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Capacity Building for the Knowledge Economy: The Cuban Experience (1959-2009)

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Abstract

This paper describes and analyzes the foundation of Cuban commitment to enhancing human resource capacity building since the outset of the Revolution in 1959. It gives an overview of the achievements in the education sector, especially the expansion of higher education. The higher education system has facilitated the link between higher education research and development by emphasizing the importance of social relevance in the strategic planning of the institutions, as well as in evaluation and accreditation processes. The paper highlights the expansion of medical services and, finally, the paper reviews some success stories, where university research has been linked to meeting social needs, especially in the health sector.

1. The Education Revolution

Educational reform was one of the pillars of the so-called Moncada Programme. It was from the outset a commitment of the Revolutionary Government to not only raise the educational levels of Cubans in general, but especially integrating the rural areas and women in this process. It started with the literacy campaign in 1961, when illiteracy was brought down from around 23% to 3.9% through a mobilization of literacy brigades. This claim was later investigated and corroborated by UNESCO, hailing the achievement as being probably unequalled in the world (Brundenius 1984).

The literacy campaign was followed by measures such as the nationalisation of teaching, free access to education, and a wide-ranging policy of publishing and distributing books free of charge. Mass scholarship plans made access to education possible for students from all parts of the country and any social background. The development of adult education, training

programmes for *campesinos* – particularly women – were some of many actions to provide mass education.

The University Reform of 1962 was another significant landmark for the expansion of higher education. It profoundly modified degree courses and study plans, incorporated scientific research and created a close link between theory and practice within university. At the same time enrolments in primary schools and secondary schools were rapidly increasing, and gradually also at the university level. But the educational upsurge was not limited to expansion of enrolments. As a follow up to the successful ambitious program to elevate the educational levels of the people at large, a programme was launched for adults having no or little education. Adult education was offered on a large scale in farms, factories, offices and night schools. Courses leading to a third-grade education were facilitated to more than half a million adults in the mid-1960s. The next phase was the "battle for the sixth grade", with the aim that all economically active Cubans should have completed primary education. This target was reportedly reached in 1980, when the new battle, "the battle for the ninth grade" (completed lower secondary education) was launched. Successively a similar battle was launched for the twelfth grade. By 1986 no less than 38.7% of the Cuban active population had completed secondary education, compared to 4.5% in 1953 (see Table 2).

By the end of the 1980s practically all children up to 17 years of age were enrolled in primary schools and lower and upper secondary schools. Increasing numbers also continued to tertiary education, either at universities or at other higher education institutions.

2. The Universalisation of Higher Education

However, this development came to a halt in the 1990s when tertiary (higher education) enrolments started to decline as a result of the economic crisis. Not so much due to budget consideration but to the fact that the state could not guarantee jobs to university graduates any more (Brundenius 2002a). Tertiary enrolments dropped from 263 000 in the peak academic year 1987/88 to 106 000 in 1999/2000. At that time it has been estimated that 46% of young people (age cohort 20-29 years) were inactive, that is they were neither studying nor working. The government got aware of this worrying tendency and a crash programme started, motivating these youngsters to start working as social workers with the possibility to study at university at the same time (that is combining relevant work with studies). This crash program was a success and in 2004 the idea of "universalisation of higher education" was born.

In Cuba's 169 municipalities, there are more than 800 municipal university branches (SUM). The basic goal is to contribute to the achievement of a general comprehensive culture among citizens and to make higher education possible for anyone, by creating equal opportunities available to all. In the academic year 2007/2008 there were more than 744 000 students enrolled in institutions of higher learning in Cuba (ONE 2008). As a result, tertiary enrolments in Cuba are today at the level of economically advanced countries and were in 2006, together with Venezuela, the highest in Latin America (Table 2).

