



University, innovation and society: Cuban Higher Education in the national innovation system

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Summary

In this document we state that Cuban higher education exerts a prominent role in the national innovation system. It provides a high level education and trains the university graduates and most of the postgraduate training programs. It conducts a sizable portion of the national scientific research and innovation. Cuban higher education institutions are strongly associated to the main social priorities (education, energy, among others), those which frequently incorporate innovation and it is also responsible for the preparation of the leaders in the country. The concept of social pertinence is an important value of our higher education system, understood as the multiple relations that are built between the university and the environment, linkages, bonds, interactions in which both the university

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and society undergo profound transformations. We also show the significance of the process of "universalization of higher education" and its influence on innovation processes linked to local development.

Introduction

Cuban higher education has been giving significant contributions to the innovation system. In this document we state that such contributions do not come only from the R&D activity that the universities develop. Our model also incorporates variables such as the undergraduate and postgraduate training processes, and also the preparation of executives. Those processes link the university to the innovation system.

We shall begin by outlining the more salient features of the Cuban economy and the trend to improve its performance after the serious crisis which began in the early 1990's. Then, we shall characterize the innovation system in Cuba, called "Science and Technology Innovation System" (STIS) which is a stage in the evolution of the national Science and Technology Policy.

Then, the participation of universities in the National Innovation System (NIS) shall be assessed from a three-angled perspective: the education and training of professionals, the postgraduate education, including the preparation of leaders, and activities of science, technology and innovation. The active participation of universities in the Science and Technology Innovation System (STIS) will be noted. In the end, the many challenges that need to be overcome shall be identified.

The economic context

For Cuba, the early 1990s were characterized by a quite complex economic situation. It resulted, primarily, from the disappearance of the Union of Soviet Socialist Republics (USSR) and the loss of the trade linkages established with the rest of the socialist countries in Europe⁶.

The negative impact on the Cuban economy brought about by the change in Eastern Europe was compounded by the effects of the growing globalization process and the existence of an economic blockade imposed by the U.S., which was tightened by the implementation of the Torricelli Act⁷ (1992) and Helms Burton Law⁸ (1996).

Under the influence of extreme changes and the conditions that characterized the domestic situation, the government initiated a process of transformations aimed at halting the decline of the economy and preparing the country to take up growth again on new basis

In 1994, after a long economic decline⁹, Cuba began a process of small economic recovery. In 2006 the economy reached a growth of 12.5%, the highest since 1959. In 2007 the growth was only 7.5%, it was under the 10% scheduled. This indicator was altered due to climatic phenomena all along the year that impacted the sectors of construction and agriculture. (Rodríguez, J. 2007)

⁶ The rupture of the lasting integration relationships with those countries meant for Cuba a drastic reduction of the imports in more than 70%, the loss of markets insurance for its products, quick decrease of the imports and the impossibility of consenting to soft credits in international organizations. In these difficult circumstances, the continuity of the social and economic development that had been reached by the end of the 80's was in risk.

⁷ Law whose objective is to impede Cuban trade with branches of North American companies in other countries.

⁸ Law guided to stop foreign investments in Cuba and to paralyze the supply of products for the concerns that it originates for a company or for a supplier.

⁹ Technological supplies from the USSR were stopped between 1989 and 1992. In three year, imports fell by 72% and exports by 67%, the investment rate was 7% down from 26%, the gross capital formation dipped by 60% and oil imports dropped in over 50%. In 1993, the GDP sank by 35 % compared with 1989.

In the period 1990-2006, Cuba continued to turn into a service economy based in the policy of giving priority to foreign exchange-generating activities that save energy and reduce energy dependence, use qualified human resources and make their productions in dynamic markets. The effect of this behavior can be seen in the shift of sectors share in the GDP structure. In 2006 the structure of the GDP was the following: primary sector 4%, secondary 20% and third 76% (Rodríguez, J. 2007)

The recovery process began in the mid-1990s and was accompanied by a diversification of the sources of growth. Thus, the Cuban economy went from an economy where the key factor of growth was centered on a pattern of low technology-intensive¹⁰ specialized production and export of goods (namely sugar and tobacco) to an economy where the production of services with high added-value, such as health related, education and tourism, prevailed (Terrero, A. 2006).

Economic efficiency and productivity have been severely criticized recently (Castro, R. 2008) and a group of priority sectors have been identified: electro-energetic, transport, hydraulic development, social programs, feeding and housing.

The economic recovery of the country and the structural transformations that should be carried out in the immediate period will rely on the Cuban Science and Technology Innovation System (STIS).

¹⁰ Kelly typology, extending technological intensity as the relation between the total expenditure (current plus investment expenditures) allocated to R+D and the value of production of an economic activity. The critics of this typology points out, among other limitations that an industrial branch can directly qualify as low technology intensive, while being an indirect user of technology generated in other branches by way of inputs. Its advocates justify the use of this classification on the basis of empirical evidence, in many industries, between the intensity of R+D expenditure and the technological complexity (Fernández, C. 1994)

The Cuban Science and Technology Innovation System (STIS)

In the mid 90's, the policy of Science and Technology in Cuba evolved toward the construction of a Science and Technology Innovation System¹¹.

To characterize STIS¹² we will comment on the main players, the environment where the system operates, its priorities, some indicators, limitations and strengths.

Main players of STIS

An important role is played by the Central State Administrative Bodies (OACE). They are divided into two, the bodies with a global reach and those of branch reach. The global organizations (i.e., Ministries of Economy and Planning, Foreign Trade) are regulatory institutions and are in charge of the functioning of the issues involving all activities and organizations and institutions of the State. Regarding STIS, their roles basically relate to activities of planning, funding, evaluation and control of science and technology. Particularly, the Ministry of Science, Technology and Environment is the governing body for the activities of science and technological innovation. It is also responsible, *inter alia*, for designing the policies of promotion and development of innovation according to strategic projections to optimize the available investment, as well as for regulating and facilitating the actions between the players taking part in the process of innovation.

The branch organizations are in charge of leading one or various branches of the economy and they have two roles regarding STIS. First, promote scientific and technological

¹¹ CITMA, 1995. "The System of Science and Technological Innovation". Basic Document. Havana, December, p.3-61.

¹² Here we assume the conception of "innovation "system as a "group constituted by the organizations, institutions, interactions among different collective actors and the social general dynamics that have a higher incidence in the capacities available for research, experimental development, technological innovation and the diffusion of productive technical advances".(Arocena, R and Sutz, J, 2005, p.96)

development in order to increase the efficiency in their activities. Second, evaluate the process of development and technology transfer in the activities in their charge, the functioning of the scientific and technological entities, as well as the effective use and development of their scientific and technological potential¹³.

