or the promotion of higher added value products derived from typical Dominican products on which IIBI is already working.

The Plan's goal is to raise the percentage of GDP allocated to research and development investment in the country to 0.5 per cent by the end of the Plan's implementation period, that is, to double current investments in R&D. In order to achieve that goal and implement that Plan, an investment of 1,451 millions of dollars will have to be made over 10 year period (table II.6). Funds for financing the Plan will come primarily from transfers from the Government, tax incentives granted to companies and loans and grants from international donors.

Table II.6. Budget of the Strategic STI Plan, 2008–2018

Components	Investment (millions of dollars)
Institutional and financial strengthening of the STI system	551.36
Implementation of the programme of technological research and innovation	580.38
Training of human resources for science and technology	203.13
Dissemination and social adoption of science and technology	116.08
Total	**1,450.95**

2. Clusters and industrial areas

Clusters and industrial areas are forms of industrial organization that produce efficiency gains through geographical grouping and specialization. The experience of successful clusters in several countries in the world has led to the idea that clusters can be easily promoted and that they are a good strategy when the industrial tissue is formed by small and medium-sized companies.

In the Dominican Republic, the cluster strategy is focused on promoting the association of small producers whose production can be sold on export markets. The association of these producers can create an exportable supply and, therefore, access to more profitable markets. This strategy is clearly used in the case of agricultural clusters.

Nevertheless, the problem of implementing this strategy is that producers have very limited management and technological capabilities. That restricts the ability to join together and cooperate because competences are very heterogeneous and it is natural to want to join with peers at a similar level ("which can add up"). Furthermore, it is difficult to create a homogeneous exportable supply. One of the main problems of agricultural clusters is the rejection of shipments because of quality problems.

The promotion of associations must be accompanied by technical assistance programmes and financing in order to eliminate bottlenecks that prevent the development of production chains that form the heart of the cluster. Likewise, it is important to identify a common demand agregator for these chains in order to ensure a stable demand for producers. Another reason is that the link to international markets has to be made exclusively through a single player. It may be a good idea to look at the experience of USAID in Peru with the PRA project, which has been able to coordinate several production chains in dynamic markets (not only for export but also for domestic markets) and whose philosophy is "that we must sell what is bought and not only what is produced". Likewise, the competitiveness promotion programme of the Corporación Andina also has several successful experiences in various Andean countries, in which efforts have been made to associate and eliminate bottlenecks in production chains.

The experience of programmes encouraging association promoted by SEBRAE in Brazil stresses the creation of contractual obligations in order to prevent behaviour that runs counter to agreements (free riding) and create distrust among participants.

3. Free trade zones

The Dominican Republic is the country that has the most free trade zones in Latin America. According to Ibarra (2005), in 2004 there were 58 free trade zones in operation with 569 companies producing 189,000 jobs and 4,416 millions of dollars of exports. These figures make the Dominican Republic one of the region's leaders.

Despite the fact that free trade zones in the country have a rather broad level of sectoral diversification (including textiles, clothing manufacturing, footwear, electronics, health products and medical applications), there are other countries in the region that are specializing in attracting companies in highly dynamic sectors. For example, there were 1,500 companies located in 2000 in the Iquique free trade zone in Chile, which created approximately 10,000 direct jobs and more than 20,000 indirect jobs and CIF exports of 4,000 millions of dollars (Ibarra 2005).

Although free trade zones have been a successful strategy for promoting exports and economic growth in the Dominican Republic, changes in the global economy require that this policy instrument be updated and adapted to new conditions. The challenge of free trade zones is for them to become part of global supply chains. In that sense, Ibarra (2005) points out that what is needed is to develop the local logistic services market, which requires the development of world-class infrastructure and of the productive market, and to establish adequate legislation. Sgut and Cañas (2004) state that the main weakness in logistics concern difficult Customs requirements, land transportation of freight and a lack of trained manpower.

One weakness of the Dominican free trade zones is the lack of interaction between the companies located there and local companies, thus losing the opportunity to produce technological spillovers and transmit economic stimulus to local industry. Ibarra (2005) recommends creating a mechanism for partial processing that allows products that begin their processing in free trade zones to continue their production in the rest of the Dominican Customs territory and be reintegrated into the free trade zones. Subcontracting to satellite companies would be authorized by Customs. Local manufacturers could

then provide services in the free trade zones. Several of these recommendations have been included in changes made to Law No. 8-90 in 2007.

F. INSTRUMENTS FOR SCIENCE, TECHNOLOGY AND INNOVATION

Strategies for promoting competitiveness in the Dominican economy have been accompanied by STI instruments, many of which have been implemented cautiously. This section reviews competitive funds, the scholarship programme, intellectual property rights, fiscal and financial incentives, quality regulations and norms and public procurement.

1. Competitive funds

One of the STI instruments that is being used successfully is the National Innovation and Scientific and Technological Development Fund (FONDOCYT). This fund was created in the 2001 by Law No. 139-01 in order to promote scientific and technological research. This fund can also finance activities for innovation programmes and projects. However, it was only in 2005 that calls for tenders were opened for financing research.

As shown in figure II.3, the fund has grown steadily with some accesleration over the last two years. Representatives of FONDOCYT declare that this growth is the result of greater awareness and spread of information about the fund among eligible institutions and the prestige that it has gained within the academic community. Likewise, they state that there are currently no limitations on the fund's size, and the fund should continue to increase to cover the growing demand of the academic community. In terms of areas of research, table II.7 shows that during 2005–2009 FONDOCYT has given preference to financing projects in basic sciences, health, biomedicine and biotechnology.

The main beneficiaries of this fund have been research institutes such as IIBI and IDIAF, which together obtained contributions that are the equivalent of 41 per cent of the funds granted. Likewise, the country's most prestigious universities have attracted a large proportion of the funds. UASD has received 20 per cent of the funds, PUCMM 12.3 per cent, INTEC 9.5 per cent and ISA 5.7 per cent (see table II.7).

Figure II.3. Evolution of FONDOCYT, 2005–2009 (dollars)

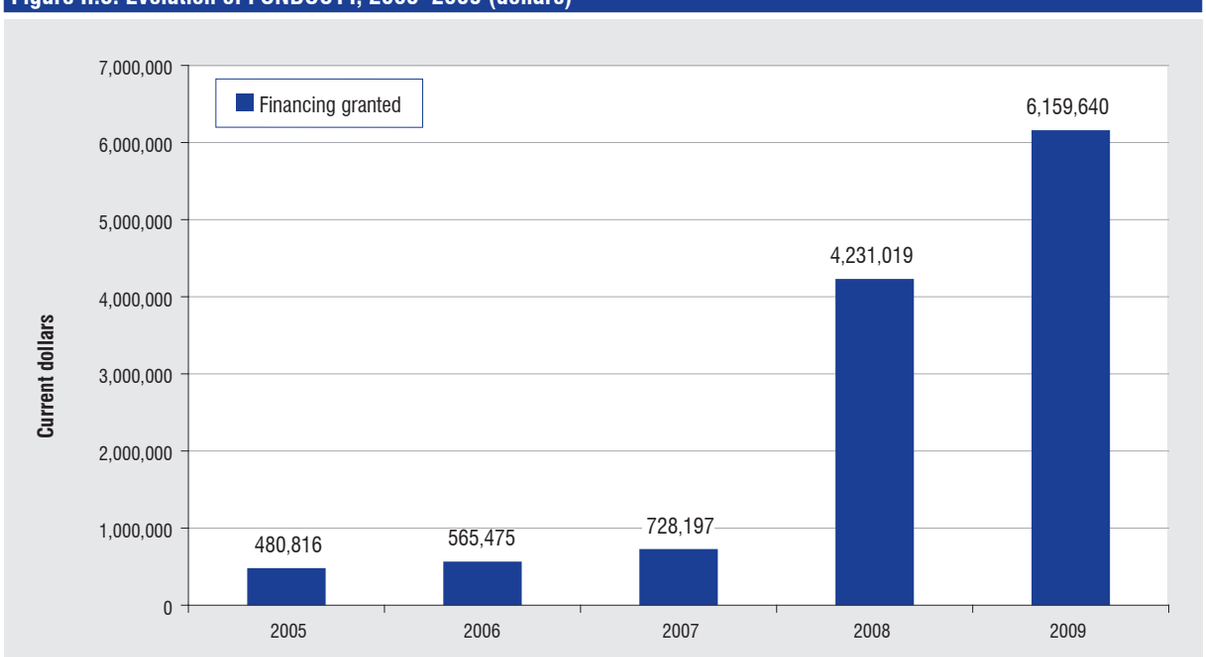


Table II.7. Beneficiaries and FONDOCYT contribution, 2005–2008 (in pesos)

Beneficiaries	FONDOCYT contribution	%
Centre for Plant Biotechnology (CEBIVE)	2,560,522	1.2
Institute for Innovation in Biotechnology and Industry (IIBI)	46,482,871	22.6
Dominican Institute for Agrarian and Forestry Research (IDIAF)	37,620,951	18.3
Higher Institute for Agriculture (ISA)	1,166,379	0.6
Technological Institute of the Americas (ITLA)	3,333,450	1.6
Technological Institute of Santo Domingo (INTEC)	19,530,810	9.5
National Meteorology Office (ONAMET)	2,956,000	1.4
Pontifical Catholic University Madre y Maestra (PUCMM)	25,350,772	12.3
APEC University (UNAPEC)	2,918,705	1.4
Autonomous University of Santo Domingo (UASD)	41,124,136	20.0
Pedro Henríquez Ureña National University (UNPHU)	2,532,200	1.2
Technological University of Santiago (UTESA)	6,266,197	3.1
Miscellaneous	3,054,617	1.5
TOTAL	**205,391,611**	**100.0**

Source: MESCYT – FONDOCYT.

2. Scholarship programme

As described earlier, STI stresses stimulating the supply of highly qualified human resources that can carry out academic research for creating knowledge in the country. Thus, an ambitious programme of post-graduate scholarships in universities abroad has been implemented. As can be seen in table II.8, during 2005–2009 4,556 scholarships were awarded, of which 929 were for undergraduate studies and 3,627 for post-graduate studies.

Table II.8. MESCYT scholarships for study abroad, 2005–2009

	Undergraduate	Post-graduate	Total
2005	215	190	405
2006	126	483	609
2007	189	791	980
2008	325	1,390	1,715
2009	74	773	847
Total	**929**	**3,627**	**4,556**

Source: MESCYT.

The scholarship programme has been expanded during the past two years. According to the information facilitated by the Ministry for Higher Education, Science and Technology, 1,345 scholarships were granted in 2010 and that rose to 1,656 in 2011. All together almost 8,000 scholarships have been granted since the programme began in 2005. Likewise, a programme of scholarships in ICT aimed at building capacities in one of the sectors prioritized by the Government has begun.

The fruit of this programme should have effects in the short and medium term as trained personal begin to meet the demand of the more dynamic sectors of the Dominican economy. However, it is important to mention that efforts have to be made to build demand for professionals working in scientific and technological research. Thus, the national research institutes and universities must be reinforced in order to be able to attract graduates of PhD programmes.

3. Intellectual property rights

The signing of the Free Trade Agreement with United States (DR-CAFTA) has created a series of obligations in the field of intellectual property aimed at creating a better business environment and

attracting foreign investment (Rivera 2005; Genovesi 2010). That has required accession to a series of international treaties signed with the World Intellectual Property Organization (WIPO), including treaties on copyrights, patents, recognition of micro-organisms and trademarks.

As for trademarks, it was required that an electronic system for the application, processing and registration of trademarks be created and an electronic database be made available to the public. Likewise, it was stipulated that activities related to the pirating of satellite signals be legally defined as a specific offence.

As for patents it was required that ONAPI make the process for granting them more flexible. Because Dominican legislation requires a system for fully reviewing patent applications, training and other capacity building for examiners were provided.

These changes seem to have had favourable results in patent applications by Dominicans. According to declarations of an advisor to ONAPI, three years after the signing of the DR-CAFTA, applications have been made for 11 international patents, which is a record in comparison with the other Central American countries that have also signed CAFTA. Likewise, that official stated that collective trademarks for exports complying with international quality standards and prestige have been used (Revista Summa 2010).

4. Fiscal and financial incentives

Fiscal and financial incentives have been used extensively in the Dominican Republic for promoting industrial activity.

First, free trade zones grant a series of tax benefits for companies that locate there, including income tax, taxes on imports and exports and on construction. Likewise, transport equipment and other equipment that serve to provide services to their employees also are freed from import taxes. In order to promote cooperation between companies in the free trade zones and local companies, the amended law on free trade zones permits duty free transfer to Customs warehouses of products from the textile, confection and accessories, animal skins, manufacturing of footwear and leather chains.

However, as described in section B.6, the changes imposed by globalization require that the benefits of free trade zones are complemented with advanced services in logistics, adequate infrastructure and qualified human resources for attracting high technology companies or companies interested in locating their global supply centres in the Dominican Republic.

Second, within the framework for promoting competitiveness and industrial modernization (Law No. 392-07), companies that introduce innovations will be able to depreciate at a faster rate (double) the value of machinery, equipment and technology acquired. Likewise, it will be possible to deduct up to 50 per cent of the income tax from the previous year for investments in machinery, equipment and technology. Finally, fixed assets acquired for renovation of the industry will not be considered as taxable. Towards the end of 2009, that classification had been granted to 259 companies allowing them to have access to these benefits.

Third, the law on reactivating exports (Law No. 84-99) grants reimbursement of taxes and Customs duties paid by exporting companies on raw materials, inputs, intermediary goods, labels, packaging and imported packaging material. Likewise, a regime of temporary admission was established for all export products. Finally, tax on the transfer of industrialized goods (ITBIS) that are exported are reimbursed.

5. Quality norms and regulations

One of the weak points in the export policy promoted by the Dominican Government is that of quality norms and regulations. The low technological capacity of the micro and small companies that mostly make up the industrial sector results in very low quality of production, and that production does not conform with national and international technical standards. Weak regulatory institutions and a lack of quality infrastructure, primarily the lack of accredited laboratories, do not help to redress this situation.

As a result, exporters in the agricultural clusters have problems satisfying the quality requirements requested by North American importers, making the Dominican Republic one of the 15 countries with the greatest number of rejected shipments.

DIGENOR is taking steps to build its institutional capacity by subcontracting requests for certification to the Spanish agency AENOR for processing. Likewise, technical cooperation programmes, including a project for assisting the agro-industry to become more competitive (PATCA), financed by IABD, plan to deal with the issue of sanitation and food safety in its second stage.

G. LINKS BETWEEN INNOVATION POLICIES AND OTHER POLICIES

The Dominican Republic has recently begun a series of deep transformations in the Government aimed at establishing the basis for ensuring "competitive and sustainable growth that permits generating productive employment and remunerative salaries, thus promoting integral human development of the local population" (National Competitiveness Council 2007).

Two of the tools that are serving to guide these changes are the "National Competitiveness Systemic Plan" and the "National Development Strategy 2010–2030". Both documents define a long-term vision in which the country is fully integrating into the world economy and which requires the maximisation of its resources to develop in an innovative and sustainable manner. There is an explicit declaration of the importance of the promotion and use of innovation and, therefore, of science and technology in all productive activities that favour participaton in the world economy.

Nonetheless, when examining in detail both documents, the issue of STI is not seen as a cross-cutting policy but as one point among the policies to be implemented.

In the case of the National Competitiveness Plan, the concept of innovation in the national innovation system is considered a function of development of high technology or knowledge industries. Progress has been made in some of these industries, such as in the case of ICT, where it is hoped to develop software providers and an industry of call centres, although this industry is not most advanced one of the ICT sector. Other potential sectors for development are biotechnology, for which there is no particular plan except use of IIBI; mechatronics, in which the country has no particular advantage, except several courses at ITLA; and nanotechnology, which is planned to be included in the university curricula.

In developing the priority productive sectors listed in the National Competitiveness Plan (tourism, agro-industry, manufacturing and construction), there is explicit mention of using innovation to correct weaknesses in each value chain or identified needs. What is missing is identification of participants responsible for satisfying these needs or a strategy to be followed. In the specific case of tourism, which is one of the country's main industries, there is no mention of the issue of STI for the development of competitive and sustainable tourism. The pillars identified on which this sector must grow are: infrastructure and land use planning, human resources, promotion, sanitation, public safety, community integration and development of social capital and communications (National Competitiveness Council 2007).

The issue of STI is included in the National Development Strategy in strategic axis 3, which calls for "An articulated, innovative and sustainable economy with a productive structure that creates high and sustained growth with decent employment and which is inserted competitively in the global economy" (Ministry for the Economy 2010). However, when the specific goals are examined, there are only two that explicitly deal with this issue. In the axis "Promotion of development of research, science, technology and innovation as the means for introducing knowledge into society and the economy" only the strengthening of the innovation system and of linkages between universities and the productive sectors are mentioned. The strategy then describes other activities related to the supply of STI.

The strategic goal "to achieve universal access and productive use of information and communication technologies" only proposes activities related to digital literacy, expansion of infrastructure and promotion of ICT use in the public and private sectors.

Finally, in the strategic goal related to raising the competitiveness of agricultural chains, there is mention of a specific activity concerning the need to "promote research, technological development and innovation for improving production processes, processing and marketing of agriculture, livestock and forestry products" (Ministry for the Economy 2010).

H. THE EFFECTIVENESS OF THE DOMINICAN INNOVATION SYSTEM

As was stated in section A of this chapter, the effectiveness of innovation systems in achieving the goal of "creating, disseminating and using knowledge" depends on the capacity of the participants in the system to implement a series of functions that contribute to this goal. This section evaluates the implementation of these functions.

1. Knowledge development

The Dominican innovation system is in a formative stage. Work has begun to provide an institutional basis for the system through MESCYT and CNC.

MESCYT has taken the lead in developing knowledge. Its policies for improving the quality of higher education aim at establishing the basis so that universities can fulfil this function. Its emphasis on supply seeks to generate a critical mass of researchers that can begin to produce knowledge in the priority areas identified in national plans. Taking the above into consideration, the emphasis that its more powerful STI instrument (FONDOCYT) gives to academic research must be evaluated, because only universities and research institutes can be the direct beneficiaries of these funds. Companies and technological institutes can only be indirect beneficiaries if they associate with universities or research institutes.

On the other hand, the Government of the Dominican Republic is making a serious effort to produce knowledge that can be used in vocational training in order to be able to satisfy industry's requirements. The National Institute for Technical Vocational Training (INFOTEP) is the institution charged with leading, coordinating and promoting national vocational training for the productive sectors, taking into account the training needs of the economic units. INFOTEP provides five types of vocational training: accreditation, complementary education, continuous training in centres, dual training and training of technical teachers.

Likewise, INFOTEP has a service aimed at supporting competitiveness and increasing companies' productivity. This service has a programme for managing knowledge, focused on promoting a culture of continuous improvement in many business processes. Furthermore, it provides competency-based training services and support services to entrepreneurs.

2. Influence on the direction of search

The National Competitiveness Plan defines various sectors as strategic for achieving competitive and sustained growth. These sectors are tourism, agro-industry, manufacturing and construction. The same plan defines several technologies that must be promoted in the Dominican Republic, such as biotechnology, ICT and nanotechnology.

In the case of the first two technologies, the Dominican State has institutions and initiatives that can serve as the starting point for channelling research. In the case of biotechnology, IIBI and IDIAF provide research services for the agricultural and industrial sectors. Likewise, there have been initiatives for the development of agro-industry clusters and in several of those concrete needs for the application of biotechnology have been identified, especially those linked to the need to produce seeds or genetic material resistant to pests and diseases.

In the case of ICT, there is a coordinated strategy for promoting the software cluster, which provides research capacities, training of human capital and infrastructure, among others. It is important to mention that there is an important, potential, participation of the private sector in this cluster in implementing training and research activities.

In the case of nanotechnology, there is no concrete evidence that the Government, academic institutions or the private sector are seeking to carry out research using this technology. There is also no clear idea of the use that would be given to this technology or its potential users.

As for the results of the previous projects or at least demand for research financed by FONDOCYT, it can seen that the financed technologies or knowledge areas were basic sciences, health and biomedicine, and biotechnology to which 3.8, 2.0 and 1.9 millions of dollars were allocated respectively (see table II.9). Likewise, these three disciplines are those that have a greater number of financed projects, although it is important to stress that health and biomedicine projects have a greater average cost than the two other knowledge areas (175,000 dollars for health versus 140,000 dollars for basic sciences and 70,000 dollars for biotechnology). It is also important to point out that the financing of research on biotechnology and genetic resources, projects probably focused on satisfying agricultural sector needs, reached 724,000 dollars (five projects were financed at an average cost of 145,000 dollars).

The previous figures indicate that biotechnology is an knowledge area in demand. The financing of biotechnology and biotechnology and genetic resources reaches 2.6 millions of dollars. Likewise, it is important to mention that the financing granted also responds to the availability of scientists with the capacity to produce research proposals that meet the requirements demanded by FONDOCYT.

Table II.9. FONDOCYT financing, 2005–2009 (current dollars)

Area of science	Total financing 2005–2009	Number of projects financed
Basic sciences	3,784,004	27
Health and biomedicine	1,919,735	11
Biotechnology	1,888,044	27
Environment and natural resources	985,168	11
Sustainable production and food security	889,285	9
Biotechnology and genetic resources	723,764	5
Energy and biofuels	715,168	4
Development of hardware-software and innovation	630,235	4
Energy	125,679	3
Productive innovation	96,874	1
Food technology	95,768	2
Atmospheric sciences and climate change	85,905	1
Material research/applied physics	77,053	1
I+I in engineering	73,889	2
Health	74,573	2
Total	**12,165,144**	**110**

ICT projects received 630,000 dollars of financing, with an average financing per project of 158,000 dollars. This low level of financing compared to that of biotechnology projects could be an indication that there is a scarcity of researchers in this field. In fact, one of the limitations mentioned by the participants in the software cluster is the lack of trained human resources.

Finally, although there is no field for nanotechnology in table II.9, a likely estimation would be the financing for materials research is one of the uses for nanotechnology. Only one project in materials research has been financed, for 77,000 dollars.

3. Resource mobilization

As mentioned earlier, STI initiatives are not cost free. Many resources must be mobilized. In the previous section, we have seen that in the past five years the Government has financed 12 millions of dollars of research projects through FONDOCYT. However, the total amount of resources mobilized has been many times more.

For example, multilateral cooperation has channelled significant resources for promoting and strengthening clusters. The scope of action of these projects covers the areas of technical assistance, promotion of association and, in several cases, training of human resources.

An area that is somewhat neglected, despite being labelled a priority in both plans, is manufacturing. The programmes for assisting this sector are managed by PRO-INDUSTRIA, and in the interviews it was stated that there is no or, at any rate, a very low budget. Therefore, use is being made of a Banco Agrícola fund, which at some time was managed by PRO-INDUSTRIA. However, these funds are being used for business incubation and very little is being done to promote the dissemination of good practices or the transfer of technology. This is an issue that was identified at the beginning of the 2000s, at a time when it was proposed to finance an industrial extension system with an IADB loan (Mullin Consulting Inc. 2003), but this was rejected. For companies in free trade zones to coordinate with local industry, a system such as this must be implemented so that local companies can increase their capacity and satisfy the technical requirements of exporting companies. The law can provide tax incentives, but without eligible local companies, it will be impossible to take advantage of those incentives.