Table 1. Educational Attainment of the Cuban Labour Force by Level of Education

	With at least Lower Secondary Education	With at least Upper Secondary Education	With Higher Education
1953	12.4%	4.5%	1.5%
1978	46.4%	20.2%	3.9%
1986	76.5%	38.7%	8.9%
1999	83.0%	52.7%	12.8%
2007	92.0%	64.8%	14.9%

Sources: Brundenius (2002b, Table 7.2) and ONE (2008)

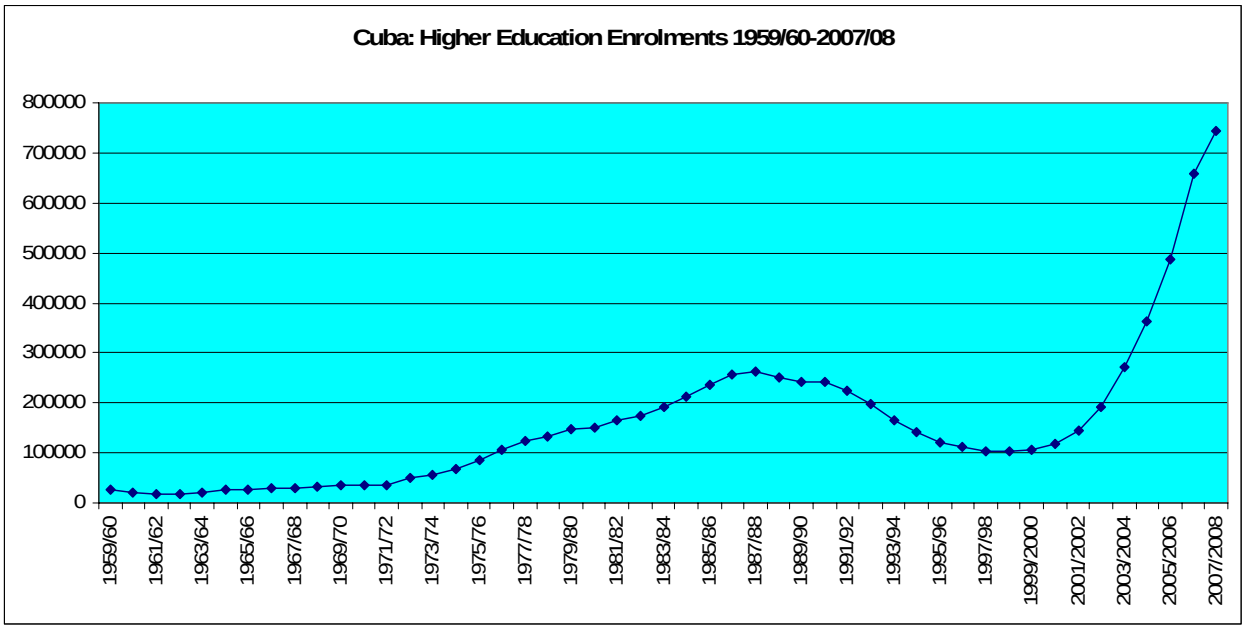
Table 2. Gross Tertiary Enrolment Ratios[1] in Latin America

	1991	1999	2003	2006
Cuba	22	21	34	88
Venezuela	28	61	69	70
Argentina	38	49	64	64*
Chile	21	38	43	47
Uruguay	51	61	69	70
Colombia	14	22	24	31
Mexico	15	18	23	26
Costa Rica	28	16	19	25[1]
Brazil	11	14	22	25[1]
Trinidad-Tobago	6	6	8	11[1]

* refers to 2005

Source: UNESCO data base
http://stats.uis.unesco.org/unesco/TableViewer/tableView.aspx?ReportId=167

[1] Gross Enrolment Ratio (GER) refers to enrolments in corresponding age groups. In the case of tertiary education, the reference age group is 19-25. In the case of tertiary education the ratio might sometimes be "inflated" since in many countries tertiary enrolments include students that are older than 25.



