

University-Industry partnership, an important cornerstone for Puerto Rico's biotechnology cluster development

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Abstract: *Successful knowledge-based economic models rely on the synergy of government, industry and academia. This paper reviews the efforts to convert the economic model of Puerto Rico from a manufacturing model to a high-tech manufacturing/research & development economic model, with information technology and biotechnology as its main development strongholds. The formation of clusters and partnership between the government, industry, and academia are essential to achieve successful economies. This strategy will be illustrated by the university-industry partnership that has been developed by the University of Puerto Rico Industrial Biotechnology Program in partnership with locally established biotechnology industries in the island of Puerto Rico.*

Keywords: *knowledge-based economic model; industrial biotechnology; industry-academia partnership; executive committee; industrial advisory board*

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Introduction

A knowledge-based economic development model is being implemented by many small countries worldwide to improve their socio-economic status. Singapore, Ireland, and Puerto Rico have realized that the advances in technology provide important and profitable economic development niches. The establishment of a high-technology infrastructure model requires a very well planned strategy in which the three major key players: government, academia, and the private sector must act in synergy, optimizing the use of limited resources to achieve the common goal of socio-economic success.

In this article we review a particular academia-industry partnership taking place in Puerto Rico, and how this association will drive the economic development into one of a high-tech, knowledge-based model.

Economic development in Puerto Rico

Puerto Rico's economy has evolved dramatically during the past century. The island's initial transition was from an agricultural economy to an industrial economy that relied largely on the island's preferred location for manufacturing by many foreign capital investing companies. At its peak, manufacturing operations in Puerto Rico represented 44 percent of the island's gross domestic product. Over 23,000 people are actually employed in Puerto Rico's pharmaceutical industry. Pharmaceutical exports rose to 20,8 billion dollars in the year 2000,

and 21 of the top 25 selling prescription drugs within the U.S. territories are being produced in Puerto Rico (Puerto Rico Industrial Economic Development Company, 2002).

However, to increase global competitiveness, the island is now experimenting with a second economic transition. A new step is being taken towards a knowledge-based economy where science and technology will be crucial in framing a new economic road map. Information technology and biotechnology are the two major high-tech ventures chosen by the government of Puerto Rico as major players for economic development. Strategic alliances among government, private industry and academia will play a catalytic role in the conversion to a knowledge-based socio-economic model.

Shift in the economic paradigm

To shift from an entirely manufacturing economy to a knowledge-based economy, all major key players: government, industry, and academia, must be able to interact in innovative, unconventional modes. High-tech economies need the optimal use and sharing of resources because of the capital-intensive requirements of the whole enterprise. One of the starting strategies to achieve this goal is by the establishment of clusters, where representatives from the three sectors will be able to meet, discuss, delineate, and implement the road map of a sound, well-devised economic model. A cluster can be defined as an association of entities with common or related objectives, needs, products, processes and/or services; working together to promote and develop their respective enterprises, and to create new business opportunities in a defined region.

A. The Puerto Rico TechnoEconomic Corridor (PRTEC)

Established in the Western region of Puerto Rico, the PRTEC is a conglomerate of public and private entities with common economic and social interests, aimed towards facilitating Puerto Rico's economic development, with particular emphasis on commercializing new and innovative technologies. PRTEC is focused on providing an ideal environment that promotes innovation, development and commercialization in the new global economy. The principal strategy being implemented by the non-profit corporation is the development and nurturing of high tech clusters. Information technology, biotechnology, and biomedical devices are among the major clusters of PRTEC.

1) *The biotechnology cluster:* Knowledge-based economies recognize that higher education is economic development. One of the first tasks of the biotechnology cluster was the assessment of major niches in all sectors. This has led to the brainstorming of a ***Biotechnology Road Map*** (a capabilities assessment exercise that will provide guidance for stakeholders and viewed as critical in the strategic planning effort). The biotechnology cluster vision is to "***position Puerto Rico as the preferred partner for biotechnology***

enterprises". This vision will be achieved by fostering a competitive and innovative world-class biotechnology manufacturing and R&D site for which a knowledge-based economy is crucial. Cluster members who are currently leading the initiative include:

- From industry: Amgen, Lilly, and Abbott.
- From government: the Puerto Rico Industrial Development Company (PRIDCO) and the Industry-University Research Consortium (INDUNIV).
- From academia: the University of Puerto Rico's three main campuses (Medical Sciences Campus, Río Piedras Campus, and Mayagüez Campus), and the Ponce School of Medicine.

From the academic perspective, the strategic alliances will facilitate curricular revision that will provide college graduates with the knowledge and skills demanded by the biotechnology industry. This will educate the skilled workforce that will enhance the island's capability for attracting biotechnology companies.

