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TECHNOLOGICAL INNOVATION IN BRAZILIAN AND ARGENTINE FIRMS

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Mapping and comparing economies are perhaps the most important – yet difficult – tasks to be accomplished by researchers all over the world. For that reason, this book released by the Institute for Applied Economic Research (IPEA) is unique. For the first time in Brazil and Argentina a top- rate group of thinkers discuss some relevant economic issues focused on innovation and growth. It is particularly stimulating to see an arc of topics addressed at a variety of levels and from a different research perspectives.

Brazil and Argentina remain strong competitors in global markets in standardized agricultural and industrial goods. However the data show also that a small, but important group of Brazilian companies is participating in international market via exports of medium and high-technology goods. This cluster of highly competitive Brazilian firms generates growth positive spillovers in terms of wage and productivity. Contrary to expectations in Brazil of a a regressive specialization in terms of exports products following liberalization, the new competitive environment in Brazil is unleashing new business perspectives associated with innovation. This process in Brazil is different from the experiences of firms in Argentina. The ability of the Brazilian industrial elite to compete successfully in the global economy is rooted in their improved innovative capacity. In response to international and domestic conditions, Brazilian and Argentinean firms have reacted, changing their business strategies and also their attitudes towards technology, innovation and employment.

These thought-provoking essays illustrate the potential of international comparisons to advance our understanding of the way countries react to economic changes and the deep challenges the two biggest south-american economies have to face. This impressive book will be useful to anyone who cares about what emerging economies will look like in the years ahead.

Glauco Arbix

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FOREWORD

This book is part of a comprehensive project developed by the Institute for Applied Economic Research — Ipea aimed at shaping and formulating public policies for sustained economic growth with social inclusion. The studies focus on technological change and innovation together with their economic and social impacts, it being understood that a knowledge-based economy lies within the realm of sustainable development. Moreover, special attention is directed to comparative analyses of the technological paths and innovation patterns observed in Latin America and the OECD countries.

The first set of studies published within the scope of the project — entitled *Inovações, Padrões Tecnológicos e Desempenho das Firmas Industriais Brasileiras (2005)* (Innovation, Technological Patterns and the Performance of Brazilian Manufacturing Firms, now being translated) — sought to classify firms by their levels of competitiveness. This work, a joint effort between Ipea and senior researchers from the leading Brazilian universities, led to a fertile debate concerning the impact of innovation on economic growth and competitiveness. It was subsequently followed by other publications covering various dimensions of the innovation process. Among these, two should be mentioned: *Tecnologia, Exportação e Emprego (2006)* (Technology, Exports and Employment) and *Estrutura e Dinâmica do Setor de Serviços no Brasil (2006)* (Structure and Dynamics of the Brazilian Service Sector).

Encouraged by the debate on these issues, IPEA initiated a dialogue with Argentine economists, together with whom a series of studies focused on business strategies in Brazil and Argentina was undertaken, the outcome being the present publication. The pioneer nature of the research lies in the data having been gathered from both Brazilian and Argentine manufacturing firms. While this is neither the only nor the first such dialogue between economists from the two countries, it stands out because it constitutes an initial effort to access information on technological innovation. It is also original in that it compares the manufacturing sectors of these countries from the standpoint of the competitive strategies of the firms surveyed.

To this end, the Brazilian and Argentine firms were classified according to the same criteria. The classification scheme was designed to distinguish firms that compete through product differentiation via technological innovation from those that compete through price alone. The process of building a common methodological framework resulted in a fruitful partnership and has opened new avenues for further research and cooperation. During this academic journey, Brazilian and Argentine researchers had the privilege of working with Professor Daniel Chudnovsky, to whom Ipea pays homage.

Luiz Henrique Proença Soares
President of Ipea

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INTRODUCTION*

João Alberto De Negri
Lenita MariaTurchi

Policies aimed at stimulating production belong to a broader set of policies that has been widely discussed with respect to Latin American economies and, above all, with regard to the members of Mercosur. Ideally, such long-range policies should be aimed at inserting economies in higher-tech markets. In the case of Mercosur, however, protectionist and sectoral measures have hindered regional integration and failed to straiten the economic ties between the member countries, for they have neither stimulated the process of productive alignment of the firms in the region, nor strengthened the competitivity of these enterprises by enhancing their technological capacities.

To drive production, existing policies will have to be shaped to the new economic scenario and its dynamics and will have to benefit from the lessons to be learned from the successes and failures of the past, as well as from international experience. Today governments are obliged to perform in a world environment characterized by economic openness, World Trade Organization (WTO) agreements, the greater power of transnational corporations and intra-firm trade, tremendous technological dynamism, the prevalence of differentiation and innovation of products and processes, and the use of distribution channels and trademarks as extra-price dimensions for attaining higher profits.

Encouraged by the debate surrounding these issues and the publication in Portuguese of *Inovações, Padrões Tecnológicos e Desempenho das Firmas Industriais Brasileiras* (Innovation, Technological Patterns and the Performance of Brazilian Manufacturing Firms),[1] IPEA initiated a dialogue with Argentine economists, together with whom a series of studies focused on business strategies in Brazil and Argentina was undertaken. The pioneer nature of the research derives from the fact that the data were gathered from both Brazilian and Argentine manufacturing firms. While this is neither the only nor the first dialogue between economists from the two countries, it is distinct in that it constitutes an initial effort to access information concerning technological innovation collected from manufacturing firms in the two countries. It is also original insofar as it compares the industrial sectors of the countries in question from the standpoint of the competitive strategies of the manufacturing firms surveyed. To render this feasible, the Brazilian and Argentine firms were classified according to the

*. The editors wish to thank Renato Baumann, Ricardo Bielschowsky and Bernardo Kosacoff for their support.

1. See De Negri and Salerno (2005).

same criteria. The classification scheme was designed to distinguish firms that compete through product differentiation via technological innovation from firms that compete through price alone.

Using this standard classification of Brazilian and Argentine firms as their starting point, the authors of the papers presented in this book approach the theme of technological innovation from various angles. The book is divided into twelve chapters written by Brazilian and Argentine economists. The reader is advised to peruse this introduction before proceeding to the chapters since it contains an explanation of the methodology employed to classify the firms in Brazil and Argentina, as well as a summary of the major findings of this research effort.

CLASSIFICATION OF BRAZILIAN AND ARGENTINE MANUFACTURING FIRMS BY COMPETITIVE STRATEGY ON THE BASIS OF THE TECHNOLOGICAL INNOVATION SURVEYS

The articles in this book are based on data from the National Innovation Survey (PINTEC, 1998-2000) for Brazil and the Second Innovation and Technological Behavior Survey (EICT, 1998-2001) for Argentina.

The PINTEC was designed and conducted by the Brazilian Geographic and Statistical Institute (IBGE). Of the 11,000 firms covered by the sample, 10,328 responded to the questionnaire. When the sample is weighted, the number of firms rises to 72,000. In general, the concept and methodology of the PINTEC are based on the Oslo Manual (1997).[2] In specific terms, the undertaking was guided by the model proposed by EUROSTAT for the third Community Innovation Survey.

The EICT was formulated by the Argentine National Statistics and Census Institute (INDEC). The sample contained 2,225 firms, of which 1,688 responded to the questionnaire. Once weighted, the sample represents 11,000 manufacturing firms. Although the theoretical reference is also the Oslo Manual, to explain the peculiarities of the process of technological innovation in Latin America, certain aspects are considered from the standpoint of the Bogotá Manual,[3] which provides a specific methodology for innovation research in Latin America.

It should be mentioned that the innovation concept used in the EICT is broader than that employed in the Brazilian survey, for the EICT also explicitly includes organizational and trade innovations.[4] Introducing these forms of

2. OECD. **Oslo manual**: proposed guidelines for collecting and interpreting technological innovation data. Paris: OECD: Statistical Office of the European Communities, 1997.

3. JARAMILLO, H.; LUGONES, G.; SALAZAR, M. **Manual de Bogotá**: normalización de indicadores de innovación tecnológica en América Latina y el Caribe. Bogotá: Red Iberoamericana de Indicadores de Ciencia y Tecnología: Organización de Estados Americanos: Programa CYTED, 2001.

innovation created no problems for this study, however, because the surveys are comparable with respect to technological product and process innovation. In addition, the EICT covers the years 1998 to 2001, a period longer than that covered by the PINTEC, which extends from 1998 to 2000. This, likewise, led to no insuperable problems since relevant variables such as expenditures on R&D and other innovation activities are available for all three years of the EICT, whereas they were collected only in the final reference year of the PINTEC.

The first phase of the project was targeted at classifying the Brazilian and Argentine firms by competitive strategy within the same theoretical and methodological framework adopted in the above mentioned study of Brazilian manufacturing firms coordinated by De Negri and Salerno (2005). However, since the data available on Argentina were different from those available on Brazil, the classification criteria presented in De Negri and Salerno (2005) could not be applied to the Argentine firms. Consequently, the starting point became the search for identical parameters that would allow for comparison of the Brazilian and Argentine manufacturing sectors. Thus, once the Argentine firms had been classified according to acceptable criteria given the data available in the EICT, these same criteria were applied to the Brazilian manufacturing firms. A series of statistical tests employing various indicators and criteria having been performed, the following classification scheme was adopted as being the most reliable:

Firms that innovate and differentiate products: firms that innovate new products for the market, export and have above average R&D expenditure/revenue ratios within their industrial sectors. The Argentine sectors serve as the reference for the ratios.

Firms specialized in standard products: firms that export but are not among those that innovate and differentiate products, nor among the non-export firms that have above average labor productivity within their sectors at the domestic level.

Firms that do not differentiate products and have lower productivity: firms included in neither of the above categories.

One of the key differences between this study and that previously done on Brazil[5] is that this classification scheme was proposed as an alternative due to the absence of the variable "premium price" in the data on the exports of the

4. According to the methodological notes accompanying the EICT (1998-2001), "organizational innovation embraces the adoption of new ways of organizing and managing an establishment or locale; changes in the organization and management of the production process; the implantation of a significantly modified organizational structure; and the adoption of new or significantly modified strategic guidelines. Trade innovation involves the introduction of means for commercializing new products; new methods for delivering existing products; or changes in packaging and/or wrapping. Having determined if any such innovations have been performed, when in the affirmative, indicate if each of the innovations implemented was new only for the firm (already known on the market); only for the local or domestic market (though not known in the country, the process already used, product sold or organizational/ trade technique in question already employed abroad); or for the world market (a product, process or technique formerly unknown in the manufacturing sector or branch).

Argentine firms. Premium price is an important variable for proving whether or not a firm differentiates its products. In the absence of this variable, the R&D expenditure/revenue ratio served as a classification criterion for placing a firm in the first group since R&D outlays are strongly correlated with the capacity of a firm to differentiate products. This consideration aside, the lead indicators used to group the firms generaly classified them according to their competitive strategies.

To summarize, in the first category are firms that innovate and differentiate their products. They are therefore more competitive and operate closer to current international standards. In the second group are firms specialized in standard products. Although competitive, their market insertion strategies rely on less differentiated, lower value added goods. In the third and final category are firms that have efficiency and/or productivity problems and do not differentiate their products.

THE CHARACTERISTICS OF TECHNOLOGICAL INNOVATION IN BRAZIL AND ARGENTINA

The industrialization processes witnessed in Brazil and Argentina have many features in common. At the beginning of the twentieth century, both countries were strongly engaged in agricultural production and exports. Soon thereafter, the growth of the domestic market, coupled with the revenues derived from coffee exports in Brazil and beef and grain exports in Argentina, generated the surpluses that provided the springboard for the industrialization of the two countries. As of the 1930s, the open agro-export model gave way to a new production and growth regime that came to be known as "import substitution industrialization" (ISI). In both countries, ISI was responsible for consolidating the industrial production of the mining, basic metals and mechanical sectors. Then, in the 1950s, the arrival of major foreign investments contributed to strengthening the production of durable consumer goods.

Certain problems linked to economic growth via ISI became evident in the latter half of the 1970s and the 1980s. Of these, the main problems were related to the balance of payments and the rising macroeconomic instability. Thus, during this period, the industrialization process was interrupted and many of the resources on which the innovative capacities of nations depend, such as knowledge, engineering capacity, human resources and the entrepreneurial base were no longer accumulated. In both Brazil and Argentina, the late 1980s and 1990s were periods of far-reaching transformation fostered by macroeconomic stabilization programs that altered the terms of trade of the economy through changes in foreign exchange policy, opening up of the economy and a shift in the role of the State.

5. See De Negri and Salerno (2005).

In the first chapter of this book, Wilson Suzigan, João Alberto De Negri and Alexandre Messa[6] argue that, in the case of Brazil, there is evidence that the restructuring of industrial production, driven by the new economic environment that has prevailed since the 1990s, has been marked by features that set the country apart from the traditional view that, at the international level, developing countries specialize in labor and natural resources. This is so because, despite Brazil recognizably having abundant labor and natural resources, a significant group of firms, which generates 25% of industrial revenue, is inserted in the international market via medium- and high-tech goods. In this case, the new economic environment appears to have led to a new entrepreneurial stance, one linked to competition through product innovation and differentiation.

In the second chapter, Bernardo Kosacoff and Adrián Ramos[7] analyze the microeconomic adjustment of Argentine enterprises in recent decades. These authors contend that the high uncertainty and real volatility of the economy have been very costly not only in social terms but also in terms of business decisions related to investment and technological progress. In order to comprehend the recent industrial performance of Argentina, it is necessary to understand instability and uncertainty because they affect the decision-making processes of economic agents. From the microeconomic standpoint, such environments encourage firms to adopt defensive strategies that negatively affect the "animal spirit" and the long-run growth of the economy. Under these conditions, the prevailing attitude is one of reluctance to invest in physical capital, human capital and intangible assets. In this way, the macroeconomic environment induces behavior that leads to low growth.

These Brazilian and Argentine researchers, who use historical analysis to trace the behavior of firms, are unanimous in affirming that the recent microeconomic behavior of the firms in the two countries is yet to be adequately understood. It is within this context that the justification for this book lies, for the studies contained herein seek to describe the behavior of Brazilian and Argentine firms from the standpoint of their technological innovation efforts, the challenges they face once they choose to innovate and their actual performance.

In Brazil, there were approximately 72,000 manufacturing firms with 10 employees or more in 2000, while in Argentina there were roughly 11,000 such firms in 2001. As Table 1 shows, about 971 Brazilian firms and 413 Argentine firms were in the category of those that innovate and differentiate products. Whereas the average revenue of the Brazilian firms in this category was US$ 80.6 million, that of their Argentine counterparts was US$ 26.78 million. Likewise, the total industrial revenue of Brazil was approximately four times greater than

6. See Chapter 1 of this book.

7. See Chapter 2.

that of Argentina. As to the share in overall revenues by type of firm, those that innovated and differentiated products accounted for 23.2% of the total in Brazil and 12.9% of the total in Argentina.

TABLE 1
Number and production scale of Brazilian (2000) and Argentine (2001) manufacturing firms

Category	Brazil			Argentina		
	Number of firms	Average revenue (US$ million per year)	Average number of employees per year	Number of firms	Average revenue (US$ million per year)	Average number of employees per year
Firms that innovate and differentiate products	971	80.61	679	413	26.78	181
Firms specialized in standard products	13,322	16.39	165	4,644	13.85	95
Firms that do not differentiate products and have lower productivity	55,998	0.72	36	5,661	1.35	40

The production scale indicator deserves special attention because the scale of production of manufacturing firms is important to their performance and therefore to the relative competitivity of countries. In the presence of increasing returns to scale, the larger the enterprise, the higher its productivity. At the same time, scale of production is known to be a determining factor in the capacity of a firm to invest in technological innovation and differentiation activities, and especially in R&D.