3. Universal Health Care

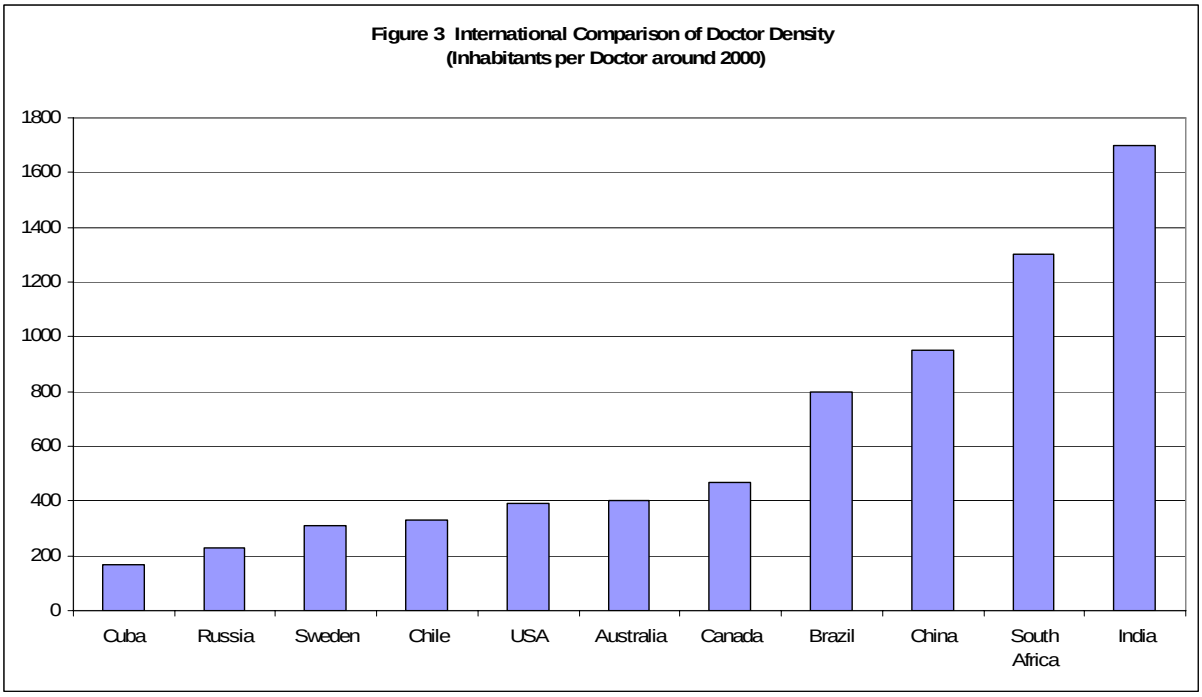
Universal health care was also one of the pillars of the Moncada Programme. But providing health care to all proved to be an uphill task. At the time of the Revolution there were only about 7000 medical doctors in the country. These were primarily employed in the private sector, and one third of them left the country during the first years of the Revolution. In spite of an endeavour by the government to increase enrolments at medical faculties at the few universities that existed at the time, it took almost fifteen years to double the number of doctors (see Table 3).

Table 3. Development of Number of Medical Doctors and Infant Mortality between 1960 and 2007

	Medical Doctors	**Infant Mortality (per thousand born alive)**
1960	6 773	37.7
1965	6 238	37.9
1970	6 158	38.7
1975	9 238	27.5
1980	15 247	19.6
1985	22 910	16.5
1990	38 690	10.7
1995	56 836	9.4
2000	65 997	7.2
2007	72 416	5.3

Sources: ONE (2002) and ONE (2008)

But in the 1980s, the number increased rapidly and by the end of the decade Cuba had already the highest density of medical doctors in Latin America. This development continued during the crisis (the Special Period), in stark contrast to what usually happens in countries in similar situations. By 2007 Cuba had a doctor density of only 155 inhabitants per doctor, the highest density in the world (see Figure). An interesting aspect with this development is that one can see a direct relationship between the increase in the number of doctors and the decline in infant mortality, which in 2007 was record low at 5.3 per thousand born alive.