2) *The University of Puerto Rico (UPR) as a strategic partner:* The UPR is one of the main biotechnology cluster strategic constituents. The UPR system is formed by eleven campuses spread through the island. The three main campuses (Medical Sciences, Río Piedras, and Mayagüez) are also the principal education and research campuses of Puerto Rico. The Mayagüez Campus (UPRM) is one of the leading members from academia that is represented in the biotechnology cluster. UPRM's Colleges of Engineering and Arts & Sciences offer competitive degrees in areas associated to biotechnology. In particular, the Industrial Biotechnology Program, an interdisciplinary collection of courses in the areas of biology, chemistry, and chemical engineering, has been categorized as attractive to industry.

The Industrial Biotechnology Program

UPRM, with a strong history of education and research in several biotechnology areas as well as collaborative initiatives (Morell, *et al.*, 2002), has been at the lead in orchestrating the multi-sector alliance to strengthen biotechnology programs in response to economic development based on high tech in Puerto Rico. It has responded with important initiatives to support the multi-sector alliance:

- An undergraduate program in Industrial Biotechnology (IB).
- A Graduate Biotechnology Initiative (GBT) composed of:
 - A PhD program in Biotechnology.
 - The development of Biotechnology Research Centres in the areas of:
 - Bioinformatics.
 - Centre for Protein Structure and Dynamics.

- Centre for Protein Visualization.

The Industrial Biotechnology (IB) program was established in 1994 at the University of Puerto Rico-Mayagüez in response to the emergence of a biotechnology industry with the need for trained, highly qualified workers. This undergraduate program, a 5-year bachelor's degree offered by the College of Arts & Sciences, provides an interdisciplinary curriculum in sciences, engineering and socio-humanities studies. Typically, the program admits 30 students per year and has the highest index of entrance in the College of Arts & Sciences, which is at the same level of entrance of the engineering students.

The IB Program produces a professional with the creativity and research skills of a scientist and the process design vision of an engineer. To achieve this profile, the IB Program has two counselling boards: an internal, IB Executive Committee, and an external Industrial Advisory Board.

1) *Executive Committee*: The IB Program is coordinated by an executive committee that includes faculty representatives from the major thrust areas of agriculture, biology, chemistry, chemical engineering, and business administration. The committee defines, organizes and implements the program's strategic plan. The IB strategic plan has the following vision: ***“to prepare professionals capable of developing and advancing biotechnology to contribute to the socio-economic development of Puerto Rico”***. Those professionals will have the knowledge and skills required to perform effectively in private industry, government or graduate studies. This vision responds to the island's economic roadmap, knowledge-based and foreseeing biotechnology and information technology as major drivers of economic growth. The IB strategic plan focuses on five major components: curriculum, research, student mentoring, strategic alliances and evaluation, Figure 1.

2) *Industrial Advisory Board*: An Industrial Advisory Board (IAB) was established to review the program's strategic plan and increase its interaction with industry. The creation of the advisory board was a challenging process that took several months of planning. It was recognized that industrial view points would differ greatly from company to company, and also according to the function(s) of the industrial representative and their background. Thus, a major goal in the selection of IAB members was to put together a group with a very diverse or varied background.

The advisory board includes members with significant scientific expertise who have made excellent recommendations towards the improvement of the curriculum. Other board members have significant management and leadership skills, and they have been very helpful in recommending strategic alliances for the program. The board also includes a graduate from the IB Program who is currently working in industry, and a Human Resources representative from a company that has hired several of the program's graduates. The IAB

includes representatives from major industries on the island such as Amgen, Lilly, Ortho, Abbott, Bristol-Myers-Squibb, Pfizer, and Bacardí. The Board also includes representatives from continental U.S.A. companies such as Schering-Plough (New Jersey) and Fibrogen (California). The IAB includes a representative from a private equity fund management group, who has been very helpful in outlining the economic development that is expected from the biotechnology industry. The participation of the Director of the Science and Technology Board of the Puerto Rico Industrial Development Company has helped the program in visualizing the government's efforts towards developing the biotechnology industry in Puerto Rico.

A major outcome of the IAB has been its contribution in the design of the IB student profile and its involvement in providing internship experiences and plant visits for IB students. The next step is to maintain communication with board members and meet with the advisory board on a yearly basis. The IAB, together with the IB Executive Committee, have developed a revised curriculum based on a student profile which was developed in concordance with the program's mission. The new curriculum will be submitted to the College of Arts & Sciences for approval this year.

Partnership with industry

As a strategic partner in the development of a knowledge-based economy, the IB Program continues to expand its relationships with industry. In addition to offering a 5-year bachelor's degree, the IB Program will initiate a new training in biotechnology track for private company employees. The training curriculum is custom-designed as required by the particular industry. The IB Program recognizes the need of biotechnology companies to provide continuing education for their employees, as well as the need to establish common knowledge, grounded on the fundamentals of biotechnology, in personnel from different disciplines such as: biology, chemistry, and engineering, among others. This approach has been accomplished in two agreements with industry: the Amgen-Industrial Biotechnology Learning Centre and the Lilly Engineering for Non-Engineers Training Modules.

