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REVIEW ARTICLE

Technological strategies of successful Latin American biotechnological firms

José Luis Solleiro[1]
Engineering Institute of the National University of Mexico (UNAM) ,
Apartado Postal 22-510.14091. México D.F.
Fax (525) 662 5852
E-mail solleiro@servidor.unam.mx

Rosario Castañón
Engineering Institute of the National University of Mexico (UNAM) ,
Apartado Postal 22-510.14091. México D.F.
Fax (525) 662 5852

This paper presents the results of the analysis of the technological strategies of eight Latin American biotech firms. There is little literature on strategies of follower firms in developing countries in high-technology sectors. For that reason, the authors undertook case studies of firms of six countries of Latin America that share the characteristics of being successful in the market place while adopting technology-follower strategies. The analysis considers five dimensions that, according to the literature on the management of technology, constitute the basic benchmarks of the strategy. These dimensions include innovating activities of the firm to improve, its position on the market; orientation of research and dominant technological goals; technology sources used by the firm to acquire its critical technologies; level of technological investments to acquire and/or develop technologies; and organizational mechanisms to manage technological functions of the firm. Results of this study clearly show that Latin American firms can sustain competitive strategies on the intelligent management, combining in-house skills with excellent capabilities to locate, acquire and assimilate external technologies.

Although biotechnology has come to be a synonym for genetic engineering in developed countries, the term has a wider conception in developing countries and comprises what is known as second generation technology (which includes tissue culture, for example) as well as classical fermentation processes. The wide use of the concept of biotechnology in countries like those of Latin America has not come about by chance, but is due to the simple reason that, in the agrifood sector, in particular, first and second generation biological techniques are still largely used in the elaboration of biotechnological goods and services, while some first incursions have only just been made into genetic engineering.

It has been empirically observed that the technological strategies followed by firms in the sector in Latin America vary according to the products, the techniques used and the market size. Thus, in general, it can be said that organizations involved in businesses where the market shows a slow rate of growth and even slower rate of innovation (closely associated with the use of second generation mature techniques) have used more "common", conservative strategies; whereas organizations whose products and/or services are more dynamic (associated with the use of third generation technologies) and whose markets promise rapid, constant growth have established novel and, in some cases, risky strategies that have allowed them to occupy highly competitive positions, at least at a regional level.

This document offers a comparison of the technological strategies of ten Latin American firms, five of which manufacture rapidly growing products, using techniques with a high rate of innovation, and are from the following countries: Brazil, Mexico, Venezuela, Argentina and Chile. The other group of companies mainly uses mature techniques and their markets are growing slowly; these companies are located in Mexico, Argentina, Guatemala and Colombia.

Methodology

In order to characterize the firms' technological strategies, it was decided to adopt, as a mark of reference, the model proposed by Zahra et al. (1994) in which four different generic competitive strategies are identified according to the following five dimensions (see Table 1):

[1] **Corresponding author**

Table 1. **Dimensions on which the technological strategy is built**

Dimension	Components
Technology innovation: Refers to the firms attitude with respect to innovations to improve, strengthen or defend its position in the markets in which it competes.	**1. Position** a) First on the market b) Quick follower c) Imitator d) Late competitor
Drive and dominant technological goals; This is related to the way in which the firm perceives technology as a tool to improve its competitive strategy	1. **Technological vector:** this refers to the firms effort in a concrete research area that may be simple or multiple, independent or dependent. 2. **Novelty:** this refers to the proximity to the state of the art prevailing in technological areas. Similarly it considers the type of improvement that can be gradual or radical and completely transforms a sectors configuration.
Sources of technology: The different ways in which the firm can acquire technology	1. **Internal:** Its own research and development (R&D) 2. **External:** Including mergers, takeovers, licensing, joint ventures, etc.
Technological investments: Specifically, the long term commitments a firm makes to develop or acquire technology	1. **Intensity** in R&D: level of expenditure in R&D activities 2. **Size** of R&D: number and capacities of R&D personnel 3. **Orientation** of R&D: Basic and/or applied research 4. **Approach** of R&D: distinctive technologies vs. Peripheral technologies vs. basic technologies vs. mature technologies
Organizational mechanisms: that make it possible to acquire, develop and exploit technology	1. **Commitment:** existence of a formal managerial level unit to coordinate and defend technological activities 2. **Connection**: coordination of the R&D units activities and the firms other activities 3. **Controls:** Type (formal or informal), levels and periodicity 4. **Structure:** organization of R&D units 5. **Technology transfer:** towards the inside and outside of the firm