Source: Ads of the World (2007)
http://adsoftheworld.com/media/print/doctors_of_the_world_netherlands_perspective?size=_original

Health care in Cuba is universal and free of charge. But the Cuban health sector also suffers from many problems. For instance, in spite of an impressive biotech sector some basic medicines are scarce, mainly as a result of the US embargo. The economic crisis after 1990 has also implied but that hospital infrastructure has suffered, although the situation is gradually ameliorating. But even with this handicap Cuban health care is considered to be the best in Latin America. Mesa-Lago (2008a) has in an interesting review of the pension and health reforms in Latin America ranked the health care in 20 countries according to eight indicators, in 1990 and 2002: (a) infant mortality, (b) mortality of children less than 5 years per 1000 born alive, (c) percentage of malnutrition among children less than 5 years, (d) maternal mortality rate per 100 000 children born alive, (e) percentage of deliveries with professional health assistance, (f) percentage of the population with sustainable access to

improved water supply in urban and rural zones, (g) percentage of the population with sustainable access to improved sanitation services in urban and rural zones, and (h) life expectancy at birth.

Cuba has the highest average ranking (of 20 countries) in both 1990 and 2002, before Costa Rica, Chile and Uruguay. Cuba had in 2002 the highest ranking in (a), (b), (c), (e) and (h) and in none of the indicators Cuba is positioned lower than number 4 on Mesa-Lago's ranking list. This is no doubt quite an achievement by a country with serious economic problems.

4. From Research University to the Innovation-oriented University.

The 1962 University Reform underscored the role of scientific research and high-level training, emphasizing sciences and engineering, as well as linking theory and practice in the training of students. As mentioned, already during the 1960s, higher education became a key player in the social transformations of the country. Particularly, universities became relevant players in building the emerging national science sector. Social relevance and commitment with society were taken up as key values of the new university and scientific institutionalization.

Practically all research and training programs developed by Cuban universities in the 1960s were oriented towards the economic and social development of the country. However, the relationship between the country's economic and social development did not always enjoy the same intensity in the following four decades. This intensity has largely depended on the government strategies, and the more or less close relationship between the universities and the main leaders of the country, which--undoubtedly--is unique to the Cuban case.

By the late 1980s, with the crisis in the Soviet Union (Cuba's main economic ally) and the need to generate new sources of wealth for the country, it became clear to government that the Cuban scientific community should play a more direct and intense role in the economic and social development of the country. At the same time research centers were criticized for the scarce application of their results. Several transformations then took place in the Scientific and Technological Policy with a view to improving the use of scientific results (Rodríguez, 1997). Probably, the most brilliant result of those changes was the emergence of a robust, biotech-based medical-pharmaceutical industry that currently exports 300 million

dollars, that is supported by the West Scientific Pole of Havana (similar to other countries clusters)[2] (Lage, 2006).

In the 1980s, the universities had received important financial and political support. Part of the university scientific community focused their work around the full cycle (from research to application of results). Groups were formed and they created production capabilities and in other cases established very close relations with the productive sectors. This innovation in the scientific practice of the Cuban universities was further strengthened by the creation, by the mid-1990s, of the Office for the Transfer of Research Results (OTRI), aimed at providing advice and commercial management to enterprises as well as the export of high value-added technology and products. (Alonso, N. and Rodríguez, D., 2007).

However, these transformations only affected one sector of university research. Other groups continued to carry out their activities in traditional research. In the 1990s the universities expanded the post graduate studies programmes. As a result, starting in the 1990s, the Cuban universities, while maintaining traditional graduate training (although with decreasing enrolment due to the economic difficulties of the country at the time), started expanding post graduate programmes. While some research groups continued with their customary programmes, some research groups oriented their research towards innovation and its relation to economic and social development. These transformations are shown in the following case study involving the Laboratory of Synthetic Antigens (LAGS) of the University of Havana (UH).