Not only were the scales of production larger in Brazil than in Argentina: there were also a greater number of firms in all categories. It is striking, however, that in Brazil there were roughly 56,000 firms, or ten times more than in Argentina, in the lower productivity category. This disparity may be explained by those in Argentina having been excluded from the market during the macroeconomic crisis of the late 1990s.

In the year 2000, Brazilian firms invested about US$ 2 billion in R&D. In 2001, Argentine enterprises invested about US$ 186 million in R&D. Table 2 presents various technological innovation indicators for manufacturing firms in the two countries.

TABLE 2
Technological innovation indicators for Brazilian (2000) and Argentine (2001) manufacturing firms

Category	Brazil			Argentina		
	Average number of R&D workers	Average R&D expenditures (US$ thousand)	Average R&D expenditure/ revenue (%)	Average number of R&D workers	Average R&D expenditures (US$ thousand)	Average R&D expenditure/ revenue (%)
Firms that innovate and differentiate products	23.8	1,174.1	3.99	6.03	274.83	1.54
Firms specialized in standard products	1.92	56.2	0.54	1.62	11.15	0.14
Firms that do not differentiate products and have lower productivity	0.30	2.7	0.53	0.53	2.13	0.17

Note: $\overline{X} = \frac{\sum_{1}^{N} \frac{P\,\&\,D}{Y}}{N}$ where R&D = research and development expenditures, Y = revenue and N = number of firms.

Whereas there were approximately 67,000 workers engaged in R&D in Brazil in 2000, the corresponding number was 14,000 in Argentina in 2001. Among the group of firms that innovate and differentiate products, the average number of R&D workers was 23.8 in Brazil and 6.03 in Argentina.

In Brazil, these same firms invested an average US$ 1.17 million in 2000, compared to the average US$ 274,000 invested by their Argentine counterparts in 2001. Among the firms specialized in standard products, the average R&D investment in Brazil was on the scale of US$ 56,200, while in Argentina the average investment of this group was in the range of US$ 11,150 per year. Thus, the technological innovation efforts of the two countries, as measured by their R&D expenditure/revenue ratios, are still relatively low. Even so, for the class of firms that innovate and differentiate their products, the share of revenue spent on R&D stands at 3.99% in Brazil and 1.54% in Argentina.

The principal characteristics of the innovation processes of Brazilian and Argentine firms are analyzed by Fernando Peirano,[8] who shows that the R&D expenditure/turnover ratios of the two countries are still very low when compared to those of the European nations. Despite R&D expenditures being higher in Brazil than in Argentina, the technological innovation efforts of both countries are mainly driven by the purchase of capital goods. As to R&D expenditures by

8. See Chapter 3.

manufacturing sector, eight concentrate 78% of the amounts spent in Brazil: chemicals and pharmaceuticals (15%), the automotive sector (13%), electronics and communications (12%), fuel (11%), machinery and equipment (7%), electric materials and apparatus (7%), aircraft and ships (6%) and food products (6%). In Argentina, four sectors concentrate 76% of the R&D expenditures: chemicals and pharmaceuticals (54%), food products (9%), plastics products (7%) and the automotive sector (6%). Whereas there are 1,375 industrial R&D laboratories in Argentina, or one for each 10 manufacturing firms, in Brazil there are 3,146 laboratories, or one per 20 firms.

Victor Prochnik and Rogério Dias de Araújo[9] underline that the scale of production is especially detrimental to the innovative performance of firms that do not differentiate their products and exhibit lower productivity, whether in Argentina or Brazil. According to these authors, since the innovation efforts of these firms are significantly affected by macroeconomic variables, the high interest rates in Brazil and the macroeconomic instability and crisis of the late 1990s in Argentina negatively impacted the technological innovation indicators for this segment. In both countries, the purchase of machinery and equipment (either acquired on the domestic market or imported from abroad) constitutes the prime innovation mechanism for the non-differentiating, lower productivity enterprises. Moreover, the credit restrictions faced by these firms thwart their innovation efforts.

Gustavo Lugones and Diana Suárez[10] analyze the national innovation systems in Argentina and Brazil. In their view, the priority in Argentina should be to increase R&D expenditures per researcher, while the priority in Brazil should be to increase the proportion of researchers in the overall labor force. They further contend that both countries need to spend more on Science and Technology (S&T) and suggest that two areas of research be reinforced: natural resources/exact sciences and engineering/technology. The failure to encourage professional training in these key disciplines for technological development has dampened academic interest in these areas in Brazil and created a shortage of workers in Argentina, both of which are detrimental to the innovation efforts of the region.

Eduardo Baumgratz Viotti and Adriano Ricardo Baessa[11] compare Brazil and Argentina to European countries on the basis of selected technological innovation indicators. In turn, Eduardo Gonçalves, Mauro Borges Lemos and João Alberto De Negri[12] estimate econometric models for the determinants of innovation on the part of manufacturing firms in Brazil and Argentina. All find evidence that, with regard to technological innovation, extramural R&D is four times more

9. See Chapter 4.

10. See Chapter 5.

11. See Chapter 7.

12. See Chapter 6.

important than intramural R&D. Complementing this conclusion are findings that point to the marked relevance of the external acquisition of technology through licensing and the purchase of knowledge, patents, trademarks and consulting services, plus the signing of technology transfer agreements. In addition, market concentration is important to explaining the decision of Brazilian firms to innovate, while market position and firm size are innovation determinants in both Brazil and Argentina.

These authors also find that, on the one hand, the transnational corporations (TNCs) are more inclined to innovate in Brazil than in Argentina, though this does not necessarily imply that they perform R&D in the country. On the other, the Argentine subsidiaries of TNCs are statistically insignificant with respect to the probability of a firm deciding to innovate. This evidence supports that presented in earlier studies which stress that the foreign subsidiaries located in Argentina generate minimal technological externalities because of the limited scale of their innovative activities and their lack of technological ties with local suppliers and research institutes.

The behavior of the transnational corporations in Brazil and Argentina is also analyzed in the chapter written by Adrián Ramos and Guillermo Anlló, [13] as well as in that by Rogério Dias de Araújo.[14] Ramos and Anlló argue that the TNCs concentrate their R&D activities in their home countries and only perform such activities in Brazil and Argentina to adapt products already developed for other markets (mainly the home market of the corporation) to the regional market. Rogério Dias compares the R&D efforts of domestic and foreign firms in Brazil and Argentina. Differences are seen to exist in both cases. In Brazil, the probability of a foreign firm investing in R&D is lower than that of a domestic firm, with the R&D expenditure/revenue ratio for the TNCs standing 62% below that for domestic firms with similar characteristics. In Argentina, while there are no statistical differences between the R&D expenditure levels of domestic and foreign firms, the probability of the former investing in R&D is greater than that of the latter.

Do the technological efforts of Brazilian and Argentine firms have an impact on the exports of these countries? Both Brazil and Argentina have natural resources in abundance when compared to other nations, a fact that renders them competitive in natural-resource-based exports such as agricultural and mineral products. Hence, if the innovation efforts of these countries were to have a positive influence on their exports, stronger technological efforts could well lead to the exportation of higher value added goods. Two of the chapters in this book are therefore addressed to answering the above question.

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13. See Chapter 11.

14. See Chapter 12.

João Alberto De Negri, Fernanda De Negri and Fernando Freitas[15] demonstrate that R&D expenditure/revenue ratios have a stronger impact on Brazilian than on Argentine exports. Nonetheless, increased R&D expenditures have positive effects on the export coefficients of firms in both countries. The econometric models estimated by these authors illustrate that the point of inflection on the curve relating the R&D expenditure/revenue ratio to the export coefficient of firms is higher for Brazil than for Argentina. This suggests that there is a closer correlation between R&D expenditures and exports among Brazilian than among Argentine firms.

On studying the Argentine industrial sector, Daniel Chudnovsky, Andrés López and Eugenia Orlicki[16] encountered similar results. In the view of these authors, the export activities of firms are driven mainly by process innovations aimed at lowering costs and improving the quality of the goods produced.

Bruno César Pino Oliveira de Araújo[17] also analyzed export firms in Argentina and Brazil. The findings of his study are presented in Table 3. This writer shows that the export coefficient of the Argentine firms is higher than that of the Brazilian firms. Especially relevant in this study is the identification of potential export firms in the two countries. On the basis of econometric models, firms that do not yet export but have characteristics similar to those that do export are identified. In this way, a policy target is delineated for broadening the export bases of the two countries. In Brazil, 4,443 potential export firms are identified. In Argentina, the corresponding number is 1,783 firms.

TABLE 3
Number and export coefficients of Brazilian (2000) and Argentine (2001) manufacturing firms

	Argentina	Brazil
Total number of manufacturing firms	10,000	72,000
Total number of export firms	3,340	7,299
Export coefficient for export firms (%)	23.20	15.77
Potential export firms	1,783	4,443

As to the similarities and differences between the industrial sectors of Brazil and Argentina, it should be emphasized that the manufacturing firms in the two countries face the same challenges with regard to technological innovation and product differentiation: a lack of adequate financing for innovative activities in general and especially for R&D; the high risk of innovative activity; and the cost of innovation. Approximately 90% of the investments in research and development by Brazilian and Argentine manufacturing firms are self-financed, that is, made without the

15. See Chapter 10.

16. See Chapter 9.

17. See Chapter 8.

support of public funds through financing or any other means. At the same time, the findings presented in this study show that the foreign firms installed in the region make weaker innovation efforts than the domestic firms, as revealed by their lower R&D expenditure/revenue ratios. The further integration of the two economies may therefore rest on the joint efforts of Brazil and Argentina to obtain adequate financing for technological innovation, to stimulate intra-industry trade, to encourage additional cross investment between the two economies and to attract foreign investment with a view to the technological development of the region.

CHAPTER 1

STRUCTURAL CHANGE AND MICROECONOMIC BEHAVIOR IN BRAZILIAN INDUSTRY

Wilson Suzigan
João Alberto De Negri
Alexandre Messa Silva

1 INTRODUCTION

The Brazilian industrialization process transformed a typical primary goods export economy into an economy with an ample productive structure. Even in the presence of protectionist measures, credit and tax subsidies, and lags in the rates of the public services and prices of the basic inputs produced by public companies, a diversified industrial base was formed in the country over the mere half-century extending from 1930 to 1980. These accomplishments were not far different from those observed in other countries that industrialized in the following decades. What did differentiate these countries was the competitive direction taken by each. While in some cases the goal of economic planning was to integrate the economy into dynamic foreign markets, this was not the key priority of the various industrial development policies implemented in Brazil.

Between the 1930s and the 1950s, ultimately protectionist economic policies stimulated "import substitution industrialization" (ISI), which gave rise to the industrialization process. Later this process would be driven by increased demand in the domestic market and by the diversification of the industrial structure that resulted from economic planning, such as the Target Plan (*Plano de Metas*) of the late 1950s, the sector policies of the late 1960s and mid-1970s and the 2nd National Development Plan (*II Plano Nacional de Desenvolvimento – II PND*) of the late 1970s. As a result, the country reached the end of the 1970s with a well-integrated and diversified industrial structure, but overprotected, low in productivity levels, significantly behind in technology and with an unimpressive degree of insertion in the international market.

From the 1970s to the 1980s, the transition of the Brazilian industrial sector offered an historic opportunity for the sector to correct its course by reducing protectionism, incorporating activities representative of the then emerging information and communication technologies, as well as seeking international integration into dynamic markets. This is not what happened, however. Due to the macroeconomic crisis and resulting instability, the industrial sector stagnated throughout the 1980s, thus interrupting the industrialization process. Within ten years, the Brazilian industry was even farther behind technologically and ill-equipped for innovative activities. The opening up of the economy, and especially the liberalization of trade in the early 1990s, therefore posed a serious challenge: to face international competitors in both domestic and foreign markets.

Unprepared and immersed in an adverse macroeconomic scenario, the only possible response was for industry to ration its productive processes so as to decrease costs and increase efficiency. The 1990s therefore came to be marked by frequent fluctuations in industrial product paralleled by consistent drops in employment within the manufacturing sectors. The positive result was precisely what was expected from the opening up of the economy – a productivity shock to the Brazilian industrial base. These efforts to cut back on the resources necessary to maintaining the same levels of return inevitably led a high percentage of Brazilian companies into markets where competition was mainly determined by price rather than by product differentiation. Nonetheless, it is precisely in these markets that technological innovation gives companies relatively more market power, even if only temporarily, thereby allowing for higher returns on capital invested and greater protection for employees compared to the recurring price fluctuations associated with standardized products. In other words, if technological innovation is granted a key role in economic development strategies, productivity and industrial employment gains arise from the insertion of companies into these markets. This, in turn, can only happen if domestic companies intensify their innovative efforts by investing in activities such as research and development.

Bearing this in mind, this paper argues that the restructuring of Brazilian industry since the liberalization of trade has been characterized by unique features that set it apart from the conventional hypothesis regarding the specialization of developing economies in labor and natural resource industries. This uniqueness rests on the fact that, though Brazil is a country recognizedly competitive in standard agricultural and industrial goods, there is a significant group of Brazilian companies – responsible for about one-fourth of industrial sales – integrated into world markets primarily through medium to high-tech goods. Therefore, instead of generating regressive specialization, the new competitive environment has led to a new entrepreneurial outlook as to the potential of the country within the world economy, an outlook that is strongly associated with competition through innovation and product differentiation. Part of today's business community is distancing itself from the recurrent passivity and traditional dependency on government initiatives and starting to consolidate itself as a segment that is willing to better equip itself to face international competition, especially by adopting best practices associated with technological innovation, thus typifying a new stance in terms of company strategies.

In addition to the introduction, this article is divided into five parts. The next part summarizes the industrial development process experienced by Brazil between

1930 and 1980. The aim is to demonstrate that this process, based on protectionism, direct investment by the State and tax and credit incentives for private capital, was responsible for creating a business perspective that was lethargic and passive in comparison to the major international trends. The third part analyses some of the conditions that determined the change in the competitive environment beginning in the 1990s, notably the opening of trade and reform of the State system. The fourth part considers the repercussions of this new scenario on Brazilian industrial performance by way of background to the presentation of evidence, in part five, that this performance is based on a new entrepreneurial stance – one that strongly conflicts with the conventional argument that developing countries are competitively inserted in world markets through labor-intensive and natural resource industries. Finally, the conclusions are presented.

2 BRAZILIAN INDUSTRIAL DEVELOPMENT IN HISTORICAL PERSPECTIVE

Prior to the 1930s, economic policies were not systematically concerned with promoting industrial development. Although there were some initiatives to protect domestic industrial activities and foster certain industries, they were sparse and inconsistent. It was only after the 1930s that, as a result of the Great Depression and the crisis in the agricultural export sector, that clearer action was taken in favor of industrial development, albeit the underlying intention of certain measures was to defend agricultural exports.

With the foreign exchange crisis resulting from the Great Depression came exchange rate devaluation policies, foreign exchange market control, and import quantity control, all with the dual intention of defending exports while maintaining their income levels and rebalancing the Brazilian foreign accounts. The indirect consequence of such measures was increased protection of the domestic manufacturing industries, which came to meet demands previously covered by imports. This spurred the growth of industrial production for the domestic market and opened the way for industry to lead the economic growth of the country through import substitution – notably the substitution of consumer goods and some lower-tech intermediary goods.

