Some Aspects of Technological Innovation and Innovation Activities in Colombia. Comparison with Three Latin American Countries*

*Álvaro Turriago Hoyos***

* Este artículo profundiza en el procesamiento de la información y el análisis de los resultados que sobre la innovación y las actividades de innovación arroja la 'Encuesta de Desarrollo Tecnológico' en empresas del establecimiento industrial colombiano, realizada en 1998 por el Departamento Nacional de Planeación, DNP. El artículo es fruto del trabajo adelantado en una estancia posdoctoral en la Universidad de Miami, como *Visiting Scholar* en el *Center for Latin American Studies* (CLAS), llevada a cabo durante el primer semestre de 2002. El autor agradece a Marisela Vargas, investigadora del Observatorio Colombiano de Ciencia y Tecnología (OCyT), por la consecución de las cifras presentadas. Igualmente, muestra sentimientos de gratitud al profesor Ezana Habte-Gabre del Área de Lenguas Extranjeras de la Universidad de la Sabana por su invaluable colaboración en la redacción del trabajo. El artículo se recibió el 04/10/02 y se aprobó el 16/05/03.

** Doctor en Ciencias Económicas y Empresariales Universidad de Navarra, Pamplona, España, 1994. Economista de Universidad del Rosario, Bogotá, Colombia, 1980. Profesor Asociado de la Universidad de la Sabana, jefe del Área de Economía y Finanzas. Correo electrónico: alvaro.turriago@unisabana.edu.co.

ABSTRACT

This article looks at frequency of technological activities and innovation in Colombian industries, and compares data with three other Latin American countries: Argentina, Chile and Venezuela. A neo-schumpeterian framework is used to structure the meaning of the main concepts. The implicit hypothesis is that both innovation and innovation activities produce increased productivity, which in turn is the source of competitiveness advantages for companies. The study finds that companies have poor technological performance in the purchasing level of hard technologies and in research and development activities. Depending on size, the greatest weakness for small and medium enterprises (SME) is in qualifications and productivity of human resources. In large companies, weaknesses are in training and work management. When looking at these countries individually, it can be seen that before the crisis, innovation activities in Argentina were more developed and there was more access to international markets. On the other hand, knowledge generation and openness to foreign markets are weaker in Colombia and Venezuela.

Key Words: Technological innovation, innovation activities, knowledge, learning, productivity, competitiveness, increasing returns, efficacy, efficiency, Small and Medium Enterprises (SME), large companies

RESUMEN

Este artículo indaga por la frecuencia de las actividades tecnológicas y la innovación en las empresas industriales colombianas; al mismo tiempo, compara estos aspectos entre Argentina, Chile y Venezuela. Para ello utiliza un marco teórico de referencia neoschumpeteriano, bajo el cual se estructura el sentido de los principales conceptos. La hipótesis es que tanto la innovación como las actividades relacionadas con la innovación producen aumentos de la productividad y éstos, a su vez, son fuente de ventajas competitivas para las empresas. El estudio encuentra que las firmas presentan pobres desempeños tecnológicos en los niveles de compra de tecnologías duras y en las actividades de investigación y desarrollo; por tamaños de empresa, las mayores debilidades de las Pyme se hallan en la calificación y en la productividad del recurso humano, en tanto que en la gran empresa, éstas se encuentran en el entrenamiento y la gestión del trabajo. Por países se muestra que, antes de la crisis, Argentina presentaba mayor desarrollo en las actividades de innovación y en acceso al mercado internacional, mientras que en Venezuela y Colombia es débil la generación de conocimiento y la apertura al comercio internacional.

Palabras Clave: Innovación tecnológica, actividades de innovación, conocimiento, aprendizaje, productividad, competitividad, retornos increméntales, eficacia, eficiencia, pequeña y mediana empresa (Pymes), grandes firmas.

Introduction

Notwithstanding the fact that in developed countries there is an important heap of information and analysis about technological innovation and related activities; this is not true of developing countries, particularly in Latin America. In spite of this, since the nineties, the study of these topics has become more important. In Colombia, for instance, in 1992 and 1994, the ILO[1] began to study innovation activities within the industrial establishment. In this paper, we present results and draw conclusions from a research project on the innovation activities of Colombian Industrial Firms.[2] Two Colombian governmental institutions, Colciencias[3] and Departamento Nacional de Planeación (DNP)[4] carried out this research project in 1996.[5]

The main objective of this essay is to describe the frequency of both innovation and the innovation activities among the Colombian industrial firms. So as to reach this purpose we support this description using a theoretical neo-schumpeterian framework that explains the meaning of basic concepts. The implicit hypothesis is that innovation and innovation activities spur productivity and through the development of it, a competitive advantage in the markets is reached. In order to fulfill this objective we have to classify the firms basically according to two dimensions: their size and their degree of innovation. Also, we are going to present the frequency of innovation activities in three Latin American countries, classifying this information by size of firms and then compare Colombian figures with three Latin American countries.[6] Finally, we will present some conclusions.

1. Theoretical Framework

1.1 *From Oslo to Bogotá*

In the late seventies, a team of Scandinavian researchers[7] began to study the relationship between knowledge and competitiveness. This group published their results as *The Oslo Manual* (1992). Inside this Manual, we can find a worldwide consensus about definitions related with technology and a worldwide-accepted definition of innovation.

---

1 International Labour Organization (ILO).

2 Only industrial firms, neither agricultural nor services firms.

3 A governmental institution that promotes scientific research in Colombia. For more and detailed information see: www.colciencias.org.co.

4 The Departamento Nacional de Planeación guides public investment in Colombia and has an important scientific production in economics. For more and detailed information see: www.dnp.gov.co.

5 Encuesta sobre el desarrollo tecnológico en el establecimiento industrial colombiano. Bogotá, DNP, 1997.

6 We are presenting outcomes of two medium and relatively technology developed countries: Chile and Argentina; and two medium but not so technology developed: Colombia and Venezuela. This work would like to analyze two giants, countries that are better technology developed: Mexico and Brazil. We are looking for data on these last two countries.