As previously mentioned, an outstanding role is given to enterprises producing goods and services. Their part is important within the STIS because of their duty to generate and increase the contribution¹⁴ to society and as an important innovation player. There are currently over three thousand companies in the country, 715 of them have undertaken a process called “Business Management Improvement”¹⁵. The rest of the enterprises shall join this process gradually. The benefits for the enterprise and society are obvious¹⁶.

Universities play a decisive role in the creation, diffusion and application of knowledge. They conduct a sizable portion of the national scientific research; they train university graduates and have a decisive bearing on the postgraduate education, notably in education at the doctorate level.

13 The scientific and technological potential (in the case of a branch) is the total of available resources to research, innovate and study problems of national or international scope raised by science, technology and the innovative process.

14 Contribution is meant to be understood as the total monetary contribution to the State, the generation of useful products and services improving the people’s lives, the jobs created, the organizational and technical contributions, the new products and services, the patents, innovations and anything increasing the efficiency of the socialist society.

15 Program for the renovation of structures and work methods in the Cuban enterprise whose main objectives seek to reorganize the flows of production and services, modernize the productive processes on the basis of economic rationality, looking for the maximum efficiency, effectiveness and competitiveness possible and observing a due protection to the environment and the fair treatment of the situation of work resources.

16 For example, in 2005, the enterprises in the Business Management Improvement System boasted a productivity increase of 54.55% compared with those which are not in the system. The contribution in foreign exchange was 1618.76 as opposed to 480.86 and the profit of the enterprises in the system was 14.50% greater than the rest. (Betancourt, A. 2005). The Cuban business landscape has both companies that from the point of view of their performance indicators are on the same level of their peers at the international level (23%) and others who need a change to respond to the demands of the Cuban economy and society of gaining more productivity and efficiency.

The entities of Science and Technological Innovation (ECIT), that is, centers for research, centers for scientific and technological services and units for scientific and technological development, are essential in the system. The main mission of these entities is scientific research, the technological development and delivery of scientific and technological services. Nowadays, the number of entities is estimated at more than 200. (OCCyT, 2005: 19).

The main mission of the financial institutions in the system is to provide funding through the different modalities, trying to enhance the capacity of the key players of the system. Now there is a group of institutions helping the entities in this regard¹⁷.

The Cuban Science and Technology Innovation System incorporates organizational forms and organizations whose goal is to promote and integrate efforts, in particular, to interconnect the scientific and technological research with the productive sectors. That is the case, for instance, of the productive-scientific Pole, the National Forum on Science and Technology, the National Association of Innovators and Rationalizers.

The productive-scientific Poles are instruments of coordination and integration whose main goal is to link up, in the most efficient way, the results of the R&D entities with the needs of the sector producing goods and services. There are presently 14 Poles, two of them in the country's capital and the rest spread across the other provinces. The territorial

¹⁷ They include the following:

Banco Central de Cuba. Governing body of the banking system; its roles include, among others, proposing the monetary policy to allow reaching the targets the country needs.

Banco de Inversiones S A. It is oriented to the production of financial services specialized in matters of investment, identifying and mobilizing available resources, both in the domestic and the foreign markets, channeling to the prioritized and more productive sectors of the economy.

Banco Internacional de Comercio S A. Provides a wide range of services to Cuban, foreign and joint entities. Their main activities include, among others, foreign trade-related transactions and transfers from and to Cuba.

Banco Financiero Internacional. Conducts operations in foreign exchange as a commercial bank, it enjoys a solid reputation and has correspondent banks in several countries.

poles constitute a setting where universities, research centers, productive sectors, the government and social organizations interact.

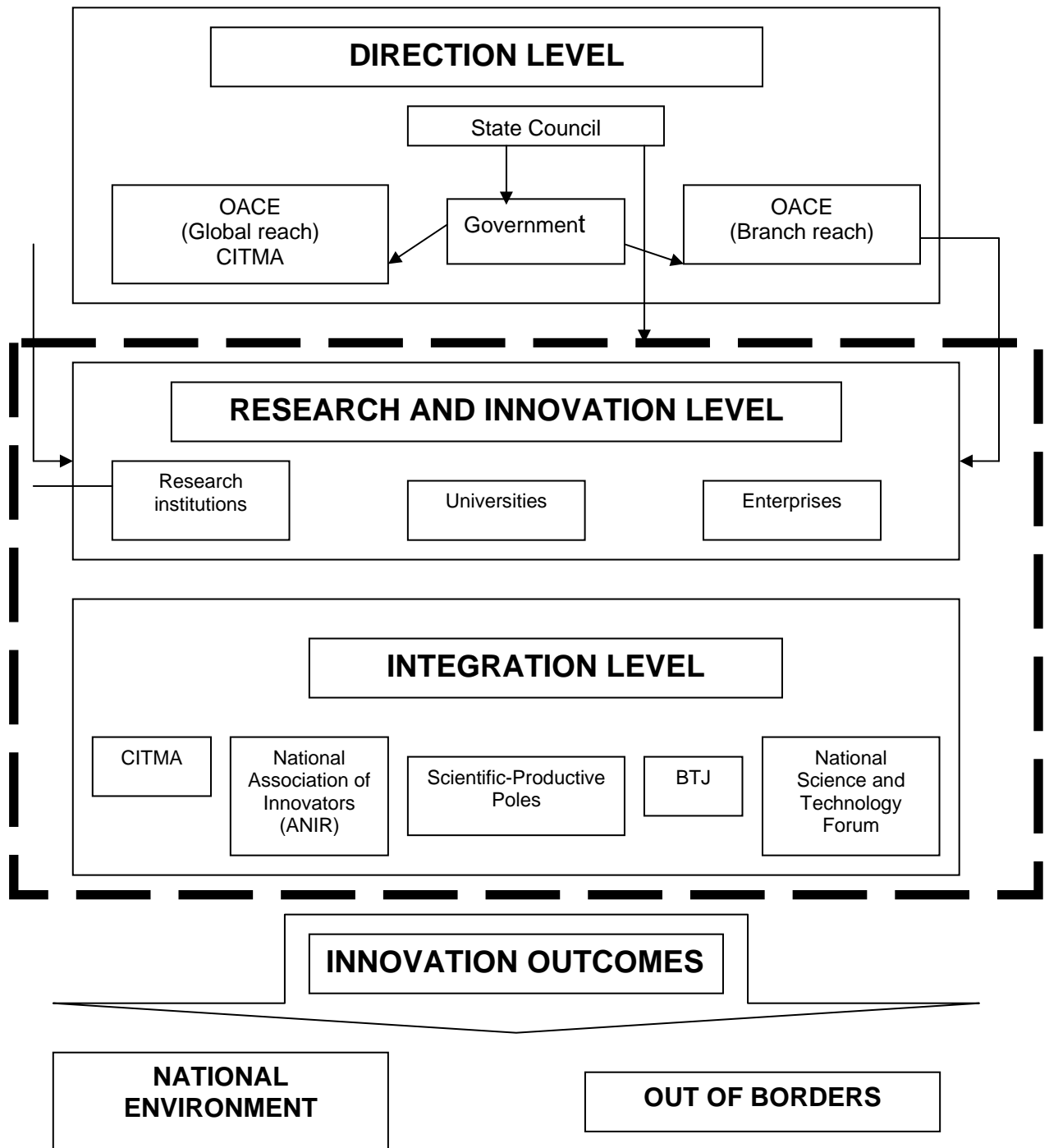
The most outstanding scientific-productive pole is the West Pole, because of its role in the creation of the new, biotech-based, medical-pharmaceutical industry. It also serves as a space promoting interactions and consensus among the actors linked with its development.