Source: Taken from Zahra, et al. (1994), Technological choices within competitive strategy types *Int. J. of Technology Management*, vol. 9, No. 2, pp. 172-195 and modified

Innovation: activities of the firm to improve, strengthen or defend its position on the markets in which it competes.

Drive and dominant technological goals: way in which the firm perceives technology as a tool to improve its competitive strategy.

Technology sources: ways used by the firm to acquire its critical technologies.

Technological investments: long term commitments to acquire and/or develop technologies.

Organizational mechanisms: activities that make it possible to acquire, develop and exploit technology.

Ten Latin American biotechnological firms were chosen whose operations have been consolidated. On different scales and in different regional markets all the firms are relatively competitive. With the exception of BIOS Chile, all have activities related to the agrifood sector. The information on the firms was obtained using different methods, including the following: in the case of the Mexican firms, interviews using semi-structured questionnaires were combined with information provided for the elaboration of the 1998 Entrepreneurial Directory (Valdés et al., 1998), public presentations made by the firms' representatives and various publications on their strategies. For the rest of the firms, information was obtained from published articles and studies, and from direct contacts with the entrepreneurs that were made from 1992 to 1997 at various events in which company representatives gave presentations about their organizations. In most cases, the information was complemented with interviews with the firms' general or technical directors.

As was mentioned in the introduction, the main purpose of this article is to compare the technological strategies of firms whose techniques and products have a high rate of innovation and those that elaborate mature products using mature techniques. However, this article does not attempt to contribute elements that could be used to make generalizations about different situations. Its intention is to study, through some cases, the different strategies that have been used by firms in the Latin American region and that as a result of their originality may be of use to those studying the subject and could perhaps be adopted and adapted by other firms. Although quantitative data are not included, due to collection difficulties, this article is considered to be a contribution to the determination of variables, associated with the technological strategies of Latin American companies, which have not been sufficiently analyzed in spite of the fact that they may indicate alternative routes to success.

Biotechnology in Latin America

Latin American has arrived late on the world markets with biotechnology derived products and services. This situation is closely linked to an industrial structure that is traditionally reluctant to introduce changes and that has little capacity for research and development that would enable it to adequately

generate ways of satisfying consumer needs and the demands created by the competition.

To speak of biotechnology in Latin America only two decades ago was to imply the use of fermentation techniques for the production of traditional products like wine, beer, dairy products, etc., which meant that the sector was almost entirely made up of firms whose products and techniques were completely mature. It was not until the mid-eighties that some firms began to apply new techniques to produce some traditional products (ornamental plants, for example) with better quality and yields, and in the nineties a few companies ventured into the use of genetic engineering techniques for the manufacture of products that had previously been put on the market by leader firms from other regions.

Due to the wide variety of situations, it is a difficult task to make an evaluation of biotechnology in Latin America. Some countries have made a great effort to strengthen their capacities in the area, while others are still only making marginal investments in this sector that will barely allow them to observe from afar what is happening on a market level. Nevertheless, a brief description of the present situation of biotechnology in the region will be given below.

In Latin America, the firms that use biological techniques are mainly grouped into three sectors: (i) agriculture inputs (seeds, plant varieties, inoculants, pesticides, fertilizers, veterinary products and animal genetics), with approximately 45% of the firms; (ii) pharmaceutical firms, and (iii) fine chemicals (amino acids, pigments, antibiotics, vitamins, etc.) (Dellacha et al., 1988).