5. The LAGS and Quimi-Hib: Science and Society Meet.

The LAGS is part of the Faculty of Chemistry of the UH. The UH is the most important institution of higher learning in Cuba. It was founded in 1728. It has 18 faculties and 21 research centers on exact and natural, education, social sciences, economic, humanities sciences and, to a lesser degree, engineering. It has campuses in all fifteen municipalities of the capital city. It offers 32 univeristy programs with some 60 thousand students enrolled, of which 58% are women. The faculty includes 1400 professors and full time researchers of which hold a 50% PhD degree and a little over 2 500 part-time researchers. There are three thousands students (600 grads per year) in some 70 masters programs. Some 800 students are

2 The Scientific Pole of Biotechnology in Cuba includes over forty institutions, more than 12 thousand staff and 7 thousand scientists, and has generated over 900 registered patents.

pusuing their doctoral degrees and some 100 graduate every year. The approval of topics for doctoral thesis take into account the priorities of the national scientific policy. Eighty five percent of the new doctors studied for their doctoral disertations in Cuba, although many conduct part of their training abroad. Scientific production in renowned journals, as recognized by the Institute for Scientific Information (ISI), amounts to 25% of the national production. From 1995-2004 the uh request of inventions amounted to 4.7% of the total requests made by Cuban residents to the Cuban Office for the Industrial Property (OCPI). (García, Arencibia, Sánchez, 2007).

LAGS has 19 researchers, 9 technicians and 7 staff, it groups professionals trained in the areas of chemical engineering and holders of bachelor degrees in chemistry, biochemistry and pharmacy. Its origin dates back to November 1983, when the carbohydrates group (GC) was formed at the Faculty of Chemistry[3] of the uh, in the context of the above-mentioned institutional and policy changes.

In the early 1980s, the GC worked with two researchers from the Center of Biopreparations (BIOCEN)[4] on the obtainment of a synthetic antigen against *mycobacterium leprae*, which causes leprosy. Successful results were obtained in 1986, making it possible to diagnose, and this led to the disappearence of leprosy as an endemic disease in Cuba in the 1990s. This was the first successful encounter of the GC with the Cuban healthcare system. Later on, the group participated in the 1989 obtainment of the antimeningococcal vaccine VA-MENGOC-BC, led by the Finlay Institute.

In the 1980s the meningitis caused by *haemophilus influenzae* type b (Hib) was the bacteria with the biggest influence on the meningitis and pneumonia in the country; consequently, it became one of the priorities of Cuban public health system.

Vaccination in the world against Hib had begun in the 1970s with a vaccine that proved to be effective for children aged 18 months and older. It was followed by a new generation of vaccines called conjugates, where a process called conjugation was used to chemically bond the same capsular polysaccharide to a protein of bacterial origin. However, a decade after the introduction of the conjugate vaccines, only 38 thousand out of the estimated 2.2 million cases every year are protected by vaccination: only 2% of the children in the world

3 Subsequently Laboratory of Synthetic Antigens (1990).

4 In this case, a number of research-production centers from the West Scientific Pole of Havana were involved: National Biopreparations Center (BIOCEN), Finlay Institute, the Pedro Kouri Tropical Medicine Institute (IPK), Center for Genetic Engineering and Biotechnology (CIGB) and the Molecular Inmunology Center (CIM).

with risk of catching the disease are protected. The introduction of the vaccine in developing countries has been slow, prices are relatively high and the Hib kills half a million children every year with pneumonia. The import of the vaccine cost Cuba about 2.5 million dollars per year.

In the 1987 Dutch scientists proved the scientific possibility of obtaining the vaccine through synthetic means. The challenge lay in turning the academic possibility of obtaining a small amount of synthetic antigen into a technology able to produce the antigen for millions of vaccine doses and that such process could compete economically with the existing one. In the 1990s several universities and laboratories worked on alternatives with synthetic compounds but failed to go beyond the phase of clinical trials in humans. One of the reasons they had to drop these efforts was that transnational pharmaceutical companies were not interested in a synthetic vaccine. A conventional bacteria-based vaccine that worked already existed; therefore, a second vaccine, although cheaper, was not needed and they were not about to generate competition to a product that was bringing in good earnings (Vérez, 2008).