7 See Lundvall (1995b), for a history of the main contributions to this task.

> Technological innovation comprises of new products new processes and significant technological changes of products and processes. An innovation has been implemented if it has been introduced in the market (product innovation) or used within a production process (process innovation). Innovations therefore involve a series of scientific, technological, organizational, financial and commercial activities. (*Oslo Manual*, 1992, paragraph 90).

Nowadays, this is the 'official' definition of innovation. The definition is clear, precise, complete and concrete. It is, however, inadequate for developing countries because it was written with industrialized economies in mind, that have a high level of human capital —both in skills and management techniques— and a complete capital accumulation (i.e. a strong industrial base). Both of these circumstances are hardly found in developing countries. For that reason, some Latin American researchers decided to write their own manual: *The Bogotá Manual* (2001).[8]

The first challenge of that effort consisted on applying Oslo's definitions to poorly industrialized environments. The patterns of measurement presented in the *Oslo Manual*, are totally inappropriate for developing economies; probably because the main inconvenience was the fact that any radical innovation requires strong technological support. The absence of this support generates a very difficult gap to fill because the scientific and technological leadership belongs to developed economies. Moreover, the international transfer of technology and know-how requires time and a high amount of financial resources to pay for royalties, fees and other costs.

Almost always, when a firm that belongs to any developing country must buy any technology, it must pay for royalties, buy patents and contract strict supervision of foreign technicians that manage and adapt these new technologies. All of these are activities linked to the improvement of new technologies. When any firm or government buys foreign technology and wants to apply it in its own environment, one of the first steps that technology buyers must do, is to adapt the new technology to their domestic environment. All these activities lead buyers to begin improving many new activities derived from this new technology purchase. For this reason, one of the main conclusions of *The Bogotá Manual* is:

> Most innovative activity in developing countries consists of minor innovations (modification or improvement of existing technologies). However, such minor innovations may lead to significant grow in productivity in certain cases. (p. 41)

In my view, the above consideration implicitly recognizes the difficulties faced by developing economies to produce new technologies, which is the same as producing new technological knowledge. In addition, there are other implicit considerations, for instance: the improvement of existing

[8] The Bogotá Manual can be downloaded in the following addresses. English version: http://www.ricyt.edu.ar/manualdeBogota.pdf and Spanish version: http://www.ricyt.edu.ar/Novedades/PubRICYT/manualdebogota.pdf.

or new technologies implies imitation as a tacit innovation management strategy instead of creation of proper and original technologies. Another implication, I think, is the fact that technological innovation and innovation activities lead firms to increase productivity.[9]

Besides these deductions, we can make another important conclusion: *The Oslo Manual* stresses the importance of innovation of products and services but ignores any theoretical consideration to innovation activities. Innovation activities surely are extremely important for the majority of Latin American firms; they cover a high spectrum of scientific, technological, organizational, financial and commercial development within the firm. Having in mind the meaning of technological innovation, we are going to define innovation activities.

1.2 *Innovation Activities*

The Bogotá Manual[10] identifies seven different types of Innovation Activities:

- Research and Development (R&D): Scientific activities developed by any firm, inside or outside of it, sometimes supported by specialized research institutions. These activities cover a large variety of things such as development of research projects, basic research, applied research, and development of prototypes, new products and new processes, and pilot plants.
- Embodied technology: Capital goods and hardware adapted into the firm and linked to new products and processes.
- Disembodied technology: Licenses and technology transfer expressed in patents, brands, and industrial secrets. Consultancies applied to production, products, productive system organization, organization and management, finance, marketing.
- Training: Technological training linked to new products and new processes. Management and administrative training in areas such as management, administrative skills, information technology, industrial security and quality control.
- Organizational modernization: Introduction of activities like strategic planning, quality circles, total quality, benchmarking, administrative process reengineering, modern management techniques of production process, vertical or horizontal disintegration, the 'just in time' technique, modern management of environment systems.
- Design: It refers to product design, industrial process design and engineering process.
- Marketing: It is related to new forms of sales and to distribution and efforts to sell and distribute innovated products.

The definition of technological innovation and innovation activities lets us begin to point out the existing relationships between this pair of variables and the improvement of productivity and competitiveness in any firm.

[9] Productivity means the final output obtained by used unit of input —capital and labor— used in any production process of any kind of firm. Therefore, there are three kinds of productivity: labor productivity, capital productivity and total productivity.

[10] See, *The Bogotá Manual*, pp. 56 to 58.

1.3 *Links between Innovation Process, Productivity and Competitiveness*

The innovation process has four distinct moments:[11] (1) start, (2) real process, (3) output and (4) final impacts. Innovation as a process is boundless. My personal point of view about this process, is that it is systemic. There are several implications in a systemic process.

- First, we have to permanently study the process as a whole.
- Second, any firm's process implies a permanent and interactive dynamic.
- Third, it is very difficult to know when the dynamic begins and when it ends.
- Finally, it implies that the final outcomes could affect both internal and external fronts of the system, in this case a firm.

The case we have studied affects both markets —which is an external front— and several firm's internal processes: production, management in general, level of productivity, finances and sales.

The start of the innovation process always begins with an individual or collective entrepreneurial decision. Nowadays, introducing an innovation in the market by oneself —as an individual entrepreneurial decision— is almost impossible; given the complexity of technology and markets, as well as the increasing globalized forces that imply working in interdisciplinary R&D teams. At the same time, this first entrepreneurial act is strictly supported in two dimensions, creativity and pragmatic human action. I say creativity, because a technological innovation implies by itself, doing new things or having new ways of doing old things. Also, I say pragmatic human action because if a firm does not introduce technological innovation into markets or implements it into production processes, the innovation does not fulfill the main purpose of its existence: generation of profits.