The distribution of firms by country is correlated with existing capacities. Thus, the large countries with greater research capacities (Argentina, Brazil, Mexico) also have the largest number of firms. The new biotechnological firms, created after 1980, represented 42% of 241 firms studied by IICA[1]. Seventy per cent of the firms identified by IICA are private with local capital, although in many cases they establish alliances and/or technology transfer with transnationals. Almost 20% of the firms are subsidiaries of multinationals and approximately 18% are government property, producing inputs for public health. Several products have been developed that are close to the commercialization stage, especially transgenic plants, but the number is very small when compared with the ones that have been developed in the industrialized countries and, to date, there has been little success.

The new biotechnological firms are on the whole small and work with fairly simple technologies. The most frequent examples of applied technologies are plant tissue culture, immunological tests and biopesticide production. Their approach and technological development are short term, since it is very difficult for them to cost R&D activities. Established firms in biological and agroindustrial inputs generally begin their activities by means of linkage with national research groups. In general terms no significant research effort is made within industry itself.

Other elements that characterize the sector are the following (Quintero, 1992):

• Most research and development is conducted in higher education institutes and the industrial sector has only marginal participation. The majority of these organizations have generated capacities in the agroindustrial sector, but little has been done in other areas such as pharmaceutics and the environment, to cite only two.

• The human resources needed by industry are almost all trained in higher education institutions and there are not sufficient resources to cover all the demands of the different industries. Similarly, due to the scarce existing linkages between the entrepreneurial and university sectors, there is little experience on industrial problems and this implies greater use of resources to solve some problems.

• Most of the researchers working on biotechnology have a background in physics and biochemistry; very few engineers (chemical and biochemical) are involved in the area.

• The fact that biotechnology is a multidisciplinary technique has been ignored for a long time and it is therefore necessary to generate capacities in both molecular biology, immunology, biochemistry, genetics, etc. and in engineering and management (Solleiro and Quintero, 1993).

• Only in a few countries have Governments considered the development of biotechnology as a priority area, establishing specific programs to foster it. In most cases, biotechnological development projects are handled with the same criteria as those used to qualify a project in an already mature industry and it is not understood that this sector can present great risks.

• Mechanisms for financing technology innovation projects in Latin America are scarce and biotechnology is no exception. Few economic resources are assigned to support industries that wish to carry out projects in this area.

• The introduction of products derived from genetic engineering has revealed the weakness of control and biosafety mechanisms in the countries of the region.

• The principal application areas (according to the number of projects and researchers) are agriculture, health, the industrial sector and the environment. It is important to point out that the livestock and forestry sectors have been neglected in some countries, although they are very important from an economic and social point of view.

It can therefore be observed that the Latin American firms participating in the biotechnology area have a great challenge ahead of them due to the diversity of problems they must solve and the lack of mechanisms developed by their governments to support them.

Brief profile of the firms included in the study

The firms chosen fill the requirement of having a good position in the markets in which they operate, that is, their sales have maintained a constant rate of growth over the last few years. The sample includes ten firms, five of which are active in very dynamic sectors, while the other five operate with mature technology and products.

The main characteristics of the firms in the sample are given below.

Pulsar* (Fernández and Martínez, 1997; Valdés et al., 1998): A Mexican firm whose origins in the agrobiotechnology field go back to 1985, when it bought the largest cigarette company in the country, and decided to introduce new techniques for producing and curing tobacco, which enabled the company to produce the volume necessary with the quality required. In 1992, it established a research center, in the south east of Mexico, in order to generate its own technologies not only for its principal crop, but also for areas it could diversify into such as tropical fruit, forest species, basic grains, vegetables and ornamentals. The results of the Research Center were so successful that in less than four years there were research sub-stations in four States of the Republic.