Another issue related to manufacturing and the private sector is the lack of a fund for business innovation. As was mentioned, FONDOCYT is a fund aimed at the academic community and although companies can participate in it, they cannot do so directly. The characteristics of an innovation fund are different from those of a research fund. An innovation fund seeks to decrease risks associated with the implemention of innovation activities with the hope that companies will have an incentive to innovate. The experience in several countries of the region indicates that these funds have positive benefits. It is recommended that a similar fund be established.

Resource mobilization also concerns the provision of infrastructure. It has previously been mentioned that there is a lack of laboratories in the country. There are few universities and research centres that have properly equipped laboratories provided with human capital for carrying out basic and applied research. Attempts are being made to revert this situation through the construction of a laboratory complex at UASD. On the other hand, the country has a precarious laboratory infrastructure for standards testing and conformity evaluation. For a country that is seeking to compete on the international market this is a bottleneck that must be overcome.

Related to that is the issue of power supply. Through the interviews held with representatives of various industries and clusters, the lack of reliable constant power supply is a major bottleneck.

Finally, as was mentioned, something is being done to mobilize resources for promoting entrepreneurship. Through PRO-INCUBE and its entrepreneurship programmes, an attempt is being made to promote new companies. Seed capital projects are being carried out timidly and should be pursued more aggressively.

4. Market formation

This is an issue that has seen very little activity. Innovation is a risky business and requires sending innovative companies the message that they can count on established markets that allows them to recover their investment in developing innovative products or services. The Government can create markets through regulations, direct industrial promotion, or through public procurement.

A major weakness of the Dominican Republic is its regulatory environment. The most representative example is the power generation sector. Although the sector has undergone a process of privatization that would have allowed the sector to modernize through investments and the establishment of an institutional and regulatory framework for the proper functioning of this market, the reality is that the functioning of the electricity market leaves much to be desired. There are substantial power losses throughout the entire network, the system cannot satisfy demand effectively and it often collapses at times of peak demand. Energy is sold at places prohibited by legislation, and the regulatory agency does not have the capacity to regulate this market. As a result, power cuts affect all the country's productive activities.

Attempts to promote other energy forms require establishing regulatory norms that guide the development of markets for alternative energies. In the case of bioenergy, there is no norm that sets the characteristics and percentage of biofuel required in fuels for various uses. The establishment of this percentage was crucial for the development of the biofuel market in Brazil. The issue of energy is discussed in greater detail in chapter V.

Secondly, the promotion of industries or products requires more than simply eliminating bottlenecks. Other steps must be taken to give clear signals that a developed market exists. For example, in the case of Peru the development of the natural gas market was backed up by the establishment of a preferential price for gas used for the generation of electricity. With gas costing less than oil for this use, it has been possible to use natural gas, and now demand has widely exceeded the initial projections.

Thirdly, government procurement is a good instrument for creating markets. If the development of a software industry is sought, the Government can request the digitization of management systems of Dominican public entities. From the systematization of clinical histories for hospitals to the interconnection of the Customs database and the General Office for Domestic Taxes, these are important business opportunities and a relatively important market for software companies. The same can be said for promoting a pharmaceutical industry or a medical exams and instruments sector that support the public health system. What must be included in the public calls for tenders is that they guarantee that the goods and services requested comply with quality and innovation criteria.

5. Legitimisation

This function is being carried out timidly to promote several national products but should be done much more aggressively. For example, there is not much promotion of Dominican textiles and clothing manufacturing or footwear although much experience has been gained in producing these products in the free trade zones. Sánchez-Ancochea (2006) reports that there are several textile companies that have moved beyond the assembly model and that have become efficient producers that sell to external markets. A government campaign based on a seal of quality could open up a domestic market interesting for these and others companies.

6. Entrepreneurial experimentation

Entrepreneurial experimentation is basic for producing innovation but it is highly risky. The role of government programmes is to help companies decrease that risk. A form of direct support is the implementation of an innovation fund. IADB has all the methodology for developing and implementing these funds, which have been rather successful in several countries of the region.

It is necessary that the Government's efforts and support not only promote the science, technology and innovation supply. It is also important to address the issue of business innovation demand and this requres programmes that decrease risk and create markets.

7. Development of positive externalities

The Dominican Government has been very active in this issue. Using clusters and industrial zones as the basis for a country's competitiveness strategy to produce positive externalities by agglomeration.

In order for these economies to be used effectively, support programmes for technology transfer and diffusion must be promoted. That is happening in the case of the agricultural clusters. Most of the programmes have actions aimed at this issue and, to a lesser degree, to provide trained human resources. However, it is also necessary to combine this function with the development of markets. Many of the cluster programmes are not working on the issue of developing markets. There is a successful example that could be considered of the development of productive chains in Peru financed by USAID. The programme secured a market by strengthening the buyers' of the supply chain (the actors that articulate the chain), and once buyers were identified the small producers were supported.

I. CONCLUSIONS AND RECOMMENDATIONS

The Dominican innovation system is a system in its initial stages. All the norms and laws needed to give it sufficient institutional stability have been established. Likewise, a development strategy has been established that places STI as a support pillar for the system. Lastly, a certain amount of resources required for the functioning of the system have been mobilised. An important example of that are the resources allocated to FONDOCYT.

Nonetheless, the system still needs to be strengthened. It is important that at the same time that organizations and programmes aimed at improving scientific and technological research and training highly qualified human resources are being strengthened, efforts are also made to promote technological innovation in companies.

The supply of STI resources will be sustainable only if there is a demand that requires these services and capacities. Otherwise, the Dominican Republic may invest in human resources that would later be forced to emigrate for lack of employment opportunities in the country.

Because the Dominican innovation system is in a formative stage, most activity has been launched by changes in regulations and legislation. However, it is important to move on to a stage at which incentives begin to act. For example, in order to achieve connections between universities and companies it is necessary that both parties know that such linkages will produce benefits for both sides. Grants, such as those by FONDOCYT or a specific innovation fund, should be awarded to projects in which there is cooperation among participants, both associated companies as well as between companies and universities or other types of institutions.

Finally, it is important that the manufacturing sector has access to technical assistance programmes. Achieving greater competitiveness implies raising the productivity of all companies. Only in that way will it be possible to create links between the more advanced companies in the free trade zones and the rest of local companies.

NOTES

[1] The Secretariat of State for Higher Education, Science and Technology was recently renamed the Ministry for Higher Education, Science and Technology (MESCYT).

[2] PRO-INDUSTRIA is the agency whose goal is to promote industrial development in the Dominican Republic. This agency was formerly called the Corporation for Industrial Promotion, which was created in 1966.

[3] Currently the Ministry for Higher Education, Science and Technology (MESCYT).

[4] Guzmán, R., Feliz, J., García, M. M. Jiménez and J. Liz (2011). Encuesta de innovación 2010.Santo Domingo: Grupo Consultoría Pareto and MESCYT.

[5] CONIAF, 2011.

[6] According to the Dominican Confederation of Small and Medium Enterprises (CODOPYME), companies are divided by size into micro-companies (2 to 9 employees), small companies (10 to 50 employees) and medium-sized companies (51 to 100 employees). In terms of annual sales, micro-companies have annual sales of less than 1 million pesos; small companies have sales of more than 1 million pesos but less than 7 million pesos; and medium-sized companies have annual sales of more than 7 million but less than 20 million pesos.

[7] The clusters used are the Dominican avocado cluster in Cambita San Cristóbal (CAD), the banana productive sector (COPROBANA) in Mao and Azua, the coffee cluster of Jarabacoa (CCJ), the yuca and casabe cluster (CYC) in Montion, the Cluster of Constanza Hortíco (CHC), the Dominican mango cluster (PROMANGO) in Bani and El Sur, the furniture cluster of Santiago (CMS), the asociation of pineapple producers of Cevicos (APROPIC), the agricultureal cooperative Union Zafarraya in Moca and the Cibao, the greenhouse cluster of Jarabacoa (CIJ), the federation of farmers of the Noroeste (FEDEGANO) in Santiago Rodríguez and the Noroeste , the confederation of Dominican cocao producers (CONACADO), the coffee growers community action (MOVICAC), the group of coffee growers and farmers of San Cristóbal (NACAS), the federation of coffee growers and farmers of San Juan (FECADESJ), development foundation of Loma and Salud (FUNDELOSA), the agricultural commercialization and services cooperative (Red Guaconejo); and the producers association of Vallejuelo.

[8] MESCYT (2011).. MESCYT, Santo Domingo.

[9] Guzmán et al, 2011. Encuesta de Innovación 2010.

[10] UASD (2011), Medidas implementadas por la UASD para el fortalecimiento de la investigación, Universidad Autónoma de Santo Domingo, Santo Domingo.

[11] IDIAF (2011), Dominican Institute for Agrarian and Forestry Research, Santo Domingo.

III

Science, technology and innovation in agriculture and agro-industry

According to CEDAF (2000), the national agricultural and forestry research system "is made up of all the institutions that observe, evaluate and describe biological phenomena that affect agriculture, animal husbandry and natural resources. The universe of institutions that carry out these activities include government agencies, educational institutions, non-governmental organizations, private companies and government-operated companies".

According to Rojas and Santana (2002), the agriculture and livestock sector of Dominican Republic has undergone important institutional changes over practically the entire twentieth century. During the first decade of that century (1900–1910), the first steps were taken to establish an agricultural school and construct an experimental station in the Dominican Republic. The experimental station opened its doors in 1908 in the municipio of Haina. In 1925, the Institute Agronómico Salesiano was founded. Ten years later, in 1935, the Secretariat of State for Agriculture (SEA), at that time the Secretariat of State for Agriculture, Industry and Commerce, created an agricultural research service, which carried out and supported various research activities. Between 1940 and 1950, SEA drew up a long list of good intentions for promoting agricultural research and creating infrastructure to provide training in agricultural research. However, those efforts had a short life, owing to institutional weaknesses.

A. THE NATIONAL AGRICULTURAL AND FORESTRY RESEARCH SYSTEM

It was only at the end of the Trujillo Era (1930-1961) that the basis for what was hoped would be a national agricultural research system was established. In 1946, the San Ignacio de Loyola Agricultural College (CASIL) was established and in 1952 the Loyola Polytechnical Institute. Central Romana, a large Corporation financed by foreign capital and dedicated to producing and marketing sugar, has operated its agricultural research division since 1947.

During the 1960s, the agriculture and livestock sector continued to develop its institutions. In 1962, the Autonomous University of Santo Domingo (UASD) created the School for Agronomy and Veterinary Sciences, and four years later the National Pedro Henríquez Ureña University (UNPHU) established the School for Agricultural Sciences and Natural Resources. In 1962, thanks to the coordinated initiative of the business sector in El Cibao, the country's main agricultural region opened its doors to the most important institution in the agriculture and livestock sector: namely the Higher Institute for Agriculture (ISA). The institutions mentioned, nonetheless, have focused on technical training for the agriculture and livestock sector, and their contribution in terms of scientific research has been very limited.

Agricultural research was formally established in 1965 by Law No. 8 that created the Department for Agriculture and Livestock Research (DIA) and the Under-Secretariat for Research, Extension and Agricultural Training, both under the Secretariat of State for Agriculture (Rivera and Brioso 2007). In the 1970s, the creation and transfer of technology were given priority in the agriculture and livestock sector, with strong support from the integrated programme for agriculture and livestock development and with foreign financing.

After a bit more than a decade of bonanza, DIA "lost all its ability to function, which was made evident by its low capacity for attracting financial resources and loss of human resources and institutional independence" (CEDAF 2000). Research was postponed and the infrastructure for the research deteriorated from lack of use and government support (Rivera and Brioso 2007).

In 1985, by recommendation of ISNAR, Dominican businessmen and the United States Agency for International Development (USAID), Law No. 289 was adopted, which created the Dominican Institute for Agricultural Research. That law was not applied, and the institute never started operating. At the end of the 1980s, another institution was created, the Foundation for Agriculture and Livestock Development (FDA), by private sector initiative with the support of the Dominican Government and USAID. FDA, which later changed its name to the current Centre for Agriculture, Livestock and Forestry Development (CEDAF), supported research with grant financing, training activities and documentation and information services. The limited resources available left very little room for research activities, leading to a very critical situation in the 1990s.

Figure III.1. SINIAF

Source: CEDAF, 2000.

In September 2000, the Government decided to strengthen the National System for Agricultural and Forestry Research (SINIAF), through the creation of the Dominican Institute for Agricultural and Forestry Research (IDIAF) (created as IDIA in August 1985 by Law No. 289) and the National Agricultural and Forestry Research Council (CONIAF).

These government efforts became operational through Decree No. 686-00 naming the directors of CONIAF and IDIAF and Decree No. 687-00 that created CONIAF and made IDIAF operational. Figure III.1 shows relationships within SINIAF.

According to IDIAF (2009), the main elements of the new institutional organization are (a) the National Agricultural and Forestry Research Council (CONIAF) and the National Agricultural and Forestry Research Fund (FONIAF) as the institutions responsible for setting policies and priorities (CONIAF) and establishing the conditions for expanding and diversifying the system's financial basis and promoting greater interaction among its components (FONIAF), and (b) the Dominican Institute for Agriculture and Forestry Research (IDIAF) which is responsible for implementing programmes and projects resulting from the policies and priorities adopted. With these new initiatives, it was hoped to break the status quo of low productivity in relation to the resources invested in research and development of agricultural technology, which had settled in as a consequence, in large measure, of the institutional limitations that the former Office for Agrarian Research faced, as an administrative dependency of the Secretariat of State for Agriculture.

According to what was stated during an interview with the management of CONIAF, 116 projects for a total of 102 million pesos (approximately 2,652,000 dollars) have been financed since 2002 in the four priority areas of food safety, biotechnology, livestock research and natural resources.[1]

About 39 per cent of the investment in projects has been for research in rice, 22 per cent for Asian vegetables, coffee, cacao, fruit and crops in controlled environments, 24 per cent for projects that improve environmental water resources, the potential for carbon capturing in agroforestry production systems and identification of fauna and flora, 8.8 per cent for obtaining new varieties of crops of national interest used in the daily Dominican diet, and 5.4 per cent for projects dealing with low yields and losses in rice production.[2] Rice is a clear priority, but other crops and technological applications receive minor support with a tendency to disperse resources. A look at the titles of the projects supported by CONIAF published on its home page leads to the conclusion that the projects cover research for gradual improvement or adaptation of technology, of relatively limited novelty.

IDIAF is without a doubt the most important agricultural research institution. It has implemented 47 projects financed by CONIAF, representing 45 per cent of its resources. Between 2005 and 2008, it received support of more than 37 million pesos for its projects, and it has a large staff with 136 researchers, of which 7 per cent have Ph.D.s, 38 per cent have M.A.s and 55 per cent have engineering degrees (Pérez, 2011). Nine per cent of its budget comes from its own funds. Its most important results have been the creation of three new varieties of rice, four of beans, two of pigeon peas, one of yucca for the export market and three of yucca for processing. It has also created technology for propagating bananas, improved clones of cacao, control of soil pathogens and organic production. As for livestock raising and aquaculture production, low-cost diets for ruminants and techniques for fish production in floating cages, among other relevant technologies, have been developed.

B. INSTITUTIONS WITH A POTENTIAL FOR INNOVATION IN THIS SECTOR

Various academic institutions in the country carry out important activities in the agriculture and livestock sector that can contribute to the improvement of productivity and competitiveness in the agro-industry. Among the institutions with the greatest potential in the sector is the Autonomous University of Santo Domingo (UASD), with the following units active in research: the School for Agriculture and Veterinary Sciences (FACV) and the Science Department (FC). FACV is divided into three departments, agricultural engineering, veterinary medicine and zootechnics, and manages the Institute for Agricultural Research, the Institute for Studies of Animal Diseases, the Engombe Experimental Station and the Dairy Training Centre (CAL), which transfers technological innovations to small and medium producers for the improvement and development of dairy products and their by-products (cheese, butter and yoghurt).

The Science Department, through the Marine Biology Research Centre (CIBIMA), is responsible for research and information on marine coastal resources and aquaculture, as well as environmental quality and the biochemistry of natural products for use in medicine. During interviews held for this survey, a visit was made to UASD to discuss with the directors of the seven schools and eight institutes of the Science Department. It was very clear that research is a secondary priority, because academics that chose a research career earn significantly lower remunerations than those who go into teaching. The experience of providing services is only just beginning.

Another institution with active participation in the field of agricultural research is the Pedro Henríquez Ureña National University (UNPHU). Within that university, the School for Agricultural Sciences and Natural Resources (FCRN) is the unit responsible for coordination and management of the study programmes in the careers of agricultural engineering, veterinary medicine, animal production, agricultural economy and natural resources. That School is formed by the School for Agronomy, the School for Animal Production, the School for Veterinary Sciences and the Department for Natural Resources. That faculty offers technical degrees and agricultural skills in animal production.

The Higher Institute for Agriculture (ISA) is another important academic institution in the national agriculture and livestock sector. It began as a specialized agricultural institute in 1962. It is the fruit of a private, non-profit initiative. In 1986, it acquired the university status and now offers a broad curriculum. ISA has a research policy and programme focused on agriculture, specifically in the fields of animal production, agronomy and natural resources. This programme is supported by a policy that requires students to write a graduation thesis. The resulting technologies are transferred to producers through seminars and workshops.[3] The institute also provides extension programmes and services, which are implemented through its Training Centre for Rural Development (CADER). This institution offers degrees in technical training and engineering.

Other research agencies

In the past few years, more than 15 private institutions and NGOs have appeared that have entered agricultural research, primarily hillside agriculture, subsistence farming and agroforestry. Among the institutions affecting the agriculture and livestock sector, CEDAF stands out. CEDAF is a foundation that promotes sustainable agriculture, livestock and forestry through the transfer of technology, training, technical assistance and information, among other services.

Another institution that has assumed an important role in the promotion of agro-industry is the Dominican Agribusiness Board (JAD). Its emphasis has been on non-traditional export products such as flowers, shrimp, out-of-season vegetables and fruit.[4]

In this sector, it should also be stressed that the participation of groups of producers that cooperate with the Government and IDIAF form productive clusters that, among other actions, promote innovation projects, although with more limited resources and scope. In fact, during the meeting held with leaders of the agriculture and livestock clusters, it was stated that support and cooperation has been successful for introducing greenhouse agriculture, although it was stated that these technologies are still beyond farmers' capacities for absorption.

It is also necessary to mention several private companies active in the agriculture and livestock sector, namely Fertilizantes Santo Domingo (FERSAN), Fertilizantes Químicos Dominicanos (FERQUIDO) and Procesadora de Semillas Quisqueyana S.A.

(PROSEQUISA). The last two have contributed to raising productivity and quality of the rice, thanks to efforts made in research.

Few institutions in the country carry out activities in agro-industry research. In this field, IDIAF is the institution with the greatest growth potential, primarily because of its closeness to the main value chains grouped in clusters and because of several successful experiences of transfer. During an interview with the representative of Tropijugos, an exporter of juice and frozen fruit, it became evident that this industry depends on foreign suppliers of equipment, packaging and secondary inputs. The country's capacity to innovate in these areas is limited. That was confirmed by the representative of the organic products cluster, which has depended on technology provided by foreign investors and certifying authorities.

C. STRENGTHS AND WEAKNESSES FOR CREATING INNOVATION

Without a doubt, the current structure of SINIAF is a key strength, because today there is an institutional base for defining a research policy and a specific fund for financing projects in this sector. Furthermore, the creation of IDIAF is an important strategy for strengthening research. The complementary activity of other public institutions that carry out research and private organizations that invest in development projects and technical assistance activities are part of a basic structure with a potential for creating and spreading innovation.

As for the national science and technology system, the 2008–2018 Science, Technology and Innovation Strategic Plan establishes an important declaration of public policy concerning the importance to be given to research and innovation. That plan is an opportunity to place science and its ties with other social development policies and competitiveness on the agenda and national budgets. Law No. 139-01 on higher education, science and technology foresees "The creation of a national higher education system for science and technology, establishing norms for its functioning, mechanisms that ensure the quality and appropriateness of the services provided by the participating institutions and the legal basis for national scientific and technological development". The legal basis establishes a solid basis for the development required for an innovation system, which is an indispensable condition, although insufficient.

Another strength is the awareness that several producer groups have developed regarding the need to incorporate new technologies. According to various specialists consulted, a culture of interaction among various participants in the system has started, which have clear expression in the work of the clusters. Training has been given in the clusters to many producers, to the extent that, according to what the president of the avocado cluster, "the cluster has been converted into a school".[5]

However, the capacities for making other types of higher-level technological contributions are still scarce. During the meeting with representatives of clusters, it was brought out that there is a lack of research in plant improvement because the varieties developed are primarily for growing rice. Also there is little qualified staff for research.

In its 2009–2018 Strategic Plan, IDIAF (2009) recognizes that "The proportion of staff with a high level of academic degrees, M.Sc. and Ph.D. is inadequate for the institution's and the country's research needs. The main areas of training and specialization in need include agriculture in a controlled environment, water management, rice genetics and management, animal improvement, animal reproduction (a priority), pastures and forage and animal nutrition, post-harvest management of promising crops, such as mango and oriental vegetables, use of waste from livestock production, soil microbiology plant and zoological genetic resources, molecular biology and plant biotechnology, in general". The problem of limited human resources is made worse by the low salaries of researchers, which provide no economic incentive for young professionals who decide to begin a research career. It already has been mentioned that there has been no policy for promoting research up until now in universities such as UASD, which is certainly a limitation that must be dealt with as a priority and urgently.

Of course, another weakness that limits the possibilities of developing an innovation system is the lack of resources for research. The Plan recognizes that "in the case of the Dominican Republic, there is a lack of appropriate measurements that permit estimating the degree of investment in R&D as a percentage of GDP. According to the estimates

made by a team of the University of La Coruña in the framework of the project on technological policies (INPOLTEC II), in the Dominican case the conclusion was reached that investment in R&D for 2003 was less than 0.06 per cent of GDP, an estimate that must be taken cautiously because of the study's limited methodological coverage. Nonetheless, taking into account public investment made during recent years in initiatives such as community technological centres made by INDOTEL, the Office of the First Lady and investments such as the Parque Cibernético of Santo Domingo, the estimate modest results on GDP can be made. Systematic investment in specific areas of R&D has been a significant step with the annual competition of projects carried out by FONDOCYT, which entered into force for the first time in 2005 with the approval of 14 projects and an investment of the equivalent of more than 443;000 dollars. The second competition was held in 2006, and 16 projects were approved for an investment equivalent to more than 575,000 dollars. During an interview with the director for promotion of research, science and technology for MESCYT, this growing trend to channel resources to the research fund was confirmed, because in 2007 24 million pesos were channelled, in 2008 145.6 million and 224.2 million in 2009.[6] That is a substantial increase, but the amount is still very small. There is a consensus among the persons interviewed on the precariousness of resources.

Although the estimate of investment in agricultural research as a portion of GDP of the sector is better, it is also recognized that that investment is used basically to cover salaries. Furthermore, "The allocation of resources from the national treasury has stagnated at the same level for the past four years" in the case of IDIAF (IDIAF 2009).[7]

Very closely linked to the issue of financial resources is that of human resources for research. It was already mentioned that there are very few qualified persons. IDIAF (2009) states that "The proportion of high level personnel with academic degrees is inadequate to meet the research needs of the institution and the country". The existing personnel is better identified with traditional research and focused on activities related to primary production. CONIAF recently began a training programme aimed at preparing persons in agricultural production technologies in a protected environment, in which 275 technical and 300 producers have participated. Also, UASD received a contribution of 12,480,000 pesos (approximately 324,000 dollars) for carrying out "a programme of two Master's degrees: one in integrated pest management and the other in animal nutrition in which 40 professionals participate" (CONIAF 2011).