The second moment, the real process, belongs to the daily routines of every firm —See, Simon (1957) and Nelson and Winter (1982)—. A knowledge process requires that the manager of every innovative firm promote social activities of transmission of information inside the firm avoiding obstacles to clear the spread of information. In this part of the process, every firm needs to manage both technological and marketing information. Roberts (1977) identifies a new structural function inside firms, metaphorically named 'gatekeeper'. A 'gatekeeper division' has to fulfill the important duty of gathering information about the trends of technology the firm is using, the technologies improved by competing firms, the ways in which current and new technologies are complementary, and the strengthens and weaknesses of current technology. In addition, and this division attempts a permanent exercise of forecasting the evolution of technologies. More-

[11] I prefer to use moments instead of words like steps because it is an interactive and enchained process neither linear nor like the steps of a recipe. When we are starting, we can continue with the real process and after this we must return to the beginning. Alternatively, when immersed in an outstanding innovation process we should go back to the beginning because of an unforeseen change in the political or technological environment. See also, Kline (1985) and Kline and Rosenberg (1986).

over, this 'division' must gather information about markets, number of potential buyers, tastes, level of income, expectations, ages, purchasing power, etc. The third moment generates two types of results, technological innovation in a pristine pure state in products or in processes, or simply innovation activities.

Final impacts are the fourth moment, which are the desired outputs of any innovation activity or innovation in and of itself that a firm could produce: increased productivity and competitiveness improvements. Innovation does not make any sense if a firm does not reach these two final effects.

Competitiveness is a very important dimension each firm in the economy must improve in order to be strong and actually survive in the market. Increased participation in the share of markets —such as the promotion of sales— could only be possible through the improvement of competitiveness in itself. When a firm has been maintaining participation in the market over time, we could say that this firm has competitiveness advantages and abilities that allow it to become successful.

Competitiveness is structured and born from the very interior of the firm. Innovation and its correlated activities are supported by the consolidation of competitiveness. We can understand innovation process and innovation activities as events that improve internal forces inside the firm generating operational knowledge. A strong base of operational knowledge within the firm is normally a more productive source of ideas to promote change, in other words, innovation. A permanent and current disposition to improve innovations is directly linked to the level of knowledge accumulated in the firm.

We can point out that if the accumulation of knowledge is permanent and is produced by innovation, the firm begins to accumulate an important amount of experience. The firm begins to become 'wise'. This wisdom is the consequence of doing its best with the learning processes and doing its best with the accumulation of operational knowledge. The work teams inside the firm increasingly learn more daily and have permanent social interaction. The final outcome is a more efficient company because its processes improve. As a consequence of this 'doing internal processes fairly well', the learning process begins to reinforce itself thanks to the daily social interaction of the work teams. We can denominate this condition as a generating a positive virtue circle.[12]

Doing things well inside the firm is not enough. In addition, it is necessary to do things well outside the firm in the market. To become successful, the market demands increasingly strong and consolidated internal processes. To win efficacy —that is to serve clients and customers well— requires a permanent and demanding philosophy of total quality. Obtaining efficacy is the dream of any manager. Efficacy is the practical manifestation of any firm's good service

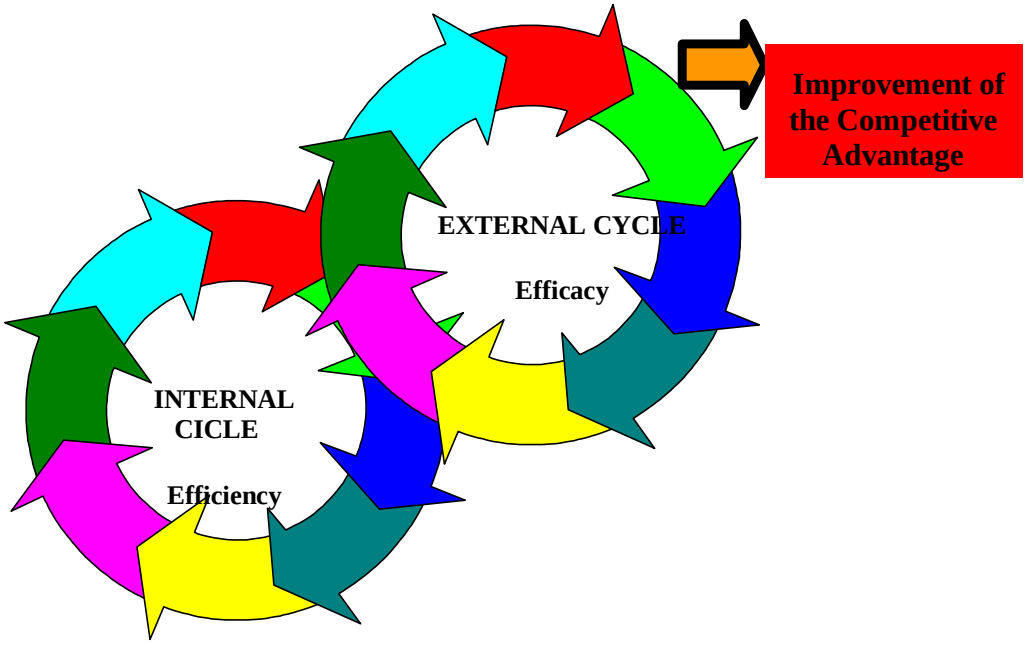
[12] Arthur (1994) used to name this situation as Increasing Returns. This is a situation when any type of dynamic is reinforced by itself while the dynamic is producing. Knowledge —as a resource— always has Increasing Returns, because of their capacity to reinforce by themselves while it is using and applying.

outside its own boundaries. In other words, it is necessary to create another positive virtue circle outside the firm, into the markets.

The secret of success is to link both positive virtue circles. Improvement of competitiveness is the result of combining both, efficiency and efficacy. Efficiency expressed in internal processes performing satisfactorily, and efficacy is expressed in excellent relationships with clients. It is very difficult to attain competitiveness without the support of these two dimensions of the two positive virtue circles.

This well fitted dynamics, where efficiency and efficacy match together, grants high levels of competitiveness to any firm that could reach this demanding level of management.