The National Forum on Science and Technology is a movement promoting a broad social participation in the process of innovation; it favors the interactions between the key actors in these processes and enables the dissemination of results. The Forum allows looking for useful solutions to daily problems of production and services, including the appropriate application of science and technology. It is organized from the local up to the national level.

The ANIR is an organization covering the entire productive fabric whose members contribute through different ways to enhance the technological performance of enterprises and improve their efficiency and competitiveness. Further to what has been indicated, its importance within the SSTI lays in the fact that their work within enterprises enhance the use and tacit knowledge and the release of technological creativity.

The BTJ is a youth's participatory movement looking for solutions to problems that usually demand scientific and technological knowledge. Its goals include import substitution and the creation of new export products, influence the introduction and generalize scientific results and their dissemination.

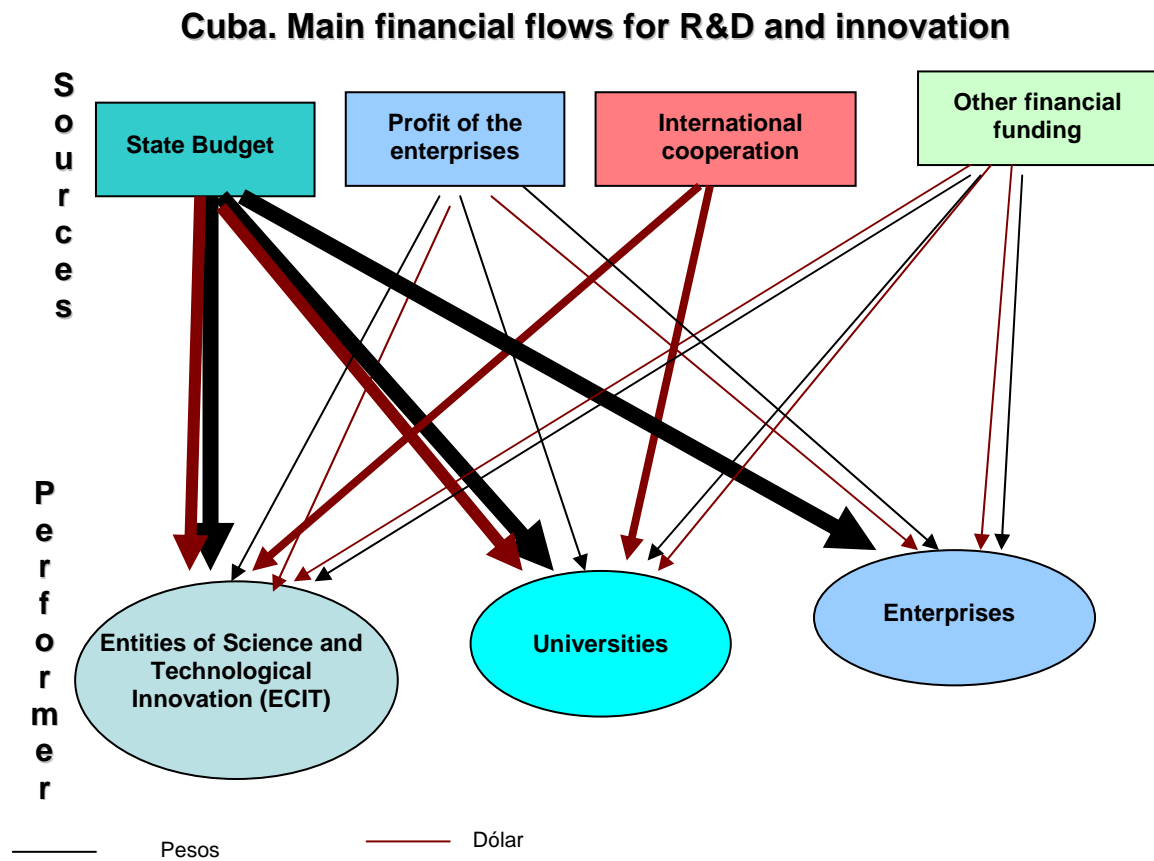
Simplified diagram of the innovation system from 1994



Source: Elaborated by the authors from (Monreal P. 2005)

However, the mechanisms through which research and training agendas are defined and these connect to the economic and social strategy of the country, are not just limited to the abovementioned organizational forms and organizations.

There are a number of mechanisms of exchange at the highest level of government, ministries, enterprises, universities and research centers that generate many joint initiatives influencing research, the exchange of specialists and training.

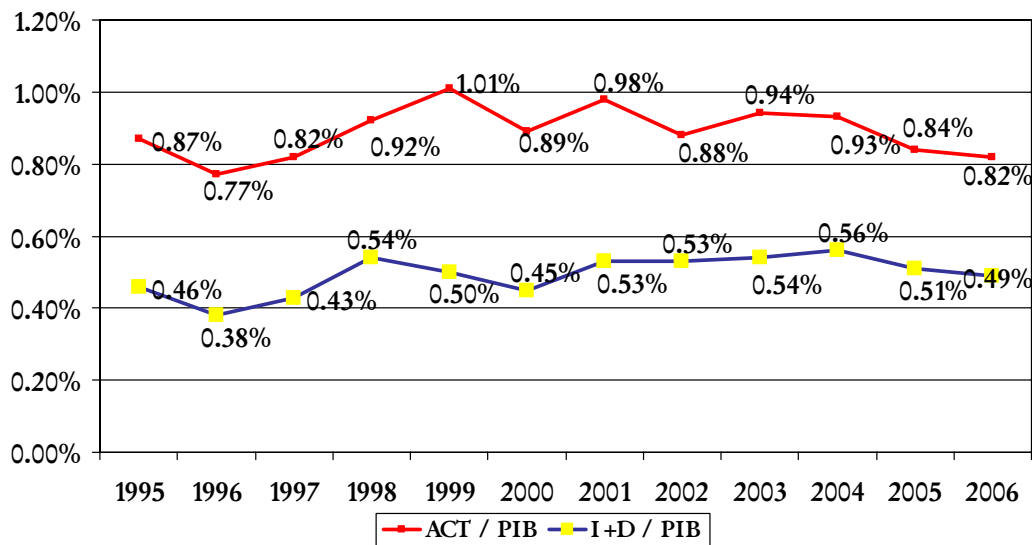


Let us see some Indicators selected from the Science and Technology Innovation System.