But the research capacity is still limited because there is no capacity to train human resources at the post-graduate level. The statistical report of SEESCYT (2004) shows that the specific importance of research within the institutions of higher education and research is very reduced, because only a small fraction of less than 1 per cent of the budget is allocated for that, with very few participants. The results are proportional, and published work is very sparse, without taking into account that the source does not specify the quality of those publications.[8]

The academic level of professors is primarily Master's degrees. It should be mentioned that there are no doctoral programmes in the country.

A very weak link is the transfer of technology, because it is concentrated on the training of producers. It is widely recognized that the linkage mechanisms with the productive sector are scarce. IDIAF and ISA have experience and contacts with clusters and independent producers, but the other universities have only occasional relations. Relations with agro-industry companies are rather exceptional and are not involved in the transfer of technology. IDIAF (2009) recognizes that "The existing strategy is not adjusted to the current context and the means of support available are insufficient".

Wide diffusion of technology is limited, and there is agreement among the experts interviewed that there is no system of agricultural extension that is operational and efficient.

The conclusions about the innovation system in the agriculture and livestock sector can be summarized as follows:

- In general, R&D is not given a central position in taking decisions or in development programmes.
- The level of public and private investment in R&D is low and is an important limitation.
- The assimilation and use of technology by the public and private sectors is very inadequate, in part because of a lack of qualified human resources and also because of a lack of adequate strategies of diffusion.
- The source of human resources is fragmented and

has limited capacities, above all in the fields of research and transfer of technology.

- Inadequate policies and legal framework for promoting alliances between industry and the universities, for the protection of R&D activities and for attracting investors;
- A limited or non-existent system of technological information that includes economic and market indicators;
- Limited channels for interaction for the development of knowledge and technology;
- Limited interaction between industry, universities and the Government.

The capacity to innovate in the area of biotechnology is determined not only by R&D capacities strictly speaking but also by the existence of an attractive market that constitutes a basic incentive for translating the results of research into products, an adequate legal-institutional framework and a business tissue that includes biotechnological companies, users of biotechnology and providers of specialized technological services.

D. ANALYSIS OF BIOTECHNOLOGICAL CAPACITY

According to what is expressed in the IDIAF Strategic Plan 2009–2018 (IDIAF 2009), "advances in biotechnology and computer technology are the basis for a new technological-economic paradigm, with deep impact on the forms of social organization and on the productive processes of current societies. These transformations are reflected in the organization of agriculture and its links with the rest of the economic sectors, such as the nature of the associated technological processes and likewise the 'making of science' in this sector".

IDIAF recognizes that, concerning organizational-institutional aspects, the main impact of biotechnology in the sector stems from the fact that the disciplines involved, as a result the sources of information used and the human resources required are significantly different from those that make up the basic scientific discipline of traditional agricultural research. Likewise, a large proportion of new technologies resulting from the application of biotechnology are appropriable, which has also redefined the public-private character of many areas of research and established the basis for active participation of the private sector in their financing and development. These relations are one central aspect of the effective use of the potential of these new technologies, which depend, in the end, on the productive capacities that exist for production on a commercial scale of the new inputs resulting from the R&D processes. The main limiting factor in this sense is the availability of financing for these undertakings. Development of new technologies and their scaling on an industrial level are processes that in most cases are the subject of complex biosafety regulations and relatively long approval processes by public regulatory bodies require investments of a certain magnitude and risk.

In this new context, fundamental changes in the development of human resources and in nature of the scientific ties and of information on which research institutes depend are required. Likewise, closer and more cooperative relationships are required with the regulatory bodies and biotechnology research centres in universities and between public research institutes and industry. In practice, the isolation between institutions of the scientific-technological community needs to be broken.

Finally, the greater applicability of the results, including basic research, bring up with renewed vigour the issue of protection for intellectual property. This is, without a doubt, a problematic aspect for public institutions. But its solution is indispensable both for achieving greater ties with the private sector that biotechnology brings and for being able to work effectively in network with other scientific institutions in the public sector (IDIAF 2009).

With this framework in mind, it can be concluded that the infrastructure for the creation, adoption and diffusion of agricultural biotechnology in the Dominican Republic is small and poorly integrated. Most of the existing institutions give priority to traditional agricultural research, and biotechnology has not been prioritized. Clear evidence of this is the type of projects financed by CONIAF in which the specific weight of biotechnology is small. In the case of FONDOCYT, projects involving traditional biotechnology (micro propagation), molecular mapping of species of commercial interest have been approved but only one project of genetic manipulation for the production of plantains resistant to Black sigatoka has been approved.

1. Agricultural biotechnology research institutions

According to the views of planners in the main institutions, biotechnology is used in the country as a tool integrated into agriculture and livestock development, giving priority to problems to which biotechnology can make a specific contribution, such as sugar cane, development of biofuels, coffee, cacao, plantains and bananas, seeking resistance to diseases for increasing agricultural productivity and reducing the environmental effects that commercial agriculture causes. Also the nutritional improvement of crops, such as that of rice, is sought in order to provide better food with more vitamins and antioxidant micro elements that add value to the country's basic crops. In several projects, there has been an attempt to develop biotechnological processes for taking advantage of secondary metabolites of industrial interest.

However, the number of institutions dedicated to agricultural biotechnology is small, as is shown in table III.1. Furthermore, the dominant technique continues to be cultivation of plant tissues. Currently, there are no institutions that carry out genetic engineering, because only IIBI has plans to provide training in the use of this technique. The country does not have experience in releasing agricultural GMOs.

In the private sector, there are several laboratories for tissue cultivation in companies such as Trébol Lab and Vitroplantas del Caribe, and programmes such as Plan Cordillera and an initiative of a religious group, Plan Sierra.

In addition, according to the study of Moquete (2006), there are several seed companies that work on genetic improvement of traditional crops such as rice, sugar cane and beans, among which Productora de Semillas Dominicana (PROSEDOCA), Procesadora de Semillas Quisqueyana, Central Romana, Impale Agricultural and Semillas Tierra Nova stand out .

IIBI was created by Decree 58-05 of 10 February 2005 to materialize the aspirations to carry out activities that promote the development of innovative technology in areas such as biotechnology in the Dominican Republic. Through capacity improvement this would allow the country to integrate adequately and competitively into the international market. There are eight researchers with Ph.D.s and 23 with M.A.s. Clearly, this is the most important biotechnology centre in the country. It has obtained ISO 9001 quality certification and it is in the process of obtaining accreditation of its laboratories under ISO norm 17025.

IIBI offers services and technology to companies. In 2010 it provided services to more than 500 companies, carrying out a total of more than 11,000 analyses. Furthermore, it has transferred technology to clients through contracts covering a diversity of food products, juices, alcohols, flours, etc. to which has been added value through bio techniques (IIBI 2011). Several of these companies have consolidated their traditional processes, such as the cases of the production of shampoo with natural extracts and prickly pear jam (personal communication of the director of IIBI on 15 September 2011).

In the area of plant biotechnology, IIBI has concentrated on large-scale propagation of plants. According to its home page, the main projects are:

- *Plantains.* Through the Centre for Plant Biotechnology (CEBIVE) the conditions have been created so that up to two million disease-free plants of plantains can be produced per year in its laboratories, free of diseases such as Black sigatoka, creating a germplasm bank with the clones of plantains FHIA-20, FHIA-21 and M-Hembra, which will make it possible to reduce the cost of producing plants in vitro;
- *Manioc (yucca)*. Together with FAO, seven clones of yucca of varieties adequate for the national market and for export to the United States have been selected and propagated. These materials have been propagated and checked for supplying groups of women belonging to the National Confederation of Mujeres Campesinas (CONAMUCA), working in agricultural as a way to increase their income and contribute to improving their living standard in several rural areas of the country;
- *Potatoes*. For the growing of potatoes in cooperation with the Dominican Institute for Agriculture and Forestry Research (IDIAF), 50,000 in vitro potato plants have been supplied to leading producers in San José de Ocoa and Constanza for basic seed production in order to reduce imports of potato seeds from Europa and the United States by more than 50 per cent;
- *Yam (yautía).* In cooperation with the Secretariat of State for Agriculture, genetic material of coco yam with potential tolerance to phytophthora and poor crop management has been distributed to most

of the more than 100,000 producers of this crop. Exports of this product have reached 10 millions of dollars per year. Initial field trials began during the first semester of 2006 with the establishment in vitro of promising clones at seven sites.

In addition, with support of the FONDOCYT, studies of molecular mapping of varieties of rice and cacao have been made.

IIBI (2011) has units that are unique in the Dominican Republic, such as: a laboratory for analysis of pesticides, a laboratory for genetic engineering (under construction, but with two projects already under way), a laboratory for detection of genetically modified organisms (GMOs, with financing from FAO, the only laboratory in the area created for backing the food biosecurity surveillance system).

This institute has strong political support and over the next three years plans to organize a large national project on molecular markers, begin to work with genetic engineering and promote the national regulation of biosecurity.

One issue that calls the attention is that IIBI has few cooperative research projects with other institutions and is even being considered to be a centre of competence.

Table III.1. Techniques and agricultural biotechnology research capacities

Laboratory/ institution	Processes	Diagnosis	Molecular markers	Genetic engineering	Cultivation of plant tissues	Integrated pest management	Crops	Personnel
Higher Institute for Agriculture			X		X		Potatoes, yam, potato, pine, mahogany, coffee	2 professionals; 2 post-graduates
IIBI	X	X	X		X	X	Pineapple, avocado, rice, mango, yucca, yams, Beauveria bassiana, flour, plantains, ornamental species, cacao, aloe vera, potato, mango, bananas, sugar cane, and orchids	40 (not all in agricultural biotechnology)
Autonomous University of Santo Domingo			X		X		Bananas, strawberries, coffee, yucca, potatoes	3 professionals; 1 post-graduate
IDIAF	X	X	X		X	X	Plantains, yucca, avocados	3 professionals
Plan Cordillera					X		Plantains, orchids, carnations, banana, garlic	2 professionals
Trébol S.A.	X	X	X			X	Azospirillum for bananas	3 professionals
Vitroplantas del Caribe S.A.	X					X	Potato, yucca, papaya, mamey	N.A.
Plan Sierra Inc.						X	Pine trees, forestry species	25 professionals; 3 post-graduates

E. BIOSECURITY

The Dominican Republic ratified the Cartagena Protocol on Biosafety on 20 June 2006. However, it does not have a specific law on biosecurity, because there is only a draft law that is still under discussion.

Existing mechanisms for dealing with issues related to biosecurity are dispersed and do not deal with the issues related to the development, use and release of genetically modified organisms for agriculture and food. The institutions working with this issue are the Office for Wild Life and Biodiversity of the Secretariat of State for the Environment and Natural Resources (which represents the competent national authority to the Convention on Biological Diversity), the National Commission for Natural Disaster Emergencies, the National Commission on Bioethics, the Department of Environmental Protection of the Secretariat of State for Public Health and Social Assistance, and the departments of Animal Health and Plant Health of the Secretariat of State for Agriculture.

Currently, the Dominican Republic is a signatory to the following international agreements that could have repercussions on the national framework of biosecurity and trade: (a) General Agreement on Tariffs and Trade (GATT), (b) Agreement on Trade-Related Aspects of Intellectual Property Rights, (c) International Plant Protection Convention, (d) Convention on International Trade in Endangered Species of Fauna and Flora, (e) Convention on Biological Diversity, (f) World Trade Organization, (g) World Health Organization, (h) Pan American Health Organization and (i) North American Free Trade Agreement.

The Secretariat of State for Agriculture is responsible for the application of laws No. 4030 (animal health), No. 231 (seeds), No. 4990 (plant health) and No. 278 (brucellosis), Regulation No. 1113 and Decrees Nos. 5304, 6412 and 607. The Secretariat of State for Public Health and Social Assistance is responsible for application of Law No. 42-01 (public health). The Secretariat of State for the Environment and Natural Resources is responsible for application of Law No. 64-00 (environment and natural resources).

Other mechanisms related to biosecurity and the protection of consumers existing in the country are the *Codex Alimentarius*, several Codes of Ethics established by international organizations and the Department for Consumer Orientation of the Secretariat for Industry and Commerce.

In conclusion, as for the current status of the regulatory framework, according to the conclusions of a group of experts UNEP/GEF (2003) and the workshop on the strategic planning of biotechnology in the Dominican Republic made in March 2006, it can be seen that:

(a) Current legislation dates from the 1950s. One recent piece of legislation is the law on seeds, which dates from 1971, but does not cover aspects of biotechnology;

(b) The first work with biotechnology began with the creation of the Duquesa Experimental Station for sugar cane in 1982. In 1987, that experiment station came under the Secretariat of State for Agriculture by decision of the Secretary of State;

(c) The project "development of the national framework of biosecurity" financed by UNEP/GEF has developed a participatory process for drafting a law on biosecurity;

(d) Current legislation, made up of laws, decrees and resolutions, is characterized by its dispersal and obsolescence.

In addition, this group identified the following as obstacles of the regulatory framework:

- Lack of information about society;
- Low acceptance of biotechnology by society;
- Bureaucratic and political aspects;
- Low level of conscience among decision-makers, including legislators;
- Low institutional capacity for identifying the need for a regulatory framework for biotechnology;
- Weak inter-institutional coordination;
- Low supply of human resources trained in biotechnology.

F. INTELLECTUAL PROPERTY

In the field of intellectual property, the Dominican Republic has adopted a complete framework, primarily in answer to the requirements of the Free Trade Agreement with United States and Central America (DR-CAFTA). However, as for agricultural biotechnology, there are several concerns that can hinder the flow of new technology towards the country because of the uncertainty of protection.

1. Protection of live matter

The law on industrial property excludes protection through patenting for a whole class of live matter and substances pre-existing in nature (see article 2, paragraph 1 (g) of that law), without making any distinction between those that have been modified or transformed by human beings (which according to existing international practices should be patentable, for example, genetically modified microorganisms), an those that are in their natural state, which is usually termed a discovery and therefore is not patentable.[9]

According to Fernández (2003), the provisions contained in article 2, paragraph 1 (g) of that law tends to discourage those who carry out research because companies want guarantees and stability that ensures the amortization of research. Furthermore, that provision conflicts with article 27 of the ADPIC, through which is permitted the patenting of modified live material or material that incorporates a technological effort.

"Article 2. Material excluded from protection by an invention patent.

(g) All live material and substances pre-existing in nature;"

It is contradictory that, despite the restriction contained in article 2, provisions are later included concerning the procedure for applying for a patent on biological material (article 13. 3).

"Article 13. Description

(3) When an invention concerns biological material that cannot be sufficiently described so that the invention can be carried out by a person working in that field and that material is not available to the public, the description will be complemented by a deposit of that material in a institution of registration previously designated by the National Office for Industrial Property."

An additional element that can hinder the transfer of technology concerns the use of biological material as the basis for obtaining new biological material, as one of the acts in which the right to a patent expires. This is a provision "imported" from the rights of the patent holder and is not part of patent legislation. What is usually done in this case is to include an exception that facilitates the use of the invention with research proposals, but never as a source for producing a new material or in an activity that exhausts the right to a patent.

"Article 30. Limitation and expiration of patent rights

A patent does not give the right to prevent:

(f) When a patent protects biological material capable of propagation, the use of that material as an initial basis for obtaining new viable biological material, except when that requires the repeated use of the material patented;"

2. Regulation of licenses

Moreover, the law on industrial property steps into the field of regulation of licenses in a way that is contrary to practice. By establishing that exclusive licenses cannot be granted, it is seriously limiting the possibility that a Dominican licensee can benefit from obtaining a license for exploiting a patent. It is also illogical to prohibit by law that sub-licenses are granted, which can be a practice that is convenient for the parties to a contract, when those sub-license can produce benefits.

"Article 33.- Contractual licences.

(3) In absence of a stipulation to the contrary in the contract of license of exploitation, are applicable the following norms:

(b) The licensee cannot cede the license or grant sub-licenses;

(c) A license is not exclusive, and the licensee may grant other licenses for exploitation of the patent in the country or exploit the patent himself in the country;

(4) Contracts for licensing must not contain restrictive commercial clauses that affect the production, commercialization or technological development of the licensee and restrict competition, such as exclusive conditions of retro-cession that impede the impugnment of the validity and that impose mandatory joint licenses or any other anti-competition or restrictive conduct by competition."

The chapter on mandatory licenses is also a source of concern. Article 40.1, seeks to establish as the reason for a mandatory license that the patent holder refuses to concede a license to an interested user. That implies ignoring the very essence of a patent whose holder has the choice of deciding whether to concede licenses or not and deciding to whom.

"Article 40. Mandatory licences

When a potential user has tried to obtain a license from the patent holder in commercial terms and reasonable conditions and has not been successful after a period of 210 days from the date of the request for the license in question, the National Office for Industrial Property, after a hearing with the patent holder, can issue mandatory licenses for that patent.

In all appropriate cases, the National Office for Industrial Property shall grant mandatory licenses when the interested party shows that:

(a) Possession of technical and economic capacity for exploiting the patent. The technical capacity shall be evaluated by the competent authority in accordance with the specific norms in effect in the country, which exist in each field of activity. By economic capacity is meant the possibility of fulfilling the obligations that derive from the exploitation to be carried out;

(b) When the patent covers a raw material on the basis of which a final product will be developed, the petitioner may develop the final product himself or by third parties in the country, except in cases of the impossibility of production in the national territory.

(2) For determining what is meant by commercial terms and reasonable conditions, the specific circumstances of each case and the economic value of the authorization must be taken into account, keeping in mind the average rate of royalties for the sector in question in contracts for commercial licenses between independent parties.

Article 41.- Mandatory licence for lack of exploitation.

(1) Three years after concession of the patent or four since presentation of the request, using the period that expires the latest, if the invention has not been exploited or when its exploitation has been interrupted during more than one year without justification, any person who has the capacity to exploit the invention may request the National Office for Industrial Property to grant a mandatory license for the patent in question.

(2) A mandatory license shall not be granted when it is shown that a lack or insufficient exploitation is the result of an arbitrary case or force majeure or is due to circumstances that escape the will or control of the patent holder and that justify the lack of or insufficient exploitation. Justifiable circumstances are not a lack of economic resources, nor a lack of economic viability of exploitation."

As can be observed, strict application of the law on industrial property could be an opportunity for an imitative technological strategy, given that any Dominican company that has the technical and economic capacity to exploit the patented invention could demand a mandatory license. That represents an opportunity to use technology that could be used with the participation of research centres as technical support for a company.

3. Rights of the patent holder

The protection of plant varieties is stipulated in Law No. 450-06 of December 2006 on protection of the right to obtain plant varieties. That law adheres to international standards established in the act of accession to the International Convention for the Protection of New Varieties of Plants of 1991, guaranteeing protection for all species and defining the requirements for granting rights to a patentee.

G. HUMAN RESOURCES FOR AGRICULTURAL BIOTECHNOLOGY

The human resources available for agricultural biotechnology activities are very scarce (see table III.1) and, according to the persons interviewed and the reports consulted, that is a serious limitation on development.

Even in the case of the research in traditional genetic improvement, the situation is not very promising. Despite that IDIAF has 136 researchers, the study by Moquete (2006) reveals that "currently, there are 26 researchers in all of the Dominican Republic working in plant improvement. Their academic degree is a B.S. or Master's degree (12 researchers) and only two Ph.D.s. The average age of these researchers is 50 years, which shows the urgent need to establish a training programme for new researchers".

For the specific case of biotechnology, IIBI is the key institution and recognizes that its principal need is to have high-level researchers, but, at best, the number of researchers in agricultural biotechnology is only 10 persons.

H. COLLABORATION AND STRATEGIC ALLIANCES IN BIOTECHNOLOGY

Alliances (see table III.2) are considered important, especially because centres can expand their capacities and reinforce their infrastructure. The persons contacted stress the need for human resources and that, in the short term, they must attract cooperation with other national and foreign institutions. Of course, the establishment of alliances has been critical for equipping laboratories, given that local economic resources are scarce. Collaboration with international organizations has been useful for identifying strategic development goals.

I. CONCLUSIONS AND RECOMMENDATIONS

The country's capacity for developing, adopting and spreading agricultural biotechnologies is limited. The main problems that have been identified are described in table III.3.

There is no national policy in this field. Although there is explicit mention in the Plan Strategic for Science, Technology and Innovation 2008–2018 of the creation of a sub-programme for plant biotechnology and another for animal biotechnology, although these proposals have not produced a specific policy.

Human resources and infrastructure for agricultural biotechnology are scarce and deal with only traditional techniques. The scientific and technological areas that feed more modern biotechnologies have been neglected. Creation of the capacities required needs a major effort and planning, with long-term goals and dedicated resources much more important than are currently available.

Of course, the regulatory framework governing biosecurity requires urgent attention, because its almost non-existence constitutes serious discouragement on investment in development, transfer and diffusion of modern biotechnology. In this same order of ideas, the protection regimen for biotechnological inventions has contradictory aspects, legal vacuums and messages that discourage the transfer of technology.

Several Dominican experts have recommended that the Secretariat of State for the Environment and Natural Resources prepare and submit to the Executive Power a draft temporary decree on biosecurity, regulating the use of modern biotechnology in the country until a law on biosecurity is adopted and creating a transitional commission that regulates the introduction of GMOs until a law is approved and include that in the proposed modification of the law on seeds.

Table III.2. Types of alliances among biotechnological centres

Types of alliances	ISA	UASD	IDIAF	IIBI
Building of laboratories	IDIAF CONIAF USAID Multilateral Investment Fund	FAO CONIAF Belgium technical assistance	FONTAGRO JICA AECI	FAO CONIAF IICA CYTED IRTA ITESM
Training of human resources	Helvetas	Dominican and foreign universities		Dominican and foreign universities
Technology transfer			ISA	INTA Argentina CIAT
Development of technology	CONAGRO Cacao producers Cooperative	Gembloux University (Belgium)	CIAT ISA	CONIAF

Source: UNCTAD.

Table III.3. The main limitations on development of agricultural biotechnology

Limiting factor	Status
Biotechnology policy	Even though general guidelines have been identified, no policy has been established, primarily because no priority has been assigned to this issue.
Almost exclusive use of traditional techniques	IIBI, as the leading centre, is proposing a national project of molecular markers and the possibility tp start using genetic engineering, which shows that currently there are limited capacities in the use of these techniques.
Resources	The country's resources for research and development in biotechnology are insufficient. It is imperative to increase them and ensure that their use corresponds to the priorities of the productive sectors
Human resources	There is very little personnel with the qualifications required for developing and adopting advanced biotechnologies. A training programme must be established with a strong component of international cooperation. Post-graduate training with emphasis on the doctoral level must be promoted.
Technology transfer	It is imperative to define a strategy for substantially increasing relations between research centres, companies, clusters and producers.
Regulation	The legal framework is incomplete and uncoordinated. It is incorrect to assume the Cartagena Protocol as the applicable law, because it lacks the regulatory provisions that would facilitate interpretation and application. Given the lack of institutional experience in applying the regulation, it may be necessary to seek international assistance
Intellectual property	Patent legislation contains various elements that create uncertainty for creators of biotechnology. The law seeks to protect Dominican interests, but enters into contradictions and vacuums that have the opposite effect (for example the prohibition of exclusive licenses and sub-licensing). The legal framework must be reviewed in order to prevent contradictory provisions. In the meantime, there must be a plan for taking advantage of the loopholes in the law for the obtaining mandatory licenses on patents.