1) *Amgen-Industrial Biotechnology Learning Centre*: Amgen has invested a total of \$750 million in their biotechnology product (Neupogen ®) transfer to Puerto Rico. The IB Program and Amgen signed an agreement in which 20 of Amgen's Technical Associates spent two months in a hands-on training session with an interdisciplinary team of IB faculty at UPRM. The training curriculum was customized to Amgen's needs in several key knowledge areas like environmental control, manufacturing technology, validation, and control. The curriculum was prepared between the company's Training Department and the IB Program Coordinators.

2) *Lilly Engineering for Non-Engineers Training Modules*: Lilly is investing \$450 million in transferring

the production of recombinant insulin (Humalog ®). Their operators have a very diverse background: from highly experienced ones to newly hired personnel with technical associate degrees. The training that they received from IB faculty consisted of basic engineering from modules that will cover most of the chemical and bioprocess engineering aspects which will be fundamental to their biotechnology applications in the plant.

3) *Industry-Academia Partnership Benefits*: The main mutual benefits that industry and academia will get by this kind of partnership are listed in Table 1 below. As stated earlier, high-tech initiatives are consequently high-cost, so sharing and partnering is a way of optimizing the use of available resources in a region or country. In short, the industry can benefit tremendously from the available intellectual capacity of academia, while the university can take advantage of applied research and development projects that the industry is willing to share.

Future partnership initiatives

As a consequence of the on going initiatives within UPRM's IB Program, a two-phase initiative is being developed: the *Industrial Biotechnology Learning Centre, and the Biotechnology and Bioprocessing Pilot Plant*. These two initiatives are being encouraged by the biotechnology cluster associates.

1) *The Industrial Biotechnology Learning Centre (IBLC)*: This facility will be a multi-user laboratory facility where customized training in biotechnology to industry employees, as well as university student teaching and K-12 teachers orientations are to be performed regularly. The facilities will be conditioned to have a state-of-the-art computer room and laboratory benches for the hands-on instruction of industrial microbiology, biochemistry, and bioprocess engineering. Experiments will be performed at the bench scale and preparative scale, showing students the applied aspects of a biotechnology process. UPRM has already assigned an existing structure that will house the laboratory. Grants for conditioning the IBLC are being requested through the biotechnology cluster to local industries and government. The IBLC will establish the basis for the learning and training in current biotechnology practices.

2) *Biotechnology and Bioprocessing Pilot Plant*: This is an ambitious project whose main objective is to place Puerto Rico as a global biotechnology site by providing the capability to perform research and development projects in biotechnology and bioprocess engineering. The pilot plant would be equipped with state-of-the-art pilot scale equipment to perform biotechnology processes at good manufacturing practices (GMP)-quality. Small biotechnology companies could use the facilities to scale-up and develop production of their products for clinical trials. If these products are found to be successful and with good commercial potential, Puerto Rico would have the priority for the establishment of their commercial plants. Large biotech companies could also use the facilities to perform research and development of some of their products which are

in the pipeline but do not have a high priority level in their R&D headquarters. The pilot plant would represent the most desirable result of an industry-government-academia partnership, and would mean a large step forward in the knowledge-based economic development of the island of Puerto Rico.

Conclusion

The development of a knowledge-based economy strongly depends on the commitment of the three main constituents of the developing region or country: government, industry, and academia. The university-industry partnering is essential to the process, since these two constituents will provide the necessary technical knowledge and development projects. The government must act as a facilitator in this partnership to promote the economic activity to be developed. UPRM's Industrial Biotechnology Program has proactively worked towards the realization of such partnerships with success, although more work should be done to fully complete the knowledge-based economy in the field of biotechnology.

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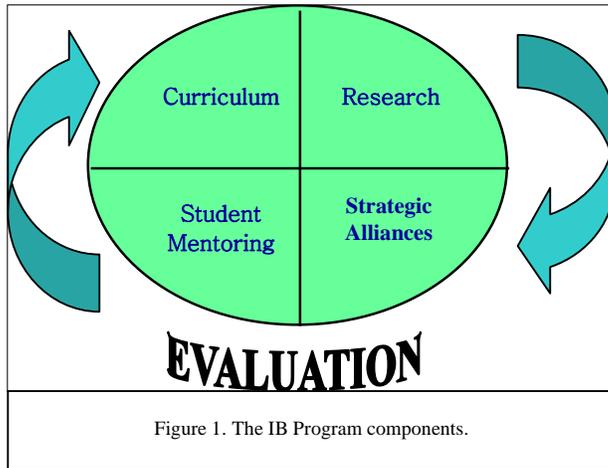


Figure 1. The IB Program components.

Table 1. Industry-academia benefits in a knowledge-based economy partnership model.

Industry	Academia
Skilled workforce Employee training Process improvement opportunities	Faculty internship & development Curriculum improvement Window for applied research projects
Start-up of R&D initiatives in a historically 100% manufacturing site	Student's internships, fellowships
Appointments as visiting faculty	Infrastructure development Faculty consulting opportunities