The efforts carried out for years by the government to promote science and technology activities (ACT) can be best seen through some of the selected indicators shown below. Note on the Chart No. 1 how, as of 1991 in spite of the financial difficulties that the country went through in the 1990s, the total expenditure in ACT as GDP percentage showed an upward trend. Its most recent descent is because the GDP growth has not been accompanied by proportional increments in the investments in science and technology.

Chart No. 1. Total expenditure on ACT and R&D as GDP

percentage

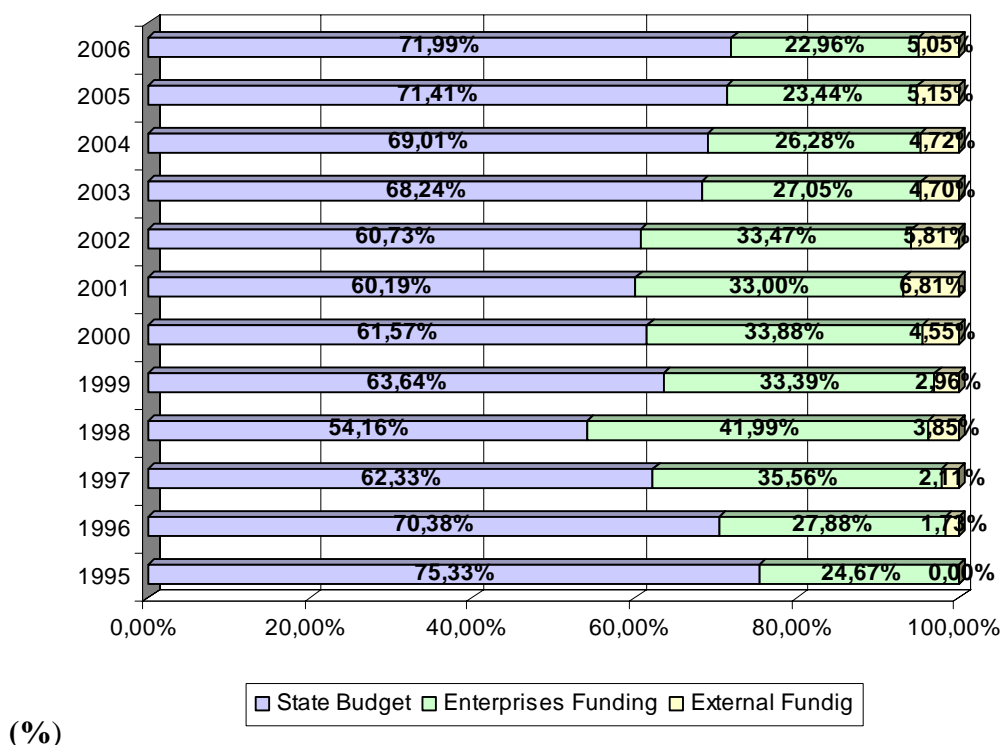


Source: ONE / CITMA (Dirección de Planificación)

Chart No. 2 shows also the efforts in ACT, identifying the sources of funding. It shows the relative participation of the government, enterprises and the external funding in these efforts. As is known, private business in Cuba have a limited scope and maybe except in areas where foreign capital is involved, they are enterprises which do not carry out ACT,

so when a company funding is discussed, it refers in most of the cases to state-owned enterprises. So, however it is calculated, the State appears as the almost absolute financier of ACT efforts in Cuba.

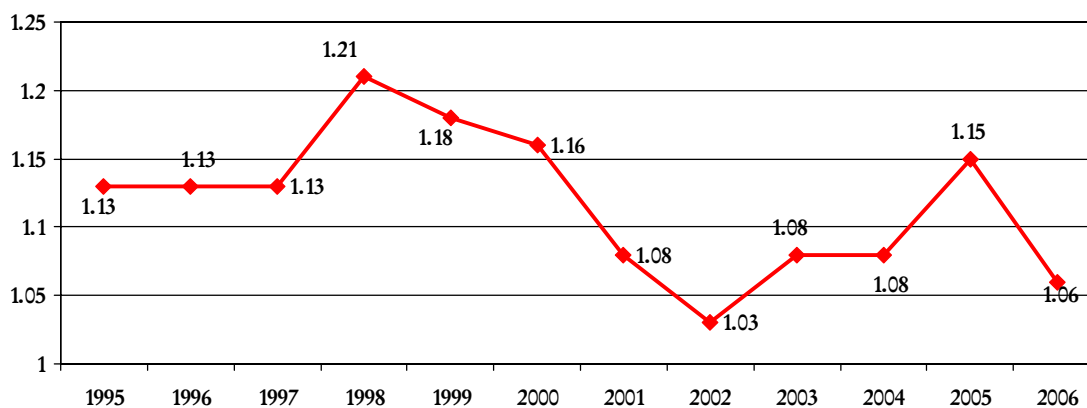
Chart No. 2. Current expenditure in ACT per source of funding



Source: Calculated according to CITMA information (Dirección de Planificación).

Finally, Chart No. 3 shows the number of researchers per 1000 inhabitants of the employable population. Note that by the end of 2003, the country had 1.27, showing an important human potential for R&D if compared with countries like Chile (1.17), Colombia (0.52), Panama (0.35), Latin America and the Caribbean (1.02) (RICYT 2003).

Chart No. 3. Number of researchers per one thousand inhabitants of the employable population (PEA)



Source: CITMA (Dirección de Planificación).

The building of the system of innovation is still an unfinished process. The foundations have been laid, progress is being made, but the SSTI has limitations curbing its effective functioning.

As pointed out earlier, the undercapitalization of the productive sectors was accentuated when the country began the so-called "Special Period" in the early nineties. Many enterprises were operating with obsolete technology and with a high level of inputs and energy carriers¹⁸. This situation somewhat remains and has an influence in the productive development and the innovation capacity.

¹⁸ The impact this had on the country in energy terms is illustrated by Figueras, by highlighting that in 1978 Cuba consumed 1,111 kg of energy (in terms of oil equivalent) for every million dollars of the GDP. Due to the economy downsizing efforts, the figure was reduced to 848 kg by 1987. However, in the referenced years, the value of that indicator was brought to 323 down from 407 in Spain, 259 down from 322 in Italy and 205 down from 286 in Japan (Figueras, 1994:46).