Source: UNCTAD.

This recommendation can be useful for implementing the agreement provided for in the Cartagena Protocol, aimed at defining a national biosecurity policy, accompanied by regulations.

In this environment of scarce policies and resources, everything seems to indicate that, for Dominican Republic the only short-term possibility for adopting productive modern biotechnologies is the model of Honduras, in which a leading company introduces technology in association with a local research centre responsible for supervising and evaluating field trials and later participating in the training of producers. IDIAF would be the best indicated. However, it must be clear that for a model of adoption to materialize, it is indispensable to have an efficient system of evaluation of risk and decision-making concerning biosecurity.

IIBI has the broad support of the Executive and should take advantage of that opportunity to assume leadership for promoting a national policy and the instruments that catalyse not only the generation but also the acquisition of biotechnologies. IIBI should also take advantage of its leadership to support SINIAF for acquiring the skills necessary for managing modern biotechnologies.

For the medium and long term, there is only one option: invest now in training qualified human resources. The Dominican Republic has not paid sufficient attention to this issue, which is apparent because in the period 2005–2008 only one international scholarship for studying for an M.A. in veterinary medicine and zootechnology was granted, and in 2010 there were three recipients of scholarships for studying for an M.A. in molecular biology at the University of Murcia

(MESCYT 2009 and 2010) . That is insufficient and if things continue that way, the country will be restricted to the role of spectator of technological change and user of mature technologies. Opportunities for making considerable progress in this area are abundant. That is shown in table III.4.

Table III.4. Opportunities for the development of agricultural biotechnology

Opportunities	Implementation mechanisms
Support of the Executive for IIBI.	To take an active role for creating a national biotechnology policy. IIBI must quickly finish preparing solid legal proposals for regulating biosecurity.
The importance of the agriculture and livestock sector in the economy.	Generate soon experience in the use of modern biotechnologies that fulfil a demonstration effect of the benefits for national agriculture.
Participation of producers and several private seed companies and widespread propagation of plants.	The existence of several companies that have begun to use traditional biotechnologies can be used as a platform for promoting adoption of other more advanced technology, if clear economic incentives are offered. The integration of a complete regulatory framework that achieves a balance between protection of health and the environment and promotion of innovation and investment is a prerequisite.
Possibilities of international cooperation.	A technical cooperation plan that defines the training of human resources in modern biotechnology as a priority. Bilateral and multilateral agreements. Relations with other countries in the region (such as for example Cuba, Puerto Rico and Mexico) can be fruitful, because of the availability of high-level post-graduate programmes and regional cooperation agreements.
Interest of multinational companies in introducing technology.	Establish a framework for biosecurity that permits evaluating requests for releasing GMOs into the environment under supervision of national entities (for example IIBI and IDIAF). Form a national researcher group that monitors technology transfer as training. Request companies interested in assisting the country to provide a training programme in modern biotechnology.

Source: UNCTAD.

NOTES

[1] Henry Guerrero and Gabriel Domínguez.

[2] CONIAF (2011).

[3] Personal communication of Dr. Angel Castillo, Vice-rector for academics.

[4] JAD offers support and technical assistance, including support for increasing productivity, agricultural laboratory services; training and practice, direct technical assistance, integrated pest management, protection of natural resources, agricultural reforestation, support for trade and investment, agro-industry scholarships, policy reform, the Agro-industry Information Centre (CIAGRO), marketing support, livestock improvement, special projects and programme support for organic agriculture.

[5] José Rosa.

[6] Dr. Carlos Rodríguez, personal communication.

[7] According to Pérez, 0.21 per cent in 2001.

[8] Fewer than 0.3 articles per researcher.

[9] Law No. 20-00 on industrial property (2000).

IV

Science, technology and innovation in health

The country's main health problems are the following:[1]

- *Infants 0–4 years*. The infantile mortality rate is 40 for every 1000 births;
- *Children 5–14 years.* External causes and transmissible diseases have been the main causes of death;
- *Adults (15–59 years)*. The more frequent causes of death are external causes and transmissible diseases;
- *Adults of more than 60 years*. The main causes of death are cardiovascular diseases and neoplasias.

In the case of diseases transmitted by vectors, there were 1,233 cases of malaria in 2000. Dengue fever is endemic in the country, where 3,462 probable cases were reported in 2000. A survey carried out in 1999 reports that 65.5 per cent of school-age children had intestinal infections.

This brief summary of the country's epidemiological profile shows that there are two problems: diseases that are specific to poor countries, primarily infectious diseases and diseases of the more advanced countries. These represent, without a doubt, a challenge, because it requires the development of domestic capacities to fight local diseases.

The Ministry for the Economy, Planning and Development (2010) stated that, "during the past few decades, the country has experienced improvements in life expectancy at birth and a decrease in mortality rates. Likewise, the entry into force of laws Nos. 42-01 and 87-01 has made it possible to begin establishing contributive and subsidized social security regimes, while the country is making progress in developing a new model of public care focused on primary care."

As part of the modernization process launched during the second half of the 1990s, care was decentralized and services and medicines were made available, which was adopted for dealing with problems of coverage, organization, management and quality of services. Reform of the health sector is based on six principles: universality, equity, comprehensiveness, solidarity, participation and sustainability. A social security reform separated financing, medical attention and insurance, creating a mandatory basic insurance (family health insurance). However, "progress in creating models for regulating care services for individuals has not been accompanied by advances in the design of new ways of organizing and monitoring the promotion and protection of collective health."[2]

It is recognized that the changes have not advanced at the pace planned and that it will be difficult to fulfil the targets. "The country must concentrate efforts on several main points: increasing the flow of public resources for financing health services for the poorer groups of the population, while ensuring quality and efficiency in the use of those resources, promoting the provision of a range of relevant and sustainable health services for the target population, refining the mechanisms for monitoring results and making progress in decentralizing public networks."[3]

As can be seen, research and innovation are not included in health policy priorities, which is an explication for the country's institutional weakness, which will be analysed in this document.

A. THE NEED FOR INNOVATION IN HEALTHCARE

A national pharmaceutical and health policy is an integral framework within which each component plays an important role for the success of one or more general policy goals: access, quality and rational use. Policy must balance the various targets and goals, forming a complete and coherent entity. For example, access to basic medicine can be achieved only through rational selection, accessible prices, sustainable financing and reliable systems of assistance and supply. Each component of the "framework of access" is essential, but is insufficient alone to ensure access. Similarly, rational use of medicine depends on many aspects of biosecurity, such as rational selection, regulation, educational strategies and economic incentives.[4]

Table IV.1 shows how the research component has a direct impact on the three policy objectives (access, quality and rational use). Likewise, an increase in human resources and training is required for providing care, prescribing and providing medicines rationally, so that a positive impact on health of the recently insured population is achieved.

In a policy whose basic goal is protection of the general population's health, there are four basic axes: (1) quality, efficiency and safety of medicine, (2) availability and access to medicines, (3) rational use and (4) innovation (see Figure IV.1). Again, it is clear that innovation occupies a very important place in creating new products, improving plans to develop services,

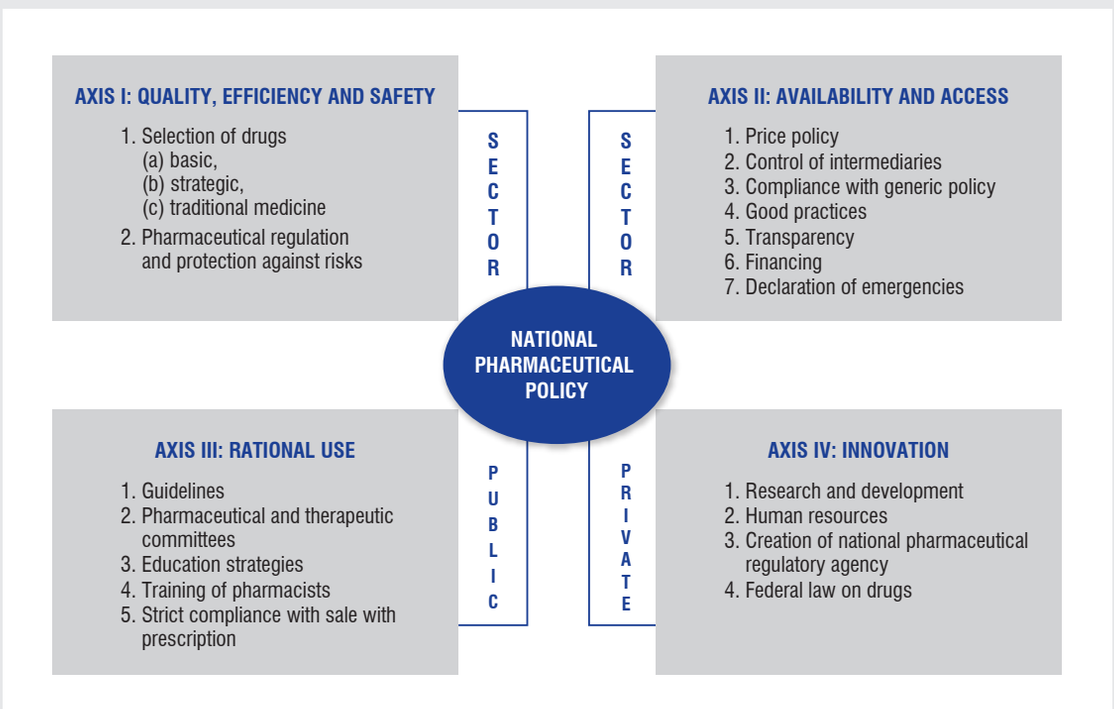
Table IV.1. Basic components of a pharmaceutical policy

Components	Goals		
	Access	Quality	Rational use
Selection of basic medicines	X	(X)	X
Accessibility	X		
Financing of medicine	X		
Supply systems	X		(X)
Regulation and quality guarantee		X	X
Information to the consumer for rational use			X
Research	X	X	X
Human resources	X	X	X
Monitoring and evaluation	X	X	X

X= direct relationship; (X) = indirect relationship.

Source: UNCTAD based on information from the National Institute of Public Health (2009).

Figure IV.1. The national pharmaceutical policy



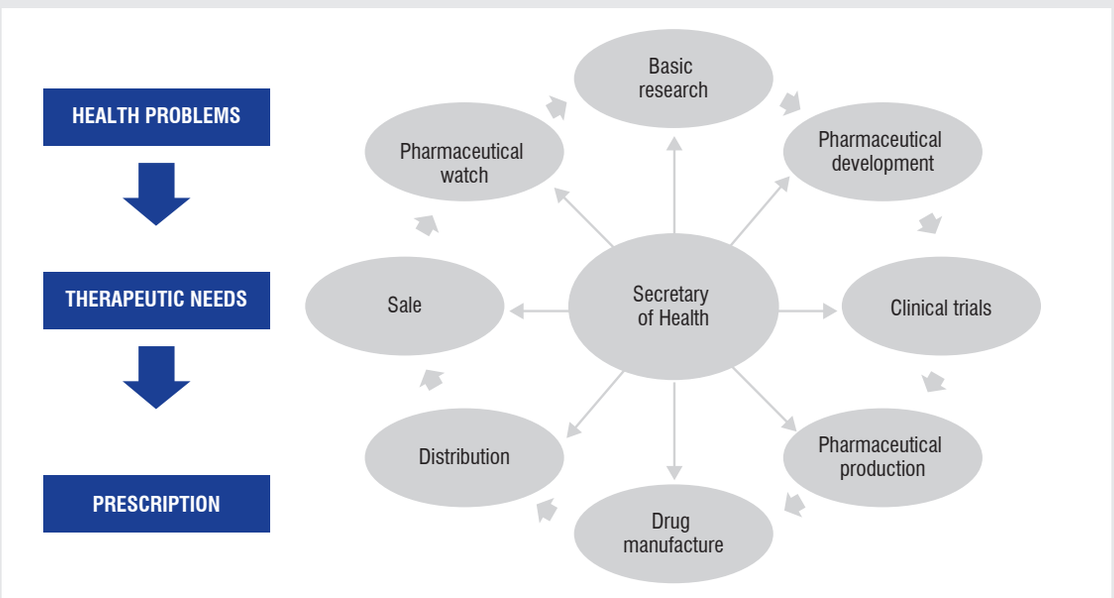
Source: UNCTAD based on information from the National Institute of Public Health (2009).

development and improvement of treatment and care for patients; introduction of forms of organization that ensure the efficiency and effectiveness in providing services, greater quality in human resources for prevention, attention and monitoring; timely identification of needs and relevant technologies for satisfying needs; evaluation of health policies, performance of the elements of the health system and development of quality indicators; development of medicines and specific treatment for the country's epidemiological profile; and opportune responses to eventualities.

Figure IV.2 shows how, based on research, order and coherency can be given to government strategies with a integral vision in health.

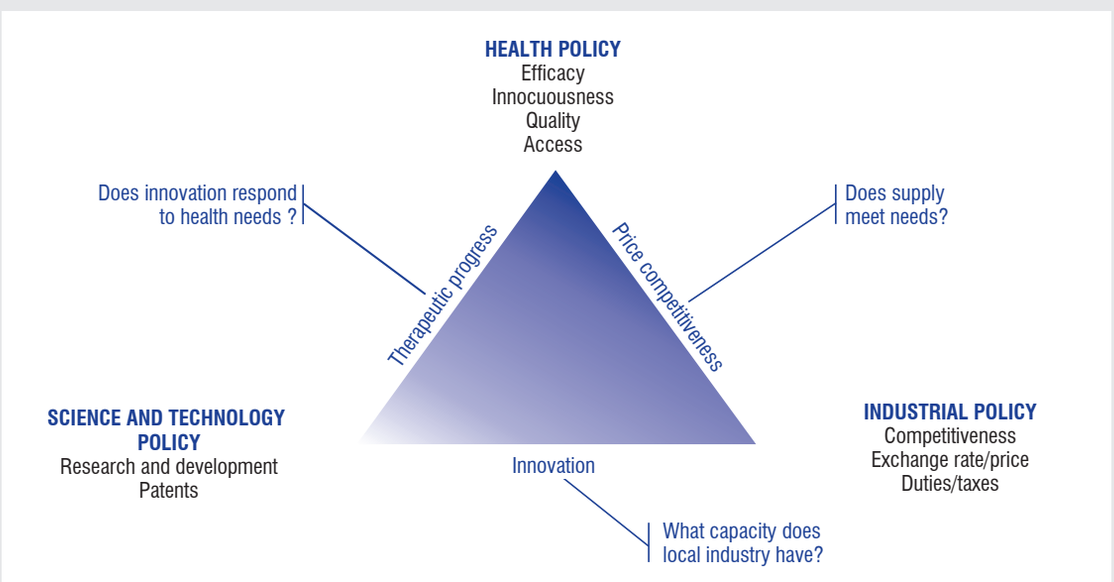
Furthermore, strengthening of research permits producing synergy between the policies of promoting industry, public health and science and technology, in favour of the efficient achievement of the country's major health goals, as illustrated in Figure IV.3.

Figure IV.2. Focus of pharmaceutical health policy concerning the supply of medicines



Source: UNCTAD based on information provided by the National Institute of Public Health (2009).

Figure IV.3. Focus of industrial policy in the pharmaceutical sector



Source: CONASS (2009).

B. THE PRIORITY OF RESEARCH AND INNOVATION IN THE HEALTH SECTOR

Interviews with key actors in the health, science and technology sectors and the analysis of many legal documents, programmes and diagnoses point to the conclusion that scientific development and innovation have played a secondary role in the country's health agenda.

In the Strategic Plan for Science, Technology and Innovation 2008–2018, a specific programme is identified for the promotion of this area, although there are no strategies for achieving its goals and no basis for a concrete diagnosis. That programme has the following components.

1. Health and biomedical programme

The health and biomedical programme is expected to have significant impact on the standard of living of the Dominican people by making available resources that permit systematic research and development in key issues such as tropical diseases, namely dengue fever, elephantiasis, which still constitute public health problems in the country.

Research and improvement in the field of occupational health, biomedicine and the development of sports medicine are promising fields in this programme. The overall budget estimated for this programme is 31,340,000 dollars. This programme must be coordinated by the Secretariat of State for Public Health and Social Assistance. That programme is broken down into the following sub-programmes:

- General sub-programme for health and welfare studies (5.33 millions of dollars);
- General sub-programme for tropical diseases (10.03 millions of dollars);
- General sub-programme for biomedicine (6.89 millions of dollars);
- Sub-programme for labour and occupational health (4.7 millions of dollars);
- Sub-programme for sports medicine (4.39 millions of dollars).

In appearance, the amount planned for that programme is very important, but it is divided into five very broad sub-programmes, and it is a question of an investment over 10 years. Resources will have to be divided up, which can limit their effectiveness. Furthermore, it is very important that a consensus be reached in order for this amount to remain allocated, because already one decade ago "the Dominican Innovation Plan proposed raising the country's investment in R&D to 8 per cent of GNP", but that never happened.[5]

The Secretariat of State for Public Health and Social Assistance is the authority for research and health processes. In function of the obligations given it by ministerial provision 013, the National Office for Health Research (DINISA) was created in 2010. DINISA "has among its goals the preparation and implementation of public policies that orient health research and preparation and implementation of the regulations on research that will serve as a norm for the various institutions of the Dominican Government." Based on WHO guidelines, the priorities and specific research policy is currently being discussed, but is is planned only to hold workshops with key actors. It is know that DINISA is working within a very tight budget and with a small staff.[6]

DINISA assumes that the country's research capacities are primarily in universities, because private laboratories do not have the incentive to carry out research, because they obtain their technology abroad.

2. Research activities in health

Overall investment in research and development activities was estimated to be 0.06 per cent of the GDP according to a survey made by Bravo (Bravo et al, 2004), an amount that has been questioned, because the calculation was made on the basis of an estimate of expenditure per researcher. In this study, it was estimated that in the entire country there were with 359 researchers (72.7 per cent with a Master's degree and 29.5 per cent with a Ph.D.) in 2004, but only 57.6 per cent of those work full time on research. According to the same source, it was estimated that 24 per cent of the researchers work in the field of health, which means 86 researchers. That is a very small number given the country's size and the challenges it faces in the field of health.

The following universities have teaching programmes in the health sciences or medicine:

- Iberoamerican University (M.A. level)
- Autonomous University of Santo Domingo

- Pontifical Catholic Madre y Maestra University (PUCMM)
- Central University of the East
- Catholic Technological University of El Cibao
- Technological Institute of Santo Domingo (INTEC)
- National Pedro Henríquez Ureña University
- Nordestana University
- Technological University of Santiago

The results of the survey mentioned earlier seem to indicate that these institutions carry out very little research. There is no evidence that they have specific budgets. They also do not publish results, and the few references made to their research are more related to general conventions for cooperation. Also institutions were identified that declare carrying out research such as the Dominican Institute of Medicine[7], the Metropolitan Hospital of Santiago[8] and the Dominican Academia of Medicine.[9]

The most recent issues of three publications were consulted: *Acta Médica Dominicana* (2000), *Archivos Dominicanos de Pediatría* (2004) and *Revista Médica Dominicana* (2007). The type of results published in these journals are from clinical trials, surgical cases and epidemiological studies. That is important knowledge, but with few of fundamental research components or testing of advanced technologies.

A more worrying matter is the fact that research is not treated as a priority.[10] Both the academics at the Science Faculty of UASD and those at the Centre for Biomedical and Clinical Research of PUCMM state that "to be a researcher is now a personal decision". In most institutions, there is no research policy, to the extent that UASD would have defined one, but aimed at prohibiting research.[11] As was commented previously, UASD has implemented a series of activities to promote research, but the results will become evident only in the medium term in this institution, because those activities are not at the national level.

There are no signs that research is being carried out on the application of advanced technologies such as biotechnology, functional genomics and computer science for use in medicine. The one institution with basic capacity in this area is the Institute for Research in Biotechnology and Industry (IIBI), which has a medical biotechnology unit for research in genetics and molecular biology that contribute to the health of the Dominican population. The main activities of this unit concern the application of molecular techniques for diagnostic of diseases. It offers DNA identification services for research, proof of paternity and criminal investigations. There are no basic research projects or applied research that offer solutions for funding research on current health problems. IIBI plans to follow a strategy of developing products that lead to the creation of new companies and currently has approximately 50 business proposals, but admittedly one of its weaknesses is a lack of experience in preparing business plans, and that is why it is seeking an association with PROINCUBE.[12] It should be noted that IIBI has little interaction with other local research institutions, and its leadership is not used to produce synergies and build better distributed capacities.

Between 2005 and 2009, FONDOCYT has supported only 13 projects in health and health and biomedicine with an investment of approximately 1,750,000 dollars. A promising sign is that 10 of those projects correspond to the 2009 budget. As for research sponsored by the Secretariat of State for Public Health and Social Assistance (SESPAS), the only mention made in its operational plan for 2009 is in the framework of international cooperation with the goal: "To strengthen international relations of cooperation for activities through technical and scientific exchanges and presentation of short, medium and long-term proposals". No programme related to research has yet been established.

Review of the 2010 report of SESPAS reveals that activities related to research were limited to:

- Creation of the site Access to Research in Health Programme (HINARI) in coordination with the World Health Organization (WHO), which contains comments and other content on health care for biomedical research and establishing information standards for academic hospitals, non-profit research, government departments and creators of policies in developing countries.
- Preparation of a National Policy Document on Research in Health, fruit of coordinated efforts with many institutions and organizations working in health research, including the Ministry for Higher Education, Science and Technology, the Pan American Health Organization and the National Centre for Research in Maternal and Child Health.
- Incorporation of the Research Office as a member of the Science and Technology Fund for Development (CYTED), formed by countries of Latin America and the Caribbean that receive funds from the European

Union and other international donors, allowing a country to have access to funds for promoting research in health beginning next year, in addition to incorporating FONDOCYT as a beneficiary, allowing institutions in the health sector access to research funds in health.[13]

There is no evidence that resources for research have been channelled, even although the health budget has increased consistently over the past few years (in 2010 investment was 185 per cent more than in 2004).[14] There is also no information on concrete research projects or activities promoted by SESPAS.[15]

As for application of information and communication technologies to medicine, no document was found that speaks of research activities and technological development with this orientation. Efforts have been focused on developing a software industry for promoting the country as a destination for unique and exceptional outsourcing (ClusterSoft, 2010), but without projects related to health or medicine. In 2007, SEESCYT (2007) carried out a survey on the use of ICT in Dominican institutions of higher learning. The results show that those institutions did not go beyond constructing and equipping classrooms with video equipment, conferences or virtual classrooms, improving and up-dating infrastructure, technology and creation of wireless networks in their fields, provision of audiovisual equipment for classrooms and services through the Internet for students. No research is being carried out to develop applications for telemedicine or the processing of medical images, which are classic areas of ICT use in this sector.