Figure 1
Internal and external effects of technological innovation and innovation activities: A cybernetic approach



In summary, we can point out that both technological innovation and innovation activities are operational impacts of accumulated knowledge. Innovation ocurres as a result of learning and experience processes of work teams inside the firm.

A technological innovation has two main impacts in a firm environment. The first is related to internal processes leading the firm to better levels of efficiency thanks to the achievement of improvements in productivity that grant low level production costs. The

second, in the external front of any firm is the market, thanks to improvements in competitiveness.

Finally, if an innovation does not improve a firm's productivity and/or competitiveness growth, it is useless.

2. A Scope of Technological Innovation and Innovation Activities in Colombian Industrial Firms

2.1 *Taxonomy of the Firms*

The taxonomy of firms that we will use in this work is linked to two dimensions: degree of innovation and size of the firms. According to the degree of innovation we could classify the firms in four groups: strictly innovative, highly innovative, potentially innovative and finally, non-innovative.

According to size, there are only two classifications: Small and Medium Enterprises (SME) and Big Enterprises. Having said this, which is the current classification that DNP has been using in its surveys of Colombian industrial firms, we are going to give a brief explanation of the degree of innovation taxonomy.

The first set of firms is **Strictly Innovative**, which means that these firms must develop innovations of product and process, perform R&D activities and sell all or part of these goods and services produced in international markets.

The second are **Highly Innovative**; these are firms that produce innovation in both products and processes sometimes generating R&D and sales, which are limited to the domestic market.

A **Potentially Innovative** firm is one that only generates innovation activities such as R&D, embodied technology, disembodied technology, training, organizational modernization, design, and marketing. Neither innovation of products or processes nor exports are presented.

A **Non-Innovative Firm** does not present either technological innovation or innovation activities.

Table 1 presents the share of Colombian industrial firms in the market and production; the chart also presents the participation of firms by degree of innovation.

Table 1
Classification of Colombian Industrial Firms According to Degree of Innovation 1998

Degree of Innovation	Firms	Sales	Production
Strictly innovative	10.1%	25.5%	24.8%
Highly Innovative	64.1	66.5	65.9
Potentially Innovative	7.2	5.2	6.3
Non-Innovative	18.6	2.8	3.0

Source: Duran, and others, 1998, p. 38.

It is easy to conclude that a small set of firms, 10.1% of the total, which are strictly innovative, explains 25.5% of the total sales and 24.8% of the total production. We can assume that there are links between the level of innovation and competitiveness advantages. If any firm has some level of competitiveness advantage, it is basically because that firm could get some levels of efficiency and efficacy.

Therefore, we can point out that the level of competitiveness improvements[13] of strictly innovative firms is higher than in other types of firms.

Table 2 presents the same set of firms presented in Table 1, but it also explains the participation of these firms by size.

Table 2
Classification of Colombian Industrial Firms According to Degree of Innovation and Size
1998

SME

Degree of Innovation	Firms	Sales	Production
Strictly innovative	6.7%	2.8%	2.4%
Highly Innovative	49.9	16.8	18.7
Potentially Innovative	5.9	4.2	5.3
Non-Innovative	17.1	2.2	2.6
Subtotal	79.6	26.0	29.00

Big Firms

Degree of Innovation	Firms	Sales	Production
Strictly innovative	3.4%	22.8%	22.4%
Highly Innovative	14.3	49.7	47.3
Potentially Innovative	1.4	1.0	1.0
Non-Innovative	1.3	0.5	0.3
Subtotal	20.4	74.0	71.0

Source: Duran, and others, 1998, p. 38.

It is easy to point out that SME have the greatest participation among the total, but lesser competitiveness improvements than larger firms do.

The big firm's financial and marketing muscles are stronger than SME. In spite of their little participation in the total only 3.4%, they sell and produce almost 22% of the total. We can affirm that this is possible because big firms almost always have complete networks of distribution, an important number of clients, well-known prestige among financial institutions, high levels of cash flow generation and other important capabilities that lead them to leadership in the markets. This competitiveness advantage guarantees the stability of existing firms.

[13] We have said that competitiveness is obtained through the combination of efficiency and efficacy but as a concept is still difficult to define. Although several authors, among them Porter (1990), have written a lot about this topic unfortunately we still do not have a concrete microeconomic definition. Here the increase of sales is defined as the approximation to measure one dimension of competitiveness.

2.2 *Size of the Firms*

In this paper, we use the Colombian definition that describes a SME as one that hires less than two hundred employees. Likewise, a large enterprise hires more than two hundred employees. As one can observe from Appendix A, this definition depends on many local factors. Table 3 presents some indicators of the economic performance of industrial firms in Colombia.

Table 3
Colombian Industrial Firms: Economic Performance 1998 (Millions of US$)

	Average yearly sales by firm	Average yearly production by firm	Generation of employment (%)
SME	US$2,9	US$2,4	54.5%
Big Firms	31,8	23,8	45.5
National Average	7,6	5,7	-

Source: DNP, 1998.

The figures presented below show that Colombia's large firms produce and sell more or less ten times more than SME Also, SME are almost half of the national average account for production and sales. The main strength of SME is very clear: it generates more than half of all Colombian employment.

Table 4
Colombian Industrial Firms: Productivity Indexes 1998 (Colombian pesos)

	Labor Productivity[14]	Capital Productivity[15]
SME	$57.500	$487
Big Firms	93.402	85
National Average	73.845	130

Source: DNP, 1998.

Labor Productivity measures the total amount of sales of one employee. In this category, big firms by far exceed both the national average and SME. On the other hand, SME performs better in capital productivity; almost five times more than big firms and three times more than the national average.

[14] This index is estimated as Total sales/Number of employees.

[15] This index is estimated as Total sales/Purchase of new machinery and tools.