The lack of funding is another major problem. The policy of the Cuban government of preserving and supporting the R&D efforts has led to keeping the institutions operating with the existing resources in spite of the severe economic restrictions. State support to R&D funding allows ensuring basically the salaries of the staff involved in the activity, as well as covering other domestic currency expenses.

The most negative effect in R&D funding relates to the State's supply of foreign exchange. The considerable shortage of foreign exchange has led to allocating these resources with much selectivity, with a view to ensuring the appropriate functioning of institutions and R&D efforts of specific sectors involved in high-priority work. The inability to cover the foreign exchange needs of all R&D institutes, universities and enterprises, among other actors of the system, creates great difficulties for acquiring materials, specialized inputs, international mobility, equipment, as well as limitations in the access to national and international information networks and Internet.

These limitations are compounded by organizational difficulties. In spite of the statements contained in the SSTI documents, R&D continues to take place predominantly outside enterprises. Enterprises are not the axis of the system. The technological efforts of the business community have failed to secure effective linkages between R&D and production. The specialized entities in the interface services have focused their work on organizational development and have given less attention to technological management.

It is also very likely that in various sectors, training of workers, technicians and professionals does not live up to the industry's development needs.

The systematic follow-up and evaluation mechanism for SSTI has not worked ideally. In some cases, there is no precise information providing assistance in the decision making process (OCCyT, 2005).

The limitations identified indicate, *inter alia*, that the effective implementation of SSTI still requires a long and complex process of maturation.

The sociocultural and educational environment is favorable for SCIT. The Cuban higher education system¹⁹ plays a significant role in the system of innovation. It provides the university graduates that the country needs, contributes most of the continuing and postgraduate education, conducts a sizable part of scientific and technical research and is incorporated to the main social programs (education, energy, etc) which the country is carrying out, which frequently incorporate technological innovation. It guarantees the access with equality of opportunities for all and allows developing the continuous formation of the human capital²⁰. The literacy rate between 15 and 24 years is 99.96%; the enrolment rate in primary education is 99.4% and (98,5% reaches the fifth grade) the average level of workers is 10,8 grades (over Taiwan, Chile, China, Brazil). The population with university instruction in the ages between 25 and 64 years is 11% (similar to France and over Italy and Portugal). Studies are compulsory up to ninth grade.

According to UNESCO, the amount of students per professor, in primary education and mid level is 14 and 12 respectively (in USA it is of 15 in both levels). In 2005, the television dedicated 62.7% of its transmissions to educational programming (Rodríguez, J. 2005).

19 General information on Higher Education was provided by the Statistics office of the Ministry of Higher Education.

20 In 2006 Cuba dedicated to the education 9.6% of the GDP and 24.6% of the domestic budget (Prontuario estadístico. MES, 2008).

There is however sectors of the Cuban economy and society that constitute successful examples of innovative efforts of great social impact. There are, for example, very serious advances in the energy sector innovation, with significant transformations in the production and distribution of electric power and the use of non renewable energy sources. The innovation associated to the assimilation of technologies for nickel production has also been important.

The sectorial system of the biotech-based medical-pharmaceutical industry can be considered a success story of knowledge-based economy (Lage, A. 2000). It is based at Havana's West Pole, a cluster with more than 40 institutions and 12 000 workers, seven thousand of which are scientists. These institutions operate in a "closed cycle": research, design, product development and product manufacturing and marketing.

The biotech industry operates with a positive cash flow²¹, it has generated over 900 patents and its importance within Cuban exports has risen. For example, in 2002 foreign sales of medicinal and pharmaceutical products were valued at 50 million dollars (CEPAL, 2003:5) and in 2005 they are estimated at between 100 and 200 million, becoming the country's second export category. Cuba is probably the main exporter of medicines in Latin America with exports to over 50 countries. There are technology transfer agreements and commercial negotiations underway with hundreds of countries.

21 In the US and Europe, barely 20% of biotech companies are able to finance themselves with their sales of products. They are funded, above all, by venture capital and speculations in the stock exchange (Lage, A. 2005 : 35p). As can be seen, the experience of the Cuban biotech is radically different to the one in the US and Europe. Maybe the crucial difference lies in the ownership regime. In Cuba ownership is social and society receives the benefits. A fundamental role is played by the moral motives of scientists and other actors.

The higher education system

The Cuban higher education system²² plays a significant role in the system of innovation. It provides the university graduates that the country needs, contributes most of the continuing and postgraduate education, conducts a sizable part of scientific and technical research and is incorporated to the main social programs (education, energy, etc) which the country is carrying out, which frequently incorporate technological innovation.

Higher education is not, however, an isolated player (Arocena, R and Sutz, J., 2005), at least as it is in other developing countries. There are relatively important R&D+innovation institutions under other organizations such as, productive ministries (Agriculture, Transport, etc), academic institutions (namely, the system of the Academy of Sciences) and R&D+innovation labs working in tandem with enterprises. A significant case is the already mentioned sector of the medical pharmaceutical and biotech industry.

The system consists of 65 higher education institutions²³, all of them public. The Cuban IES offer 98 university degree programs needed for the country's development. Higher education employs a little over 56 thousand full-time teachers and around 94 thousand part-time teachers. The Higher Education Ministry (MES) is responsible for the methodological orientation of the whole system (MES, 2008).

22 General information on Higher Education was provided by the Statistics office of the Ministry of Higher Education.

23 All higher education institutions carry out continuous education, postgraduate training and research, with variable intensity and depending on their academic profiles. Some ten universities carry the main burden of research and doctoral training.

Professional training and education and the innovation system

We will discuss the activities through which higher education contributes to the Science and Technology Innovation System.

There are two modalities of study in higher education: full time or part time studies. The former includes regular day courses and responds to a plan of matriculation in higher education approved by the country, depending on the envisaged demands in the socio-economic strategy. These types of studies require a certain time for its completion (usually five years) and a similar progress pace for all students. Upon completion of these studies, the State guarantees all graduates a job in accordance with the title conferred. These courses are fed by young high-school grads that, in most cases, must take and pass entrance exams for higher education.

Full time studies are characterized by a greater presence of students in the classroom and are usually conducted in the main campuses and teaching units²⁴ of the universities. During academic year 2007 – 2008 enrollment in this type of course amounts to 149 953 students. Nearly 60% of the students registered in these studies graduate in the foreseen terms. The composition by specialities is displayed in the following chart.

24 Those working entities with the appropriate scientific and technological development in the field of the specialty at hand, the sufficient amount of specialists for the required attention to students, the general conditions to favor the teaching of classes, study practices, on-the-job training and term and diploma papers, the extracurricular scientific research etc, which may contribute to the development of professional skills and habits. These units must guarantee the development of systematic or concentrated teaching activities with or without the presence of students there.