Subsequently, from the 1930s to the mid-1950s, the State deliberately intervened in favor of industrialization by financing private investment or directly investing in the development of given primary industries (steel, mining, alkali, petrochemicals) and infrastructure (energy and transportation). However deliberate, this State action in favor of industrialization did not follow a precisely defined industrial development strategy. This would occur only in the mid-1950s.

Due to the persistence of external crises and subsequent changes in trade policy, this protection of domestic industry increased considerably until immediately after the war. Foreign exchange policies[1] continued to be the main protective instruments, initially via devaluations until the end of the 1930s, and thereafter through the introduction of exchange-rate controls that established a scale of priorities for imports. After the war, the exchange rate was held fixed (overvalued), while the controls were intensified and broadened through the discretionary administration of import policies.

The need for financing policies regarding industrial investment became increasingly evident as import substitution investments grew. The private financial system (trade banks) lacked instruments for obtaining the resources that would allow it to guarantee medium and long-term loans for industrial investments. This task was therefore taken on by the State through the Bank of Brazil's Agricultural and Industrial Credit Portfolio (*Carteira de Crédito Agrícola e Industrial – CREAI*), created in 1937.

Although a strategy for coordinating the State's industrialization efforts was never implanted, several attempts were made to formulate economic development plans during these years. This demonstrated that those responsible for economic policies (and for the emerging industrial class) were concerned with the need to promote industrialization as an alternative for social and economic development. In this sense, the Joint Brazil-United States Economic Development Commission, created in the late 1950s to prepare a broad diagnosis of the economic situation of the country, stands out. The Commission identified "strangulation points" that needed to be eliminated in order to render economic development feasible. To do so, forty-one projects were conducted in the areas of transportation, energy, agriculture and industry. Although industry was considered in only two of the projects (representing 2.8% of the investment foreseen), it is important to note that the idea of creating a development bank arose from the Joint Commission's studies on financing the administration of these projects. The outcome was the National Economic Development Bank (*Banco Nacional de Desenvolvimento Econômico e Social – BNDES*), founded in 1952. It is widely recognized that the role of BNDES was fundamental in the subsequent phases of the industrialization process and economic development of the country in that it financed private and public investments that diversified the industrial structure and broadened the economic and social infrastructure.

Simultaneously, the direct investment of the State in primary industries and in electricity generation greatly enhanced the industrial development of the period. The State's main accomplishments included:[2] creating the Vale do Rio Doce Company in the mining sector in 1942; founding the National Steel Company

1. The other historically important instrument – customs tariffs – had lost its effectiveness due to a lag in nominal rates in relation to import prices in domestic currency. Its role was only restored after the customs tariff reform that accompanied the creation of the Customs Policy Council (*Conselho de Política Aduaneira*) in 1957.
2. See Suzigan (1976) and Malan et al. (1977, p. 369-370).

in 1941, complemented by the Bank of Brazil acquiring majority control of the Itabira Special Steel Company (ACESITA) in 1952 in the iron and steel sector; creating the National Alcalis Company in 1943 in the chemical commodities industry; creating the National Motor Factory in 1943 for producing heavy motors; and founding the São Francisco Hydroelectric Company in 1945 for generating and distributing electric energy.

The first industrial development plans with defined broad-spectrum goals and strategies for developing specific industries appeared in the mid-1950s. The most significant were the Target Plan in 1956-60 and the II PND in 1975-79.

The Target Plan marked the beginning of a period in which the Brazilian government would come to promote industrial development in an active and organized fashion. The starting point was the set of "strangulation points" identified by the Joint Brazil-United States Commission in the areas of transportation, energy, agriculture and industry. With BNDES in operation, the government initially began directing funds towards investments in infrastructure, but soon after the bank began financing investments in primary industries as well. Likewise, measures similar to those taken in the first half of the decade contributed to boosting industrial development throughout the remainder of the 1950s. Of special note are: the creation of PETROBRAS in 1953, leading to the rapid expansion of petroleum prospecting, production and refining activities; Instruction 70 (1953) of the Currency and Credit Superintendency (SUMOC),[3] which established a system of foreign exchange auctions with five import categories, thus favoring industrial machinery and equipment imports; and Instruction 113 (1955) of SUMOC, which allowed the subsidiaries of foreign corporations established in Brazil to import machinery and equipment without foreign exchange coverage. Those most benefited by the latter measure were the automotive, chemical, and capital goods industries.

However, it was only after 1956-57, following the implementation of the Target Plan, that a deliberate and coordinated industrial development policy could be identified. It consisted of a general economic development strategy that linked the role of the State and that of private capital (both domestic and foreign) by setting goals for investment in infrastructure and in the development of specific industries. For this purpose, Executive Groups comprised of government technicians and entrepreneurs were created with the power to manage incentives (financing, tax exemptions and the granting of land and improvements), tax exemptions and financing and to regulate investment in the respective industries.

One of the main instruments of this strategy was a system that substantially increased the protection offered industry in the domestic market. The principal

3. Founded by the Central Bank of Brazil.

features of this system were: a new customs tariff, *ad valorem* for the first time and strongly protectionist (1957 Tariff); a new foreign exchange policy having two import categories (general and special), which subsidized machinery, equipment and primary industries, as well as recording the importation of "less essential" goods; and the imposition of non-tariff barriers on imports, notably by applying the so-called Law of Similar Domestic Production (*Lei do Similar Nacional*) administered by the Customs Policy Council (*Conselho de Política Aduaneira*).

BNDES financing for industrial investment initially focused on primary industries, especially steel. However, by the late 1950s and early 1960s, the bank was financing private domestic investment in nearly all branches of the manufacturing industry.

Moreover, the direct participation of the State in the economy increased significantly through investment in primary industries (steel, mining and petrochemicals) and infrastructure. At this time, the State also launched its first initiatives to create institutions to coordinate research and bring together resources for higher education, these being CNPq (the National Council for Scientific and Technological Development) and CAPES (the Coordination Agency for the Improvement of Higher Education).

As a result, the structure of Brazilian industry evolved and diversified, coming to embrace heavy industry, durable consumer goods industries and capital goods industries, thus allowing for import substitution. The economic infrastructure became better equipped for industrial development and an institutional system for scientific development began to form. It was thanks to these advances that the growth of industrial production accelerated during the initial phase of the expansion cycle that extended from 1968 to 1973-74. Before this, however, the industrialization process experienced a strong setback.

In 1963, Brazilian industry entered a recession that lasted until 1967. The recession was essentially brought on by a cyclical component – a drop in the growth rate of gross fixed capital formation, which was related to the "conclusion of the voluminous public and private investment packages initiated in 1956-57" (SERRA, 1982, p. 80). However, there were also other components involved, mainly related to the management of economic policy, among which the following should be mentioned: 1) the new law to control profit remittances approved by Congress in 1961, which possibly contributed to reducing foreign direct investment (FDI). It should be noted that foreign capital had substantially participated in the aforementioned investment package, but its growth "had already been showing a declining tendency since the end of the fifties" (SERRA, 1982, p. 82); 2) alterations in the foreign exchange policy, also in 1961, which considerably reduced the subsidies to capital goods imports implicit in the "general category" of the multiple exchange rate system; 3) credit reductions and restrictions on public expenditures, including investments, as part of the anti-inflationary policies of the Three-year Plan (*Plano Trienal*) adopted in 1963 and; 4) the macroeconomic stabilization policy of 1965-67, which aggravated the cyclical trend and prolonged the recession.

During the crisis, and in the midst of reforms promoted by the authoritarian regime established in 1964, the economic policy institutions were extensively reorganized. From the standpoint of industrialization, the most relevant measures were: 1) the creation of the Industrial Development Commission, later denominated Council, (*Comissão de Desenvolvimento Industrial – CDI*) in 1964. The CDI incorporated the former executive groups and was responsible for administering industrial incentives and formulating the country's industrial policies. The main incentive administered by the CDI was an import tax exemption (and, by extension, other tax exemptions) on capital goods destined for industrial projects approved by the entity; 2) the strengthening of the Bank of Brazil Foreign Trade Department (*Carteira de Comércio. Exterior – CACEX*) as the entity responsible for import administration once the Customs Policy Council (*Conselho de Política Aduaneira - CPA*) transferred the implementation of the Law of Similar Domestic Production (*Lei do Similar Nacional*) to CACEX in October 1967. It is important to remember that the foreign exchange system had been unified in March 1967 and that customs tariffs in general had been reduced in the same year (BERGSMAN, 1970, p. 34-35; SUZIGAN, 1975, p. 460-461). This would later accentuate the importance of the Law of Similar Domestic Production and other discretionary tools (non-tariff barriers) managed by CACEX for the purpose of controlling imports; 3) the diversification of the private financial system via the indexation of financial assets, long-term deposits and savings accounts (thus giving rise to non-bank financial intermediaries specialized in supplying mid-term credit, including direct consumer credit), as well as of the Housing Finance System (*Sistema Financeiro da Habitação*); 4) the growing diversification of the types of investments made by BNDES and other official banks in funding industrial investments that encompassed a greater number of industrial sectors and different size companies (including small and medium-sized firms) in the manufacturing industries.

This institutional reorganization facilitated the renewed growth of industrial investment and production and led to accelerated economic growth as of 1968. In fact, once the recession had ended and the institutional reforms of 1964-67 were in place, the Brazilian industrial sector experienced its most rapid growth cycle and period of structural change. Despite the liberalizing rhetoric of the authoritarian regime, the State played an active role in expanding the domestic market and promoting manufactured goods exports, both of which were complemented by favorable world conditions in terms of dynamic international trade and foreign investment flows.

In the first phase of the cycle, the growth of industrial production was based on the idle capacity inherited from investments made while the Target Plan was in effect. Minimum scales and other indivisibilities had overexpanded investments in sectors such as the automotive industry, and the excess capacity had been accentuated by the 1963-67 recession. However, once these margins of idle capacity had been absorbed, investments were resumed with even greater vigor beginning in 1970.

The State strongly subsidized the formation of industrial capital during this new investment cycle. The main instruments were: 1) exemptions or reductions in customs tariffs and other taxes such as the federal VAT (*Imposto sobre Produtos Industrializados – IPI*) and merchandise sales tax (*Imposto sobre Comércio de Mercadorias – ICM*) levied on machinery and equipment imports destined for industrial projects approved by either the CDI or by sector and regional development agencies. After 1971, the IPI and ICM exemptions were extended to machinery and equipment purchased on the domestic market so as to eliminate discrimination against the domestic production of capital goods; 2) implicit subsidies in the long-term financing for industrial investment granted by BNDES. This financing was indexed at pre-established limits significantly below the inflation rates observed throughout the 1970s; and 3) tax incentives administered by regional development agencies for industrial investments in less developed regions.

In the period 1968 to 1973-74, the broadening market for manufactured products was the result of increased domestic demand coupled with export growth and diversification. The growth in domestic demand had three main sources: expansionist macroeconomic policies, a boom in housing construction and the recovery of consumer levels. With respect to the first source, the major component was a broad public investment program in social and economic infrastructure (energy, transportation, communications, urbanization and basic sanitation), as well as direct investment by public companies in primary industries – mainly petroleum exploration and mining, steel, chemicals, petrochemicals and fertilizers – and the weapons and aircraft industries. These investments were largely financed by foreign resources given the facilities available at the time for obtaining currency loans and import financing on the international financial market, even after the international crisis of the mid-1970s. In contrast, private domestic companies were financed by funds subsidized by BNDES and regional and state development banks, as well as being benefited by tax incentives administered by public agencies in various government spheres.

The domestic demand for manufactured goods was also driven by the financing facilities for real estate construction that contributed to the urban housing boom. This began amidst the institutional reforms of the mid-1960s with the creation of the Housing Finance System (*Sistema Financeiro da Habitação – SFH*), comprised of a "central bank" (*Banco Nacional de Habitação – BNH*) and of specialized institutions and instruments for granting medium and long-term loans and attracting funds within the financial system, such as real estate notes and savings accounts.

Favorable conditions were also created for consumer growth, which had been repressed during the long recession of 1963-67. Consumer demand grew not only as a result of higher employment rates and increased payrolls, but also due to financing facilities aimed at developing a segment specialized in direct consumer credit within the private financial system. With this, the production of durable goods – particularly automobiles and household appliances – expanded rapidly, leading the growth of industrial production at the peak of the expansion cycle (1968-1973).

In turn, two groups of measures stimulated the exportation of manufactured products: 1) a substantial devaluation of the exchange rate in August 1968, followed by mini-devaluation of the exchange rate in step with the inflation rate and 2) the creation of new fiscal and financial subsidies and incentives for exportation, for the formation of trading companies and for the production of goods specifically for export. The latter were offered through the Commission for Granting Fiscal Benefits to Special Export Programs (*Comissão para Concessão de Benefícios Fiscais a Programas Especiais de Exportacao – BEFIEX*), created in 1972. It should not be forgotten, however, that the expansion of Brazilian manufactured exports was also facilitated by the dynamism of world trade, which lasted until an international crisis took hold in middle of the decade.

Following the petroleum shock and raw material price increases on the international market (1973-74), the State began to intervene even more in industrial development. Although macroeconomic policies had continued to be moderately expansionist – at the cost of greater foreign debt – the rate of industrial production and level of consumption dropped in the latter half of the 1970s. Due to the trade deficit, the incentives and subsidies to manufactured exports were not only maintained but expanded, while non-tariff barriers to imports were raised. However, industrial investments remained high because the State adopted measures similar to those of the 1950s.

By implementing the II PND in 1975-79, the State initiated a new phase of public and private investment in the primary and capital goods industries, in addition to public investment in infrastructure. The goals were to reform the industrial structure so as to match the standards observed in the industrialized countries, and to facilitate the exportation of basic inputs in which the country enjoyed comparative advantages. Despite certain financing difficulties – especially on the private investment side – that kept the program from wholly achieving its goals, there is no doubt that the investments made under the II PND represented "an unprecedented effort in the history of Brazilian industrialization to accumulate capital and to diversify the industrial structure toward heavy industry" (TAVARES; LESSA, 1984, p. 6).

At the same time, the State sought to move forward by establishing a National System for Scientific and Technological Development (*Sistema Nacional de Desenvolvimento Científico e Tecnológico – SNDCT*). Two institutions were created in the 1960s: the BNDES National Technological Development Fund (*Fundo Nacional de Desenvolvimento Tecnol̃ogico – FUNTEC*) and an agency for promoting technological development (*Financiadora de Estudos e Pesquisa – FINEP*), which managed the National Fund for Scientific and Technological Development (*Fundo Nacional de Desenvolvimento Científico e Tecnológico – FNDCT*). For many years, FNDCT was the most important instrument in the country for financing scientific and technological activities. Later, research and post-graduate programs were established at universities and various research institutions were created, such as technological institutes, research and development centers in public companies, specialized laboratories and other entities, including for agricultural research (*Empresa Brasileira de Pesquisa Agropecuária – EMBRAPA*). The success of products on the international market is often due to prior efforts at these institutions. The general direction of these initiatives in science and technology was established in the Basic Plans for Scientific and Technological Development (*Planos Básicos de Desenvolvimento Científico e Tecnológico*) designed together with the National Development Plans (PNDs).

Thus, by the end of the 1970s, the country had succeeded in building a well-integrated and diversified industrial structure and was beginning to develop a corresponding institutional structure to support scientific and technological endeavors. The State strongly supported these structures, whether through protection policies (customs tariffs, non-tariff barriers, exchange rate policies and the regulation of private investment), promotion policies (tax incentives and subsidized credit), action plans or direct investments.