Table 5
An approximation at the competitiveness of Colombian Industrial Firms

	National Average		Big Firms		SME	
	1997-1998	1998-1999	1997-1998	1998-1999	1997-1998	1998-1999
Sales Yearly Increase (%)	12.88%	8.39%	9.99%	9.74%	17.12%	6.67%
Exports Yearly Increase (%)	28.33	4.09	24.16	0.90	35.69	9.22

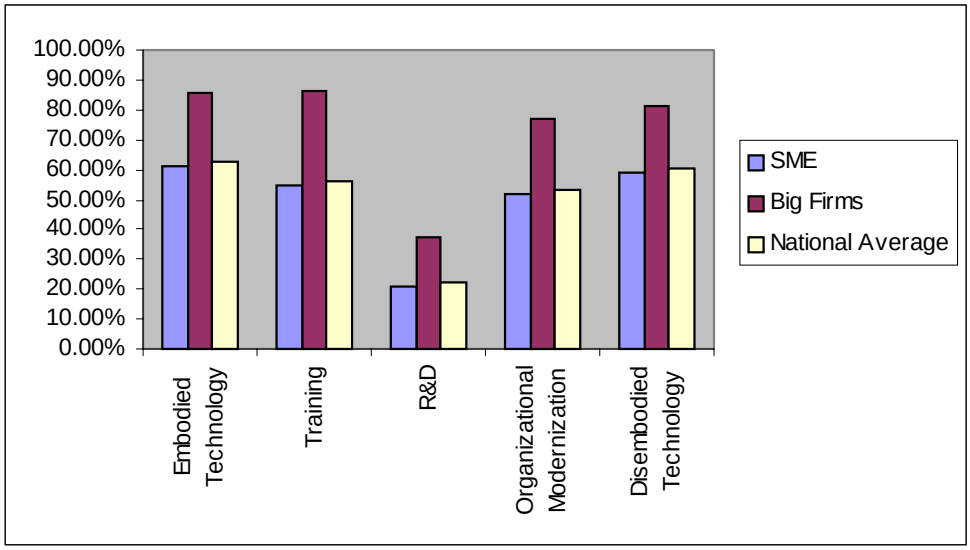
Source: DNP, 1998.

An approximation to the slippery concept of competitiveness is the increase of sales and exports. Figures in Table 5 show the superior performance of SME over Large Firms. This advantage is maintained in both domestic markets and foreign markets.

2.3 *Innovation Activities in Colombian Industrial Firms*

We present some dimensions that help capture the scope of Colombian Industrial Firms and their links to innovation.

Figure 2
Innovation Activities by Size of Firms 1998



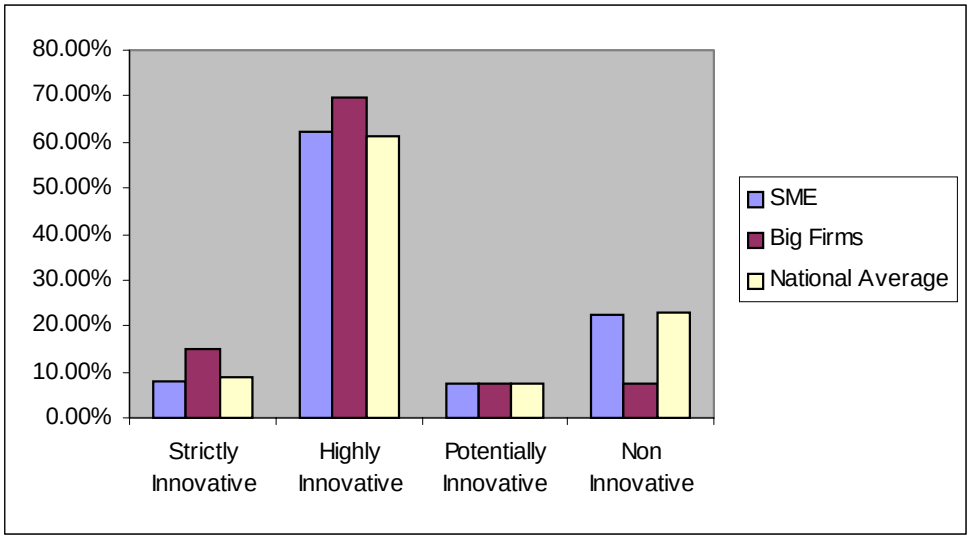
Source: DNP, 1998.

The high frequency of embodied technology underlines the fact that imitation is one of the strategies that Colombian firms follow. We said imitation because it is easy to deduce imitation as a derived activity of embodied technology because always

when any firm buys new technology it must be adapted and new performance ways have to be implemented in the new environment.

Big firms have the highest ranking in innovation activities. Alternatively, low R&D —in SME, big and national average— points to the low level of local scientific production.

Figure 3
Classification according degree of innovation and size 1998



Source: DNP, 1998.

The high participation of SME as highly innovative leads us to presume that the main lack of these firms is the participation in foreign markets. This is because one of the conditions required for any firm to be strictly innovative is that its products must be sold in foreign markets.

Table 6
Colombian Industrial Firms: Kind of Innovations 1998

	Product Innovation	Process Innovation
SME	43.3%	69.1%
Big Firms	63.4	84.7
National Average	44.4	68.2

Source: DNP, 1998.

In all the cases considered, process innovation exceeds the level of product innovation. Therefore, we can deduce that activities related to training, management and disembodied technologies matter more in the daily innovation activities of Colombian industrial firms.