Enrollment per branches of study (%). Full time study

	%
Technology	19.3
Natural Sciences and Mathematics	2.5
Medical Sciences	19.9
Agricultural Sciences	1.6
Economy	4.7
Social Sciences and Humanities	7.4
Pedagogy	36.3
Physical Culture	7.8
Arts	0.4

Source. MES. Prontuario Estadístico, 2008

Part time studies are offered to everyone with completed higher secondary level, without age limit, and are geared to ensure full access to higher education. It is conducted after working hours. There is no commitment by the State to guarantee these students an appropriate job in accordance with the profile of their studies, although very frequently these studies are chosen by people who are already working²⁵. Students move at their own pace, without time limit to complete their studies, they have less demands in terms of class attendance and these studies are mainly offered at the municipal university campus or other training spaces.

²⁵ Account must be taken of the fact that in Cuba the unemployment rate is below 2%, which technically is considered “full employment”.

After 2001 with the process of " Universalization oh higher education" and the creation of university campuses in all the municipalities of the country, this modality has expanded considerably in several municipalities and other productive and service spaces. This has generated a modification process in the institutional system that has brought about new programs and forms of civic participation in higher education.

With this process university campuses were created in the 169 municipalities of the country. There are 3150 university campuses ²⁶ where 609 thousand young people study 47 university degree programs in them. This process has allowed the access of 743 thousand students to higher education, which represents around 68% of young people in the ages between 18 and 24 years. 63% of the students are women and 37% men. Social and humanistic sciences have been predominant in the first stage; the policy aims now at fostering training processes in degree programs needed for local development (agricultural sciences and industry processes, industrial engineering, computer science, maintenance).

Training processes are characterized by a group of features which allow them to interact with the productive sectors and to influence in the learning and innovation processes. Some of them are the following:

- Curricula integrate activities of teaching, production and research.
- University education and training is fully spread, reaching a significant part of the youth and workers wishing to continue their studies.
- University studies are closely related to the socio-economic strategy of the country and, above all, at the end of their program full-time students have a guaranteed job in keeping with the completed studies.

²⁶ 340 of them are linked to the Ministry of higher Education, 2361 to the Public Health ministry, 209 to the Ministry of Education and 240 to the National Institute of Physical Education, Sport and Recreation.

- The IES, with their municipal campuses, span across the whole national territory, enabling for proximity of professional training and local needs.
- The process for the establishment of university programs, modification of curricula, conducting on-the-job training, students research, creation of training spaces in enterprises and other organizations, and even the founding of universities is directly associated with the solution of social, economic, cultural and environmental demands. Thus, the knowledge involved in the education and training of professional is closely related to the development of the country.

Innovation system and postgraduate training

Postgraduate education entails a great importance for the innovation system. Cuba is among the Latin American and Caribbean countries which have been able to structure a national system of postgraduate education. It is considered as the opportunity offered for free to all university grads to continue their training process throughout their work lives, and even after that. It is aimed at updating, qualifying, retraining and reorienting graduates in sync with the demands of their work performance: in the academic, research and professional fields.

In Cuba postgraduate education includes what other countries call continuing education, as well as master's degrees and doctoral programs, and specialties leading to new degrees. In 2005, the number of participants in postgraduate activities reached 600 000 grads, out of a total of 800 000 in the country²⁷. These are carried out not only in universities but mainly in the enterprises and other settings where the effective work takes place. Hence,

²⁷ All data on postgraduate education has been made available by the Postgraduate Division of the Ministry of Higher Education.

postgraduate certificates contribute to improve qualitatively the work performance of the mass of professionals and the process of innovation.

The master's degree programs (about 367 with around 2 thousand graduated per year) are essentially generated by initiative of the universities and some research centers, in accordance with the needs of economic, social and cultural development. The specialty (around 169) is conceived as a joint undertaking by demanding entities and the universities. In both cases the interaction between the universities and sectors of production and services are encouraged. However, specialties of the latter play a more leading role, contributing not only the demand, the physical space and resources but also part of the teachers and tutors of the programs. The academic committees (bodies where the programs are conducted) of the specialties are mixed, including university teachers and professionals from the production and services. Specialties devote no less than 50% of credits to work (oriented and supervised) and master's degree programs allocate the same percentage to research, innovation and artistic creation activities.

The doctoral program is thought of as a process of educating researchers of the highest level. Among 300 to 500 doctors graduate every year (exceeded in Latin America only by Brazil and Mexico). Two basic variants coexist nowadays, one more unstructured and individualized, that is tutor-led, without obligation of completing courses. The other is more group-oriented, including some courses and other activities of a collective nature, always under the watch of the tutor and other instructors, favoring their immersion in cooperation networks.

At any rate, the primary research nature of the doctoral program is preserved, although the concept of research fluctuates according to the different fields of knowledge.

The evaluation of the doctoral thesis incorporates the judgment of people and institutions which may give a legitimate opinion on the quality of the results, their practical applicability and social impact. Thus, the idea of peer evaluation is preserved. Nonetheless, it bears in mind the usefulness, efficacy and efficiency, which are not always taken into account by the academic peers. Very frequently, the evaluation opinion takes into account the consideration of its impacts. About 9 thousand doctors have been formed by the country in the last four decades, with the prevalence of technical, natural, agricultural and biomedical sciences.

To understand the functioning of our postgraduate education as a national system and its insertion into development, it is worth briefly commenting on the settings in which it occurs.

One setting is that of ministries, bodies and enterprises that, according with their technological, productive, social and cultural strategies, require the training of the people working for them. These institutions usually have HR representatives in charge of this activity. Ministries usually have “branch schools” in charge of that training role.

Universities cooperate actively in determining the organizations’ needs for advanced studies and, of course, in meeting them. This is the setting where specialties occur primarily. The growth of the number of specialties suggests an improvement of the organization’s response to the need of training their human resources.

Another relevant setting is that of the territories. Each territory has its own economic, social and cultural strategy, as well as a need to train their professionals. Universities, in close relation with the governments, engage in determining the learning, research and innovation needs of the territories and how to address them. The universalization of higher education has brought about the universities' offering new opportunities in knowledge management and innovation for local development.

The last setting is the academic. It covers postgraduate activities taking place within universities in order to promote teaching and research capabilities. The permanent academic improvement of university teachers is part of their contractual obligations. The main efforts are geared to the training of doctors. Among the universities with the greater traditions doctors represent 40% to 50% of the faculty. The other 20% is in the other end. The most encouraging data is that around 50-60% of teachers without a doctorate are currently working to get one.