In the period 1993-1994, knowing it would be necessary to develop advanced techniques for which the existing capacities in the country were limited, Pulsar signed collaboration agreements with the Universities of Arizona and Cornell. In Mexico, various activities were conducted with the main biotechnology applied to agriculture research center: CINVESTAV- Irapuato Unit. Furthermore, during 1995, contacts were made with several agrobiotechnology programs in institutions such as the Autonomous University of Nuevo León, the Postgraduate College, the Autonomous University of Chapingo and the National Institute for Forestry, Agricultural and Livestock Research.

The generation of research capacities was enormously strengthened through the takeover in 1995 of the world's principal seed companies: ASGROW SEEDS and PETO SEEDS of America and ROYAL SLUIS of Holland. It is important to stress that the purchase of these firms did not only mean possessing enormous technical capacities but also the control of a large part of the vegetable seed market and commercialization channels. The culmination of the takeover of technical capacities took place with the purchase of the majority of the shares of DNA-PLANT TECHNOLOGY, with which Pulsar strengthened its capacity in genetic engineering to improve industrial, vegetable and fruit agricultural species, reaching levels comparable to those of the world leaders.

Valleé* (Silva et al., 1996): A Brazilian firm belonging to Grupo CARFEPE that was formed by three entrepreneurs at the end of the fifties and that produces veterinary vaccines and pharmaceuticals. This firm has based its technological strategy principally on the identification of the critical technologies for its productive processes that it groups into the following categories: base technologies (based on mature scientific and engineering knowledge); key technologies (based on uncommon inventive knowledge); transit technologies (those that are at the beginning of the growth phase in their life cycle); and emerging technologies (still in an embryonic phase). Valleé considers technology to be the accumulation of its own skills and considers knowing how to use and combine human skills and the firm's capital to produce and put planned products on the market to be a competitive advantage.

The firm's technological strategy was conceived of within a formal, systematic strategic planning process in which the aspects that give the organization competitive advantages were identified. Thus, Valleé has developed methodologies that have enabled it to identify a technological route and main technologies, as well as the areas of knowledge involved. Similarly, part of the process has led to the identification of the factors of competitiveness and the positioning of the firm with respect to the competition. These planning techniques have allowed Valleé to build up its technology portfolio and decide on the best ways to acquire it: its own research and development, training of human resources, contracts for technology development and transfer with universities and research centers, etc.

Bio Sidus* (Criscuolo, 1992): An Argentine firm, immersed in the development and creation of biological molecules for use in drugs for humans. This firm was conceived of in 1980 when a group of entrepreneurs, directors of the Instituto Sidus (a pharmaceutical firm with national capital, established in 1938) decided to systematically invest in research and development of avant garde biological techniques.

In order to face the challenge, a special laboratory was created in the areas of cell culture, genetic engineering and protein purification. Similarly, highly qualified specialists were recruited in biochemistry, biology, chemistry, bacteriology, engineering, physics, pharmaceutics, statistics, computation, etc. to form a multidisciplinary team in line with the demands of the sector they wished to enter.

The success obtained in the goals drawn up, made it necessary to establish Bio Sidus S.A. in 1983 as a firm dedicated to the production of interferon, with a view to developing recombinant interferon - a fact that makes it unique in Latin America. Thanks to the technical capacities it accumulated,

Bio Sidus has created a new subsidiary dedicated to plant tissue culture for plant propagation.

Bios Chile* (Yudelevich, 1992; Waissbluth, 1992; Arroyo and Jedlicky, 1994; Jaffé, 1993): This is the largest pharmaceutical firm in Chile and is dedicated to research, development, production and commercialization of human health and animal products derived from modern biotechnology. Examples of these are: vaccines, development of monoclonal antibodies, diagnosis products, human growth hormone, etc. The firm was founded in 1986 by a group of Chilean scientists and entrepreneurs..

The strategy followed by the firm has included the following elements:

- Association with third parties to produce and develop products.
- Establishment of market niches.
- Close contact with university researchers.
- Closeness to clients to solve their problems.
- Development of strong alliances with government institutions (financing and regulations) and leader companies at a world level (Chiron) for product development and commercialization.