Although effective at the time, these State operations had after effects. While striving for a "complete industrial structure," or ideal and permanent scheme for protecting and promoting industrial activities, they ultimately generated a series of inefficiencies that hindered specialization and limited insertion into the international market. As a result, the Brazilian economy became extremely closed, resulting in one of the lowest import coefficients in the world and causing many industries to lose competitiveness in both domestic and foreign markets.

3 MACROECONOMIC CRISIS, INDUSTRIAL STAGNATION, REDEFINING THE ROLE OF THE STATE AND THE OPENING UP THE ECONOMY

The transition from the 1970s to the 1980s was historically decisive in the development of Brazilian industry. The time had come to leave the normative model aside and shift the focus of industrial development policies by reducing the protective measures and subsidies aimed at structuring manufacturing sectors and establishing qualitative goals focused on innovation, technological development, and productivity. Such a change had been considered when an attempt was made to reform foreign trade and tax incentive policies at the end of 1979. The first policy measure for stimulating the new information technology industries was the creation of the Special Department for Information Technology (*Secretaria Especial de Informática*), which would later give rise to the Information Technology Law (*Lei da Informática*), enacted in October 1984. However, this process of change was halted by the change in economic command at the end of 1979 and by the macroeconomic crisis initiated in 1980-81.

From 1981 on, therefore, instead of advance there was a setback in the industrial development process: the industrial and institutional structures regressed, the economic infrastructure deteriorated, and the nascent National System for Scientific and Technological Development (*Sistema Nacional de Desenvolvimento Científico e Tecnológico - SNDCT*) was abandoned. Development and State intervention in the fields of political and economic policy lost ground to the dominant goals linked to macroeconomic stability. As of then, stabilization targets, followed by monetary policies and exchange rate policies, took priority over industry and the productive sector as a whole, making it unfeasible to guarantee the continuity of industrial development. Several attempts to implement industrial policies were either completely thwarted or only partially realized.[4]

All types of coordination were abandoned. Economic, scientific and technological development plans were interrupted, targets were abandoned and sector programs were deactivated. The policy instruments that had once served industrialization were now placed at the service of macroeconomic stabilization. By the end of the 1980s, non-tariff restrictions limited access to imports even more, exports were subsidized, public infrastructure investments were reduced, public budgets for industrial financing and for the SNDCT (National System for Scientific and Technological Development) were drastically cut and incentives to development were reduced, while public prices and tariffs were subjected to tighter control. Timid signs of change appeared in 1988-89 in the form of a customs tariff reform, which proved innocuous because protection continued to be provided by non-tariff restrictions, and in the form of the incentives to investment and technological development offered by the New Industrial Policy (*Nova Política Industrial – NPI*) of 1988. However, the failure of the inflation stabilization policy buried any hope of resuming the path of industrial development.

4. In late 1984 and early 1985, after the election of the New Republic government; in 1988 during the Sarney administration – New Industrial Policy (*Nova Política Industrial - NPI*); at the beginning of the Collor administration – Industrial Policy and Foreign Trade (*Política Industrial e de Comércio Exterior – PICE*); and at the beginning of Fernando Henrique Cardoso's first term.

By contrast, the 1990s were years of significant transformation. At the beginning of the decade, industrial development momentarily returned to the economic policy agenda; on the whole, however, the attempt to implement an industrial policy within the Collor Plan failed. The only component of the Industrial and Foreign Trade Policy (*Política Industrial e de Comércio Exterior – PICE*) effectively implemented was the liberalization of foreign trade. The multilateral trade agreements signed within the sphere of the World Trade Organization (WTO), coupled with the subsequent overvaluation of the *real*, planted the foundations for the opening of trade in the country. At the same time, a greater openness to foreign direct investment arose and the State renounced its role in fostering industrial development. A broad course of action was then taken to privatize industries and infrastructure.

As an outcome of the privatization process, the new role of the State was to establish regulatory frameworks and supervise services that had previously been in the hands of the State. Regulatory agencies were therefore created, with three types of institutions being defined under the new system. First are the departments responsible for formulating public policies and participating in strategic governmental decisions. Next come the agencies responsible for executing the policies defined by the government. These include: the National Water Agency (*Agência Nacional de Águas – ANA*), the National Health Vigilance Agency (*Agência Nacional de Vigilância Sanitária – Anvisa*) and the National Supplemental Health Agency (*Agência Nacional de Saúde – ANS*). Last are the regulatory agencies endowed with greater autonomy and responsible for creating and applying rules so as not to allow the competitive market to set all the standards. They are: the National Petroleum Agency (*Agência Nacional de Petróleo – ANP*), the National Telecommunications Agency (*Agência Nacional de Telecomunicações – Anatel*), the National Electricity Agency (*Agência Nacional de Energia Elétrica – Aneel*), the National Waterway Transportation Agency (*Agência Nacional de Transportes Aquaviários – Antaq*) and the National Ground Transportation Agency (*Agência Nacional de Transportes Terrestres – ANTT*).

The impetus for creating regulatory agencies began to cool in 2003 when the existing agencies started to lose power due to budget cuts and recurrent delays in appointing directors and holding civil service exams to select permanent employees. This was clearly due to increasing pressure from the respective ministries, coupled with the Congressional debate of bill 3.337/04, which included measures that would withdraw the power of the agencies to grant concessions and control anti-competitive practices. Thus, the previously planned institutional framework is gradually being abandoned, while no alternative models are as yet being developed for regulating the infrastructure industries.

Other factors that shaped the new competitive environment of the 1990s were the increasing international liquidity and spread of new financial instruments that triggered widespread mergers and takeovers, both as a result of the redefined role of the State, as well as of the competitive positioning of private corporations.

To assure that the business environment remained competitive, the Brazilian Competition Defense System (*Sistema Brasileiro de Defesa da Concorrência*) was consolidated in 1994. Its function was to coordinate the activities of the Economic Law Department (*Secretaria de Direito Econômico – SDE*) of the Ministry of Justice, the Economic Monitoring Department (*Secretaria de Acompanhamento Econômico –SEAE*) of the Ministry of Finance, and especially the Administrative Council for the Defense of Competition (*Conselho Administrativo de Defesa da Concorrência – CADE*), an independent government entity administratively linked to the Ministry of Justice. Thus, equipped with the necessary powers of enforcement, this system played an important role in combating anti-competitive practices – a role that would gain in importance as the economy became more open and privatization and deregulation became increasingly more common.

It was in this new competitive environment – so different from the scenarios in which earlier industrial policies had been designed – that the Industrial, Technological and Foreign Trade Policy (*Política Industrial, Tecnológica e de Comércio Exterior – PITCE*) was introduced at the end of 2003. In addition to being launched after the opening of the economy and with the State in a new role, PITCE is in step with the current historical context in that it primarily focuses on innovation and technological development. It underlines the importance of certain strategic sectors for diffusing technology and innovations (semiconductors, software, capital goods and pharmaceutical products) and demonstrates concern as to long-term competitiveness when defining the activities of the future, such as biotechnology, nanotechnology, and biomass.

It was within the PITCE sphere that the creation of the National Council of Industrial Development (*Conselho Nacional de Desenvolvimento Industrial – CNDI*) and the Brazilian Industrial Development Agency (*Agência Brasileira de Desenvolvimento Industrial – ABDI*) were proposed as entities for coordinating the many instruments tied to industrial policies.[5] The most important aspects of PITCE are its focus on technological innovation, its definition of specific goals, and its recognition of the need for a new institutional framework for coordinating the policies formulated. However, despite its merit in regulating the Biosafety and Innovation Laws, the advances observed are still modest, and future opportunities lie in offering more credit while reducing its cost, solidifying and carrying out the measures proposed and simplifying the current legislation.[6]

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5. ABDI was regulated in February 2005. Presided over by the Minister of Development, Industry and Foreign Trade, the CNDI includes an additional twelve ministers and the president of BNDES, as well as representatives from private enterprise and the labor force.
6. For more information on PITCE, see Suzigan and Furtado (2005).

4 PRODUCTIVITY, INSERTION IN THE WORLD MARKET AND BRAZILIAN INDUSTRIAL EMPLOYMENT

Since the 1990s, two features have marked the behavior of industrial GDP. First was the drop in the average growth rate, especially in comparison to the figures for the 1970s, as shown in Table 1. Even more important is the fact that this average was a result of intense fluctuations. Although this volatility was less pronounced in the 1990s than in the 1980s, the growth of industrial activity continued to be unstable.

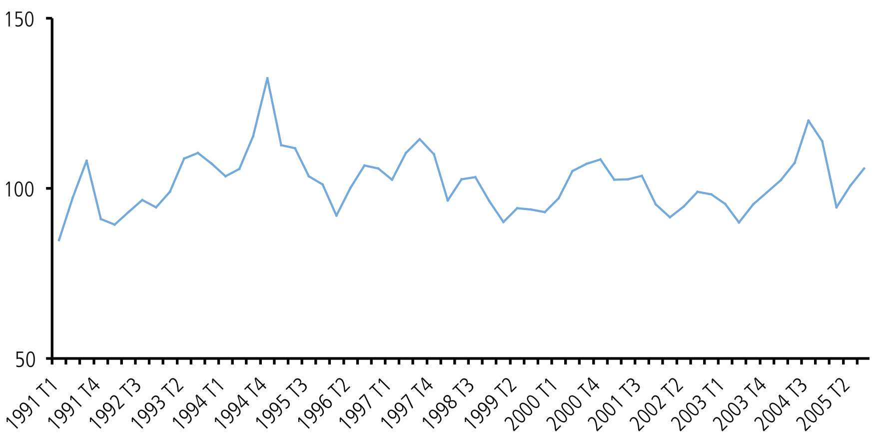
TABLE 1
Average growth rate of industrial GDP and of investment as a share of GDP
(%)

	1971-1980	1981-1990	1991-2000	2001-2004
Growth of industrial GDP	9.38	0.45	2.12	2.16
Investment / GDP	21.87	21.92	19.41	19.02

Source: IPEA.

This behavior partly reflects variations in the level of investments. Figure 1 shows gross fixed capital formation in comparison to the preceding year. It is evident that there is a series of fluctuations analogous to industrial production. Even more evident are the brief investment cycles that peaked in the fourth quarter of 1994, the third of 1997, the fourth quarter of 2000 and the third of 2004, respectively. Bielschowsky (1999) contends that these brief cycles reflect the fact that these investments were directed not to expanding productive capacity, but to modernizing the industrial base in technological terms.

FIGURE 1
Net accrual of fixed capital
(moving average: previous year = 100)



Source: IPEADATA.

The figures on labor productivity and employment growth show that the growth of industrial production in the 1990s was due more to gains in productivity than to expansion of the industrial base. Table 2 shows the average annual growth rates of labor productivity by manufacturing sector over the last three decades. Productivity clearly grew at a faster rate in the 1990s than in the previous two decades in all sectors, with the exception of leather and furs, chemicals, plastics products and tobacco products. The highlights were transportation equipment and textiles, with annual averages of 9.10% and 9.04%, respectively.

TABLE 2
Growth of labor productivity by manufacturing sector
(%)

Sector	1972-1980	1981-1990	1991-2000
Total manufacturing industry	4.43	1.44	7.75
Non-metallic minerals	6.45	1.10	6.85
Basic metals	3.98	1.40	7.59
Machinery	2.75	0.41	8.33
Electrical and communications equipment	6.01	3.87	8.86
Transportation equipment	3.80	-2.65	9.10
Wood	-	-	5.34
Furniture	-	-	4.55
Paper and cardboard	2.63	3.47	7.69
Rubber	6.31	0.04	7.96
Leather and fur	-	-	-1.13
Chemicals	7.70	3.29	7.23
Pharmaceuticals	-	2.35	2.44
Perfume, soap and candles	5.36	5.01	5.56
Plastics products	7.71	-1.05	6.86
Textiles	3.46	-0.25	9.04
Wearing apparel, footwear and accessories	2.90	-0.45	6.66
Food products	3.13	0.78	5.30
Beverages	5.74	3.61	8.68
Tobacco products	6.07	6.97	6.07

Source: Prepared by the authors based on data from IPEA.

The increase in productivity was accompanied by a decline in employment. Table 3 shows the average annual growth rate of employment over three decades. The declines in all manufacturing sectors were even more significant than those observed in the 1980s. It is worth noting that the two sectors that present the greatest declines in employment are labor-intensive, namely the textile and wearing apparel, footwear and accessories industries.

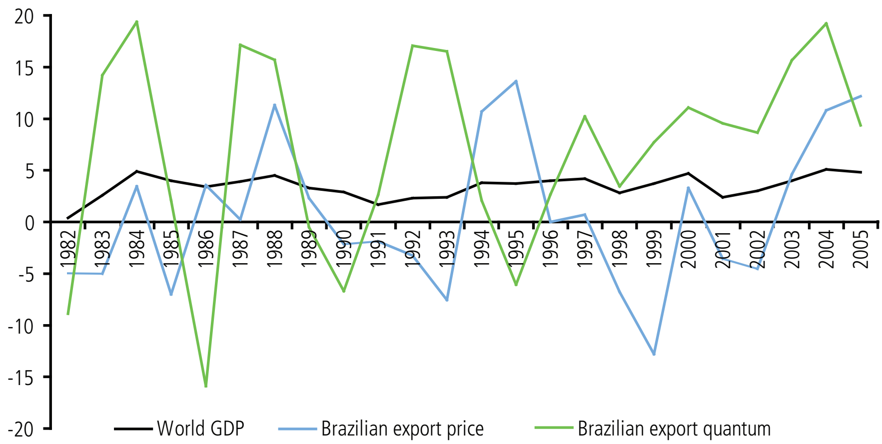
The changes that occurred in the 1990s were eventually reflected in Brazilian foreign trade. The manufacturing sectors were under strong pressure to modernize due to the threat of competition from imports, thus being forced to present significant productivity gains in order to survive in the new competitive context. The sectors that succeeded not only gained in productivity, but expanded their foreign markets as well.

TABLE 3
Growth of employment by manufacturing sector
(%)

Sector	1972-1980	1981-1990	1991-2000
Total manufacturing industry	4.07	-1.44	-5.13
Non-metallic minerals	3.60	-2.03	-4.13
Basic metals	4.55	-1.64	-4.45
Machinery	8.17	-2.62	-6.02
Electrical and communications equipment	6.27	-2.51	-5.60
Transportation equipment	6.81	0.01	-3.83
Wood	-	-	-4.04
Furniture	-	-	-1.71
Paper and cardboard	4.14	-0.70	-3.89
Rubber	3.58	1.18	-5.42
Leather and fur	-	-	-3.85
Chemicals	2.13	-1.71	-4.57
Pharmaceuticals	-	-1.08	-1.37
Perfume, soap and candles	3.11	0.00%	-1.96
Plastics products	5.60	0.85	-4.23
Textiles	0.71	-1.04	-9.44
Wearing apparel, footwear and accessories	3.83	-2.00	-8.41
Food products	3.04	0.67	-2.80
Beverages	2.61	-0.39	-5.52
Tobacco products	0.55	-3.16	-5.68

Source: Prepared by the authors based on data from IPEA.