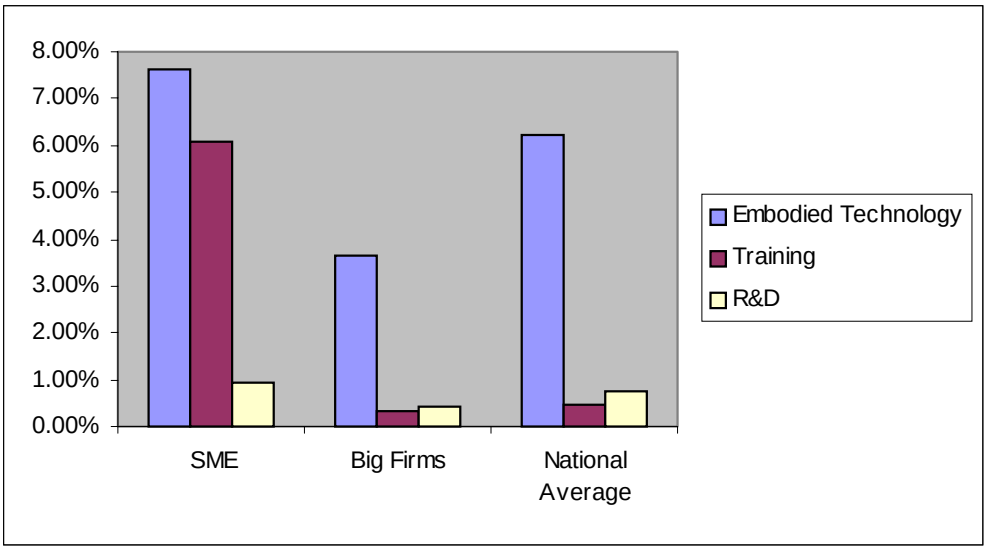
Table 7
Colombian Industrial Firms: Destination of Sales of Product Innovation 1998

	Domestic Markets	International Markets
SME	3.3%	18.9%
Big Firms	7.0	37.8
National Average	3.8	20.8

Source: DNP, 1998.

Obviously, big firms have better infrastructure to export their innovated products. This condition gives them a strong competitive advantage to overcome challenges in their own countries, provides them with cash flow in strong foreign currencies (basically, US Dollars) and offers them a prosperous future. SME must invest more funds to improve their international capacity to begin exporting.

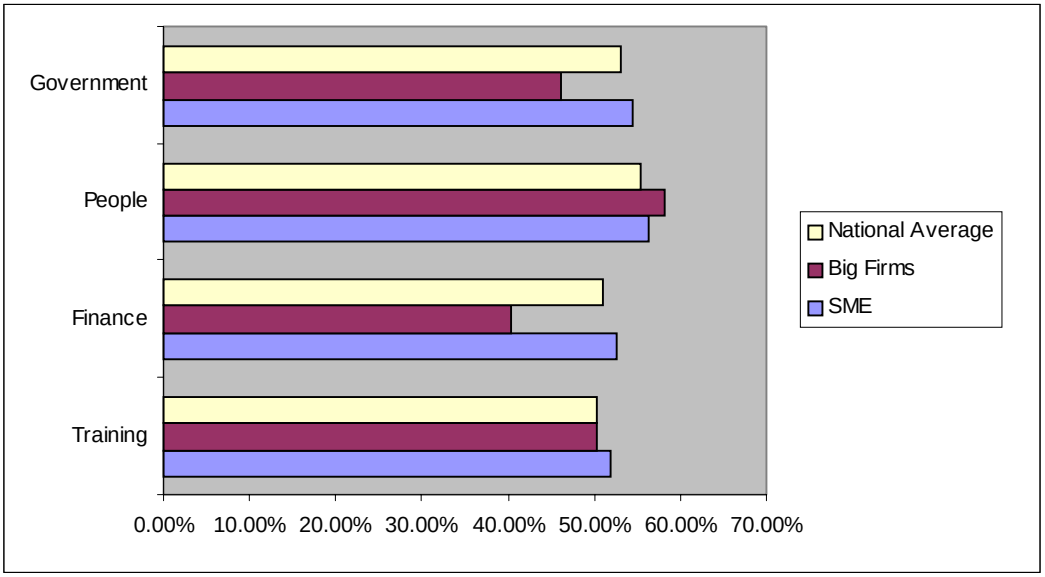
Figure 4
Investment in Innovation Activities in 1998 (Percentage of sales)



Source: DNP, 1998.

An immediate observation is that the levels of investment of innovation activities, as a percentage of sales, are extremely low. Among developed countries, this participation is at least 10% of the total sales. In the case considered the smaller the size of a firm the higher the amount of investment in innovation activities. These figures reinforce one of the hypotheses of *The Bogotá Manual*: the remarkable activity of incremental innovations in developing countries. Incremental innovations almost always express a strategy of incremental improvement leading to imitation strategies. The imitation activity of embodied technologies highly exceeds the other two, R&D and training. The low level of R&D expresses the poor generation of domestic technological knowledge and a poor level of creativity. Training is an expression of the technological learning of people. Accordingly, the low level of investment in training, especially in big firms, poses a threat to their future.

Figure 5
Colombian Industrial Firms: Main Obstacles to Innovation in 1998



Source: DNP, 1998.

Frequencies in both SME and big firms are almost the same. Obstacles related to training people are relevant. What the numbers indicate is that investment in training is what most Colombian firms want.

3. Some International Comparisons

Table 8
Economic Performance Millions of US$ 1995

	Yearly Average Sales by Firm	Yearly Average Export by Firm
Argentina	US$31,0	US$5,6
Chile	4,5	0,7
Colombia	8,7	1,1
Venezuela	10,5	1,6

Source: DNP-Colciencias, 1996, Bogotá.

Argentinean firms were by far the highest. Therefore, we can deduce that they had a clear openness to international trade due to their amount of exports.