Polar* (Rangel, 1998): A Venezuelan firm in the food and beverages sector. In 1987 it decided to launch a biotechnology program to support the acquisition of basic knowledge. The initial development plan lasted six years during which the basic infrastructure was laid down and the necessary human resources trained. During this period, a network of first level university laboratories in molecular biology, biochemistry, genetics and molecular immunology was established with the objective of acquiring the necessary technical skills. Collaboration was established with the most important national universities: Simón Bolívar University, Central University of Venezuela and the Venezuelan Institute for Scientific Research and guidelines for alliances and allocation of the benefits obtained (intellectual property rights among others) were established in detail. In addition, the research laboratories were equipped with material and human resources in accordance with the objective and goals established.

One important aspect of the strategy followed by POLAR was that the firm decided to develop capacities in generic technologies (PCR Techniques, for example) that led them to develop, although not with sales in mind, diagnostic kits for the human papilloma virus, hepatitis B and tests to detect Chagas' disease – all products that have little to do with the firm's operation sector. Once these techniques were dominated, they were then used in areas of commercial interest to the firm, food and beverages, where they have produced very successful results. The knowledge was used in particular to elaborate rapid diagnostic tests for microorganisms that alter the quality of the products Polar elaborates. Due to the success obtained, Polar decided to establish its own research center that is run by young scientists, trained during the early phase of the program.

Polar is at present seeking to extend the benefits of its knowledge through the use of biotechnological techniques to improve the grains needed in elaborating its products.

Table 2. Technological strategies of Group 1 firms*

			FIRMS				
	Dimension	**Components**	**Pulsar**	**Valleé**	**Bio Sidus**	**Bios Chile**	**Polar**
TECHNOLOGY STRATEGY	**Technology Innovation**	**1. Position**	Close to the leader	Quick follower	Minimum cost	Specialization	Quick follower
	Drive and dominant technological goals	**1. Vector** **2. Novelty**	Multiple Very close to state of the art	Multiple Close to state of the art	Simple Little proximity	Simple Little proximity	Multiple Close to the state of the art
	Technology source	**1. Internal vs** **2. External**	Combination, international emphasis**	Combination	Combination	Combination, with international emphasis	Combination, with internal emphasis
	Technological investments	**1. Intensity** **2. Orientation** **3. Approach**	Greater than average Basic and applied Generic, key and emerging	Average Applied Key	Average Applied In transit	Average Applied In transit	Greater than average Basic and applied Generic
	Organizational mechanisms	**1. Commitment** **2. Structure** **3. Control** **4. Technology transfer mechanisms**	Strong Decentralized Formal Formal	Strong Matrix Formal Formal	Strong Functional Formal Formal	Strong Functional Formal Formal	Strong Functional Formal Formal

* Firms whose products and technology have high innovation rates
** Tend to strengthen access to advanced technologies via acquisitions
Pulsar, Valle, Bio Sidus and Polar are considered to be large firms (over 250 employees); Bios Chile is a medium firm (101-250 employees)

Biogenética Mexicana** (Solleiro et al., 1996; Solleiro et al., 1994; Jaffé, 1993): A Mexican firm created in the mid-eighties by a scientist after making a detailed analysis of both the technologies that were emerging in the first world and those supplied on the national market for the micropropagation of ornamental plants. The choice of business area and techniques was based on two fundamental facts: market opportunity and technical capacity at a national level that would be used to achieve an advantage in production costs. It was also decided from the outset that Biogenética would be an exporter firm.

During 1989, Biogenética negotiated and obtained support from a development bank in the form of venture capital, thus becoming one of the few national firms that have had this support. The distribution of the capital was as follows: 30% of the shares remained with the firm's groups of scientific advisors; 49% with the national development bank and 21% with an enthusiastic group of entrepreneurs with little knowledge of biotechnology. The firm's capitalization made it possible to construct suitable installations for the mass production of ornamental plants.