FIGURE 2
World GDP, price and quantum of Brazilian exports
(% per year)

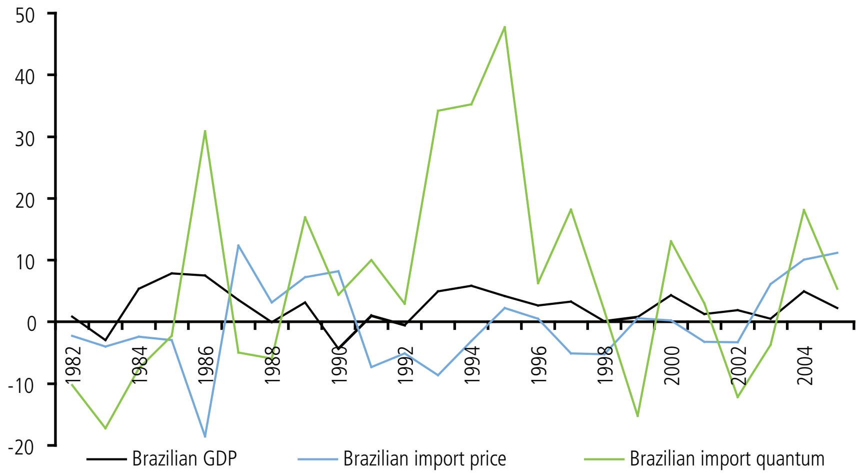


Source: IPEADATA.

A structural characteristic of Brazilian foreign trade is found in the differences between the export and import lists (DE NEGRI, 2005). Historically, the Brazilian export list has been comprised mainly of commodities and labor-intensive products. Because such products face strong competition, their prices are subject to recurring fluctuations in relation to world economic activities. This is illustrated in Figure 2, where years of high world GDP growth are normally seen to have been followed by increases in Brazilian export prices, while the opposite is observed to have happened in years of more modest world activities.

Turning to the import list, higher-tech products are ever present and their prices are more stable over time. In this case, the correlation is between the quantum of Brazilian imports and the national GDP. In Figure 3, the years in which Brazilian economic activity registered higher growth were followed by jumps in this quantum, which, in turn, was relatively stable when the domestic economy slowed down.

FIGURE 3
Brazilian GDP, price and quantum of Brazilian imports
(%per year)



Source: IPEADATA.

Under these circumstances, the fluctuations in Brazilian foreign trade are subject to both internal cyclical factors that greatly influence imports, as well as to external factors that have an even greater impact on exports.

Resende (2000) tested a hypothesis regarding the function of imports in adjusting the balance of payments, given that variations in the availability of foreign currency affect the growth cycles of the Brazilian economy. He shows that during periods of limited availability of foreign currency, both tariff and non-tariff barriers and non-barriers to imports tend to increase, as do adjustments of other variables that affect import demand, such as the real exchange rate and income.

Despite bringing large increases in productivity, the fact that Brazilian exports are concentrated in standardized products leaves little room for long-term growth and reinforces the need for investments that would generate technological innovation. Innovation opens the door for companies to acquire the market power necessary for competitive integration into the higher-tech markets that bring greater returns on capital invested and greater protection against recurring price fluctuations.

As of the year 2000, the significant increase in Brazilian exports therefore reflects the growing capacity of Brazilian firms to enter higher-tech markets. De Negri (2005) corroborates the hypothesis that the productivity gains seen throughout the 1990s contributed to increasing the efficiency of these firms, with clear consequences for their international competitiveness.

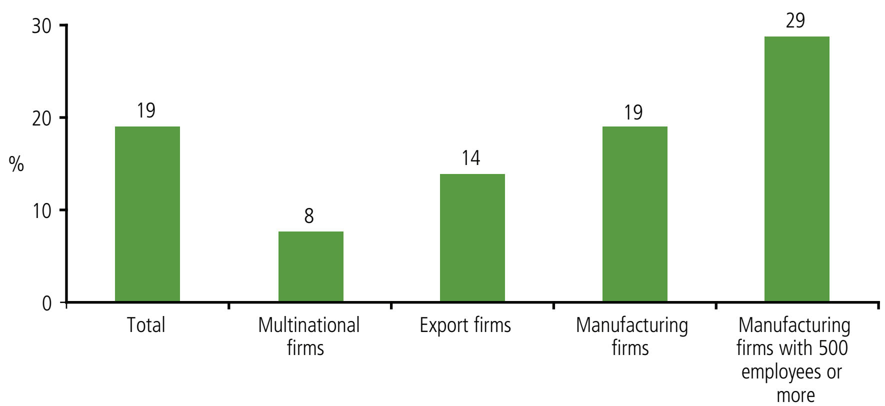
Once a significant portion of Brazilian industry became more globalized, the impact of the opening of trade on the level of employment became more evident. The initial drop in employment in the manufacturing industries immediately after the opening of the economy has been gradually offset by their dynamic and more globalized productive structure, which, in turn, has been an important source for the growth of employment.

The insertion of Brazilian firms into world markets has revealed dynamic opportunities and enhanced productivity. Araújo (2006) demonstrates that firms that export and continue to export see their sales increase 53.1% in the first year and 61.4% in the second year when compared to firms that do not export. Likewise, employment increases 21.3% in the first year and 20.3% in the second year. The fact that the revenue of these firms increases at a faster rate than their employment allows them, on the one hand, to enjoy significant productivity gains and, on the other, to hire more workers.

These figures indicate that increasing the number of export firms and maintaining these firms in the competitive international environment, are effective means of generating employment in the country. According to Araújo (2006), in the period 2000-2004, firms that continuously exported were responsible for creating approximately 400,000 new job posts. In turn, De Negri *et al.* (2006) show that a significant portion of the hiring and dismissal of employees was subsequent to the opening or closing of firms, especially due to the great number of firms that open or close in Brazil every year. In this sense, new firms can be said to have generated a significant portion of the employment growth. Likewise, on analyzing only those firms that continuously operated in the Brazilian market between 1997 and 2003, Homsy and Costa (2006) confirmed that those that exported generated more employment than those that did not export.

Figure 4 shows that the large Brazilian firms (500 employees or more) are not only more innovative and technologically advanced, but also generated a number of jobs far above the national average. There was a 29% increase in employment in these firms, which means that almost 500 thousand new posts were created. This suggests that, at the same time that technology is labor-saving and capable of creating new growth opportunities for companies, it is also capable of offsetting initial negative effects on employment levels.

FIGURE 4
Growth of formal employment in Brazilian firms (2000 - 2004)



Source: De Negri *et.al.* (2006).

5 THE NEW COMPETITIVE OUTLOOK OF THE BRAZILIAN ENTREPRENEUR

The new competitive scenario that has existed in Brazil since the 1990s has motivated a series of studies regarding the changes that have taken place in the manufacturing industries. This research primarily focuses on topics such as the evolution of sector imports, changes in the control of firms and the retraction of certain industrial segments. Within this context, one of the principal debates has centered on the comparative advantages Brazil possesses and the possibility of regressive specialization on the part of domestic industry.

According to one such analytical approach (FRANCO, 1998; MOREIRA, 1999), up to that point, protectionism favored the development of sectors that depended on scarce domestic resources (capital and technology) to the detriment of others that used abundant resources (labor and natural resources) Moreover, protection of the domestic market had caused an excessive number of producers to emerge in capital and technology-intensive sectors, inevitably leading to inefficiencies of scale. Taken together, these factors formed a weak base for the development of these sectors, at the cost of wasted resources, high prices for the domestic consumer and incapacity to enter world markets.

It was therefore considered necessary to create new competitive scenarios focused on generating specific pressures to correct the inefficiencies. On the one hand, it was argued that structural adjustments should allow for higher imports to the detriment of capital and technological-intensive sectors. On the other hand, firms should be pressured to achieve higher efficiency levels through enhanced productivity and reduced mark-ups. Theoretically, all this would lead to specialization within the Brazilian industrial base that would better reflect the true resource endowments and comparative advantages of the country.

The second analytical approach had reservations concerning the first, attributing the distortions in the competitive capacity of certain sectors to the trade and financial opening of the economy combined with a policy that combated inflation based on exchange rate appreciation and high real interest rates. In this scenario, the only ones able of competing internationally would be the producers of agricultural and natural-resource-based commodities with relatively low levels of industrial processing. Thus, productive investments would be shifted mainly to these sectors, which would cause certain industrial segments to be dismantled and links in the domestic productive chain broken. According to these writers, directing investment toward those sectors in which Brazil is historically competitive, while weakening higher value-added sectors, would lead the country in the direction of so-called "regressive specialization" (COUTINHO, 1997; KUPFER, 1998).

The outcome, however, has been different from those foreseen in the preceding analyses. Despite recognizing the competitive capacity of the country in these lower value-added sectors (i.e. agricultural goods and manufacturing sectors specialized in standardized goods), a significant group of Brazilian companies – responsible for about one-fourth of industrial revenue – currently place medium and high-tech goods on the international market. Seeking to better understand this phenomenon, new contributions regarding the insertion of Brazilian industrial companies into world markets were made in a series of studies conducted by the Institute for Applied Economic Research (*Instituto de Pesquisa Econômica Aplicada – IPEA*) through its project on Innovation, Technological Standards and the Performance of Brazilian Industrial Firms (*Projeto Inovações, Padrões Tecnológicos e Desempenho das Firmas Industriais Brasileiras*).[7]

For this project, Brazilian manufacturing enterprises were classified in three categories according to their competitive strategies:[8] *i*) firms that innovate and differentiate products, covering those that produce higher-tech goods and compete through product differentiation, adopt more promising competitive strategies by concentrating on the leading edge of the industry and tend to earn a

7. See De Negri and Salerno (2005).

8. This project brought together the largest amount of data ever used to analyze the Brazilian industrial sector.

relatively high portion of the income generated by the sector; *ii*) firms specialized in standard products, encompassing those that are relatively up-to-date from the operational standpoint (manufacturing and logistics), but essentially compete via cost and price, being out-of-date with respect to modern competitive tools such as research and development, marketing and the use of trademarks; and *iii*) firms that do not differentiate and have lower productivity, including companies that, while offering lower quality goods and not being exporters, are still capable of finding space on the market through low prices and other possible advantages.[9]

Based on the findings of the IPEA project, Arbix and De Negri (2005) argue that there are strong indications that the competitiveness of Brazilian industry is supported by a new entrepreneurial outlook that arose with the opening of the economy. The authors reached this conclusion after analyzing the competitive behavior of Brazilian manufacturing firms and noting that certain aspects of this behavior can be explained as a business response to the breakdown of the domestic/developmental model. The features of this new business perspective are discussed in the following sections.

5.1 Competitive strategies focused on technological innovation and product differentiation

The first indication that a new business perspective is taking shape in Brazilian industry is the weight of firms that innovate and differentiate products in overall industrial production. According to the conventional view, these companies would be expected to account for a small, or even marginal, share of total industrial revenue in a developing country. However, despite representing only 1.7% of the Brazilian manufacturing firms numerically, they are responsible for 25.9% of total industrial revenue. At the same time, firms that do not differentiate products and have lower productivity comprise the large majority of Brazilian industrial firms – a total of 77.1% – but answer for only 11.5% of the revenue. In turn, those specialized in standardized products represent 21.2% of the total number of firms and respond for 62.6% of industrial revenue.[10]

A second feature refers to the qualification of the labor force. While hard to measure, the educational and professional levels of the workers employed at a company demonstrate the company's attitude toward the accumulation of knowledge. For example, higher remuneration is an undisputable sign that the company values knowledge, experience and the importance of retaining its more productive workers.

9. Although not included in this project, a fourth category includes technology-based firms that are either in the initial phase of operation or in a position to leave the incubators in which they were conceived.

10. Indicators for the year 2000 show that the production scale of firms that innovate and differentiate products is significantly larger than those in the other categories. The average sales of these firms is R$ 135.5 million, while the average for firms that specialize in standardized products is R$ 25.7 million, and that for firms that do not differentiate and have lower productivity is R$ 1.3 million. Despite the significant differences in the average size of firms in different categories, De Negri *et al.* (2005) show that the scale efficiency of firms that innovate and differentiate products is similar to that of firms that specialize in standardized products.

With this in mind, it is revealing that the average monthly wage is R$ 1,254.64 for firms that innovate and differentiate products, R$ 749.02 for firms that specialize in standardized products and only R$ 431.15 for firms that do not differentiate and have lower productivity.

De Negri and Freitas (2006) show that the wage is affected by more than employee qualifications, firm characteristics and industrial sector, for companies also pay wage premiums related to their competitive strategies. According to these authors, firms that innovate and differentiate products pay their employees approximately 23% more than firms that do not differentiate and have lower productivity and 12% more than those that specialize in standardized products. This higher remuneration by Brazilian firms that innovate and differentiate products clearly demonstrates that their competitive edge is not based solely on offering products at lower prices – via lower costs or poorer quality – as would be expected according to the conventional view concerning the market insertion of developing economies.

A third feature concerns the innovation standards adopted by each of these categories. While 70.6% of the firms that innovate and differentiate products performed both product and process innovations between 1998 and 2000, those specialized in standardized goods centered their innovation efforts on process only. In other words, the innovative behavior of the latter is strongly associated with technological diffusion, especially with the acquisition of machinery and equipment, most of which is imported.

This is confirmed by the source of innovation in each category. Whereas 78% of the firms specialized in standard products declared to have introduced process innovations indicated that the processes were originally developed by other companies, only 47.5% of the firms that innovate and differentiate products said the same.

5.2 Corporate alliances and structural changes aimed at technological innovation

The technological standards of the firms that innovate and differentiate products confirm a new business perspective, as well as characterizing in detail the structural differences between the enterprises. Other signs of the new outlook that must be highlighted are cooperation in technological innovation, structural and organizational changes within firms and technological cooperation between firms for the purpose of innovation.

The ability of firms to enter cooperation agreements and partnerships for the sake of technological innovation is an important aspect of their innovative efforts. In fact, 29.3% of the firms that innovate and differentiate products made their innovative efforts either in collaboration with affiliates from within their own business groups or in cooperation with other companies. However, among the firms specialized in standardized products, the percentage was 15.9%. Likewise, in comparison to other firms, those that innovate and differentiate products also spend a higher proportion of their revenues on research and development (R&D) and on the acquisition of extramural knowledge, which corroborates the fact that they cooperate or innovate within their company groups.[11]

Another relevant aspect of the competitive process is the capacity of firms to promote organizational changes and changes in their market strategies. Companies that are willing to make such changes are usually more dynamic and likely to be directed by more visionary entrepreneurs.[12] It is hardly surprising, therefore, that 39.1% of the firms that innovate and differentiate declared they had implemented changes in corporate strategy in relation to product and/or the market in which they operated, while more than half had implemented organizational, administrative or marketing changes or undergone changes in management. This is to be expected since innovative firms are usually more aggressive due to the fact that launching new products implies conquering new markets.

5.3 Adaptation to international standards and norms via technological innovation

Technological innovation efforts are structurally different in firms that innovate and differentiate products. The executives of these companies guide their efforts with a view to broadening their markets, improving the quality of their products and achieving more competitive positions. One fact in particular calls attention: among the firms that innovate and differentiate products, 23.1% attributed a high degree of importance to having their innovations conform to norms set by the foreign market, whereas the figure for firms specialized in standardized products was only 13.2%.

The relevance of this finding lies in the fact that, until quite recently, it was widely held among Brazilian industrial firms that insertion in the foreign market was simply a by-product of the performance of an enterprise in the domestic market. In other words, in the growth strategies of these firms, exports were seen merely as options to be explored when the domestic market contracted. Foreign sales were therefore assigned a secondary role and held in reserve for specific occasions. Thus, the fact that a significant portion of the firms that innovate and differentiate products, as well as of the firms that specialize in standardized products, performed technological innovations in such a manner

11. It should be observed that the cause-and-effect relationship between the technological innovation performance of the firm and cooperation is not trivial. Firms can innovate and thus broaden the spectrum for cooperation/partnerships, exchange information with other firms that innovate or form associations to perform the intended technological innovation. Regardless of the direction that the cause-and-effect relationship takes, the fact is that cooperative alliances are more frequent among firms that innovate and differentiate products than among other types of firms.