Table 9
Economics Performance: Share by Size Millions in US$ 1995

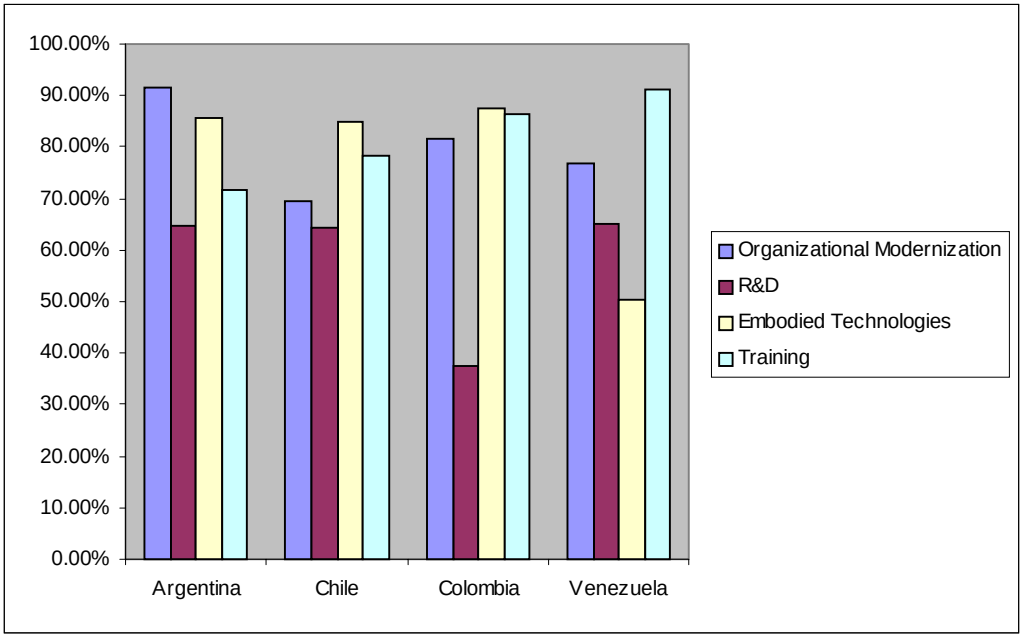
	Argentina	Chile	Colombia	Venezuela
Big Firms				
Yearly average sales by firm	US$86,8	US$40,2	US$36,4	US$34,5
Yearly average exports by firm	17,0	5,2	4,0	6,2
SME				
Yearly average sales by firm	13,3	6,2	3,6	4,4
Yearly average exports by firm	3,3	0,6	0,5	0,3

Source: Observatorio Colombiano de Ciencia y Tecnología (OCYT), 2002.

Big firms are, on average, six times larger than SME. In addition, big firms show more openness to international markets. Argentinean firms were in all cases the largest, almost twice the size of firms in the other countries analyzed (See Katz, 2000, 1998, 1997, and 1976).

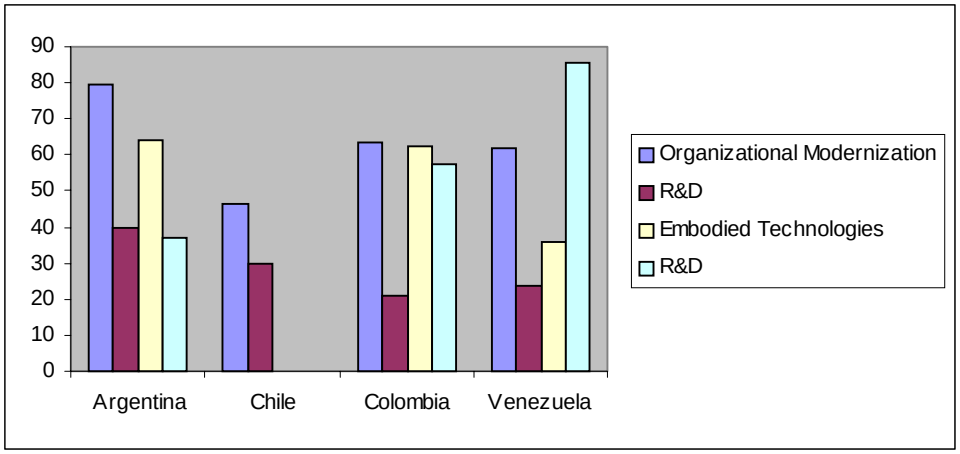
In both SME and big firms, organizational modernization is the innovation activity that records the highest frequencies. Embodied technologies rank as the second innovation activity level. The levels of R&D in all cases, with the exception of Argentina's largest firms, are poor. These conditions confirm the general trend, which we have found before, in this set of Latin American firms analyzed: low levels of domestic scientific production and a remarkable interest in training and the imitation of soft technologies, at first, and then adoption of hard technologies.

Figure 6
Innovation Activities: Share by Size and Country Big Firms 1998



Source: Observatorio Colombiano de Ciencia y Tecnología (OCYT), 2002.

Figure 7
Innovation Activities: Share by Size and Country SME 1998



Source: Observatorio Colombiano de Ciencia y Tecnología (OCYT), 2002.

Table 10
Main Obstacles to Innovation: Share by Size 1998

	Argentina	Chile	Colombia	Venezuela
Big Firms				
People	1	3	3	3
Finance	3	2	1	1
Government	1	1	2	2
SME				
People	1	3	2	3
Finance	3	1	1	2
Government	1	3	2	1

Source: Observatorio Colombiano de Ciencia y Tecnología (OCYT), 2002.

People[16] are the main obstacle to innovation identified by this set of industrial firms. Finance, as the second ranked obstacle points to the absence of a risk market promoted by governments or private foundations in these economies. Neither large nor small firms considered the role of government as a lagging force against innovation (See Katz, 2000, 1998, 1997, and 1976).

Conclusions

- Colombian industrial firms showed a poor technological trend both in purchasing strong technologies and in domestic generation expressed in low levels of R&D.
- The poor domestic trend of generation of technical knowledge must be avoided by Colombian industry in order to face the demanding conditions international markets are requesting. It is one of the main challenges the Colombian industrial establishment must overcome.
- Strengthening SME's marketing techniques would help them improve performance in foreign markets. Big firms seem to be more aware of this current reality.
- Imitation had been the innovation management activity prevalent in Colombian firms during the period of analysis. It could be a sound idea to better study Japanese policy, which improves this strategy, and to try to apply some of their ideas in the environment. Probably the challenge could be 'kaizening', the Japanese management strategy of imitation and adapting it to the Colombian industrial environment.

The contents presented before, both in figures and tables, could help us identify some strengthens and weaknesses of the set of firms analyzed. A summary of this strategic analysis is presented in Table 11.

[16] This refers to lack of good disposition to work well, lack of entrepreneurship, lack of leadership, lack of creativity.