Fundamental factors that have allowed the firm to cover both international and national markets include constant product quality in accordance with international standards; competitive prices and reliability in delivery dates. The constant growth of the firm over the last few years has led management to pose the problem of diversification. Although the markets of interest are to be found in the agroindustrial sector, the forestry sector to be more specific, Biogenética has not discarded the possibility of going into other areas, providing there is a market for the products.

From the onset of its operations, Biogenética maintained formal and informal relations with the main plant biotechnology research centers in the country. It also has relations with government and private agencies in different countries (Canada, United States and Spain, for example) that can make valuable technological contributions to the firm. Furthermore, it should be pointed out that the firm has formed various strategic alliances with other companies.

Síntesis Química** (Giambiagi, 1998): the central activity of this Argentine firm up to the end of the seventies was the manufacture of organic products derived from chlorine. However, the establishment of free trade in the country forced the entrepreneurs to seek new business lines that would give as many advantages to the firms as those it had previously enjoyed. They thus decided to explore three new areas: fine chemistry, specialties and biological products for agriculture. Even though it seemed attractive, the last line represented a great challenge for the entrepreneurs since it meant incorporating a new industrial culture with new concepts, techniques and novel products.

One of the main strategies followed by Síntesis Química was to capitalize on the experience of the entrepreneurs in the development of their own processes and products. This was strengthened with the signature of long term collaboration agreements with research institutions that were important in the country in the area of industrial fermentation. Furthermore, investment was made in the plant, in terms of equipment and instruments necessary for handling the new products.

The firm's principal products are inoculants and biopesticides based on *Bacillus thuringiensis* with which they have been able to establish market niches in Argentina and even export to the United States and Canada. The success they have had in this area has been a great stimulus for the firm to build up a portfolio of technological projects that have enabled it to keep its position in the Argentine market.

LAPRE** (Valdés et al., 1998): A Guatemalan firm, producing chemical and biological pesticides. The recent importance of subjects like sustainable development and care for the environment has contributed significantly to the firm's giving more attention to its biological products business line.

The firm handles few biopesticides but they are in great demand on the local market and in Mexico and Central America. This fact became a fundamental factor behind the firm's decision to implement an export strategy and to begin to look for alliances with similar companies.

The firm's developments have basically been generated with its own resources. Indeed its success has stimulated shareholders to invest as much as 10% of their sales in R&D activities.

Levapan** (Moreno, 1994; Hodson, 1995; Jaffé, 1993): The firm has grown considerably over the last ten years and is now considered the largest yeast manufacturer in Latin America. It is widely represented at national (Colombia) and international levels. The strategies and objectives of Levapan are aimed at achieving a better world position in its sector using biological techniques to do so.

Levapan has an informal strategy that stresses applied development over basic research since it does not have the necessary human and material resources. It sees itself as a quick follower that rapidly assimilates innovations generated elsewhere. Nevertheless, it tries to avoid licensing from third parties, which it considers to be a type of technological dependence.

There is no definite budget for the R&D area. The firm is ready to finance any project that seems promising, even though it may have to increase its investment in relation to net sales in order to do so.

* **Firms whose products and technologies have a high rate of innovation**

Although it has agreements with other firms to exchange technical information, these agreements are informal and based only on good faith. There are virtually no relationships with universities or research centers for the firm is considered to have reached a greater level of development than that attained by these institutions.

Market penetration is principally based on two parameters: quality and price.

There is no formal policy to train human resources; however, short courses, seminars and conferences are constantly being sought that will make it possible for the personnel to up-date their knowledge. Most of the R&D department employees have no background in higher education. This is no obstacle for the firm since many of the workers have been trained in the job and are now considered to be highly qualified although they have no academic degrees. The firm is open to the acquisition of technologies that feed its strategy.

Sucromiles* (Hodson, 1995): this firm is a subsidiary of an important multinational. It is dedicated mainly to the production of vinegar, alcohol and organic acids. The firm has aimed its efforts at two basic sectors: chemical products and the environment. The fundamental research lines within these sectors are: unicellular protein production from dregs and the anaerobic treatment of dregs to produce biogas, and other devices to control pollution and optimize processes in order to decrease costs and increase product quality.