12. Once again, there is not a well-defined cause-and-effect relationship between these changes and technological innovation. Although technological innovation drives the process of change, it is also driven by it.

as to adapt them to international norms and standards constitutes a third indicator that something is new in the Brazilian business perspective, something that sees the insertion of developing economies in world markets in a way that diverges from the conventional view.

5.4 Export performance of companies via technological innovation

The literature on the determinants of international trade affirms that, on the one hand, exports are related to traditional comparative advantages, which are defined by relative factor endowments (e.g., labor and natural resources) and intimately related to inter-industry trade. On the other hand, exports are also influenced by economies of scale, technological innovation, and product differentiation. In this case, they are essentially linked to intra-industry trade.

Being a country with abundant labor and natural resources, Brazil is competitive in markets for goods that require a greater relative endowment of these factors. However, the size of the domestic market and the innovative efforts of its firms also make the country competitive in certain segments in which technological innovation and production scale are fundamental requirements for international competitiveness.

Taken together, these conditions make Brazil unique in terms of the process of insertion into world markets. While the country is competitive in segments that are intensive in labor and natural resources, the innovative efforts of its industrial firms facilitates its integration into the international market. Therefore, the recognition on the part of the business community that it is possible to be more virtuously integrated into world trade through technological innovation, despite the country being abundantly endowed in labor and natural resources, offers the fourth indicator of the new business perspective.

It is also important to observe that the foreign trade indicators signal very different patterns for firms that innovate and differentiate products and firms that specialize in standardized products. While there is no question that firms that innovate and differentiate products command higher prices on the international market in comparison to other Brazilian exporters, they also require more imported components and other inputs to maintain their international competitiveness because the country is partially or totally non-competitive in many high-tech segments. For these reasons, they end up adopting a pattern of partially intra-industry, partially intra-firm trade characterized by technological exchange with other countries.

In contrast, firms that specialize in standardized products manufacture and export goods that are less differentiated, more homogeneous and less technologically advanced. They can therefore take more advantage of the abundant factors of production available on the Brazilian market. These companies are particularly competitive in inter-industry trade with other countries - a type of trade that is less dependent on imports and in which exports make a greater contribution to revenues. In this case, imports are based on intra-industry complementarity, that is, made for the purpose of benefiting from the domestic scale of production.

5.5 Globalization of companies focused on technological innovation

The need to form ties with foreign countries is manifested in many ways. On the one hand, part of the business community establishes these ties in a loose fashion, such as participating in fairs and meetings abroad. On the other hand, another part uses company contacts in foreign countries as a prime source of technological information. This type of entrepreneur – for whom globalization rests on technological innovation – establishes alliances with carefully selected foreign firms or even makes foreign direct investments, subsequently using these channels as a kind of technological antenna. Therefore, the fifth indicator that a new business perspective is consolidating in the Brazilian industrial sector is based on evidence that a significant number of Brazilian entrepreneurs are going abroad in search of the information required for technological innovation.

In 2003, according to data from the Central Bank of Brazil, there was US$ 82.7 billion in Brazilian capital in other countries. Brazilian direct investments – that is, stockholdings above 10% and inter-company loans – totaled US$ 54.9 billion. Of this total, Brazilian industrial firms accounted for US$ 13.7 billion.

Alliances with foreign firms, or even with subsidiaries of domestic firms, contribute to export performance in several ways, such as opening trade channels, granting access to less expensive financial resources, creating new markets, adapting products to specific market demands and offering access to technology not available on the domestic market. Arbix, Salerno and De Negri (2004 and 2005a) show that globalization processes focused on technological innovation have a positive effect on export performance, having verified that globalized firms focused on innovation hire workers with more schooling, pay them better and thereby generate better quality employment. In addition, globalized companies spend a higher percentage of their revenues on training, which evidently contributes to the formation of a more qualified domestic labor force. Since these firms export more than those that do not pursue this kind of globalization, the evidence suggests that the technological innovation resulting from this process raises their competitiveness.

The authors also highlight the links between technological innovation, the globalization of Brazilian firms via foreign direct investment and premium prices for exports (ARBIX; SALERNO; DE NEGRI, 2005b). In their view, these links exist because technological innovation produces specific assets that enable and facilitate globalization, which, in turn, contributes to obtaining premium prices for exports. Thus, Brazilian firms that make direct investments in the United States and Europe have 17.40% and 14.01% more chance, respectively, of exporting at premium prices than Brazilian export firms that do not make such investments. It is also important to underline that, via a reciprocity mechanism, globalization favors innovation, while innovation increases the possibility of obtaining premium prices in comparison to those received by other exporters.

6 CONCLUSION

In Brazil, the industrial development process has successfully consolidated a high-density, relatively well-integrated manufacturing sector endowed with a substantial network of local suppliers. For several decades, however, State subsidies and an overly protected domestic market were responsible for creating a relatively lethargic and passive business perspective compared to the leading international trends. This lethargy distanced Brazilian industrial enterprises from the more modern international standards of competition, standards that are basically guided by firms' capacity to perform technological innovation and to differentiate products. As a result, the pro-domestic market bias was strengthened while the performance of Brazilian firms on the international market was increasingly neglected.

The opening of the economy in the 1990s sought to correct these inefficiencies and forced companies to adapt to a new scenario in which they faced competition not only from imported products but also from foreign direct investment. For the manufacturing industries, the outcome was a combination of substantial productivity gains coupled with significant reductions in industrial employment levels.

It should be emphasized that, with respect to the restructuring of the manufacturing industries, the evidence shows that the Brazilian experience diverges from the conventional hypothesis which contends that the competitive insertion of developing countries in world markets is strictly associated with labor and natural-resource-intensive sectors. Despite the weight of these segments on the Brazilian export list, it is readily noticeable that the modernization of the industrial base has enabled a significant number of Brazilian firms to enter medium and high-tech overseas markets. These firms have succeeded because they have adopted competitive standards based on technological innovation and product differentiation, thus revealing the existence of a new business perspective in Brazil, one based on a willingness to compete and to match the best international competitive practices.

Indeed, a robust series of indicators points to the fact that a change in entrepreneurial outlook has accompanied the new competitive environment in existence since the 1990s: i) technological innovation and product differentiation shaping the competitive strategies of enterprises; ii) cooperation agreements and organizational changes focusing on technological innovation; iii) firms adapting to international norms and standards through technological innovation; iv) technological innovation strongly influencing the export performance of firms; and v) the globalization of firms seeking technological innovation.

These findings show that the idea of pursuing industrial development based on higher-tech segments instead of only on lower-value-added sectors is rooted in the competitive strategies already adopted by a large number of Brazilian entrepreneurs. Within this context, it is now up to the State to stimulate other manufacturing firms to adopt these competitive standards – whether by diminishing the risk of entrepreneurial and innovative activities, by disseminating information and eliminating bureaucratic barriers, or by refining and coordinating the instruments for financing the research and development conducted by enterprises.

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CHAPTER 2

MICROECONOMIC BEHAVIOR IN HIGH UNCERTAINTY ENVIRONMENTS: THE CASE OF ARGENTINA

Bernardo Kosacoff
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1 INTRODUCTION

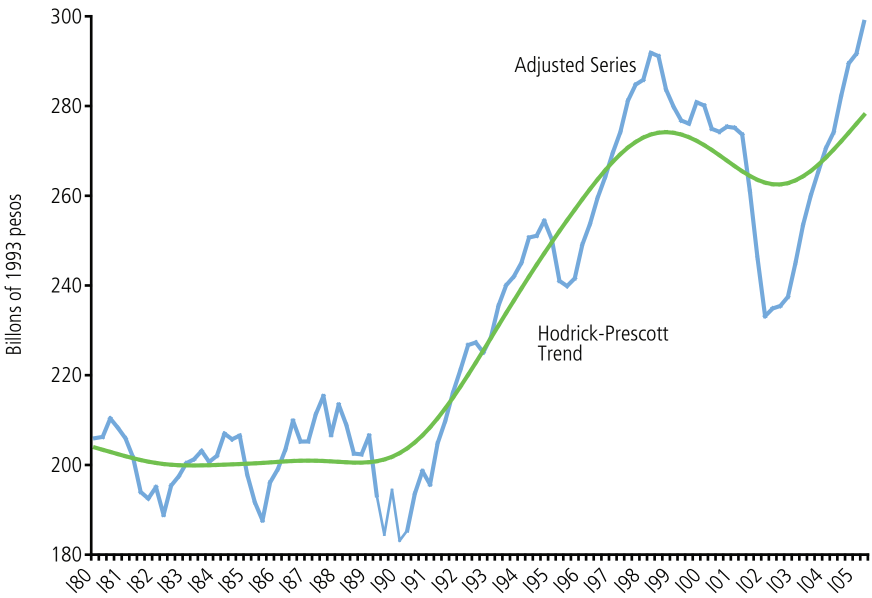
In recent decades – or to establish a more specific starting point, since the middle of the 1970s – Argentina's real output has undergone violent and frequent fluctuations. Intense short-run variations have coincided with striking changes in the long-run tendencies of the economy. The unstable behavior of the Argentine economy is outstanding even within the group of so-called (for reasons that escape us) "developing countries." Repeatedly, real volatility has been associated with very poor economic growth.[1] Therefore, short-term effects and their dynamic interaction with long-term effects have disturbed investment and growth and caused an accumulation of irreversible losses of business assets – tangible as well as intangible in nature. In essence, the history of Argentina of the period has ruthlessly demonstrated that real volatility is very costly in social terms.

The difficulty in identifying and extrapolating tendencies in income and expenditures was also reflected in the fierce fluctuations of per capita output in constant dollars:[2] in 1980, or until the revaluation of the euro, Argentina generated a GDP per capita similar to that of Spain, that is, approximately 15,000 dollars. This level was unsustainable, however, and within another two years, per capita output had fallen – after a crisis, naturally – to roughly 5,000 dollars. The instability of the late eighties, which culminated in the hyperinflationary episodes of 1989 and 1990, reduced GDP per capita to slightly more than 3,000 dollars, a level lower than that of many other Latin American countries. Nonetheless, not long after, in the nineties, Argentina reached and maintained for nearly a decade a GDP that oscillated around 8,000 dollars per capita. As a result of the post-convertibility depreciation and drop in the level of activity, the lowest value in the series (somewhat below 3,000 dollars) was recorded in 2002. Despite the evident economic recovery, per capita output was just over 4,000 dollars in 2005. In short, observing the pattern of

1. The annual average growth rate of per capita output between 1950 and 2004 was a disappointing 0.6%. This performance intensified with time. Thus, between 1950 and 1974, the rate of annual increase of GDP per capita reached 1.3%, but in the period encompassing the last thirty years it was a mere 0.1% per annum. Whereas until 1974 the probability of experiencing a downturn was 20%, in the subsequent period that frequency increased in abrupt fashion until it reached a probability of half that time (47%).
2. In this calculation of output in dollars, 2000 is taken as the base year.

fluctuations over the last 30 years, the amplitude of the series is striking (almost 5 to 1). Even more remarkable is the absence of periods of moderate and persistent growth free of shocks. This behavior, which occurs within a feedback process, hinders identification of "permanent" income and expenditure and therefore disrupts consumption and investment decisions.[3]

FIGURE 1
Seasonally adjusted GDP per quarter, at constant prices. HP values and trends



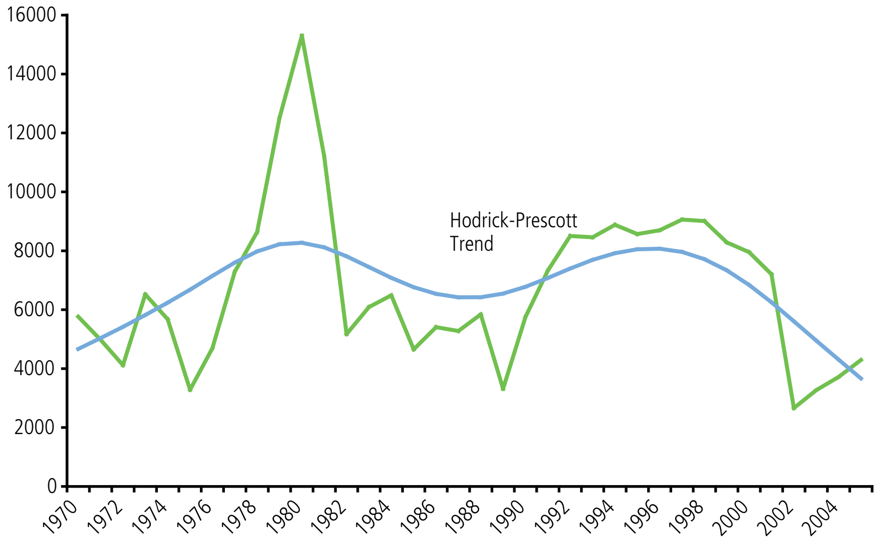
Source: Elaborated by the authors on the basis of official figures.

Several studies have recently presented empirical evidence demonstrating that high output volatility negatively affects long-run economic growth, imposes high costs that undermine the welfare of economic agents and adversely impacts on the poorest members of society.[4] The studies show, moreover, that these effects are particularly severe in developing countries. The two mechanisms most frequently cited in an attempt to explain the negative correlation between volatility and growth are: 1) that greater uncertainty reduces growth as investment falls and 2) that the existence of credit restrictions or imperfect access to the capital market aggravates the impact of short-term volatility on long-term growth by limiting the options for financing long-term investment. In addition, these studies indicate that economic welfare

3. See Heymann and Sanguinetti (1998);
4. Kose, Prasad and Terrones (2005) and Aizenman and Pinto (2005) present recent surveys of the economic literature on the topic while Fanelli (2003) studies the Argentine case.

sharply diminishes in the presence of the greater range of fluctuations in consumption deriving from output volatility. Lastly, they show that the poorest classes are the most affected by these economic dynamics. Because they suffer limited access to financial markets, the poor are unable to diversify the risks associated with their main sources of income: wages and government transfers. Also, because they use public services to a greater extent (e.g., health and education), they are subject to the procyclical pattern of public spending observed in developing countries, especially in times of economic crisis. In the Argentine case, extreme volatility resulted in a fiscal breakdown not only in terms of the sources of financing of expenditures but also in the erosion of the quality and allocation of the amounts earmarked for the provision of public goods.

FIGURE 2
GDP per capita in year 2000 dollars. HP Trend



Source: Elaborated by the authors on the basis of official figures.

The above mentioned studies focus on certain of the aggregate economic effects of real volatility. However, few existing studies attempt to explain the microeconomic aspects of the decision-making process of agents and the reciprocal influence of this process on macroeconomic behavior in countries characterized by high volatility and low institutional quality.

This paper aims to identify, in exploratory fashion, some of the effects of real volatility on the structure of the industrial sector and on the evolution of the micro-economy of industrial firms, emphasizing that what happened subsequent to the most recent period of market reforms provides evidence that contributes to understanding why macroeconomic sustainability and solid micro foundations are interlinked. Therefore, following a brief review of the history of industrialization in Argentina from the end of the 19th century, we will explore the micro-foundations of decision-making processes in the context of high instability and economic reform. In this study, the concepts underlying the analysis of the behavior observed embrace an eclectic range of fragmented evidence rather than a unified body of theory.[5] In particular, some of the questions that will be considered in the following sections are: uncertainty, investment and productive strategies; the opening of the economy, learning and imports; the effects of imperfect financial markets; the technological path and trade liberalization; the evolutionary perspective and microeconomic dynamics; trends, fluctuations and the perceptions of economic agents; heterogeneity and productivity gaps; the differentiated responses of heterogeneous economic actors; and idiosyncrasies in knowledge and crisis management.