C. THE PHARMACEUTICAL INDUSTRY

According to INFADOMI (2007), the first efforts to develop a pharmaceutical industry go back to the 1930s, when several companies began to prepare and market several pharmaceutical products. During the dictatorship of Trujillo, there was a period of stagnation and then in 1953 the Government created a government-owned business, Laboratorio Químico Dominicano. At that time, the local market was supplied with medicine imported primarily by multinational companies. Beginning in the 1970s, thanks to the incentives of Law No. 299, which taxed imported articles and exonerated Customs duties on imported raw materials for use in domestic processing, other laboratories began to operate in the country, which increased competition.

In 1984, there were 59 laboratories, and domestic companies held 12 per cent of the market. Currently, 150 companies operate in this field, of which 39 are Dominican. The pharmaceutical industry supports approximately 10,000 jobs, which is 3 per cent of total industrial employment and 0.3 per cent of the economically active population of this country of more than 9 million inhabitants. Foreign companies established in the Dominican Republic operate as importing and distributing subsidiaries, but do not produce. Eighteen of them are from the United States and 56 are from Europa. Eighteen per cent of imports come from companies in the United States (Pina 2006), while local companies hold approximately 50 per cent of the market.[16]

There is no solid evidence that this industry carries out research activities. There are also no specific studies of innovative practices in the pharmaceutical industry, only generic studies. In this sense, the report of Mullin Consulting (2003) is very eloquent in stating:

"Rather significantly, and as far as companies are concerned, the Dominican innovation system is built around the diffusion and absorption of external knowledge, where equipment suppliers play a key role. From the firms' perspective, universities give the impression of being almost irrelevant from the point of view of technology, except as a source of trained professionals working for companies. Even concerning training itself, frequent criticism is heard of the universities in the sense that they do not answer companies' needs. The fact that they do not even have a post-graduate programme in engineering underlines the system's weakness. The need to train experts and develop capacities for management of technology will be a prerequisite that must be satisfied before economic benefits from local technological activity can be expected. The few companies that today are capable of creating and managing technical change will continue to be more the exception than the rule".

The innovation survey carried out by Grupo Consultoría Pareto (2007) confirms the perception that the industry is disconnected from the universities and centres of research, as illustrated in table IV.2.

The 2011 survey does not change much these conclusions. As illustrated in Figure IV.4, the survey indicated that respondents attach limited value to enterprises as a source of ideas and information.

Table IV.2. Source of innovations made by innovative Dominican companies

	Percentage	Accumulated percentage
The company itself	90.5	90.5
The company together with other companies	6.1	96.6
The corporation or subsidiary abroad	1.4	97.9
The company with a university	0.7	98.6
Another company of the business group abroad	0.7	99.3
Another company not directly related	0.3	99.6
Another company in the business group in the country	0.2	99.8
Miscellaneous	0.2	100.0
Total	**100**	...

Source: Grupo de Consultoría Pareto (2007).

1. The legal framework

Recently, Law No. 392-07 on competitiveness and industrial innovation oriented to the creation of industrial zones, parks and clusters was approved with the idea of creating more effective methods for stimulating industrial development and integration.

That law promotes the transfer of knowledge, innovation and technological development from the manufacturing industry, according to the following provisions.

TITLE V Promotion of innovation and industrial modernization: Chapter I Innovation

Article 46. It is recognized that innovation is a process that leads to improved productivity in industrial processes, products and services. The policies and programmes for innovation in industry form part of the national innovation system and as such must be coordinated with other government entities in order to maintain coherence and harmony with the vision of national development.

Article 47. In order to promote the transfer of knowledge, innovation and technological development of the manufacturing industry, companies shall be exempt from the obligation of retaining income tax (ISR) on foreign physical persons or legal entities that provide professional services related to the development of products, materials and production processes, research and development of technology, training of employees, innovation, research, training and environmental protection, as well as all types of consultancy services and technical advice.

Article 48. Subject to the regulations established for each case, the DGII, in coordination with PROINDSTRIA and in accordance with the national innovation policy, the following activities are considered activities for promotion of innovation, research, training and protection of the environment:

(a) Development of industrial prototypes or technological applications for industry;

(b) Projects for saving and the efficient use of energy;

(c) Projects for producing renewable energies;

(d) Projects for installations or productive processes that reduce, neutralize or recycle industrial waste produced, whether hazardous or not where it is produced;

(e) Installations or processes aimed at reducing pollution emissions into the atmosphere.

Article 49. PROINDSTRIA shall coordinate with the Institute for Technical Vocational Training (INFOTEP) training programmes, technological training and promotion of a culture of innovation with the participation of the Institute Technological of the Americas (ITLA), the Institute of Excellence and Business Competitiveness and the technical and post-graduate schools accredited in the country. INFOTEP shall dedicate fifty per cent (50 per cent) of the resources made available by the manufacturing industry to finance training programmes and training as required by industry provided by INFOTEP, ITLA or any other competent institution.

As can be seen, the law establishes a system of tax incentives but does not use direct subsidies as an instrument for promoting innovation (Guzmán 2008). That can be effective, if the companies hire professional services, but there is no explicit mention of the possible deduction of investment in R&D projects made by the company itself.

THE NEW REGULATION OF THE PHARMACEUTICAL INDUSTRY AND POSSIBLE IMPACT ON RESEARCH

DR-CAFTA, as stipulated in article 15.10 of that agreement, could be a source of greater employment and increased foreign investment in the pharmaceutical sector without affecting prices and local industry.[17]

Article 15.10 (a) states that *"If a Party requires, as a condition for approving the marketing of a new pharmaceutical or agricultural chemical product,*

submission of undisclosed data concerning safety or efficacy, the Party shall not permit third persons, without the consent of the person who provided the information, to market a product on the basis of (1) the information or (2) the approval granted to the person who submitted the information..."

That article offers protection for "at least five years" to the person who presents proof (scientific studies on the active principle patented), which will be added to the 20 years of exclusive exploitation rights that medicines enjoy already under the original patents.

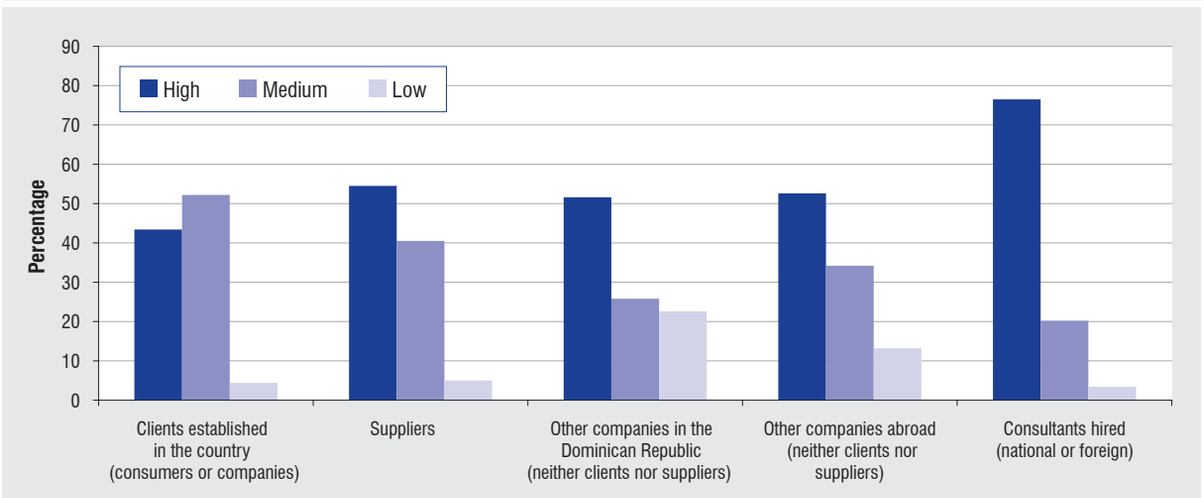
Industrias Farmacéuticas Dominicanas (INFADOMI) has considered "optional" the Government's policy "to require data confidential trials", while "insisting on the interpretation of the article in benefit of the pharmaceutical industry in the United States". Dominican pharmaceutical companies represented by INFADOMI claim that to apply the letter of the law without proper interpretation to all medicine on the market, even generic medicines, would create a sort of monopoly during five years allowing prices to increase. Health policy emphasizes improving access to medicine, which implies reducing prices. The interpretation should be that there is a plan for data protection that authorizes the Ministry for Public Health and Social Assistance to use information from clinical trials as reference for generic medicine.

In marked contrast, the Association of Representatives, Agents and Pharmaceutical Producers (ARAPF), an association of subsidiaries of foreign laboratories considers that that is not what the agreement says and feels that the medicine that is already on the market, such as the antiretroviral drugs used in therapies against AIDS, will not be affected by prices, although new products that are registered in the country for sale to the public, "will definitely be protected".

What has happened and what impact this has had on industry is that the approach of the United States Food and Drug Administration (USFDA) will be adopted, namely that a medicine can be considered generic when it is identical or "bioequivalent" of an innovative one as to the dose, safety, means of administration, quality, characteristics of development and purpose of use. In a scheme of "exclusivity of data", the bioequivalence (equal therapeutic effect, safety and effectiveness as the original) and safety must be proven through clinical trials that imply a cost and, of course, a number of technical complications for the industry.

Furthermore, the requirement by the United States that confidential clinical data be protected for five years must be mentioned. Domestic manufacturers that have based their development on the production of generic medicines once the patents expire have raised their opposition, because this measure would stretch the possibilities of manufacturing medicine in the country. Decree 246 regulates the manufacture and elaboration of medicine, among other aspects, and stipulates in its article 37 that an "application to the Health Register must be accompanied with

Figure IV.4. Interest groups: The perceived value of the ideas and information contributed by various interest groups



Source: Guzmán et al, 2011.

published clinical documentation, confirmation of the request concerning this item will be based on published clinical trials, including published clinic pharmacological trials, in order to determine the safety and effectiveness of the specified conditions of use". If the clinical information is not released, then a local company requesting a registration must carry out its own studies, except if, as has been mentioned, the data protection plan provides that information from clinical trials can be used as reference by the health authority in order to study the requests of the manufacturers of generic medicines.

The marketing of duly registered products is important, because falsification of medicines brands has begun to proliferate, a situation that would affect public health and legal certainty[18]. As for public health, the use of falsified medicine can lead to serious health consequences. Measures to eradicate illegal trade have not succeeded as the mentality of local consumers and the conscience of merchants still needs to be changed. The confidence on the legal system, on the other hand, is also being affected given the limited capacities of the judicial system to persecute illicit acts against the law on industrial property.

This situation can be an excellent opportunity for universities, hospitals and research centres to establish agreements with the domestic pharmaceutical industry in order to carry out bioequivalence tests and clinical research respective, which already has happened in other countries.

However, it must be underlined that, as stated by Mullin Consulting (2003), "there are very few persons and institutions that have the training and experience necessary for scientific research, technological development, formulation of public policies for science, technology and innovation, financing of research, development and innovation or transfer of technology within the domestic of economy. These shortcomings are not the responsibility of the individuals that currently are attempting to carry out these tasks but are the result of the country's economic history and policy that, until very recently, assigned neither priority nor resources to these very important activities". Therefore, urgent and close attention must be paid to stimulating the creation of research capacities, but following an explicit and active policy.

It would be very important for industry to assume that its competitiveness is closely linked to develop capacities for innovation in some of the lines of its value chain. Table IV.3 shows a summary of the analysis of the source of competitiveness for the pharmaceutical industry of Great Britain, which clearly illustrates the importance of having research activities, capacity to carry out clinical trials and practice of high-level human resources.

2. Intellectual property

Concerning intellectual property, the Dominican Republic has established a complete framework, primarily as an answer to the requirements of the Free Trade Agreement DR-CAFTA.

However, as for biotechnology, there are several worrying aspects that can inhibit the flow of technology towards the country because of the uncertainty concerning protection. Specifically, it must be stressed that the protection of live material is excluded. The law on industrial property excludes from protection patents for the entire range of live material and substances pre-existing in nature (see article 2, section 1, paragraph g of that law), without making any distinction between those that have been modified or transformed by humans (which should be patentable), for example genetically modified micro organisms, of those found in their natural state, which we understand to be a discovery, and therefore not patentable.[19]

According to Fernández (2003), the provisions contained in article 2, section 1 paragraph (g) of that law tends to discourage whoever is already carrying out research that the companies seek a guarantee and stability that ensures amortization of research. Furthermore, this provision enters into conflict with article 27 of ADPIC, through which the patenting of modified live material or of that which incorporates technological efforts is permitted.

Moreover, the law on industrial property contributes to the regulation of licenses, in a manner that is contrary to practice. Because it has been decided to prohibit the concession of exclusive licenses, the possibility that a Dominican licensee can enjoy advantages by obtaining the license for exploiting a patent is seriously limited. It is also not logical to prohibit by law the granting of sub-licenses, which can be a practice that is convenient for the parties to a contract, where benefits can be obtained by sub-licensing.

Article 33.- Contractual licences

3. In the absence of provisions in contrast to the contract of license for exploitation, are applicable the following norms:

(b) The licensee cannot cede the license or grant sub-licenses;

(c) The license is not exclusive, and the licensee can grant licenses to others for exploitation of a patent in the country, as well as exploit the patent himself in the country;

4. Contracts for licenses must not contain restrictive commercial clauses that affect the production, marketing or technological development of the licensee and restrict competition, such as exclusive conditions for backing down, that prevent challenging the validity and that can impose mandatory joint licenses or any other anti-competition or restrictive conduct of competition.

The chapter on mandatory licenses is also a source of concern for patent holders, although it offers opportunities for companies manufacturing generic medicines. Article 40.1 seeks to establish that the patent holder refuses to grant a license to an interested user as a reason for a mandatory license. That means ignoring the very essence of the patent, whose holder has the ability to decide whether to grant licenses or not and to decide to whom.

Article 40. - Mandatory licenses

6. When a potential user has tried to obtain a license from the patent holder in reasonable terms and commercial conditions and those attempts have not been successful after a period of 210 days from the

Table IV.3. Competitiveness of the pharmaceutical industry (United Kingdom)

INDICATORS IN THE PHARMACEUTICAL INDUSTRY OF THE UNITED KINGDOM					
Supply conditions		**Demand and regulatory conditions**		**Industry outputs**	
Workforce	1. Number of graduates	Uptake	16. Number units/ month-5 years	Innovation	33. Patents/expenditure on R&D
	2. Perceptions of labour regulation		17. Units-month		34. Medicine produced in the UK
	3. Total hourly labour costs		18. Sales		35. Percentage of the R&D expenditure market
Capital	4. Venture capital		19. Percentage of new molecules		36. New molecules created in the United Kingdom
	5.Percentage of taxes-utilities		20. Percentage of generic		
	6. Market capitalization	Price/profit regulation	21. Setting of prices		37. Percentage of UK companies
	7. Number of businesses created and closed	Research and regulation	22. Time-submission of protocols		38. UK percentage of global sales
	8. Foreign investment		23. Approved studies		39. Number of UK companies launching a medicine
			24. Granting of license		40. UK share of US market
Basic research infrastructure	9. Expenditure on R&D		25. First authorization/ use		41. Molecules in main markets
	10. Number of research citations		26. Authorization -approval		42. FDA review
	11. Number of publications		27. Approval-launch	Macroeconomic contribution	43. Added value
Infrastructure for clinical research	12. Patients in studies		28. Opportunities		
	13. Studies completed in time and form		29. Agency chosen		44. Trade balance
			30. Opinions-procedures		45. World distribution of the production
	14. Cost of study		31. Nominated by the industry		
	15. Studies made in UK		32. Nominated by the agency itself		46. Employment

Source: Pharmaceutical Industry Competitiveness Task Force (2001) of the UK.

date on which the respective license was requested, the National Office for Industrial Property, after a hearing with the patent holder, can grant mandatory licenses related to that patent.

PARAGRAPH. In all appropriate cases, the National Office for Industrial Property will grant mandatory licenses when the interested party proves:

(a) Possession of the technical and economic capacity necessary for undertaking exploitation of the patent in question. The technical capacity will be evaluated by the competent authority, based on the specific norms in force in the country in each field of activity. By economic capacity is understood the possibility of complying with the obligations that derive from the intended exploitation;

(b) When a patent covers a raw material from which a final product will be developed, which the applicant can develop as a final product by himself or by third parties in the country, except in the event of the impossibility of production in the national territory.

(2) In order to determine what is understood by terms and reasonable commercial conditions the particular circumstances of each case and the economic value of the authorization must be taken into account, keeping in mind the rate of average royalties for the sector in question in contracts for commercial licenses between independent parties.

Article 41.- Mandatory licence from lack of exploitation

(1) After three (3) years from the concession of a patent or four years (4) from the presentation of an application, applying whichever period expires the latest, if the invention has not been exploited or when that exploitation has been interrupted during more than one (1) year without a justified cause, any person who has a capacity to exploit the invention can request the National Office of Industrial Property to grant a mandatory license for the patent in question.

(2) A mandatory license shall not be granted when it is shown that the lack or insufficiency of exploitation is due to a chance case or force majeure or a circumstance that escapes the will or control of the patent holder and that justified the lack or insufficient exploitation. Circumstances such as a lack of economic resources or a lack of economic viability of the exploitation shall not be considered justified.

From the perspective of national industry, these provisions in industrial property represent an opportunity to require licenses on patents of multinational companies, but it must be stressed that reproducing an invention patented in this area requires scientific and technological capacities as well as adequate infrastructure to manufacture products under certified conditions of good manufacturing practices.

D. TIES WITH THE NATIONAL INNOVATION SYSTEM

According to the results of the survey carried out by Grupo Consultoría Pareto (2007), only "nearly 8 per cent of the companies declare having some type of agreement (generally covering work experience activities) with a university. In the field of innovation, however, "cooperation" among companies, the Government and universities is very low. The Government's financial support for innovation in companies is also minimal, except in the case of credit institutions, whose use was mentioned by 5 per cent of the companies. In general, the universities' role seems to be limited to the provision of human resources by producing graduates, a function in which, as we shall see, universities receive a relatively favourable evaluation by companies".

During the interviews held for this review, this opinion was fully confirmed. University institutions not only lack basic ties for provision of technical services to industry and the experience necessary for managing knowledge transfer projects and technology but also do not seem to be concerned by defining a policy for that.

Given this situation, Mullin Consulting (2003) states that "a key policy instrument that is needed in the technology market is the function of intermediation for creating links between companies with technology needs and the combination of sources of technology, financing, information of market and elevation of the current level of skills, which could answer those needs". Guzmán (2008) adds that "The depth of innovations in Dominican industry is shallow and they happen outside any coordination among the various actors".

E. CONCLUSIONS AND RECOMMENDATIONS

The main conclusion of the study made by Mullin Consulting (2003) seven years ago is that the Dominican system of innovation is weak in all its

aspects and lacks a sound policy and financial instruments for remedying its deficiencies. It is important and promising, however, to identify recent real changes, above all in starting up FONDOCYT, which has been given growing resources and which supported 158 health and biomedicine projects in 2009. This growing tendency to allocate resources for research must be maintained and an allocation included for healthcare industry's projects, including the topic of clinical research.

As for human resources, PECYTI recognizes in its diagnosis that "concerning advanced training of human resources, there is no doubt that the country requires a critical mass of researchers, engineers and technicians trained in accordance with international quality standards [..]. As for the need for physicians, there is no doubt that physicians are required as advanced human resources that carry out basic research projects, research and development and guide the training of engineers and technicians. Based on the parameters of training of physicians compared to the economically active population of countries like Argentina, Brazil, Chile, Cuba and Mexico, the country would have to train between 100 and 150 physicians per year over the 10 years of the Plan's implementation in order to train between 1,000 and 1,500 physicians, which would be the critical mass that would produce knowledge for innovation and technological development".

Fulfilling this goal is essential and requires short, medium and long-term strategies. In the short term, it may be necessary to resort to contracting scientists educated in other countries, repatriate Dominican researchers or to international cooperation. It is suggested to start a scholarship programme for highly competitive students for training in advanced disciplines such as genomics, biotechnology, medical physics, nanotechnology and medical computer technology. In 2010, only 25 professionals were graduated from the programme of international scholarships who studied for an MA or medical specialization, which reveals that the numbers are insufficient given the challenge of promoting research and innovation in this sector.

In the medium term, forming research groups in universities and supporting the training of capacities in local companies, as well as attracting investment by multinational companies for R&D projects can be considered.

In the long run, an effort is being made to use national post-graduates, which requires activities in agreement with a vision that gives priority to capacity-building.

As for cooperation between the elements of the innovation system, the lack of an effective market for services and technology, both in supply and demand must be recognized. A direct economic incentive must be established for projects linking industry and institutions of higher education and research. But training of technology management capacities, including the management of intellectual property, the diagnostic of companies' technological needs, the drafting of R&D projects in the sector, the preparation of protocols for clinical trials, the definition of good manufacturing practices and standard operating procedures, management of financial instruments and development of innovation plans should also be stressed.

According to Mullin Consulting (2003), another gap in the technology market is created by the absence of internationally accredited laboratories for certifying Dominican products and processes against domestic or international technical standards. This gap will especially affect pharmaceutical companies in this highly regulated industry. Establishment of a network of internationally recognized support institutions must be considered.

The pattern followed up to now by most Dominican companies has been to adopt technology often provided by suppliers of machinery and raw materials (local representatives of machinery companies or the home office). According to Mullin Consulting (2003), that has been a relatively effective means, because there has been commercial financing, including public promotion and at the required pace. Dominican companies that take advantage of this form of acquisition of technology are connected to networks of international suppliers and learn through them about progress, sometimes meeting other producers abroad, going to trade shows and in general solving their problems. In several cases, they use international technological consultants. The structure of intellectual property and protection by patents and confidentiality of the information force industry to adopt new strategies. The law on industrial competitiveness and innovation establishes fiscal incentives and direct subsidies and access to local laboratory capacities, hospitals are required for clinical trials and complementary human resources. All these can only be achieved through specific policies. Box IV.1 summarizes the study's conclusions.

Box IV.1. Main limitations identified

- In general, R&D is not given a central position in the taking of decisions by academic institutions and companies or in development programmes, which can leave PECYTI isolated.
- Low level of public and private investment in R&D;
- Limited absorption and use of technologies by the public and private sectors;
- Fragmented sources of human resources and limited access to cutting-edge knowledge;
- Unclear priorities for scientific and technological development in this sector;
- Lack of a specific programme for developing and registering generic medicine, in accordance with the recent changes in legislation;
- Inadequate policies and legal framework for promoting alliances between industry and universities for the protection of R&D activities and for attracting advanced technologies and investors;
- Limited incentives for private investment in innovation in the health sector;
- Limited information system with science and technology indicators, economics and of market;
- Limited channels for interaction between institutions for the development of knowledge and technology;
- Limited interaction among industry, the universities and the Government.

Source: UNCTAD.

NOTES

[1] www.paho.org/english/dd/ais/cp_214.htm, consulted on 2 November 2010.

[2] Ministry for the Economy, Planning and Development, 2010.

[3] Ibid.

[4] WHO, 2003.

[5] Guzmán, 2008 p. 79.

[6] Personal communication from Sonia Sánchez of the Department for Research in Public Health.

[7] It searches for solutions in health together with farmers and neighbourhood organizations. The Dominican Institute of Medicine wants to contribute to the creation of a health system that is available to all both culturally and economically; through participatory methodology promoting the search for solutions for health together with farmers and neighbourhood organizations and private and governmental organizations, building on traditional knowledge and ensuring that that population is the object of its development.

[8] The Metropolitan Hospital of Santiago and its physicians feel an obligation towards education and research. The fruit of that shared responsibility has given rise to medical residencies that currently have physicians in training in the specialities of: internal medicine, general surgery, anaesthesiology, radiology and critical medicine.