In the above-mentioned settings, continuing and postgraduate education pays special attention to the people holding leadership posts in ministries, enterprises, the government and other organizations, as well as the people getting ready to hold those responsibilities²⁸. There are specific strategies of education and training incorporating various components: modern management techniques, technical and professional advanced studies, economic training, as well as training for the defense of the country and political education. These processes of education include the highest leaders of the State and Government up to executives operating at the grassroot levels of the organizations and territories. This

²⁸ They are officially called cadres and reserve, respectively.

enables that people in leadership positions, most of them university graduates, are qualified for the duties of their post, improving their performance. In addition, quite often they are also involved in other postgraduate education and training programs.

The last decade, in particular the last five years, has given birth to a concept of quality management of postgraduate education very close to the national needs, as well as adjusted to international experiences. Quality is very much linked with the problem of innovation. In Cuba the concept of quality includes not only what is understood as academic excellence, i.e., the one which is determined by the peer review of publications, thesis and other products of knowledge. Quality also incorporates a central concern over social pertinence of the programs of postgraduate education. A socially relevant postgraduate education is being developed, in accordance with the needs of production, services, research and with a good academic level at the same time. This relation between postgraduate education and social demands favors the role of postgraduate education as a driver of innovation.

University, science, technology and innovation.

Cuban universities are closely related to society. The social relevancy is an important value of the Cuban higher education. The undergraduate and graduate training programs and research university strategies are built in interaction with society. Hence we have called the Cuban model of relationship university-society as an "interactive model"²⁹.

²⁹Núñez, J y Castro, F (2005): "Universidad, innovación y sociedad: experiencias de la Universidad de la Habana, Revista de Ciencias de la Administración, V.7,n.13, enero/julio, Florianópolis, Brasil.pp. 9-30

The undergraduate and graduate training programs and research agendas are led by the objective of promoting the widest social appropriation of knowledge and its benefits, seeking for equity and social justice. All the areas of knowledge are potentially useful: basic science, technology, social sciences, art and humanities.

We consider that the "interactive model" facilitates the participation of the university in the innovation system. Moreover, that model contributes to the objective of creating a model of social development based on knowledge. The universalization of higher education promotes the universal access of citizens to university studies and creates learning spaces in all the localities of the country.

The agenda that guides the scientific and technological research also aims to produce social favorable impacts, scientific research of high level, graduate training programs and international collaboration.

The 17 IES directly linked to the MES³⁰ stand out because of their contribution to the national scientific development. They get over 50% of the awards handed out by the Academy of Sciences of Cuba (ACC) every year to the main scientific contributions in the country and 50% of the Cuban articles registered in the Science Citation Index; they train over 50% of doctors in sciences and get around 20% of the awards associated mainly with innovation. Cuba has been conferred a total of eight medals by the World Intellectual Property Organization, six of these have been granted to institutions of higher education.

These IES employ some 5807 teachers, 620 researchers, 254 young graduates primarily working on research (scientific pool) and 787 youth (work trainees) carrying out several

30 Other IES fall under the Ministry of Public Health, Ministry of Education, Ministry of Culture, Ministry of the Armed Forces, etc.

training activities, including a research component, who can start to work in other organizations upon completion of their training. A little over twenty-one thousand students do some kind of research incorporated in their training curriculum, of which thirteen thousand are seniors and around four thousand are considered top academic performers whose involvement in research is usually important. Generally speaking, the organization of research tends to incorporate young graduates and students into the research teams.

Research in IES takes various institutional forms. Teaching departments are the most traditional. Around 80% of faculty is involved, with varying degrees of intensity, in some kind of research, some times associated with their master's degrees and, especially, doctoral programs. There is an institutional policy and incentive mechanisms favoring the doctoral training, emphasizing the youth.

Quite often scientific work is organized in the departments through the research teams. The research team thus associated with the so-called "Mode 1" of knowledge production (Gibbons, et al.1994) usually in a disciplinary way, takes place in the academia, basically generating publications, thesis and is evaluated by academic peers.

There are also over 50 "Entities of Science and Technological Innovation" made up by some twenty research centers (the bigger ones may total around one hundred researchers) and around 30 Units of Scientific and Technological Development, usually smaller and with less economic autonomy than the research centers. Frequently, they both had moved to alternative forms of knowledge production similar to the ones described in "Mode 2" of knowledge production (Gibbons, et al, *ibid*): the "application context" determines the course of the research, which is organized multi-disciplinarily, there are interactions with

enterprises and productive organizations, it is subject to a different kind of quality control and generates products and technologies which can be commercialized both domestically and internationally.

A little over 90 “Centers of Study” conducting postgraduate education and doing research, operate within the IES.

The more significant fields of research include, *inter alia*: Medicines, vaccines, diagnosis kits, medical equipment, agricultural biotechnology, animal feed, educational and medical informatics, hydraulics, agribusiness, new materials, neurosciences, electromagnetism, enzyme technology, fine chemistry, computer chemistry and social and human sciences.

The presence of universities in the national scientific efforts is revealed in the fact that 43% of their research projects are directly involved in the top priorities of the country organized through the national, branch and territorial scientific and technological programs.

The greatest weight of research lies in the University of Havana, the Jose Antonio Echeverría Higher Technological Institute, the Agrarian University of Havana, the National Center for Plant and Animal Health, National Institute of Agricultural Sciences, the Institute of Animal Science, the Central University of Las Villas, and with less specialties and with a more regional approach, the Universities of Ciego de Avila, Matanzas and Camaguey.

Since the 1980s, within the context of changes in the National Scientific and Technological Policy, higher education has been striving to increase the linkages between their research and the productive sector, and even commercialize its results, including exports of products and technology, preferably to Latin America, Europe and Asia.

In order to facilitate this undertaking, interface institutions were created in the second half of the 1990s under the name of Office for the Transfer of Research Results, as well as mechanisms for the specific funding of product development efforts with revenue-generating capabilities (Núñez, J. y Alonso, N., 1999).

A recent study about the University of Havana (Núñez and Pérez, 2007), some conclusions can be drawn. Let us look at some of them:

- Development-relevant research must take its application very much into account. It does not reduce the scientific value of the development. The context, the fabric of relations into which the scientific practice is inserted, can generate research agendas and technological and scientific paths allowing for new explorations of the scientific and technological frontiers. These research projects can have a scientific relevance and their application go beyond the limits of the context which generated it³¹. Social pertinence can be placed at the core of our values without hurting academic quality.

³¹ A good example is the most recent and probably the most brilliant success of science in the UH which is the creation of a new vaccine against *Haemophilus influenzae* type b (Hib) based on a synthetic antigen. At present work is underway in the production of this vaccine at large scale which will save the country 3 million dollars every year, previously used to import Hib vaccines. A Cuban pentavalent vaccine is also incorporated, probably the second pentavalent vaccine in the world. The exports envisaged are for the Latin American and Asian markets. The results were published by the journal *Science* [305,522(2004)] and the UN Task Force which prepared the document “Innovation: Applying knowledge in development” (2005) reflected it extensively. It was also given an award by the World Industrial Property Organization in 2005.