2 A BRIEF HISTORY OF ARGENTINE INDUSTRIAL DEVELOPMENT

In Argentina, the industrialization process began in the late 19th century. Initially, the industrial sector was driven by an open agro-export economy based on the production of cereals and meat. This setup, with its vicissitudes, lasted until the agricultural frontier expanded to its limits and the world was beset by wars, economic crises and protectionism.[6] Similar to what was happening in other nations around the globe, in response to this new scenario, a new economic regime began to develop from the thirties onwards. The new regime was termed "import substitution industrialization" (ISI), and during this process, industry gradually came to hold the most privileged position in the Argentine economy. Initially, the most prominent economic actors were the large State-owned companies in sectors labeled "of national interest" (steel, iron, energy and transport, among others), together with small and medium-sized enterprises in the private sector that were stimulated by unsatisfied domestic demand and by high trade tariffs (clothing, footwear, other consumption durables and basic machinery).

From the fifties on, industrial activity was the engine of the economy and of job creation, as well as the basis for capital accumulation. In addition, the remarkable local technological capacity that gradually developed became outstanding in Latin America. At the end of the 1950s, a massive influx of foreign subsidiaries into the industrial sector[7] transformed these international corporations into important actors in the domestic setting. This phenomenon shook the structure of existing markets, altered the production framework and stimulated the development of new,

5. Dal Bó and Kosacoff (1988) or López (2005), for instance.
6. Villanueva (1972) and Schvarzer (1996) showed that the strong industrial expansion of the thirties and early forties did not constitute a rupture with the dominant tendencies of the 20th century.
7. Between 1957 and 1965, approximately 200 subsidiaries of the major international corporations set up industrial production facilities in Argentina. (SOURROUILLE *et al*. 1985).

more technologically complex activities for which the demand was not satisfied locally (vehicles, pharmaceutical products, petrochemicals, agricultural equipment, processed foods).

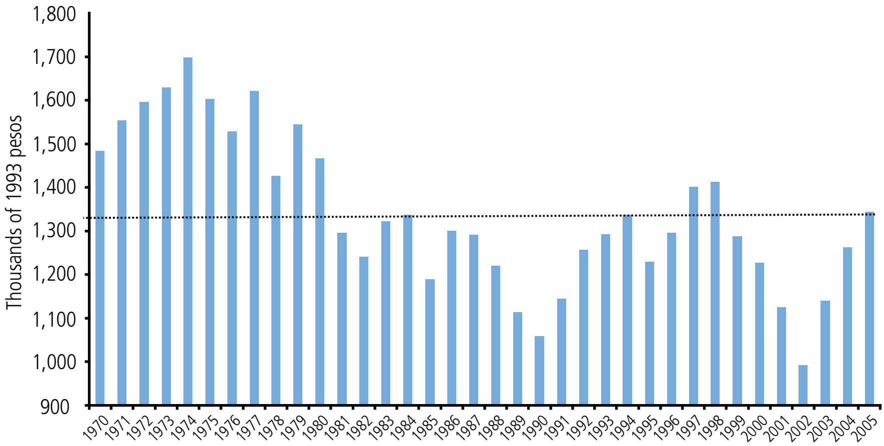
In the decade between 1964 and 1973, industry enjoyed continuous growth, without a single decrease in production in any given year. In addition, this latter period was characterized by a fall in the relative prices of industrial goods due to increases in productivity, a rise in industrial exports and an increase in the average size of plants (with the metal and mechanical sectors, together with chemical and petrochemical activities being the most dynamic). Simultaneously, job creation rates were surpassing the population growth rate.

During this prolonged process of industrialization, however, the Second World War came to an end and external growth and commercial opportunities began to reappear across the globe. On the one hand, the substitution strategy had been exhausted, so the option to maintain a closed economy would subject Argentina to progressive deterioration relative to other countries.[8] On the other, a decision to open up the economy would harm the lower classes, whose interests were best served by a strong currency, which made exportable foodstuffs less expensive, and by a protected industrial sector, which demanded a large amount of labor.

By the mid-1970s, this growth scheme faced an increasingly more evident set of difficulties. These difficulties included aspects related to the general operation of the economy (balance-of-trade limitations and persistent inflation, among others), as well as those associated with the form of industrial organization that was unfolding (plants working at reduced scale, weak subcontracting and specialized supplier networks, low international competitiveness, among others). At the productive level, the local answer was an initial attempt at structural reform consisting in the opening up and modernizing of the economy within the framework of an abrupt appreciation of the domestic currency. Unfortunately, it was not taken into account that during the four decades of ISI, an entrepreneurial base and a substantial supply of skills, knowledge, engineering capacity, equipment and human resources had accumulated. Thus, the "regressive" industrial restructuring that took place made no attempt to salvage the positive aspects of the previous phase and thereby failed to take advantage of valuable existing economic resources.

8.Through import substitution, Argentina grew more slowly than other countries of the region that were better prepared for this industrialization strategy (Brazil and Mexico, for example).

FIGURE 3
Industrial GDP per capita (1970-2005)



Source: Elaborated by the authors on the basis of official figures.

From 1975 on, the Argentine industrial sector lost its capacity for productive dynamism, for employment generation, and for leadership in the investment process that had characterized it in the past. Pressured by changes on the international technological frontier, coupled with local instability and uncertainty, considerable modifications occurred at the institutional, sectoral, microeconomic and commercial integration levels. Gradually, a pattern of specialization characterized by a predominance of natural resource and capital intensive activities was taking root in Argentine industry. In these activities, the weight of the labor factor in the production function is low and the larger economic agents play a central role. In contrast, knowledge intensive activities, in which the weight of labor in production functions is high and small and medium-sized enterprises (SMEs) have considerable participation, were present in lesser proportion (KOSACOFF; RAMOS, 2001).

As a result, by 2004, the per capita industrial value added of Argentina was 40% lower than it had been thirty years before. Over these years, the manufacturing sector had expelled labor, drastically reduced the number of plants and intensely increased the openness of its commerce. Thus, remarkable changes had occurred in the nature and composition of industry. Today we see a smaller, more concentrated industrial sector, characterized by a high degree of transnationalization and an organizational model for the production of goods that is far different from that of the period of the semi-closed economy. The metal and mechanical activities, which displayed the most dynamic behavior during ISI, now represent only one-third of what they did three decades ago. In addition, as an inheritance of the sectoral and regional public policies implemented as of the early seventies to strengthen the substitution strategy and expand industrial capacity in capital-intensive goods, the production of basic inputs (steel, aluminum, paper and petrochemicals, among others) has become the new pattern for industrial specialization thanks to the enormous transfers of public resources in their favor. Also, after four decades of stagnation, the natural resource sector, under the leadership of agriculture (specifically soybeans) and energy, has again expanded and become the most dynamic sector, as reflected in its substantial incorporation of new technologies in recent years.

TABLE 1
Industrial map - IO matrix (1997)

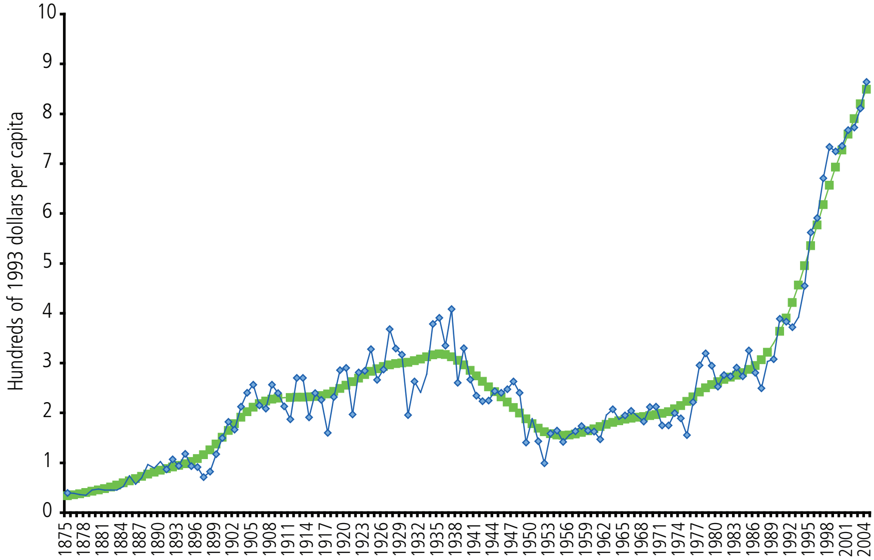
Relative intensity	Industrial activity	Manufacturing industry (Total)		
		GP	L	M
			(%)	
K & imported inputs	Automotive, Electric Machinery, Chemicals, Pharmaceuticals, Audio, Packaging and containers	32.8	22.6	64.2
K & domestic inputs	Commodities, Beverages, Cosmetics and cleaning products, Household appliances	28.5	13.8	15.5
L & imported inputs	Capital goods and components	5.5	9.0	8.4
L & domestic inputs	Non-durable and semi-durable goods	33.3	54.6	12.0

Source: Elaborated by the authors on the basis of official figures.

The structural pro-market reforms of the nineties left a set of lessons about the transformation of the productive apparatus. The rise of a business platform subject to the restrictions of an accelerated process of trade liberalization (reinforced by the effects of a disproportionate appreciation of the exchange rate); to the imperfections of capital markets (with real interest rates at times inconsistent with production); and to competitive and foreign trade policies that were neither examined, coordinated nor evaluated in any depth, gave rise to an extreme degree of exposure to international competition. Within this context, activities based on natural resources and basic inputs, which were already endowed with considerable capabilities, quickly advanced towards alignment with the best international practices. This explains to a great extent the export dynamics of the nineties: the sale abroad of items based on natural resources performed well and generated an outstanding mass of foreign currency, despite the products offered reaching only the first stages of value added.[9]

9. The performance of these products, along with that of the manufacture of gearboxes, valves, etc., is only understandable from an evolutionary perspective that combines routine, learning and selection. Also, it suggests that the local economy is ready to advance towards more sophisticated productive processes.

FIGURE 4
Export Volume and Hodrick-Prescott Trend (1875-2004)

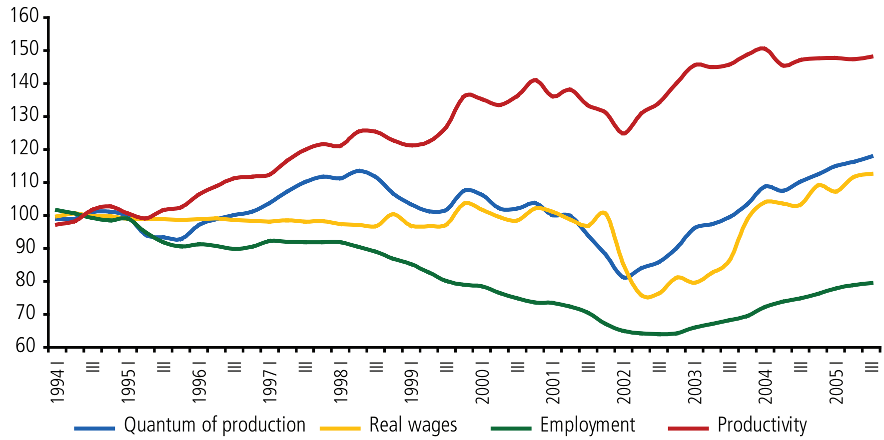


Source: Elaborated by the authors on the basis of official figures.

In contrast, there was a remarkable loss of social capital in broad sectors of the economy that were unable to adapt to the new scheme, so the majority of activities resorted to survival strategies, moving from the world of production to the world of assembly and commercialization of imported inputs and products. The end result of these processes was a pattern of export specialization excessively concentrated in primary products. At the same time, productivity increases came to be associated with the dismissal of labor and a merely negligible promotion of new production initiatives.

The economic reforms caused imbalances, diverse contradictory phenomena and heterogeneous responses. Since economic processes are evidently non-linear, it is necessary to avoid the pitfalls of oversimplified analytical models. For example, privatizations and public service concessions, though set within the framework of insufficient and inadequate regulatory schemes, succeeded in setting in motion the substantial modernization of the telecommunications, energy and port infrastructure systems, among others. Furthermore, during a certain period of the post-convertibility transition, there was a generalized perception that a process of massive destruction of entrepreneurial capacities had occurred. However, the business sector once again displayed a remarkable capacity to adapt to contexts of excessive uncertainty and loss of institutional quality. It was thus that industrial firms and natural resource enterprises adopted a position that allowed them to continue to operate and survive the widespread closure of companies. The following pages attempt to bring to light some of the factors underlying the historical events from the perspective of economic analysis.

FIGURE 5
Microeconomic adjustment - manufactures (1994-2005)



Source: Elaborated by the authors on the basis of official figures.

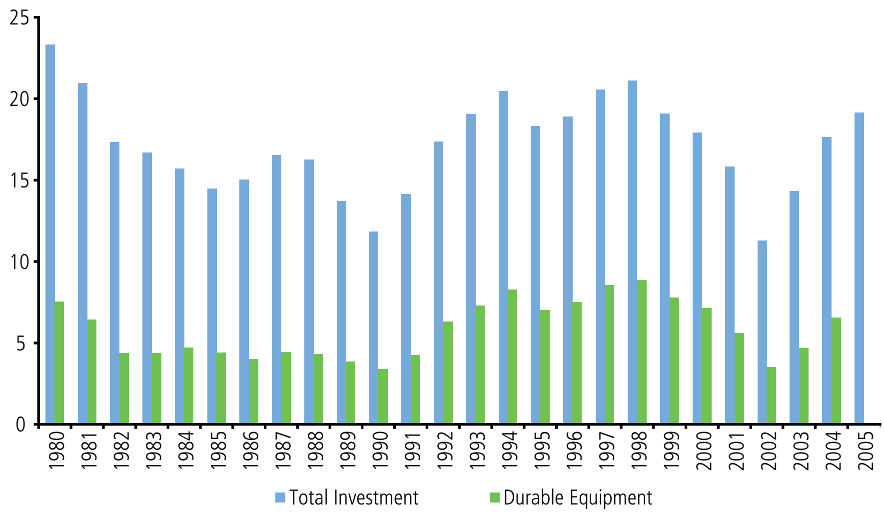
3 INVESTMENT DECISIONS AND ACCUMULATION OF CAPABILITIES UNDER HIGH AND CHANGING UNCERTAINTY

As noted above, instability and elevated uncertainty are essential issues for understanding Argentine industrial performance during recent decades. The economic history of Argentina demonstrates that in unstable economies with high uncertainty, flexibility is a very valuable and tremendously profitable attribute. This fact should not be ignored when analyzing the decision-making processes of economic agents.

In contexts of high volatility and low institutional quality there is great uncertainty – which manifests itself in a multitude of ways – concerning the evolution of the economy. The planning horizon of firms therefore becomes shorter. From a productive perspective, microeconomic behavior in general translates into a predominance of defensive strategies that negatively affect the "animal spirits" and long-term growth, feeding back on the unstable workings of the system. Under these circumstances, the prevailing attitude becomes one of reluctance to invest in specific assets or commit to long-term strategies. Regarding investment in fixed capital, as well as in intangibles and human capital, the maxim seems to be one and only one: "wait and see." Thus, in Argentina, uncertainty and recurrent macroeconomic fluctuations induced microeconomic behavior that resulted in low growth and reinforced tensions at the aggregate level.