[9] The Academia Dominican of Medicine Inc. is a scientific institution created on 12 August 1971 of physicians dedicated to teaching and research of Dominican medicine.

[10] In the Informe General sobre la Educacion Superior en la Dominican Republic 2002 it is stated that “the Dominican institutions of higher education are exclusively teaching institutions, except for several exceptions and in several periods of time” “The research in Dominican institutions of higher education is still at very basic levels, as to the number of researchers, the resources available and the results obtained”.

[11] Personal communication from José Miguel Estévez, director of the laboratories of the Engineering School of UASD.

[12] Personal communication from Dr. Bernarda Castillo, Director of IIB.

[13] The CYTED programme supports the training of research networks financing mobility of researchers, but not research projects. The perception that European Union funds will be available through CYTED is incorrect.

[14] Ministry of Public Health and Social Assistance (2011).

[15] In the presentation of this study to the participants in the innovation system, DINISA officials promised to send detailed information, which at the time of the drafting of this document has not yet been received.

[16] According to the Association of Representatives, Agents and Pharmaceutical Producers (ARAPF), 60 per cent of the medicine consumed by local inhabitants is imported and the remaining 40 per cent is produced locally.

[17] Pina, 2006.

[18] As indicated in IP Tango, 2010.

[19] Law No. 20-00 on industrial property (2000).

V

Science, technology, innovation and energy sustainability in the Dominican Republic

The energy sector is considered by many analysts as one of the main bottlenecks limiting the competitiveness and economic growth of the Dominican Republic[1]. Despite purchase contracts and financing under an agreement with Petrocaribe and various regulatory reforms, the Dominican economy continues to show a marked susceptibility to external shocks caused by increases in the price of oil and its by-products on the international market. It also has a high degree of dependency on imports of fossil fuels. In addition, owing to structural peculiarities and inefficiencies in the domestic energy market—both in supply and in demand—the energy supply available for productive activities and consumption is clearly deficient in quantity and quality and imposes high costs on the public (subsidies) and private (large-scale self-generation) sectors which restricts the country's potential development.

In this chapter, the main technical characteristics and economics of the Dominican energy sector are described, existing steps aimed at improving the efficiency of that sector are analysed and, in function of this analysis, several recommendations are made for increasing the contribution of more innovative alternative sources and renewable energy in solving several aspects of the energy problem of the Dominican Republic.

A. ANALYSIS OF THE SITUATION

The poor quality and high cost of supplying electricity have had a negative effect on Dominican competitiveness during decades. In particular, the electricity sector has problems such as insufficient investment, high production costs, high levels of fraud and low rates of cost recovery[2]. Frequent supply cuts force companies and families to use their own small generators, with the resulting loss of efficiency and negative environmental impact, while the Government assumes the cost of subsidizing the system.

During the past decade, the Government has tried to restructure the energy sector. In 1999, the government-owned electricity company, the Dominican Electricity Corporation (CDE), was divided up in order to separate generation, distribution and transmission. Generation and distribution were partially privatized, with 50 per cent of government participation. The transmission sector was kept in the public domain, under the recently created Dominican Corporation of State Electric Companies (CDEEE). The law on electricity (2001) established norms, and the approach to setting prices for the electricity system was restructured.

The results of the restructuring did not satisfactorily meet expectations. Responding to the continual lack of reliability of supply and low investment, the Government reached an agreement in September 2002 with private producers and distributors to raise tariffs considerably, eliminate State subsidies and renegotiate contracts. However, difficulties in the sector continued. In 2003, the Government repurchased two of the distribution companies, EDENORTE and EDESUR. An increase of the international price of oil, devaluation and the Government's budget difficulties added complexity to the sector's problems.

In order to deal with that situation, measures were adopted aimed at improving the management of power rationing, introducing more stringent collection of overdue bills and reducing fraud. An attempt was made to bring down the operating costs of EDENORTE and EDESUR in order to be in a position to transfer them again to private management. The formula for adjusting tariffs was changed, delays were reduced and a financial recovery plan was prepared. Measures were also taken to improve the provision and promotion of efficient energy, such as free distribution of low-consumption light bulbs.

In 2007, the main electricity law was changed, imposing new sanctions on fraud and electricity theft. Nonetheless, various institutional and political factors as well as the persistence of fraud among large consumers and in the residential sector continued to make significant reform in that sector difficult. Public subventions have remained above 1 per cent of GDP. Losses of energy in transmission and distribution due to fraud and technical factors increased from 38.3 per cent in 2003 to 45 per cent in 2006, and at the beginning of 2008 were still around 40 per cent (EIU 2008).

In 2009, CDEEE adopted a programme of rationalization, reducing costs by 40 per cent (EIU 2009). In order to decrease the serious problem of lack of payment for electricity, an education campaign was begun and a policy of zero tolerance was adopted for companies. Billing improved by 23 per cent between August and October 2009. Reduction of the burden that the electricity sector imposes on the public treasury was also one of the key points of the structural reform programme linked to the "stand-by" agreement for 1,700 millions of dollars signed with the

International Monetary Fund in November 2009, together with improvement of the efficiency of tax collection and the freezing of current expenses.

The electricity sector has been the source of several of the main difficulties in implementing the IMF stand-by agreement. Given that the transfers to cover the electricity deficit allocations were made for the 2011 fiscal year using the hypothesis of an oil price of around 80 dollars per barrel, the persistence of considerably higher prices has forced an increase of electric tariffs by 11 per cent in 2010 and an additional 8 per cent in March 2011. The goal of reducing the burden of that sector on the public budget continues to be difficult to reach. In November 2011, the possibility of another rise in electricity tariffs of 18 per cent in order to bring tariffs closer to real production and distribution costs, and thus reduce the deficit of this sector, raised strong resistance and was rejected by the Government.

B. SOURCES AND USERS OF ENERGY

It is estimated that the approximate size of the current national energy consumption is the equivalent of 55 million barrels of oil per year. The total amount of these imports is 5 per cent of GDP, or 13 per cent of total imports (having reached 17 per cent with the peak prices of petroleum in 2008) and up to 70 per cent or more of the recurrent deficit of the commercial and foreign currency balances of payments.[3]

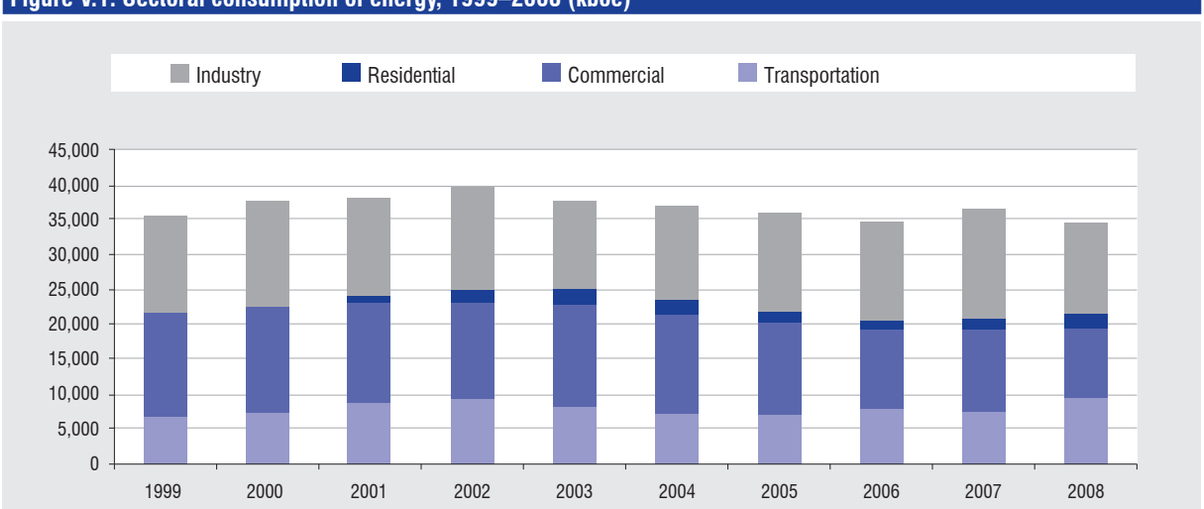
As shown in figure V.1, the use of energy has remained relatively stable during the past decade. That also shows that the main consumer of energy has been the residential sector, followed by transportation and finally by industry. The commercial use of electricity has been relatively recent and has remained relatively insignificant. The use of private generators is frequent in both the residential and commercial sectors, because of frequent and prolonged interruptions.

In 2005, gasoline and electricity were the main sources of power. In 2008, electricity and liquefied petroleum gas became the main sources of power (see table V.1). The country's annual production and consumption of firewood has been reduced by half from 3.2 million tons in 2000 to 1.5 million tons in 2008 (OLADE 2009). The cutting of trees for firewood in poor rural areas has been a factor of deforestation. The use of sugar cane waste, however, has remained relatively constant at an annual average of 2,000 kboe.

C. ACTIVITY OF THE NATIONAL INNOVATION SYSTEM IN RENEWABLE ENERGIES

As described in chapter II of this document, the Dominican national innovation system (NIS) is still

Figure V.1. Sectoral consumption of energy, 1999–2008 (kboe)



Source: Latin American Energy Organization (OLADE) Informe de Estadísticas Energéticas 2009. Based on 2008. Chapter 5: Demanda de energía.

Table V.1. Main sources of energy (percentage) and total energy consumption, 2005–2008 (kboe)

	2005	2006	2007	2008
Firewood	13	9	8	9
Sugar cane waste	5	5	4	5
Electricity	20	21	21	23
Liquid gas (LPG)	14	16	16	23
Gasoline and alcohol	20	18	16	16
Kerosene and peat	9	9	8	0
Diesel fuel	*14*	*14*	*15*	*13*
Fuel oil	*4*	*4*	*5*	*4*
Miscellaneous	0	3	5	6
Total	**100**	**100**	**100**	**100**
Energy consumption (kboe)	***36,585***	***35,324***	***38,104***	***35,592***

Source: OLADE Report on Energy Statistics, various editions.

in a very early phase of its development. That is particularly true in the power sector. Except in the area hydroelectricity, no government or private sector institution has been created with the specific goal of promoting research and development in energy, whether renewable or alternative, with the possible exception of the Office for Alternative Sources and Rational Use of Energy (FAURE) within CNE and the Directorate for Non Conventional Energies of MIC. However, none of these institutions has the specific remit of carrying out research and development in house. Their main functions are to monitor, support, promote, evaluate and commission research and development studies[4].

Despite the incipient nature of photovoltaic activity in the energy sector, it should be pointed out that several institutions, universities, institutes, NGOs and study and research centres have already begun studies, research and experiments concerning agro-energy, hydroelectricity and wind, solar and oceanic power. Various agencies have carried out renewable energy projects as examples and specific solutions in rural or distant areas with available natural resources of hydro, solar or biomass electricity, but at a scale that is still of little significance. There is a noticeable lack of ties between these activities and the business sectors. Therefore, only to a certain degree can we speak of the existence of innovative activity in this area if we use the concept of innovation as the marketing and creation of economic value based on the development of new knowledge. The following are the main specific alternative energy projects and potentially attractive innovative research, whether linked to an institution or local or foreign company.

Small Grants Programme (SGP) of the Global Environmental Facility (GEF). A total of 49 projects:

- 14 small hydroelectric stations that will benefit 483 families;
- 33 photovoltaic systems installed in houses, aqueducts and community centres;
- 2 biogas projects.

Programme for Promotion of Renewable Energies (PER) of NRECA

- Rural electrification with funds from USAID for rural families that live more than five kilometres from the electricity grid;
- 19 photovoltaic projects that will benefit 9,902 families;
- A technical GIS platform (digitalized maps with various layers' superimposed on a system of computerized Information) for the entire country, which has remained under-used.

Project for Promotion of Renewable Energies (PROFER) sponsored by the German International Agency (GIZ)

- Support for the National Energy Commission and the State Secretariat for Industry and Trade (SEIC) (now the Ministry for Industry and Trade (MIC)) in preparing goals and strategies, but primarily the drafting of a proposal of incentives for renewable energies (57-07) and projects with private parties for rural micro hydroelectric projects and in several

pilot projects for producing oil (for example using *jatropha*) for biodiesel fuel;

- Workshops, exchanges and participation in local and international forums on the issue of renewable energies, such as the International Conference for Renewable Energies at Bonn in 2004.

Rural photovoltaic projects

- Approximately 20,000 photovoltaic units for an equal number of families in rural areas, with a large part of the cost reimbursed with a modest monthly payment. It is a form of "leasing". A search was made to determine a means of management and shared cost. The first projects were financed with funds from USAID and implemented by NGOs such as WINROCK;
- An SEIC programme (the current MIC) with funds from Law No. 112-00 (one of the few using that fund) for installing photovoltaic units for thousands of families in rural areas. In some ways, this programme was similar to the previous programme, but on a larger scale. However, SEIC donated the photovoltaic units instead of subsidizing them, charging a minimum monthly payment. According to the statements of several NGOs involved in the project mentioned in the previous point, the difference between the two programmes is the concept of a subsidy offered to families led to a loss of interest in the programme implemented by the NGOs.

Activities of institutes and universities

- **The Institute for Industrial Biotechnology and Innovation, (IIBI, formerly INDOTEC).** This government institute has been especially active in research and teaching in the field of renewable energy. It was the pioneer in the preparation of the first draft law of incentives for renewable energy and has maintained an alternative energy unit permanently since the 1980s. It has carried out research in solar energy for cooking, the drying of wood, photovoltaic systems and other applications. It also carries out research and experiments on wind potential in several provinces. It has implemented research and projects on its own initiative and at the request of third parties on biofuels, (biodiesel, ethanol) and especially on bio gases with biodigesters for agricultural or livestock waste, providing assistance to ranchers and farmers. It has also provided experimental and evaluation services for various innovative technologies for external researchers. Much of its work in this area has been interrupted because of a lack of funds. It also performed other teaching functions, including a post-graduate course in renewable energy.
- **The Energy Institute of UASD.** This institute has carried out several experiments with biofuels, varieties of energy crops and conversion of ethanol into biodiesel. More recently, it has studied the use of sea energy with a pilot project for obtaining energy from ocean waves and the mouths of rivers (reverse osmosis). Together with teaching duties on conventional and renewable energy, it has carried out research on the economics of the energy sector in general and on the crisis of the electricity sub-sector in particular, analysing critically various aspects of its reform and counter reform.[5]
- **The Institute for Agro Forestry Research (IDIAF).** This institute has carried out the first studies on the potential of agriculture soils and livestock available for a large-scale agro-industry energy project. It has also studied varieties oil-producing plants and cellulose. There is interest in further evaluating potential yields from improved soils and the availability of irrigation, making it possible to prepare detailed cost estimates and real limitations on expansion of Dominican agro-industry energy.
- **The University UTESA.** Apart from teaching duties in energy, it has been active in carrying out research, experiments and development of various prototypes of renewable energy solutions. It has experimented with micro wind turbines, solar energy for refrigeration and a system for obtaining drinking water from atmospheric humidity, using solar energy (solar cells) with the support of the University of Florida. It has also made proposals for exploiting the energy of sea waves.
- **The University UNAPEC.** This university has a department that has carried out various research and projects with its students, combining teaching and research in alternative renewable energy technologies (solar, wind). It has carried out studies on new designs and construction of turbines and various mechanisms for improving wind yield.
- **The University National Pedro Henríquez Ureña (UNPHU).** This university has also participated in research on alternative energies. Its best known project is research and application of a technology for exploiting sea waves. That project obtained financing from the World Bank for a prototype of the project that is currently being built on the south-west coast of the province of Barahona.

- **The Institute for Technical Vocational Training (INFOTEP).** This institute of mixed capital (with participation of the Government and the business and labour sectors) makes an important contribution to the preparation of the technical personnel required for possible large-scale development of renewable energies. The institute already has delivered some training and workshops in solar, wind and biofuel energy. It has also supported some research in alternative energies.
- **The Dominican Institute for Integral Development (IDDI).** This NGO, one of the oldest working in rural development, is carrying out research on production of oil producing plants for biodiesel in rural areas and in the outlying provinces.

Private activities

In addition to the R&D work carried out by the institutions listed above, there are various initiatives by Dominican businesses, scientists and engineers that are worth mentioning. There has been work on technologies using enzymatic hydrolysis for obtaining ethanol from cellulose biomass, improved yields in traditional crops for ethanol and use of cellulose biomass for synthesizing gas.

D. PROMOTION OF INNOVATION IN RENEWABLE ENERGIES

The enormous importance that energy issues have for the resolution of the main economic and environmental problems that the international community faces justifies that the development of technologies dealing with renewable energies be considered a very high priority in the public research and development programmes of the main developed and developing countries. The private sector is also making large investments in the development and use of renewable energies. For example, a recent UNCTAD study (*Technology and Innovation Report 2011: Powering Development with Renewable Energy Technologies*) reviews the evolution of costs and yields of renewable technologies such as wind energy, solar (in its various forms), biomass and others and concludes that with good public policies these technologies can already contribute significantly in many developing countries to redressing the lack of energy (especially electricity) in order to achieve the goals of productive and human development while implementing environmentally sustainable development strategies .

In the case of the Dominican Republic, the potential of STI in this sector has not yet been exploited significantly, although, as has been noted before, the energy sector is a serious structural problem in the Dominican economy. Although FONDOCYT granted 29 million pesos between 2005 and 2009 to projects in the categories of “biofuels” and “energy”, that represents only 6.9 per cent of what was invested in that fund.[6] There is no information on implementation of the funds theoretically allocated in Law No. 112-00 for development of renewable energies, which have not been submitted to a process of transparency comparable to that of FONDOCYT. According to several estimates, these funds could be approximately 1,500 million pesos annually for promotion of renewable energies.[7] However, there is no official information on their use, and there is no evidence of the use of potential synergies with STI policy instruments.

Law No. 57-07 on incentives for development of sources of renewable energy and its special regimes, and the regulation of application approved by Decree 202-08, establishes a broad range of tax exemptions and incentives for activities leading to the development of renewable energy. That law authorizes the transfer to general distribution networks of surplus production from renewable sources. The rates of the wholesale electricity market have been guaranteed, including tariff incentives for producers enrolled in the special regime for renewable energies. Later regulations fixed the amount of incentives for various types of renewable energy and the mechanisms for their updating. The total amount of incentives authorized by the National Energy Commission in 2009 by that legislation was 12.9 million pesos, and in 2010 exemptions totalling 116.7 million pesos for self-producers and 283.7 million pesos for the owners of electricity generation projects using wind energy were authorized.[8] Law No. 57-07 also established the possibility that the National Energy Commission set minimum quotas for the energy market (both electricity and fuels) that must be reserved for suppliers of renewable energies.

A description of the results—with figures of projects and amount of exonerations—of the entry into force of Law 57-07 of incentives for renewable energies are presented in the annex to this chapter.[9] From these figures, it can be seen that, although only just beginning, the policy of incentives has produced positive results by increasing the use of renewable

energies in the system. It is worthwhile pointing out that this policy of incentives was considered during 12 years in discussions in Congress, since its initial official discussion in the House of Representatives. Currently, the Dominican Government intends to apply these incentives in order to place the country in a relatively favourable position in the use of renewable energies in the Latin American context.[10]

Before entering into an analysis of innovation activity occurring in the Dominican Republic in each of the various forms of renewable energy, it seems necessary to consider several aspects that must be taken into account when integrating renewable energy into an optimized national energy matrix in terms of economic, financial and environmental sustainability. It is fundamental that STI policy be prepared and applied as a component of general economic development planning and land use planning. As described in UNCTAD (2011b), it is necessary to prepare an integrated framework for STI policies for use, adaptation and innovation in renewable energies. For that, mechanisms must be established for coordination between the actors in the national innovation system (without which it is impossible to develop renewable energies) and the participants in the energy system in order to promote gradual integration of renewable energies into the country's industrial development. For that, it is necessary to have, first of all, a general quantitative perspective about the potential of various alternatives.

1. Sustainability, energy and development

The current world energy panorama is characterized primarily by the rising cost of oil that many estimate to be long lasting and with a tendency to worsen, and by the growing need to reduce the use of fossil fuels in order to be able to keep the problems caused by climate change at tolerable levels. The advantage of developing strategies that permit an orderly transition towards a more sustainable model based on a growing contribution of renewable energies can be justified both from the energy and from the environmental perspective. In the case of the Dominican Republic, the arguments in favour of an energy policy that includes promotion of innovation in the renewable energy sector could also include considerations concerning the model of economic development. Transition towards greater energy sustainability through a more significant participation of renewable energies would contribute to reducing the "carbon footprint" of the Dominican economy, which can be a competitive advantage once the risks of obsolescence of technologies based on fossil fuels is confirmed. The technological capacities that would be generated would provide in the medium-term spill over benefits beyond the energy sector. Problems of equity in energy supply could be reduced. Finally, several of the causes of the economy's systemic vulnerability that already have been pointed out and that reduce the country's growth potential could also be remedied.

The experience of several developing countries indicates that policies promoting renewable energies can result in benefits along various fronts, especially by making compatible the reduction of the CO_2 intensity of their energy systems with the improvement of energy supply to the public and to the productive sectors. Systems based on fossil fuels are subject to high price volatility while in the case of various renewable technologies production costs are easily predictable, and in many cases the equipment necessary has declining costs. Thus, several renewable technologies are already cost competitive in certain applications and present certain advantages in terms of reliability of supply. For example, in many cases electrification of rural areas can be carried out more economically through projects based on renewable energy technology than through the extension of large distribution networks. Another valid reason why developing countries promote renewable energy technologies is to improve the security of supply. For example, during the past decade Chile has been explicitly seeking to diversify its energy matrix in order to improve the certainty, efficiency and environmental sustainability of its energy system. Starting with a similar situation to that of the Dominican Republic, given that all of its hydrocarbon needs are met with imports, which results in fluctuating electricity costs depending on changes in the price of petroleum and gas, the Chilean energy policy has sought to integrate renewable energies into the energy matrix with notable results. In particular, the production of wind energy increased eight fold between 2007 and 2010 thanks to a combination of regulatory and investment incentives.[11]

Large-scale integration of renewable energies in the Dominican energy matrix supposes a radical change in this sector that can be achieved only through a joint effort between the Government and a broad range of social and economic participants,

especially through the components of the national innovation system, which has been described in chapter II of this document. The strategic framework for a national effort of this type would have to incorporate considerations concerning energy policy (improvements in energy security and independence of the country, improvement of the quantity and quality of supply) and improvement of the productive capacity and competitiveness, training technological and environmental sustainability. In other terms, an energy policy aimed at promoting the development of renewable energies would contribute significantly to the modernization of production and development of the general innovative capacity of the Dominican economy.

An integrated focus of energy policy and STI policy to promote economic and environmental sustainability must fulfil five main functions: (a) definition of strategies and goals in this field; (b) establishment of a policy of incentives for research and development, innovation and production of renewable technologies; (c) definition of a policy of incentives that creates absorptive capacities for these technologies into the Dominican productive fabric; (d) incentives for investment in this sector and for demand for renewable energies and (e) use of international cooperation for improving technological capacity in this area.