LAGS set out to make efficient the process of chemical synthesis for the reproduction of capsular polysaccharide. In this connection, a close cooperation was established between LAGS and various research institutions in the West Pole of Havana and the Ministry of Public Health. In the case of the cooperation between LAGS and West Pole, the role of the State as promoter of cooperation networks was crucial. In 1999 the vaccine was given top priority in the Cuban biotech industry and, by a decision of the Council of State, the CIGB, its staff and scientific and productive infrastructure were put at the disposal of the development of the Hib vaccine.

Relevant foreign institutions and international organizations took part in the success of the development of the vaccine. Also important was the participation of the University of Ottawa, Canada, through professor Rene Roy, who is a co-author of the vaccine patent. Similarly, the World Health Organization (WHO) and the Pan-American Health Organization (PAHO) gave support to the Cuban researchers in terms of control methods for conjugates vaccines and the purchase of equipment and reagents that were difficult to get as a result of the US economic blockade on Cuba[5]. Little by little, the optimization of the technological process was achieved, the chemical synthesis was made efficient enough to compete with the conventional method. Clinical trials were conducted in the province of

5 Doctors Jose Luis DiFabio from PAHO and Edwin Griffith from the WHO facilitated very much the work on the vaccine.

Camaguey, with the decisive cooperation of the network of Family Doctor Offices[6], as well as the interaction of the educational sector, both primary schools and day care centers.

After two years of clinical trials, the vaccine proved to work with infants and induced a very high level of protection. Then, the Center for State Control of Medicine Quality (CECMED)[7] issued the manufacturing license and the registration of the vaccine. As a result of these efforts of fifteen years, with the cooperation of several institutions, led by a small lab in the University of Havana, the study was completed and showed that the Quimi-Hib vaccine developed from a totally synthetic antigen is very safe and efficient. It was the first synthetic vaccine for human use approved in the world. Although at least ten institutions and over three-hundred people were involved in obtaining it, the main author Vicente Verez (2006) thinks that the vaccine is: “the first major product of the Cuban biotech industry with origins in university laboratories". Until now 4 million doses have been produced V´rez 2008).

The results achieved can be summarized as follows:

1) A world level scientific and technical result was achieved, proving that the talent and capabilities are not exclusively the domain of large companies and that a lot can be done from the countries of the South.
2) A health problem was solved in Cuba and similar opportunities were opened for other countries.
3) It proved that university science can be both at the forefront of science and meet pressing human needs.
4) It proved that the motivation to make a relevant social and human contribution can become the main driver for researchers (professors, technicians, students, academic leaders) seeking to achieve major scientific results.

The results were published by the journal Science [305, 522 (2004)]. The UN Task Force that drafted the document “Innovation: Applying knowledge in development” (2005) reflected on it extensively. The vaccine won the WIPO Gold Medal Award for Best Invention (2005) and

6 National network at the level of primary healthcare which ensures one doctor and nurse every 120 families. They are the first level of care in every disease prevention program in the country.

7 The drug regulatory body of the Republic of Cuba, it performs the basic roles of access control to laboratories, registration of medicines and diagnostic kits, clinical trials, post-sales surveillance, good practices inspections, lot releases and issuance of licenses to establishments.

the Health Award from the Technical Museum of San Jose, California (2005). It also received several national and higher education awards.

Work is currently underway on the large scale production of the vaccine. Over one million doses have been administered to Cuban children. The vaccine has patents in several countries and export agreements have been celebrated. It is part of the world's only pentavalent vaccine against diphtheria, tetanus, whopping cough, hepatitis B and *haemophilus influenzae* type B. According to the researchers themselves, the greatest prize is having created a vaccine that can save the lives of many children.