- The relevant research demands high academic level and requires a good level of scientific education, including postgraduate education. Learning is essential.
- Multidisciplinary, networked work in cooperation is also indispensable.
- The evaluation system of university science must go beyond the exclusive privilege of peer review and should take on board diverse criteria, stimulating the work for the solution of social problems. Unfortunately we still do not have indicators describing the significance and social appropriation of knowledge.
- Society is much more than market. Science tends to commercial demands but must also tend to social needs. Research agendas must also be led to the goal of promoting the broadest social appropriation of knowledge and its benefits. Knowledge can be a source of social justice and equity.

Innovation and local development

As we have showned, the municipal university campuses (SUM) have become an important vehicle for the widespread of university education. But they are also an institutional new player with enormous potentialities to impel local development based on knowledge and innovation. These institutions have the potential to be a factor that integrates the territory's human resources in function of social local innovation. The universalization of higher education endows the municipalities with institutions of tertiary education (nonexistent before) that gather a significant part of the most qualified people in

each locality, thus opening the possibility to build networks that lead knowledge and technologies to the solution of social, economic, cultural and environmental demands in close relation with the local governments.

In other words, the municipal university campuses can collaborate in the identification of local problems and contribute to identify the organizations or people that may contribute to it, create the links, the networks and the flows of knowledge that allow the assimilation, generation and use of that knowledge. Those are strategic tasks that SUM's are beginning to carry out.

Thus, the knowledge involved in the education and training of professional is closely related to the development of the country.

Recent studies (Núñez, Benítez, Pérez, Hernández, Figaredo, 2007) reveal that certain SUM's are innovating in hardware (equipment, products), software (computerized systems, management technologies) and orgware (methods of strategic public management).

It is clear that this new process faces various challenges. This transformation of the universities will require looking after the academic level of their training programs, to recognize interlocutors in the whole society, to study and improve local innovation with its particularities and to transform the traditional systems of evaluation of the university performance.

At local level, and in relation to the SUM's, there are a group of networks working promoted by universities and research centers with a great impact on local development. Among them we can mention the Program of Local Agricultural Innovation led by the National Institute of Agricultural Sciences, with remarkable benefits in feeding and biodiversity. Also the network of eco-materials of the Central University of Las Villas, engaged in the production of materials for the construction of houses; the network of energy efficiency led by the University of Cienfuegos with an important contribution to the saving of energy and the network of dairy farms schools of the Institute of Animal Science with important contributions in the production of milk. Several of these networks are supported by international collaboration.

These offer great opportunity to link university knowledge to social development.

Final considerations and challenges

As we have seen, Cuban universities are closely related to society. The social pertinence is an important value of Cuban higher education. The training and research university strategies are built in interaction with society. Hence we have called the Cuban model of relationship university-society as an "interactive model" (Núñez and Castro, 2005).

The undergraduate and graduate training programs and research agendas are led by the objective of promoting the widest social appropriation of knowledge and its benefits, seeking for equity and social justice. All the areas of knowledge are potentially useful: basic science, technology, social sciences, art and humanities.

The "interactive model" makes possible the participation of the university in the innovation system. Moreover that model contributes to the social objective of advancing toward a model of social development based on knowledge. The universalization of higher education promotes the universal access of citizens to university studies and it promotes learning spaces in all the localities of the country.

The scientific and technological research agendas aim at producing social favorable impacts, supported by scientific research of excellent academic level, postgraduate training and international collaboration.

However, the concerns and challenges are multiple. The following are among the most important ones³².

1. The coexistence of three different university ideals (what Tunnerman (2006) calls "idea of university"). The idea of university of innovation with social relevancy (Didriksson, 2006), in our opinion coherent with the trajectory of the Cuban university. The university whose main objective is both the training of students and basic research and the third one, the university dedicated mainly to the training of students. It is obvious that those different ideals have political-institutional consequences that may influence in the forms of participation of higher education in the innovation system.
2. In the productive sector we find enterprises and institutions that take little advantage of the training university programs, the research and university innovation. This is

³² Identifying these challenges is the result of the work carried out at the Seminar "University, Innovation and Society" developed by the program on Science, Technology and Innovation by the University of Havana.

influenced by the non existence of a widespread system of incentives for the managerial innovation neither a policy to boost the productive sector to support the university, although good examples exist in this respect.

3. The national Science and Technology Policy require actualization and support. During the last decade it was devoted to create an innovation system strongly supported by science. However, after a decade, it does not seem to be successful enough in the generation of widespread systemic interactions among the actors of innovation. The application of research results in key sectors as food production is still insufficient. This suggests the necessity to modify approaches, priorities, management styles and other instruments that favor, among other things, the integration among institutions of knowledge and other players.
4. Severe financing and investment problems are observed, as well as an important deterioration of the infrastructure in research institutes and university laboratories. Investments that favor the access to scientific information are also required.
5. Difficulties are observed with the generational relief of staff and high-level researchers associated to the decreasing number of graduates in basic sciences and engineering, the displacement to other better remunerated economy sectors and migratory processes.
6. The research oriented towards innovation in the university needs more institutional, stable and sufficient legal bases: incentives, financing mechanisms, channels for the commercialization, among others.

7. The universalization of higher education outlines countless challenges. First of all, challenges related to the quality of training in a context of remarkable massive access. And secondly, challenges associated to the management of higher education institute and their capacity of generating benefits to local development. Real possibilities exist of creating local systems of innovation, with the active participation of the university municipal campuses . But this will demand very well guided institutional policies that mobilize the consent of numerous actors.

Let us finish with a brief consideration about the next stages of the research that we have conducted within UniDev.

Queries such as the following are posed worldwide and on most of the countries:

Are science, technology and innovation, able to contribute to satisfy the social needs of the greatest majorities, to favor inclusion and social sustainable development?

May higher education contribute to those goals? How?

These questions require a systematic study of the scientific policies, the innovation systems and also the role of higher education within them. In Latin America and The Caribbean the University is usually the knowledge institution with larger capacities. But those capacities may serve fully to social development only in a social context and within institutional policies that allow it.

Cuba is an excellent laboratory to continue exploring the relationships among higher education, innovation and development, mainly in the context of the current process of universalization of higher education and in the perspective of local development, both newly approached issues in the country.

In order to research in that field we have created a National Research Program, very well articulated to the policy makers. It tries to answer the queries formulated before, whose advances and results will be interesting to share with the UniDev colleagues.

There are other interesting topics associated to the previous one, among them the one of public policies of science and technology for social development and the ruling of the international system, what includes the international cooperation for the high level formation and the scientific and technological research.

We hope to be able to share these and other topics.

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