Given the scale of the changes required, the time horizons for this integrated strategy must inevitably be long-term. Possible incentives (fiscal, regulatory or others) should be aimed at supply (research, development and innovation) as well as demand (use and adaptation of technologies). It is important to fix quantifiable goals, which although do not need to be legally binding but, that, if accompanied by a set of measures, incentives and regulatory changes, represent in themselves a signal of political compromise and reduce the uncertainties with which economic agents must deal with at the time of taking their investment decisions related to the adoption of renewable energies.

During recent years, there has been a rapid increase in the number of developing countries that have established goals or some other type of policy incentives for promoting the use of renewable energy. In many cases, goals have been set for contributions of renewable energy that range between 15 and the 30 per cent of the total of the electricity supply. In other cases it is hoped that renewable energy reaches percentages between 10 and the 20 per cent of the total primary energy or the final energy supply. For example, in 2009 China set a goal of 15 per cent for participation of renewable energies in the final consumption of energy by 2020. Brazil intends to achieve 75 per cent of its electricity from renewable sources, including large-scale hydroelectric projects, by 2030. Goals can also be limited to renewable technologies more specifically indicated for a country's particular situation. For example, India has fixed the goal of producing 20 GW of solar power in 2022 and Kenya 4 GW of geothermal origin by 2030. Other countries, including Egypt, Indonesia, Malaysia, the Republic of Korea and South Africa, have established similar goals.[12] In the case of the Dominican Republic, the 2004 National Energy Plan includes non-binding estimates of the levels of production of various forms of renewable energy that could be reached within various time frames.[13] Later, Law No. 57-07 on incentives for renewable energies stipulates in its article 21 a goal of 25 per cent of the needs of the service to be reached by 2025, complemented by sources of renewable energy and for 2015, if at least 10 per cent of the energy bought by the distributing and marketing companies come from sources of renewable energy.

From the above explanation, it is clear that adoption of renewable energy technologies, just like in general that of any innovative technology, requires public support in the form of measures that facilitate changes in the organizational, commercial and technical structures of the sector and incentives that introduce changes in the behaviour of the economic and social agents involved. Those incentives can be aimed directly at compensating the disadvantages faced by renewable technologies because of non recognition of the externalities imposed by fossil fuels. In other cases, incentives will take a more indirect form, promoting the innovative activity of companies (usually adaptive and gradual innovation) that reduces the cost of these technologies for end users. In many cases, these support measures will basically be those which are used for promoting innovation in most sectors, such as the concession of financial assistance for research, the promotion of clusters or other measures encouraging cooperation between the public and private sectors. In other cases, it is a question of trying to stimulate more specific energy production, as is the case of tariffs guaranteed for the purchase of electricity from renewable sources.

In the context of this science, technology and innovation policy review of the Dominican Republic,

it has not been possible to observe an integral articulation of the innovation policy and the energy policy aimed at producing the development of renewable energies along the lines presented in the previous paragraphs. For example, the considerable Dominican sugar cane agro-industry could have enabled the development of competitive production of ethanol in similar terms to that of Brazil. The arguments against a promotion policy in this field were based on the costs of these developments and its limited justification in commercial terms. However, it is difficult to argue that at least part of the many and very large subsidies that the electricity sector has received during decades, and despite of which continues to provide a precarious service, could not have a more effective alternative use in the promotion of a national bioenergy industry.

There is a broad potential for improving the contribution of STI to the sustainability and competitiveness of the Dominican energy sector so that it stops being a drag and becomes a motor of the economy. For better general evaluation and to illustrate its potential contribution to the country's development, security and economic independence of renewable and alternative energies, a comparison between various technologies, focusing on the electricity sub-sector, will be presented in the following sections.

2. Sources of renewable energy

Under the term renewable energies are included very different technologies that have reached different levels of technical maturity. Hydroelectricity, biofuels, wind, geothermal energy and solar-thermal power can be considered mature technologies that already have a broad installed base. In contrast, others, such as second generation biofuels or ocean energy, cannot be considered in a level of full commercial exploitability. Several of them (photovoltaic or wind) have problems of intermittency of supply, but in general current technological development gives to most forms of renewable energy levels of versatility that permit their use in varied configurations and contexts, whether by themselves, in combinations of various renewable technologies or complementing conventional installations.

In relation to this point, a paradox of the Dominican energy sector and one of the perhaps positive consequences (a strength) of the continual crisis of the Dominican electricity sector is the practical familiarization with a certain form of "distributed generation": tens of thousands of generators or emergency generators, as well as more than 100,000 inverters with batteries. Although that generation is inefficiently distributed and the population and companies have been forced to use and acquire it, it could be argued with certain irony that the Dominican Republic is one of the countries best prepared for adopting a new mode of production and use of energy as a result of a successful technological breakthrough of these alternative energies, most of which constitute forms of distributed generation.

1. Solar power

Currently, there are three main forms of solar power technology: concentrated solar power, thermal solar energy (active and passive, both used primarily for obtaining hot water) and photovoltaic energy.

The technologies of concentrated power are based on the use of mirrors or lenses to capture solar energy, which in the form of heat can be accumulated for later use to produce steam or electricity. Its current costs are estimated to be 0.15–0.20 dollars per kWh.[14]

Thermal solar power is a mature technology. In countries where heating is important, this technology combined with modern techniques of thermal isolation can reduce the energy needs for these purposes by 90 per cent, although the capital cost can be up to a 10 per cent greater than projects based on conventional techniques.[15]

Photovoltaic solar power is based on the use of semiconductors to convert solar energy into electricity. Current photovoltaic systems can be used well in individual systems that are not connected to electric distribution networks and for supplying small networks or even integrated into large-scale distribution networks. There are also hybrid forms that combine photovoltaic technology with eolian or conventional systems. At any rate, the intermittency of the supply still presents difficulties. The variability of the generation levels presents management and control problems in the distribution systems. Despite that, photovoltaic technologies are expanding quickly and the costs of some equipment has recently dropped notably (25 per cent in the first half of 2011), which has caused great acceleration in the installed capacity of photovoltaic generation. It is estimated that in 2010 17 GW of capacity were added throughout the world, compared to 7.3 GW in 2009.[16] Photovoltaic power is especially appropriate for use in the electrification of remote areas. However, give the current cost levels,

large-scale electricity production based on thermal solar energy is still much more feasible.

In the case of the Dominican Republic and the hypothetical case for a strategy that seeks to meet electricity demand exclusively through thermal solar energy a large-scale and rough estimate of the capacity that would have to be installed would be of the order of 6,000 MW (2,000 MW of average demand and 4,000 MW necessary for production for storage) which at current costs would require an investment of between 15 and 20 billion dollars.[17]

2. Hydroelectricity

Hydroelectric technology is the more mature form of renewable energy in a large-scale application. For a calculation similar to that of solar power (in other words, the capacity necessary for satisfying demand exclusively from this source of energy), would require raising the current installed capacity to 2,000 MW for continuous use (starting with 650 MW of nominal capacity that already exists and that cover 12 per cent of total demand - although only 200 MW are really of almost continuous use). An additional 1,600 MW would be required for continuous use. The physical capacity of the country's hydraulic resources does not permit that. There are plans, nonetheless, to expand the capacity already installed by up to an additional 328 MW between 2012 and 2016[18].

3. Wind power

This comparison is very similar in its required installation to the scenario of solar-thermal power described above. It would be necessary to install a capacity of 6,000 MW, because wind, although available at any hour, day or night, usually has an average yield of only one third of the installed capacity (33.3 per cent). Using a more optimistic estimate, based on wind studies already carried out (National Renewable Energy Laboratory) and the country's potential, a 40-per-cent yield from the installed capacity can be assumed (which has, already been surpassed regionally in the case of the Colombian Caribbean Coast, Costa Rica and Jamaica). That way, the total installed capacity necessary would drop to only 5,000 MW. However, as in the previous estimate for solar energy, it would be necessary to have a means to store energy to cover the hours in which the total supply of the power generated from wind is lower than demand, which we assumed as a total (2,000 MW average). It is estimated that the cost of a wind energy production plant is slightly less than thermal solar generation. Even in that case, the amount of investment required would be well beyond 10 billion dollars[19].

Solar and wind energy have differences in terms of environmental impact. Wind energy has greater risks in the event of cyclones than solar thermal energy and cannot be located at just any site, as solar collectors can, because although some areas of the country have greater solar radiation, there are immensely greater options for producing electricity using solar energy than wind. In this most recent case, many locations would require costly infrastructure for access, connexions to networks (which we have not included in the cost), etc. In any case, it is estimated that the Dominican Republic would have the capacity to install approximately 5,000 MW of installed capacity of wind energy. However, until it becomes a reliable source, constantly and continuously available, its contribution should not exceed 20 per cent of the potential average demand.

4. Biomass and biofuel

In the cases of these technologies, it is much more difficult to evaluate their global potential in total scenarios than in the previous technological scenarios. Applicable technologies using biomass and its various biofuels are much more varied and complex. However, for purely indicative purposes of the order of magnitude of what is involved, there is a hypothetical estimate of the possibilities that this technology presents for the Dominican Republic, taking Brazil as a reference.

A reasonable estimate is that a typical plant in Brazil processes more than 2 million tons of sugar cane per year, producing between 180 and 200 million litres/year of ethanol, and costs 150 millions of dollars. The area necessary for supplying the sugar cane for processing is 30,000 hectares (Goldemberg 2008, Oliveiro et al 2010). The bio electricity capacity installed in Brazil reached 1,800 MW in 2007–2008.[20] It is estimated that in 2020–2021 the electricity supplied to the system from this source would be the equivalent of an average of 14,400 MW.[21] It is also estimated that a typical distillery can produce 10 MW of excess energy. In the case of the more advanced technologies currently used in Brazil, there is surplus energy of the order of up to 50 MW.[22] The most recent projects, which use extraction and condensation technologies, can reach a surplus of the order of 80 kWh per ton of processed sugar cane. In 2010, the

cost of these technologies was about 1,670 dollars per installed kW (De Castro et al. 2010). It is estimated that in the case of Brazil, in 2012–2013, 696 million tons of sugar cane would have a generation potential of an average of 9,642 MW.[23]

In comparison, it is normally estimated that one ton of average biomass is the equivalent of the ostensible energy of a barrel of petroleum, although this relation is seen to improve using the newest biomass conversion technologies. Taking into account that local biomass has a cost of 25 to 30 dollars per ton, based on prices from the local agricultural sector, the potential savings can be estimated. Another conventional quantitative reference is the equivalent of electricity from biomass, from half to one kWh per kilo of biomass (0.5-1 KWh/Kg) or between 500 and 1,000 kWh per ton.

Returning to the hypothetical scenario used earlier, the production of 2,000 MW in the Dominican Republic with the more advanced technology available would require an investment of around 3.34 billion dollars, between 16.66 and 11.66 billion dollars less that in the case of solar power and 6.66 billion dollars less than wind power. Naturally, these tables must be understood as a rough estimate, given that it is not possible to expect that the Brazilian results can be translated to the Dominican situation; first of all because in this "Brazilian" scenario it would be necessary to produce some 145 million tons of sugar cane in the Dominican Republic, something which seems clearly impossible, even if it were desirable to transfer the entire Dominican electricity matrix to this type of generation. Despite all that, this approximate calculation permits evaluating the enormous potential savings of using biomass energy in the Dominican Republic. It should be noted that these tables refer to co-generation of bio electricity in the framework of the production of ethanol with which could be met a very considerable part of the energy needs for transportation and cooking.

During interviews organized in the Dominican Republic, mention was made of an experience in the laboratories of the former INDOTEC, today IIBI, where years ago there were experiments with the technology of enzymatic hydrolysis, which showed repeated results that would seem to permit the production of 300 to 378 litres of ethanol per ton of cellulose biomass. However, there were no financial resources to scale up and develop this technique industrially. If this materializes in the future, it could be an important opportunity for the Dominican power sector to use renewable energies. One advantage of biomass and biofuels is that in addition to permitting systems of solid potential for the electricity market, as stated earlier, they permit dealing with the two other sub-sectors of the energy matrix: transportation (with biofuels) and cooking (with biogas and ethanol). Another added factor is the generation of employment, which means higher return on investment for the society as a whole.

It must be insisted that the example based on the Brazilian parameters is only that: an example that permits understanding the orders of magnitude of the problem and the possible contribution of different technologies, but there is still a diversity of possibilities using biomass and biofuels with new, even more economical, promising and versatile technologies than ethanol. Hence the importance of having the necessary financing for exploring and developing them. Such funding—as mentioned earlier—has already been allocated and approved by Laws Nos. 112-00 and 57-07.

5. Other technologies: oceanic and geothermal

As for the various technologies of ocean power (based on the exploitation of marine currents, waves, tides and differences of temperature depending on depths and internal currents), none of them has been really evaluated and explored locally. There are several small local pilot projects under way on technologies for extracting energy from waves (one with UNPHU and another with UASD), but there is still much to be evaluated. They can, however, present an interesting long-term potential.

As for geothermal energy, the country's physical potential for this technology was initially explored in the 1980s by the former COENER without finding any opportunities of interest. However, recent advances in this technology have reduced the required difference of minimum temperature from 160 °C to less than 100 °C, thus significantly opening the country's possibilities for this type of energy. There is already a proposal by a German scientist to begin to draw up a map of the geothermal potential with FONDOCYT, a proposal that appears pertinent. Only with a map will it be possible to estimate reliably the country's potential. In comparison, in Central America there are more than 600 MW of geothermal power already installed, which have an investment cost that, although greater than wind energy (of the order of magnitude of hydraulic power), permit a "base supply" for continuous exploitation, day and night all year round, and with less risk of environmental complications than hydraulic or even wind power.

E. CONCLUSIONS AND RECOMMENDATIONS

For the Dominican Republic, the potential contribution of technological innovation to solving the problem of energy sustainability is of special interest. On the one hand, like for the rest of the international community, the problems caused by the growing cost of fossil fuels and the need to deal with problems caused by climate change provide a strong incentive for the development and use of energy technologies based on renewable sources. On the other hand, the notable deficiencies of the Dominican energy system and the obstacle that it is for the competitiveness and economic development of the country would argue for an opportunity and a special incentive to implement effective policies supporting the development of renewable energy technologies. Finally, reasons such as saving foreign currencies and increasing the country's economic security and independence would also support a reasonable gradual but large-scale change towards renewable energies. In this sense, on the base of the analysis contained in the previous sections, basic recommendations are outlined in the following paragraphs. It should be taken into account that these recommendations are complementary to those made earlier concerning the coordination and general effort of the Dominican national innovation system, and in particular the efficiency of integration between the productive sectors and the various agents that create and diffuse knowledge and technology.

First recommendation

It is desirable that energy sustainability be defined and integrated explicitly into economic development strategies in general and in particular into the national energy policy. That would lead to steps for achieving goals such as a drastic decrease of non-technical loss in the system of electricity distribution (basically various forms of fraud) to which various technologies can contribute; improved transparency and efficiency in the energy market, including the possibility of a much greater degree of competition in retail markets, to which the "distributed" nature of the generation of electricity by renewable technologies can contribute in the long run; and assuming a radical transition towards an energy matrix in which imported fossil fuels play a significantly smaller role with quantifiable targets. These goals require a strong political will, which is necessarily tied to the existence of a broad collective awareness about the seriousness of the energy problem that has existed for decades, requiring a complex solution and long-term structural measures.

Second recommendation

In conjunction with the first recommendation, it is recommended that the trend already under way in the market be facilitated and the matrix be moved towards greater use of natural gas, including development of the required infrastructure. In addition to having less unfavourable figures than other fossil fuels for emissions of greenhouse gases, natural gas is versatile (it can be used in the three sub-sectors of the matrix without major modification) and, above all it is the fossil fuel easiest to combine or substitute later with biofuels (biogases), a measure that the competitiveness of biogases increases by using advanced technology in the conversion of biomass. Examples of this progress are synthesis gas and other biogases from digesters (methane) or reactors based on catalytic pyrolysis or depolimerization. All these must be accompanied by increases in the strategic storage capacity of the main fuels in the country.

Third recommendation

It is recommended that studies be carried out on prospects and planning for the optimization of the mix of alternative and renewable energies, considering their diversity and the combination of natural technical, scientific and social resources of the Dominican Republic. That requires adequate financing for creating various simulation models, pilot projects, etc. The National Energy Commission (CNE), with adequate human and material resources and promoting synergies with the ministries that make up its management, in particular the Ministry for Industry and Commerce (MIC), can play an important role along the lines marked by laws Nos. 112-00 and 57-07.

Fourth recommendation

Reconsider the extent to which the provisions of laws Nos. 112-00, 25-01 and 57-07 are applied in what refers to the generation of financial funds that can be used to evaluate, promote and develop alternative, renewable or equivalent energy technologies, and for promoting and applying a rational use of energy. It is estimated that these provisions offer a potential financing source for these technologies that is not being fully used. It would be best to have a mechanism that can evaluate

and monitor this financing provided to several key actors of the innovation system, in particular MIC, MESCYT, the Ministry for the Environment and the Ministry for Agriculture.

Fifth recommendation

Prioritize the use of these funds for the identification, experimentation, development and adaptation of emerging renewable energies with the greatest potential for application in the country, aimed at both rural and urban markets. One case could be the use of ethanol for rural cooking and motorcycle transportation. It is also recommended that the development of this technology be given priority in the border provinces which are those that offer the best natural resources for renewable energy and, above all, for reaching a significant scale of development of agro-energy and a new productive agro-industry culture, geographically diversified and preferably undertaken in small and medium-size units. The use of funds such as those of Law 112-00 to favour the simple importation of final products of alternative technologies that are already sold (such as solar panels and micro wind turbines) and for which there are other incentives should be reduced to a minimum.

Sixth recommendation

Reinforce and empower institutions that should be more involved in an integral vision of these recommendations and in their implementation towards the three sub-sectors of the energy matrix, beginning with similar areas or departments of the various ministries such as MESCYT, MIC, the Ministry for the Environment and the Ministry for Agriculture. The National Energy Commission and technical and academic institutions, such as IIBI, UASD, UNPHU, INTEC and IDIAF, have an important role to play. The availability of financing through the application of existing legal provisions in this field is again of vital importance.

NOTES

[1] See for example the National Energy Plan, World Bank (2006), World Bank (2007) or IADB (2009).

[2] Idem. See also presentations provided by the Superintendencia de Electricidad of the Dominican Republic (www.sie.gob.do).

[3] National Energy Plan, Chapter 1.

[4] See Ministry for Industry and Trade (www.seic.gob.do) and National Energy Commission (www.cne.gob.do).

[5] This institute has prepared, for example, interesting guidelines for a national energy plan and an analysis of the 2006 energy crisis.

[6] National Innovation Review 2011 MESCYT and Grupo Consultoría Pareto, table 16.

[7] Law No. 112-00 on the tax on hydrocarbons provides that 5 per cent of what is collected by this tax is used to promote and finance development of renewable energies and the rational use of energy. The amount collected by those taxes began at less than 20,000 million pesos per year, but in 2010 was already 34,000 million pesos (899 millions of dollars), of which 1,700 million pesos (45 millions of dollars) were allocated to the fund.

[8] CNE, www.cne.gov.do, consulted on 28 December 2011.

[9] Information gathered by members of the team that prepared this document in a public statement by the president of CNE (February 2011).

[10] In declarations of the president of CNE at the end of 2011, the goal was declared of going from 35 to 85 mW of wind capacity installed in 2012 and between 30 and 40 mW in photovoltaic power, in addition to an increase in the use of biomass. See www.cne.gov.do.

[11] See UNCTAD (2011b), page 118.

[12] See a detailed analysis of the many dimensions of the general framework of innovation policy in the renewable energy sector in developing countries in UNCTAD (2011b).

[13] A total of 500 MW of wind power is planned for 2015, 10 per cent through substitution of gasoline with a mixture of bio ethanol in 2012 and 5 per cent of substitution by a mixture of biodiesel in 2015, 50 MW of biogas produced from agricultural and livestock waste in 2015, 60 MW of electric power from urban waste in 2015 and double that in 2020.

[14] UNCTAD (2011b).

[15] Ibid.

[16] Ibid.

[17] Ibid.

[18] Presentation dated 12 January 2012 by the EGEHID to the Dominican Electric Industry Association (www.adie.org.do).

[19] UNCTAD (2011b).

[20] Ibidem.

[21] Ibidem.

[22] Ibidem.

[23] Ibidem.

ANNEX
RESULTS OF LAW NO. 57-07 ON INCENTIVES FOR THE USE OF RENEWABLE ENERGY[1]

Biodiesel projects

- Eleven pilot projects in seven provinces for the growing of oleaginous plants for biodiesel fuel.
- Two projects in five provinces for growing sugar cane and sweet sorghum (cellulosic gramíneae) in order to produce ethanol.

Concessions (for the sale of energy to the network)

Aeolian parks	1,100 MW requested or granted
Photovoltaic systems	80 MW approved
Mini-hydro installations	1 MW granted
Biomass	1 MW granted
Wave-generated energy	132 MW approved
Solar thermal energy	(none)

Wind parks already under construction

JUANCHO—LOS COCOS	33 MW of installed capacity
Investment	68 millions of dollars
Unit cost	2.06 millions of dollars/MW
Company	EGE-HAINA S.A.
MATAFONGO in Baní	30 MW of power or capacity
Investment	62 millions of dollars
Unit cost	2.06 millions of dollars/MW
Company	Grupo Eólico Dominican S.A.
GUANILLO in Montecristi	50MW of power or capacity
Investment	103 millions of dollars
Unit cost	2.06 millions of dollars/MW
Company	Parques Eólicos del Caribe S.A.

Note that these three parks have the same unit cost of investment (2.06 millions of dollars per MW). The unit value is equal, although the three parks are in three different, distant, regions, presumably with unequal topography, soil, machinery, access, connections and wind regimes and, finally, operated by three different companies.

Approvals of requests for tax exemptions

(a) For photovoltaic equipment provided by intermediaries or importers.

Exemptions of Customs duties based on Law No. 57-07

Year	Approvals	Amount (millions of pesos)
2008	49	5.50
2009	37	11.08
2010	67	298.01

Exemptions of ITEBIS taxes

Year	Approvals	Amount (millions of pesos)
2008	3	4.85
2009	6	1.80
2010	41	75.5

(b) For photovoltaic equipment for self-producers. There were 30 photovoltaic systems for telecommunications stations (antennas) and many others for homes and buildings.

Year	Exemptions on imports (millions of pesos)	Exemptions of ITEBIS (millions of pesos)
2008	05.05.12	..
2009	11.08	..
2010	14.29	23.89

NOTES

[1] Prepared using information gathered during a presentation made by the director of CNE (15 February 2011) in a seminar on Dominican energy policy sponsored by the Institute of the Americas (California) and the Chamber of Deputies.

VI

Conclusions and recommendations

The Dominican innovation system is in a formative stage. All the normative and legislative bases have been established for giving it an adequate institutional foundation. Likewise, a development strategy has been agreed upon that places STI as a vital ingredient. Finally, steps have been taken to mobilize resources so that this system can begin to function. An important example is the resources allocated to FONDOCYT.

However, the Dominican innovation system still needs to be strengthened. It is important that in addition to strengthening those organizations and programmes that promote scientific research and train highly qualified human resources, efforts are also made to promote technological innovation in companies.

The resources for STI activities will be sustainable only if demand is created that requires the services and capacities of these resources. If not, investment can be made in creating human resources that without employment opportunities in the country must later emigrate to other countries.