6. Success Factors, Obstacles and Prospects.

The success of the vaccine was based in a research project that was at the forefront of knowledge and also aimed at meeting great needs of human health, both in Cuba and elsewhere. It was possible due to governmental support and the existence of a network of high level centers devoted to research in biotech, as well as the support of international cooperation. The success was achieved due to the clear objectives and the perseverance of the team leader and the support received from a group of collaborators very much committed to the social objective sought. The Faculty of Chemistry of the UH provided important human resources for the research to advance and the University did an environment of tolerance and understanding to their work. Success, however, is directly related to a number of policies, including:

1) A policy that gives top priority to public health, combining advanced services and own technology with free services. It should be noted that the project was conducted at a time of serious economic crisis in Cuba. Nonetheless, health care efforts remained a national priority.
2) The policy, both in the University and outside of it, that has favored the training of human capital. Such a result requires a broad social distribution of training and capabilities.
3) The science and technology policy promoting the biotech industry, which emphasized the health sector and that began in the 1980s. This policy led to the creation of several institutions and groups focusing on these issues. The partnership with scientific institutions of the Scientific Pole of Havana proved to be crucial to obtain the results.

4) The policy favored by higher education of promoting research institutions oriented towards innovation. The emphasis made in innovation did not prevent understanding that strategic research can require a long time to produce results and it requires tolerance and support. The success of the vaccine was based in the intelligent articulation of a research project that was at the forefront of knowledge and also aimed at meeting great needs of human health, both in Cuba and elsewhere.

Problems have certainly abounded. At times, work was limited by resource constraints. Some younger members of the team abandoned the work seeking economic improvements or less demanding academic work. At times, it seemed that the results would not be achieved: forefront science and technology contains a dose of uncertainty. The groups working to produce papers have more freedom to rectify the course of their work, adjust pace, select results. Research groups that are aiming at a product, a technology, that are required to observe very demanding requirements in the case of vaccine, and have to meet the expectations of the actors funding the project in a reasonable time, work under a lot of pressure. In the case study analyzed here that demand was not associated with a better economic payoff. The incentive was, above all, solving a health problem of great importance. This is a case where ethics, social responsibility of the knowledge community and not market, let them attain success. Inter-institutional cooperation --without excluding temporary tensions-- and not competition between firms made it possible to achieve the targeted goal.

At present, the center works on several forefront issues seeking new vaccines against infectious diseases, cancer and Aids. Thus the LAGS learning process is exploited for the creation of human vaccine and its experience in the organization of social and institutional networks. As a result of the prestige the center has gained, inter-institutional cooperation and government support has been expanded. LAGS is currently working jointly with the Finlay Institute in the development of vaccine against *pneumococcus* as it is the first cause of respiratory infectious diseases in children in the country. The vaccine has been made a priority in the public health system since 2006. In tandem with the Molecular Immunology Center (CIM), they are working on a vaccine against breast cancer as well as other therapeutic vaccines for the treatment of several other types of cancer. Currently, new forms of integrating LAGS to the West Scientific Pole of Havana are being evaluated.

6. Final Remarks

Cuban higher education has through its training and research agendas played an important role for the economic and social development of the country with contributions from programmes related to health, housing, energy, food production, just to mention some areas. Some universities have also proven to be capable of generating income through exports of goods and services. The orientation towards innovation and economic and social development is the result of the policies applied in higher education. The higher education system has facilitated the link between higher education research and development by emphasizing the importance of social relevance in the strategic planning of the institutions, as well as in evaluation and accreditation processes.

As seen, it was already in the 1980s that innovation-oriented university research became a priority area in Cuba. Several universities and research groups began orienting their research towards the "third mission", each one with its own potentials and particularities. The success has varied but there are very interesting examples. In this context we could, for instance, mention the Central University of Las Villas, the University of the Orient and various research centres linked to the agricultural sector.

The success with the synthetic vaccination against *haemophilus influenzae* Type B (Hib) can be considered an exceptional achievement, considering its world wide reach, and its scientific, social and economic value. This result, however, was possible only in the context government policies that counted on the support from higher education that was orienting its innovation research towards the economic and social development of the country. From this perspective the synthetic vaccine against *haemophilus influenzae* Type B (Hib) is *not* an exceptional case. It is the result of accumulated scientific tradition, the ethical commitment of the scientific community, and the applied policies that encouraged the orientation of universities towards economic and social development, or the "third mission".

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