The firm has a development group and laboratory that establishes collaboration links with firms and research centers both in Colombia and other countries, this is because the firm's philosophy is to attempt to gain access to tried technologies and assimilate them, rather than try to generate original products and processes. With this pragmatic approach and their quick follower strategy, Sucromiles has technological capacities that have been the result of an accumulative learning process. Indeed, thanks to the collaboration of their technical group with their head office, outstanding knowledge has been obtained in process engineering and alternative technology assessment. The company has also assimilated mature technologies to the extent to which it proposes and introduces internally generated improvements.

Table 3. Technological strategies of Group 2 firms*

			FIRMS				
	Dimension	**Components**	**Biogenética**	**Síntesis Qumica**	**LAPRE**	**Levapan**	**Sucromiles**
TECHNOLOGY STRATEGY	**Technology Innovation**	**1. Position**	Distance follower	Distance follower	Distance follower	Distance follower	Distance follower
	Drive and dominant technological goals	**1. Vector** **2. Novelty**	Simple Far from state of the art	Simple Far from state of the art	Simple Far from state of the art	Multiple Close to the state of the art	Multiple Far from state of the art
	Technology source	**1. Internal vs** **2. External**	Combination	Combination, internal emphasis	External	Internal emphasis	Combination, with external emphasis
	Technological investments	**1. Intensity**	Less than average	Less than average	Less than average	Average	Average
		2. Orientation	Applied, market opportunity	Applied	Applied	Applied	Applied
		3. Approach	Transit and mature	Transit and mature	Mature	Key and transit	Transit and mature
	Organizational mechanisms	**1. Commitment**	Strong/moderate	Strong/moderate	Moderate	Strong/moderate	Strong/moderate
		2. Structure	Functional	Functional	Functional	Functional	Functional
		3. Control	Informal	Informal	Informal	Informal/formal	Formal
		4. Technology transfer mechanisms	Formal/informal	Formal/informal	Formal	Informal	Formal

* Firms whose products and technology have high innovation rates

Discussion on the technological strategies

A summary of the technological strategies followed by the firms is shown in tables 2 and 3. In the first table, firms whose products and/or technologies are characterized as belonging to sectors with a high rate of innovation (Group 1) have been grouped together. The second table is comprised of firms that use mature techniques to elaborate mature products (Group 2). The discussion presented below is based on the information contained in the tables mentioned above.

The firms in Group 1 have greater diversity with respect to the **"technology innovation"** dimension. However, they all aim at achieving a position as near as possible to that of the world leaders. This can be explained in accordance with the sector in which they are to be found. Thus, for example, the companies that operate in the agroindustrial sector are closer to the leaders than those related to the manufacture of hu-

**** Firms whose products and technologies have a low rate of innovation**

man health products as a result of the following factors: (1) the application of genetic engineering techniques in the developed countries took place first in the pharmaceutical industry and only later in the agricultural sector; this implies that Latin American countries that went into the medicine sector have a greater gap to jump than those of other areas; (2) the investments that must be made in the pharmaceutical sector are much greater than those that are needed in the agroindustrial sector; this factor is therefore critical for the design of the strategy proposed; (3) it can be easier to gain access to agricultural markets than medicine ones.

For their part, the companies in Group 2 use a "distant follower" strategy. This means that they do not modify their processes so quickly and conduct few product innovations which is only justified by the fact that the firms have found market niches for their products (local, regional and international levels), even though their products are mature. The new ecological and quality norms call for the use of more environment friendly products, and these firms can obtain them using traditional techniques without being subject to pressures to invest in innovations that would take them closer to the frontier of knowledge.

In the case of the **"vector"** component, a relationship can be observed with respect to the size of the organization: small and medium firms tend to follow a simple model, while large companies apply a multiple one. One explanation for this situation could be that the diversification of efforts in different technological areas necessarily requires a larger number of qualified human resources, which are not always available, and it is not easy for a firm with less than 100 employees to constantly incorporate highly qualified people. Similarly, the monetary resources required by the multiple approach are much greater and it would therefore be difficult for a small firm to cover this expense, above all in an environment in which there is little public support for innovation.