Because of the current formative stage of the Dominican innovation system, most activities have been driven by normative and legislative changes. However, it is important to reinforce the current range of instruments for promoting science, technology and innovation and to pass to a stage at which incentives will also promote business innovation activities and cooperation. For example, in order to incresase linkages between universities and companies it is necessary that competitive funds, such as FONDOCYT or another innovation fund, are awarded to projects in which there is collaboration between agents, both between independent companies and between companies and universities or other types of institutions.

In addition, it is important that the manufacturing sector is supported with technical assistance programmes. Achieving greater competitiveness requires promoting innovative activities for all companies and clusters. The development of the capacities of local companies will make possible greater ties between the more advanced companies in the free trade zones and other companies.

The lack of highly trained human resources — especially those in more advanced technologies (such as modern biotechnology) — is an major bottleneck for the development of research and innovation activities in several of the areas identified as priorities (ICT, health, energy, agro-industry).

Finally, the building of the Dominican innovation system also requires a capacity for preparing and evaluating science, technology and innovation policies and programmes that become increasingly complex as progress is made in their development.

Based on this diagnostic, a series of recommendations are made aimed at strengthening the efforts that the Dominican Republic is already undertaking to transform its economy into a knowledge-based economy.

Recommendations

(1) Promotion of business innovation through for a set of supply and demand-side incentives.

- Establishment of an innovation business fund that rewards the innovative activities carried out by the productive sector and in particular those made in cooperation with other companies, universities or research centres;
- Promotion of support programmes for the dissemination and transfer of technologies in the main economic sectors, in particular in the manufacturing sector. It is essential to impulse those programmes in clusters and industrial areas, and in combination with activities aimed at developing markets;
- Establishment of a training programme for technology management, including management of intellectual property, diagnosis of technological needs, creation of R&D projects, definition of good practices, management of financial instruments and development of innovation plans;
- Promotion of the development of markets through public procurement, the promotion of productive chains, the establishment of clear signals for forming markets - such as the establishment of norms and regulations concerning alternative energies or preferential prices for these in the energy sector and through campaigns promoting high-quality Dominican products with potential international expansion, such as Dominican textiles, clothes manufacturing or footwear;
- Establishment of a programme for promoting linkages between the more advanced companies in the free trade zones and local companies;
- Reinforcement of the national quality system, stressing the development of a network of internationally accredited laboratories.

(2) Expansion of the funds available for science, technology and innovation activities, in particular for priority areas such as health, agro-industry, manufacturing, energy and biotechnology and ICT.

- Increase substantially the financial resources granted through FONDOCYT;
- Establish mechanisms that allow technological institutes also to be direct beneficiaries of public funds for the promotion of STI, permitting technological institutes to have access to FONDOCYT's resources;
- Establish the fund for business innovation described above;
- Adjust FONDOCYT and other support instruments in order to increase the funds available to the sectors and technologies identified as priorities. Identify the reasons why participation in financed projects has decreased in certain priority sectors and technologies and establish support or complementary instruments in order that the bulk of the funds is used in priority areas. Given the scarcity of available funds, it is suggested that established priorities be reviewed and the support allocated for those areas that are not expected to produce results in the medium term (for example nanotechnology, mecatronics) be reconsidered;
- Explore the availability of domestic and international public and private funds for promoting innovation in the manufacturing sector, in particular funds aimed at promoting good manufacturing practices or technology transfer;
- Reinforce seed capital initiatives.

(3) Invest in the development of Dominican human capital

- Establish a programme of scholarships that facilitates access to high-quality post-graduate training in the priority scientific areas (health, agro-industry, energy) and in more advanced technologies (modern biotechnology);
- Explore schemes that involve companies in the financing of scholarships for students;
- Reinforce international cooperation in research and post-graduate education in priority scientific fields in order to facilitate the participation of Dominican students and researchers in programmes abroad and the participation of foreign specialists in training courses held in the Dominican Republic;
- Establish a programme for repatriating Dominican talent and contracting foreign resources in order to have highly qualified human resources in critical areas as soon as possible.

(4) Build up the research capacity of universities and research centres.

- Recognize the status of the researcher and develop a mechanism for accrediting researchers;
- Promote the establishment of research policies and programmes in universities;

(5) Build the management capacity of science, technology and innovation policies and programmes

- Strengthen the gathering and analysis of information about STI activities in order to obtain more accurate information, including the scope and nature of domestic expenditure in R&D and innovation activities;
- Promote the release of studies carried out on science, technology and innovation, facilitating public access to statistical information and available studies on the status of science, technology and innovation in the country.

The analysis made of three key sectors of the Dominican economy—agricultural and agro-industry, health and energy—indicates a need to develop specific activities for building research and innovation capacities in these three sectors.

In the agricultural and agro-industry area, advances in biotechnology have led to a new technological-economic paradigm that requires the development of human resources in disciplines different from those of traditional agricultural research. This new paradigm has also modified agricultural research processes and the transfer of that agricultural research knowledge, giving an important role to private participation, as well as regulation in the area of biosecurity and protection of intellectual property.

The diagnostic made in this report shows that the current capacity for developing, adopting and spreading agricultural biotechnology in the Dominican Republic is scarce. There is no biotechnology policy that assigns priority to this issue, and current capacities in biotechnology are focused on traditional techniques; and human and financial resources for R&D in biotechnology are insufficient. In addition, an efficient system of linkages between research centres, companies, producers and cluster has not been developed that permits the transfer of technology. Furthermore, the legal framework for biosecurity is incomplete and uncoordinated and intellectual property legislation contains several contradictory elements that lead to uncertainty for potential developers of biotechnologies.

For these reasons, a set of actions for promoting innovation in the agricultural and agro-industry sectors is recommended, in particular for building capacity in biotechnology:

- Develop a national biotechnology policy that assigns priority to this subject, identifies the resources required, promotes linkages among research centres, companies and producers, and contributes to generating interest and confidence in modern biotechnology;
- Revise existing legislation governing patents in order to eliminate contradictions;
- Promote experiences of adopting modern biotechnologies that fulfil a demonstration effect and permit the training of domestic human resources in technological transfer and management of biosecurity;
- Designate a national research group to participate in technological transfer processes, in order to acquire experience;
- Increase the financial resources allocated for research in biotechnology;
- Establish a training programme for the development and adoption of advanced biotechnologies, promoting post-graduate and doctoral education and international cooperation;
- Establish a technical cooperation plan that includes training in modern biotechnology;
- Establish a biosecurity framework that enables the evaluation of requests for releasing GMOs into the environment under the supervision of domestic entities.

In the health field, scientific development and innovation have so far played a secondary role. The financial resources available for research in the health field are very limited. Trained high-level human resources are also scarce. There is little research activity in health, carried out primarily by a limited number of universities, although there is no reason to state that research has been a priority for these institutions. The research carried out consists mostly of clinical studies, surgical cases and epidemiological studies, showing little capacity for fundamental research or proof of advanced technologies. There is also no evidence that the pharmaceutical industry carries out research activities locally.

The regulatory framework governing intellectual property (although it includes several elements that deserve a revision) is quite complete and offers opportunities for greater development of the local pharmaceutical industry. Despite containing several areas subject to interpretation, regulation of the pharmaceutical industry also offers opportunities for its development. Making those industrial development opportunities materialize would require having a sufficient number of persons and institutions with the required training and experience, and with adequate infrastructure (including internationally recognized laboratories) for manufacturing products under conditions of certified good manufacturing practices. It will also be essential that public and private institutions have the capacity to manage technological activities.

On the basis of this analysis, the following is suggested:

- Maintain and promote support for research projects in health, in particular clinical research financed from public funds;
- In the short term, contract scientists trained in other countries, repatriate Dominican researchers and use international cooperation;
- Establish a scholarship programme for training high-level students in advanced disciplines such as genomics, biotechnology, medical physics, nanotechnology and medical computerised technology that make it possible in the medium term to establish research groups in these fields;
- Establish a set of incentives for promoting the development of a network of internationally accredited laboratories for certified clinical trials;
- Revise the instruments that support innovation in order to promote alliances between industry and the universities, protect R&D activities and attract advanced technologies and investors. Specifically, it is suggested that there be an increase of direct financial support for research in health and the development of infrastructure for research and innovation in health;
- Establish a specific programme to develop and register generic medicines;
- Revise the incoherent elements of the regulatory framework for intellectual property;
- Promote a training programme for technology management, including the management of intellectual property, the diagnostic of technological needs, the formation of R&D projects, the drafting of protocols for clinical trials, the definition of schemes of good manufacturing practices, the management of financial instruments and the development of innovation plans.

In the energy field, technological innovation is of special interest for the Dominican Republic because of the potential contribution that it can make to the promotion of energy sustainability. Problems caused by the growing cost of fossil fuels and the need to deal with problems caused by climate change require strong incentives for developing and installing energy technologies based on renewable resources. In addition, the notable deficiencies in the Dominican energy system and the obstacles they present for the country's competitiveness and economic development are also an opportunity and incentive for implementing effective policies supporting the development of renewable energy technologies.

Six basic recommendations are made for promoting energy sustainability in the Dominican Republic. These recommendations promote and are based on technological innovation and are complementary to those proposed concerning the general strengthening of the Dominican national innovation system:

- Explicitly coordinate energy sustainability in economic development strategies and in the national energy policy, including actions for reducing fraud in the electricity distribution system, improving the transparency and efficiency of energy markets; and for transitioning (with specific targets) towards an energy matrix in which imported fossil fuels have significantly less weight.
- Facilitate the use of a greater proportion of natural gas, including through the development of the required infrastructure;
- Carry out feasibility studies and plans aimed at optimizing the use of a combination of alternative and renewable energies;
- Reinforce the use of financial funds created through the provisions of laws Nos. 112-00, 25-01 and 57-07 for the evaluation, promotion and development of alternative, renewable or equivalent energy technologies, as well as the promotion and application of the rational use of energy, establishing an evaluation and monitoring mechanism for this financing in which several of the key actors of the system of innovation participate, namely MIC, MESCYT, the Ministry for the Environment and the Ministry for Agriculture.
- Prioritize the use of financial funds produced by the provisions of laws Nos. 112-00, 25-01 and 57-07 for the identification, experimentation, development and adaptation of the emergent renewable energies with the greatest potential for application in the country aimed at rural and urban markets. One case could be ethanol for rural cooking and motorcycle transportation.
- Reinforce and empower institutions that have to become more involved in the implementation of these recommendations, including the relevant departments of MESCYT, MIC, the Ministry for the Environment, the Ministry for Agriculture, the National Energy Commission and technical and academic institutions such as IIBI, UASD, UNPHU, INTEC and IDIAF.

Bibliography

BIBLIOGRAPHY

Altenburg, T. and J. Meyer-Stamer (1999). "How to promote clusters: policy experience from Latin America." World Development 27(9): 1693-1713.

Banco Mundial (2007). Closing the electricity supply-demand gap. Case study: the Dominican Republic

Bergek, A., M. Hekkert, et al. (2006). Functions in innovation systems: a framework for analysing energy systems dynamics and identifying goals for system-building activities by entrepreneurs and policy makers. Workshop on "Innovation on Energy Systems". Oxford.

BID (2009). República Dominicana: una revisión de la ciencia, tecnología e innovación

Bodden, R. (1991). "Antecedentes y perspectivas de las políticas sobre ciencia y tecnología en República Dominicana." Ciencia y Sociedad 16(1): 7-20.

Brasilia Carlos A. Vassallo Junio 2009 Políticas de medicamentos en América Latina CONASS – BRASILIA

Bravo et al. (2004). Estrategia de innovación y política tecnológica de la República Dominicana. Proyecto INPOLTEC II. Santo Domingo, República Dominicana. Mimeo. Documento auspiciado por la SEESCyT, PUCMM y la Secretaría de Acción Exterior de la Xunta de Galicia.

CEDAF (2000). Memoria Anual 2000, Centro para el Desarrollo Agropecuario y Forestal Inc., Santo Domingo

CEPAL (2011). La Inversión Extranjera Directa en América Latina y el Caribe. Disponible en www.cepal.org/publicaciones/xml/9/43289/2011-322-LIE-2010-WEB_ULTIMO.pdf

Clustersoft (2010). La industria del software en la República Dominicana: avances y perspectivas, Santo Domingo. Documento no publicado

CONIAF (2011). Aportes del Consejo Nacional de Investigaciones Agropecuarias y Forestales (CONIAF). a proyectos de investigación y a la formación de recursos humanos en los sectores agropecuario, medio ambiente y recursos naturales, CONIAF, Santo Domingo, documento de trabajo no publicado

Consejo Nacional de Competitividad (2007). Plan Nacional de Competitividad Sistémica de la República Dominicana. CNC. Santo Domingo, CNC.

Cosas Nuevas (2010) MESCYT dispone cerrar otra universidad. Volume, DOI:

De Castro, N.J., Brandão, R and Dantas, G. (2010). Sugar Ethanol Biolectricity in the Electricity Matrix. Brazilian Sugarcane Industry Association. June 2010.

Diario Digidal RD (2010). Las carencias de DIGENOR limitan sus funciones. Diario Digital RD Volume, DOI: Dominicana 2002. Santo Domingo: Agosto de 2004. Santo Domingo, República Dominicana.

DominicanosHoy.com (2010). DIGENOR y AENOR: Acuerdo para fortalecer su competencia. DominicanosHoy.com Volume, DOI:

Edquist, C. (2001). The systems of innovation approach and innovation policy: an account of the state of the art. DRUID Conference "National Systems of Innovation, Institutions and Public Policy. Aalborg University.

EIU (2008). Dominican Republic. Country Profile 2008. The Economist Intelligence Unit.

EIU (2009). Dominican Republic. Country Report December 2009. The Economist Intelligence Unit.

Fernández, M. (2003). Avances y desafíos de la propiedad intelectual en la República Dominicana, *Headrick Rizik Alvarez & Fernández, Santo Domingo*.

Genovesi, L. M. (2010). Retos en propiedad intelectual y en la industria farmacéutica del DRCAFTA.

Goldemberg, J. (2008). The Brazilian Biofuels Industry. Biotechnology for Biofuels. 1 de mayo de 2008.

Grupo de Consultoría Pareto (2007). Innovación, Educación Superior y Actividad Empresarial en la República Dominicana. Santo Domingo, Editora Alfa y Omega.

Grupo de Consultoría Pareto (undated). Encuesta Nacional de Innovación 2010. Borrador Marzo 2011. Ministerio de Educación Superior, Ciencia y Tecnología. Santo Domingo, República Dominicana. Documento no publicado.

Guzmán (2008). Competitividad, innovación, ciencia y tecnología. Contexto internacional y experiencia dominicana. Secretaría de Estado de Educación Superior, Ciencia y Tecnología y Consejo Nacional de Competitividad, Santo Domingo.

Hekkert, M. P., Suurs R. A. A., et al. (2007). "Functions of Innovation Systems: A new approach for analysing technological change." Technological Forecasting and Social Change 74(4): 413-432.

Hoy Digital (2010). Acreditarán Escuelas de Ingenierías de las universidades caribeñas. Volume, DOI:

IADB (2001). Competitiveness: The Business of Growth. Economic and Social Progress in Latin America. Washington, D.C.

Ibarra, M. (2005). Diseño de mecanismos legales sobre zonas francas de conformidad con las regulaciones de la OMC. USAID. Santo Domingo, USAID, ADOZONA, CNZFE y CNC.

IDB (2010). Science, Technology and Innovation in Latin America and the Caribbean. A Statistical Compendium of Indicators.

IDIAF (2009). Plan Estratégico 2009-2018, Instituto Dominicano de Investigación Agropeacuria y Forestal, Santo Domingo.

IIBI (2011). Memoria Anual, www.iibi.gov.do (consultada el 30 de septiembre de 2011).

INCAE (2011). República Dominicana bajó nueve puntos en el Índice Global de Competitividad. Nota de prensa. INCAE, 7 de septiembre 2011.

INFADOMI (2007). Memoria 2007. 20 Aniversario, Industrias Farmacéuticas Dominicanas, Inc., Santo Domingo.

Instituto Nacional de Salud Pública (2009). Avances, retos y necesidades de una política farmacéutica nacional, Instituto Nacional de Salud Pública, Cuernavaca, México.

IP Tango (2010) Sector farmacéutico dominicano y el respeto a la propiedad industrial, October 8, 2010, http://iptango.blogspot.com/2010/10/sector-farmaceutico-dominicano-y-el.html.

Johnson, A. (1998). Functions in Innovation System Approaches. Sweden, Chalmers University of Technology. PhD.

Lugo, Z. (sf). ONDA y ONAPI: pilares de la propiedad intelectual en República Dominicana. Santo Domingo, Asociación Dominicana de Propiedad Intelectual (ADOPI).

MESCYT (2009). Lista de Egresados 2009, Programa de Becas Internacionales, Santo Domingo.

MESCYT (2010). Lista de Egresados 2010, Programa de Becas Internacionales, Santo Domingo.

MESCyT (2011). Informe General sobre Estadísticas de Educación Superior 2006-2009. Ministerio de Educación Superior, Ciencia y Tecnología. Departamento de Estadística. Santo Domingo.

Ministerio de Economía, Planificación y Desarrollo (2010). Estrategia Nacional de Desarrollo de la República Dominicana 2010 - 2030. P. y. D. Ministerio de Economía.

Ministerio de Salud Pública y Asistencia Social (2011). Memoria 2010, Santo Domingo.

Moquete, C. (2006). REPORT ON PLANT BREEDING AND BIOTECHNOLOGY CAPACITY SURVEY DOMINICAN REPUBLIC, FAO, Rome, October 2006.

Mullin Consulting (2002). Un análisis del sistema peruano de innovación. Lima, Mullin Consulting.

Mullin Consulting (2003). *Preparativos para un Crédito de C&T a la República Dominicana.* Volumen 1 – El Informe Principal*.* Contrato BID # HRD.3.027.00-C*,* Mullin Consulting Ltd*,* Kanata, Ontario, Canadá*,* Agosto 2003.

Navarro, J. C. (2009). República Dominicana: Una revisión de la ciencia, tecnología e innovación. NotEs Técnicas. BID. Washington D.C., Banco Interamericano de Desarrollo.

OECD (2005). Governance of Innovation Systems. Paris.

OECD (2008). Informe sobre las Políticas Nacionales de Educación: República Dominicana. Paris.

OECD and Eurostat (2005). The measurement of scientific and technological activities. Oslo Manual. Guidelines for collecting and interpreting innovation data, (Third ed.). Paris, Organisation for Economic Co-operation and Development and European Commission, Statistical Office of the European Communities.

OLADE (2009). Informe de Estadísticas Energéticas 2009.

Oliveiro J.L, Ferreira, F. M. et al. (2010). Cogeneration a new source of income for sugar and ethanol mills. Proceedings of the International Society for Sugar Cane Technologies. Vol 27, 2010.

OMS (2003). Perspectivas políticas de la OMS sobre medicamentos — Cómo desarrollar y aplicar una política farmacéutica nacional. Organización Mundial de la Salud, Ginebra.

Organización Latinoamericana de Energía (OLADE). Informe de Estadísticas de Energía- varios años www.olade.org.

Patel, P. and K. Pavitt (1994). "Sectoral patterns of technical change: towards a taxonomy and a theory." Research Policy 13: 343-373.

Pérez, R. (2011). X Encuentro del Sistema de los INIA de Ibero América, Asunción, Paraguay, 20 de julio de 2011

PICTF (2001). Pharmaceutical Industry Competitiveness Task Force Final Report March 2001. Department of Health, United Kingdom, London.

Pina (2006). Libre comercio enferma a industria farmacéutica, Interpress Service.

PNUD (2008). Informe sobre Desarrollo Humano de la República Dominicana 2008. Desarrollo humano, una cuestión de poder.

PNUMA/FMAM (2003). Informe sobre los progresos realizados en República Dominicana en el ámbito del proyecto PNUMA-FMAM Desarrollo de un Marco Nacional de Bioseguridad (MNB). Talleres subregionales PNUMA/FMAM de bioseguridad para América Latina sobre la elaboración de sistemas reglamentarios y administrativos en relación con los marcos nacionales de bioseguridad, *Santiago (Chile), 25-28 de noviembre de 2003*.

Porter, M. (1990). The Competitive Advantage of Nations. New York, The Free Press.

Porter, M. (1998). "Clusters and the new economics of competition." Harvard Business Review Nov-Dic.

PUCMM (undated). Situación actual de las pequeñas y medianas empresas en la República Dominicana. Santo Domingo, Biblioteca PUCMM.

Revista Summa (2010). Dominicana supera a Centroamérica en solicitudes internacionales de patentes. Revista Summa Volume, DOI:

RICYT ed. (2007). Manual de Indicadores de Internacionalización de la Ciencia y la Tecnología. Manual de Santiago 2007. Red de Indicadores de Ciencia y Tecnología Iberoamericana / Interamericana (RICYT).

Rivera de Castillo, A. y Brioso de González, I. (2007). Encuesta IFPRI/ASTI. Indicadores de Ciencia y Tecnología Agropecuaria. Informe Final, Instituto Dominicano de Investigaciones Agropeacuarias y Forestales, Santo Domingo.

Rivera, H. (2005). CAFTA-DR: Compromisos asumidos por la República Dominicana y acciones que deberá tomar para aprovechar dicho tratado. USAID. Santo Domingo, USAID, SEIC y CNC.

Rojas, A. y Santana, I. (2002). Caracterización del sector agroindustrial de república dominicana proyecto alianzas público – privadas para la investigación agroindustrial, ISNAR Servicio Internacional para la Investigación Agrícola Nacional, San José, Costa Rica

Sánchez-Ancochea, D. (2006). "Development trajectories and new competitive advantages: Costa Rica and Republican Dominican under globalization." World Development 34(6): 996-1115.

Schmitz, H. (1999). "Collective efficiency and increasing returns." Cambridge Journal of Economics 23(4): 465-483.

Schwab (2011). The Global Competitiveness Report 2011-2012. World Economic Forum.

SEESCYT (2004). Informe General sobre la Educación Superior en la República.

SEESCyT (2007). Situación y perspectivas del uso de las tecnologías de la información y comunicación en la educación superior y su impacto en los aprendizajes, Foro Presidencial por la Excelencia de la Educación, Secretaría de Estado de Educación Superior, Ciencia y Tecnología, Santo Domingo.

Sgut, M. y P. Cañas (2004). República Dominicana - Auditoría de la facilitación del transporte y el comercio. B. Mundial. Santo Domingo.

Tejada Holguín & Asociados (2007). Dinámica del desempleo en el sector textil de las zonas francas de la República Dominicana entre el 2003 y el 2005. USAID. Santo Domingo, USAID República Dominicana.

Tobar F. (2002). "Políticas Para Mejorar el Acceso a los Medicamentos", Boletín Fármacos Volumen 5, número 3, julio 2002.

UNCTAD (2009). Investment Policy Review of the Dominican Republic, UNCTAD/ITE/IPC/2007/9, Geneva 2009.

UNCTAD (2011a). Information Economy Report. ICTs as an enabler for Private Sector Development. United Nations publication. Sales no. E.11.II.D.6. New York and Geneva.

UNCTAD (2011b). Technology and Innovation Report. Powering Development with Renewable Energy Technologies. United Nations Publication. Sales no E.11.II.D.20. New York and Geneva.

World Bank. (1993). *The East Asian Miracle: Economic Growth and Public Policy*. Washington, DC: Oxford University Press.

World Bank (2006). Dominican Republic Country Economic Memorandum: the Foundations of Growth and Development.