Table 11
Strategic Matrix of Colombian Industrial Firms: Technological Approach

	Strengthens	**Weaknesses**
SME	• Openness to foreign markets • High level of training investment • Generation of employment • Competitive improvements in foreign and domestic markets • High level of capital productivity	• Low labor productivity • Lack of appropriate people both in management and in labor • Low level of capital flow
Large Firms	• Openness to foreign markets • High level of capital productivity	• Low level of training • Lack of appropriate human resources both in management and in labor

Source: Own elaboration.

- Before the dramatic foreing debt crisis, Argentina had outstanding strengths, which were evident in both large firms and SMEs, in innovation activities and in openness to international trade. Unfortunately, we do not yet have figures for Brazil. They would help us better understand Argentina's strengths in relation to its largest competitor and commercial partner.
- Venezuela and Colombia looked as medium technological economies with weaknesses both in openness to international markets and technical domestic knowledge generation. Both countries have a significant gap to fill in generation and the adaptation of their own technological knowledge.
- We could not expect the high development of product innovation in developing economies. These countries lack a strong technological basis to promote technical change. On the other hand, they could improve many changes in processing soft technologies, which are easier and cheaper to apply than hard technologies. Imitation is the innovation management activity that will prevail in these firms.

Appendix A
Definition of the Manufacturing SME in Selected Countries

Country/ Region	Number of Employees	Other Conditions If Any	Basis for Definition
Australia	Less than 500 (small: up to 100)	–	Australian Bureau of Statistics
Brazil	Less than 500 (small: less than 100)	–	Foundation of the Brazilian Institute of Geography and Statistics (BRGE)
	Less than 500 (micro: less than 100)	–	SEBRAE
Argentina	Up to 300	Annual Sales: up to US$18 million Productive Assets: up to US$10 million	Ministerio de Economía Resolution
Chile	Less than 200 (micro: less than 10)	Annual Sales: up to 50,000 UF (about US$1.6 million) micro: less than 2,400UF	General Definition (No standard definition)
Mercosur	Up to 300	Annual Sales: up to US$10 million	Agreed among member countries
Mexico	Up to 250 (micro: less than 15)	Annual Sales: subject to the classification of micro, small and medium	Government circular
Korea	Up to 300	–	Small and Medium Industry Promotion Corporation
Italy	Up to 500 (small: 11-50, artigiano: less than 10)	Capital: less than Lire 3 billion	Government Law
Japan	Up to 300	Capital: up to ¥100 million	Small and Medium Enterprises Basic Law
U.S.A.	Up to 500	–	U.S. Small Business Administration

Source: Miller, Esselar & Associates, 2002.

Bibliographical References

Arthur, W. B., 1994. *Increasing Returns and Path Dependence in the Economy*, Ann Arbor, The University of Michigan Press.

Departamento Nacional de Planeación (DNP)-Colciencias, 1996. *Encuesta sobre desarrollo tecnológico en el establecimiento nacional colombiano. 1998-1996*, Bogotá.

Drucker, P., 1986. *La innovación y el empresariado innovador*, Buenos Aires, Sudamericana.

_____, 2000. *Los retos de la gerencia del siglo XXI*, Bogotá, Legis.

Duran, J., and others, 1998. *La innovación tecnológica en Colombia. Características por tamaño y tipo de compañía*, Bogotá, Departamento Nacional de Planeación.

Jaramillo, H.; Lugones, G.; Salazar, M., 2000. *Normalización de indicadores de innovación tecnológica en América Latina y el Caribe. Manual de Bogotá*, Bogotá, OEA.

_____, 2001. *Standardization of Indicators of Technological Innovation in Latin American and Caribbean Countries*, Bogotá, Manual RYCYT/ OAS/ CYTED/Colciencias/OCYT.

Katz, J., 2000, "The Dynamics of Technological Learning during the Import-Substitution Period and Recent Structural Changes in the Industrial Sector of Argentina, Brazil, and Mexico", in: Kim, Linsu, and Nelson, Richard R (editors). *Technology, Learning & Innovation. Experiences of Newly Industrializing Economies*, Cambridge: Cambridge University Press.

_____, 1998. "Aprendizaje tecnológico ayer y hoy", in: *Revista de la CEPAL*, diciembre, n. 63, p. 81-91.

_____, 1997. "Falla del mercado y política tecnológica", in: *Revista de la CEPAL*, n. extraordinario, p. 63-75.

_____, 1976. *Importación de tecnología, aprendizaje e industrialización dependiente*, México, Fondo de Cultura Económica.

Kline, S., 1985. "Innovation is not a Linear Process", in: *Research Management*, July-August, v. XXVIII, n. 4, p. 36-45.

_____; Rosenberg, N., 1986. "An Overview of Innovation", in: *The Positive Sum Strategy*, Washington, National Academy Press.

Lundvall, B-Å., 1995a. *National Systems of Innovations: Towards a Theory of Innovation and Interactive Learning*, London, Pinter.

_____, 1995b. *Users-Producer Relationships, National Systems of Innovation and Internationalization*, London, Pinter.

Miller, Esselar & Associates, 2002. http://www.milles.co.za/index.htm, SMME Presentation.

Nelson, R.; Winter, S., 1982. *An Evolutionary Theory of Economic Change*, Boston, Kluwer Aceademic Publishers.

OECD, 1992, *OECD Proposed Guidelines for Collecting and Interpreting Technological Innovation Data*, Paris, OSLO MANUAL.

Porter, M, 1990. *La ventaja competitiva de las naciones*, Barcelona, Plaza y Janés.

Roberts, E. B., 1977. "Generating Effective Corporate Innovation", in: *Technology Review*, October-November, p. 27-33.

Schumpeter, J., 1976. *Teoría del desenvolvimiento económico*, México, Fondo de Cultura Económica.

Simon, H., 1957. *Administrative Behavior*, New York, McMillan.

Senge, P., 1993. *La quinta disciplina*, Barcelona, Juan Granica.

Turriago, Á., 2000a. *Temas de innovación tecnológica*, Bogotá, Universidad de La Sabana.

_____, 2002b. *Gerencia estratégica de la innovación*, Bogotá, Alfa Omega.