The results found in the **"novelty"** component are not surprising for this, in some way, is conditioned by technology innovation. Thus, there can be no doubt that if a firm wishes to maintain a position close to the leader, it will have to do everything necessary to acquire near the state of the art knowledge. Only in this way will it be able to establish congruent strategies. The firms in group one can be seen to be closer to the state of the art than those that belong to Group 2, although they are all follower firms.

The **"source of technology"** dimension also brings out some interesting aspects. The first point to come across is that all the firms, independent of the group in which they are found, combine internal and external sources. This situation can be explained in the following way: in the first place, the multiplicity of techniques and disciplines involved in biotechnological matters make it necessary to be in close contact with the organizations that have the human resources and infrastructure needed to carry out the desired developments; in second place, when the technological strategy is a follower one the firms must keep up with the developments generated by others in order to later acquire them in many diverse ways and it is thus essential to create contacts that will advise them as to the technological trends; in the third place, the high costs of a one hundred percent internal development would make innovations little viable in firms; and in fourth place is the fact that in Latin American countries most of the investment in research is carried out in government centers and the firms therefore know that these instances are a very important option in technology transfer.

Furthermore, it is important to mention that this dimension in particular can not be reviewed in isolation since the decisions made here depend on other variables. Thus, for example, the **"technological investment"** components are closely related to the source of technology, in particular investment intensity and direction. If a firm decides to work on basic research it is highly probable that it will have to resort to external sources of technology, for it is practically impossible for the firms to have all the human resources and highly specialized equipment needed. Similarly, if the organization wishes to make use of external sources, it must then contemplate a specific item for this purpose when allocating the budget, which will be independent of the resources allocated to internal developments that must be strengthened in parallel.

With respect to the **intensity** of investments in innovation, a clear difference can be seen between the two groups. The firms in Group 1 made above average investments, while investments in Group 2 were under average. This is simply a reflection of the position they have established in the innovation parameter since if a firm intends to be close to the leader, for example, it is clear that its investment in R&D, human resources and infrastructure must be high.

In relation to **orientation**, the firms in Group 2 tend more towards applied research before committing efforts to basic science. This situation is linked to the fact that the organizations are looking for results with a quick impact on the market that will allow for a prompt recovery of the investment and will decrease production costs. Similarly, the lack of qualified resources in most firms means that it is technically very difficult for them to generate new knowledge. The case of the firms in Group 1 is different in this aspect. Even though three of them are more oriented towards applied research, they also make great efforts to gain opportune access to basic developments, since only in this way can they generate the generic and emerging technologies that are necessary if they are to keep close to the leader

Finally, in the **"organizational mechanisms"** dimension a strong coincidence can be observed between the firms that

form part of each of the groups, but a difference can also be noted between the groups' strategies. Thus, while the firms in Group 1 tend to handle commitments, control and transfer mechanisms in a formal way, the other group prefers a combination of formal and informal methods. This situation becomes clear if the aspects described below are taken into account.

In an environment where there is a shortage of resources, it is difficult for the firm to formalize technological functions. However, it cannot refuse to open up access channels for itself, which it does through the search for low cost opportunities, establishing informal contact networks with research centers, other firms and government agencies.

Nevertheless, there are situations that require the firm to formalize technology transfer agreements since as well as knowledge of restricted access, they involve investment of a larger number of economic resources, greater risks and work teams specialized in introducing the desired techniques. Thus, the parties involved in the process will need to make a greater commitment. The best way for them to comply with the agreements will be through a formal control system that makes it possible to observe project advance, but above all to assess the performance of the parties and the results in order to then make opportune decisions.

Of course, the greater the scope of the projects, the greater will be the pressure on the firms to plan economic resources allocation in order to comply with strategic goals in the longer term. This situation will also lead to the need to approach training issues in a more systematic way.

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