In general, the economic activities of companies involve the willingness to invest in specific assets with different degrees of irreversibility. When the decision to incur significant sunk costs can be postponed, the company has the "option" of delaying the investment and keeping its alternatives open. For this reason, in highly unstable scenarios, the economic value of "waiting" increases so that, in turn, the accumulation of capital in the present does not exclusively reflect the discounted value of future returns on investments. Firms must also be compensated for giving up the "option", that is, for not being able to wait until they have a better understanding of the consequences of pursuing different choices. Thus, even in the case of projects with positive net present values, companies may decide to postpone their investments. Within this perspective of "real options," the greater the uncertainty, the higher the threshold of profitability that companies will require in order to invest in the present (DIXIT; PINDYCK, 1994).

FIGURE 6
Gross fixed investment (Total and durable equipment)
(% of GDP)



Source: Elaborated by the authors on the basis of official figures.

The extreme volatility of the eighties drove economic agents to develop special capabilities to endure the situation. With average annual consumer price variations over 500% between 1982 and 1990, accompanied by sizable changes in relative prices and two hyperinflationary processes, along with frequent and abrupt modifications in economic policies and the inherent instability of the transition towards democracy, very little margin was left for making investment decisions that involved high entrepreneurial risks or substantial sunk costs, or that demanded astute capacity on the part of economic agents to foresee future scenarios. In fact, this highlights the importance of public policies: industrial policy attempted to resolve the uncertainties associated with basic inputs (uncertainties partly generated by public policy itself).

In the early nineties, the expansion of the decision-making horizon introduced a change of primary importance for the formation of capital. A decade of "investment crises" had been left behind and a wide range of opportunities for the modernization of production capacities was therefore opening up. However, the sudden modification of the competitive environment and of the "rules of the game" introduced new uncertainties. The analytical frameworks that had served for the semi-closed economy were useless for evaluating decisions relative to investments in specific assets, to the incorporation or replacement of lines of production, to in-house human resource training, or to the identification of a technological learning path within the context of an open economy (KOSACOFF, 2000).

The development of an investment strategy begins with ascertaining which measures are necessary for surviving and prospering in a specific economic environment and subsequently determining if the firm can put these measures into practice. Factors that must be taken into account include the level of vertical or horizontal integration of the company, its degree of participation in international flows, the pace of its technological progress and the ownership advantages with which it is endowed. Despite the prominent role played by financial, technological and organizational aspects in the transfer of some domestic companies to foreign hands, in certain cases the recognition by local businessmen that they would be unable to adequately respond to the challenge of operating in an open economy and in the context of a high degree of internationalization was decisive. Under these circumstances, the strategies defined by the corporate offices of transnationals proved crucial to diminishing some of the uncertainties.

In the nineties microeconomic uncertainties prevailed in the industrial sector. Argentina became a laboratory for analysis of the response of economic agents to market reforms. It was demonstrated that microeconomic actions have their own timing and their own sequence, and that this cannot be ignored when considering the overall consistency of a model seeking to explain the functioning of an economy.

In addition, given the change in economic regime that occurred in the nineties, it was hard for economic agents to discern cycles from trends. As a consequence, some firms and investors made economic decisions based on erroneous forecasts concerning future income and demand growth. Also, in the midst of the boom in corporate mergers and acquisitions, the valuation of local firms incorporated growth projections and commercial partners. This mistaken perception of trends came to determine long-term investment; in turn, economic performance itself was modified, as well as the perceptions of other actors, who also had to grope their way to forecasting future evolution.

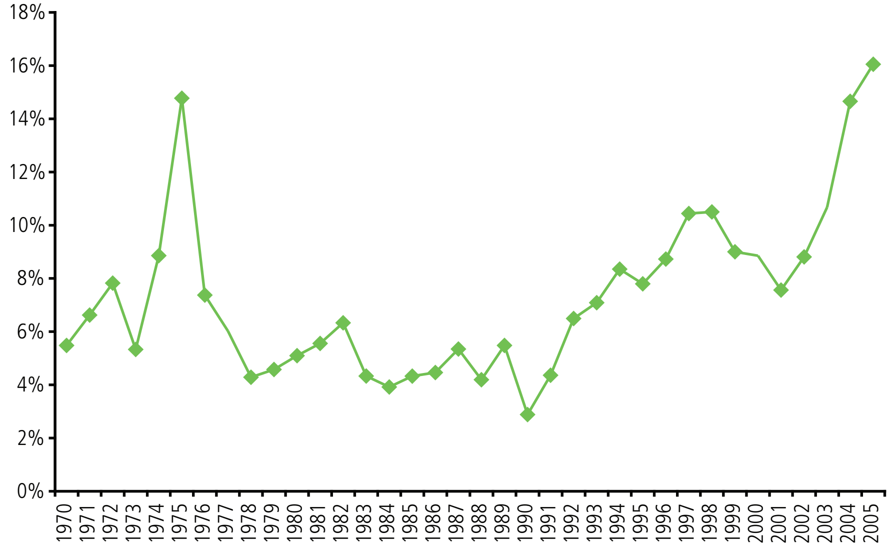
As a result, some of the investments made in the middle of the decade assumed overly optimistic scenarios in terms of economic returns and generated a growth of the financial debt of companies that became difficult to manage in the context of lower returns and the greater weight of interest resulting from sharp restrictions to financing in general. Constantly increasing real interest rates drove companies to levels of debt that often exceeded the value of their assets. Thus, during the period 1998-2001, financing at 25% per annum within a context of price deflation resulted in a generalized process of summons-to-creditors meetings.

Since the abandonment of the convertibility regime, the average real exchange rate has been almost double that which presided over the economy for almost a decade. Nevertheless, in recent years, the importation of final goods has been the alternative adopted by industrial firms – especially the larger ones – that have reached the limit of their installed capacity and still face excess demand from the domestic market. In aggregate terms, purchases of foreign goods during the first six months of 2005 were similar to those in 1997, when, with a comparable GDP, the exchange rate was considerably lower.

In this situation, two distinct economic arguments as to the behavior of local companies seem applicable. On the one hand, there is the above mentioned argument concerning the effects of uncertainty on economic decisions involving irreversible but deferrable investments: a reticent attitude towards long-term commitments and a preference for "the wait option." As a consequence, when long-term prospects are unclear, numerous local companies find it easier to import than to invest, develop suppliers or train human resources. This is particularly so because importing can be self-financed and completed in a few months, while investing implies borrowing today in order to make irreversible commitments involving high uncertainty tomorrow.

On the other hand, a variant of the "beachhead effect" may be applicable. In the mid-eighties, there was a revival of interest in research on the effects of the real exchange rate on the evolution of exports and imports in an economy. In this period, the American dollar displayed strong oscillations relative to the major world currencies. Initially, its persistent appreciation and the subsequent rise in imports affected the market positions of a broad set of local companies in the United States and opened a debate as to whether the return to levels considered sustainable would reverse those losses in market share.

FIGURE 7
GDP import coefficient, in current dollars



Source: Elaborated by the authors on the basis of official figures.

Within this context, several theoretical works emphasized the existence of hysteresis in the interaction between the exchange rate and international commerce.[10] The basic assumption behind these models was that a company that does not export must pay an entry cost to access the international market and that this cost is characteristically a sunk cost. As a consequence, given the so-called "beachhead effect," they suggested that imports would decrease more slowly than expected as the dollar weakened. This would occur because foreign exporters, once having invested in distribution channels, marketing, research, development, reputation, etc., would only expect to cover operating costs to stay in the market. Even if the real exchange rate were to return to its previous level, the trade pattern would not. Although still few in number, there are studies available that provide empirical evidence on the role of exchange rates in the microeconomic decisions of firms to enter or exit export markets.[11]

A variant of this hypothesis is applicable to the interpretation of certain business attitudes observed in Argentina. Based on this theoretical variant of the "beachhead effect," the persistence of the open economy model stimulated a set of learning processes that were reinforced by a high real exchange rate that later became unsustainable. In fact, a salient feature of the productive structure of the nineties

10. Baldwin (1988), Baldwin and Krugman (1989). Models were even presented in which those decisions prompted by overvaluation induced a permanent reduction of the equilibrium exchange rate of the economy.
11. Campa (1993, 2000), Roberts et al. (1995), Roberts and Tybout (1997).

was that industrial firms adopted a strategy that combined local production with the importation of inputs and final goods so as to take advantage of the new rules of the economic order. In this way, the establishment of import channels for local companies during the convertibility regime implied the development of experiments, routines and the payment of certain sunk costs that were not compensated once the macroeconomic situation changed.

4 FINANCIAL MARKETS AND MICROECONOMIC BEHAVIOR

From a long-term perspective, the weakness of the financial intermediation structure is a basic characteristic of the evolution of the Argentine economy. Meager financial deepening, plus the absence of certain long-term markets, of risk management and of liquidity management markets have been permanent attributes affecting the investment process. In fact, in the Argentine case, several studies have stressed that the weakness of capital markets impaired the selection of investment projects, resulting in the absence of a strong entrepreneurial core, which translated into serious difficulties in dampening the fluctuations in cash flows and diversifying company risks.

Usually, such characteristics in the microeconomic functioning of an economy induce greater macroeconomic instability and the development of abrupt stop-and-go processes. In principle, in such an economy it is hard for consumers and businesses alike to distribute the effects of a reduction in current income over time. Consequently, faced with negative shocks to the economy, economic agents tend to contract current expenditures beyond the extent to which they would do so in economies with more complete financial markets, thereby disrupting the level of aggregate activity to an even greater degree and generally causing a recession. If such a recession expands, the financial position of firms and individuals deteriorates even further, possibly to the point of affecting their solvency and perhaps even that of the economy as a whole.

The role of financial factors in amplifying shocks to an economy has been a topic of interest in economic research in recent years (BERNANKE *et al.*, 1994; HUBBARD, 1998). Certain imperfections in financial markets provoke discrepancies – variable throughout the business cycle – between the cost of own funds and funds from outside sources. These can magnify relatively small shocks, which reduce the equity and affect the value of the collateral of the firm. “Financial accelerator” models, which attempt to explain the effects of these operating characteristics on aggregate economic fluctuations, have been developed even for economies with far more complete financial markets than that of Argentina.

Despite these indissoluble attributes of the intermediation structure of the country, Argentine industrial history can be divided into two distinct periods in terms of the modes for financing manufacturing activities. The first began in the mid-forties and was symbolized by the creation of the Industrial Credit Bank (*Banco de Crédito Industrial*) for the explicit purpose of offering subsidized financing to companies. It was a period in which the international prospects raised questions concerning the future after the rapid Argentine industrial growth of the crisis and World War II years. This period came to an end with the drastic change in the previous rules of the game as a result of the Financial Reform of 1977.

A prominent characteristic of this period was that industrial companies were net financial debtors of the rest of the economy within a context of negative real interest rates. Guadagni (1972) showed that the real interest rates of the banking system applicable to loans registered positive values in only four of the 22 years between 1950 and 1971.[12] Despite the fact that the inflation rate displayed wide fluctuations and that on average it was almost 30% per year (with annual peaks exceeding 100%), nominal interest rates in the banking system experienced few modifications and reached a maximum of 16% in the final year of the period under consideration. In addition, under these highly inflationary conditions with interest rates controlled by the monetary authority, families came to demand less financial instruments and more real assets (particularly durable goods such as homes and vehicles). A similar process occurred in businesses, where the importance of real assets, such as inventories, increased. With loans generally granted in line with government economic policy, industrial companies organized production in accordance with criteria stemming from borrowing at negative interest rates. As a consequence, from the forties and until the mid-seventies, negative real interest rates for industrial producers transmitted a clear message: "Insofar as possible, borrow in order to participate in the markets protected from international competition."

From the end of the seventies on, once attempts were made to open up the economy, the financial mechanism described changed substantially. The preferential access to financing at negative real interest rates that productive activities had enjoyed during the import substitution stage was eradicated by the Financial Reform of 1977. The main features of the new system were the autonomous setting of interest rates by financial entities; a lack of constraints on the granting and orienting of credit; an absence of restrictions as to the entry, operations and competitive strategies of these entities; and the freedom to obtain credit from foreign sources. In addition, the National Development Bank (*Banco Nacional de Desarrollo*)[13] practically abandoned its guidance of overall industrial development and came to concentrate on the reduced number of large companies that were the beneficiaries of the industrial promotion schemes.

12. This behavior had its counterpart in that in 21 of those 22 years of inflation with controlled interest rates, the rates on deposits were negative. Therefore, those who saved (as well as other economic agents) contributed through this "tax" to financing the borrowers in the system, as well as the financial intermediaries themselves.

13. The Industrial Credit Bank (*Banco de Crédito Industrial*), founded in 1944, underwent several modifications in its structure, range of action and form of operation through the years. Even its name was changed: to the Industrial Bank of the Argentine Republic (*Banco Industrial de la República Argentina*) in 1952, and then to the National Development Bank (*Banco Nacional de Desarrollo*) in 1971.

From that time on, except for brief exceptions, high real interest rates persisted throughout the system. At times, these rates so exceeded the levels that would have allowed for any possibility of productive profitability that it became more lucrative to invest in external liquid assets or in public sector debt. In fact, the persistence of high positive real interest rates often diverted resources towards non-productive investments. Within a context of strong macroeconomic turbulence and high interest rates, the fate of many companies was determined by the ability of their financial management to administer net balances and adapt productive models to the new restrictions. The persistence of high positive interest rates had a strong impact on the rationality of industrial organization. The financial weight of excess inventory management, of the administration of discontinuous processes with lengthy dead times, of the lack of systematization in purchase systems, etc., resulted in the gradual incorporation into the production layout of automation technologies ranging from process control and inventory management to improved quality control systems, among others.

According to economic theory, increases in real interest rates cause reductions in company inventories. However, for a long time empirical research failed to find conclusive evidence to support this idea (BLINDER; MACCINI, 1991). This cast considerable doubt on the existence of one of the traditional channels by which it was suggested that monetary policy affected investment. A more recent line of research proposed that the answer might lie in the dynamics of the real interest rates themselves, which exhibit temporary variations around stable average values during extensive periods (regimes). In this way, firms would only modify their decisions concerning inventory levels to the degree that they perceived a change in real interest rates over time, that is, as a change in regime - a situation that is generally uncommon. There is some evidence that supports this hypothesis (MACCINI *et al.*, 2004).[14] An argument of this type could account for the behavior displayed by Argentine industrial companies described above.

In the history of Argentine industrial development, self-financing (especially profit reinvestment) has come to represent an increasingly important source of funds for firms. During ISI, high levels of protection and the concentrated industrial market structure itself allowed for domestic prices that were substantially higher than international prices to finance capital accumulation by firms. The legal frameworks for industrial promotion constituted another key mechanism for fostering investment. In the case of bank credit, until the mid-seventies, the larger firms had readier access to credit and collateral (within a context of excess demand), while the main form of financing for the remaining companies was commercial credit. In fact, direct investment by international firms had existed in Argentina since the very beginning

14. Other studies postulate that in the short run the level of inventories is more influenced by financial restrictions and the company's availability of internal resources than by the real interest rate itself (KASHYAP *et al.*, 1994; GERTLER; GILCHRIST, 1994). However, in the long run, financial conditions permitting, firms will adjust their inventories in accordance with the prevailing interest rates.

of its industrialization process. Since these firms enjoyed privileged access to local credit at negative interest rates, they operated with financing that was, to a large extent, from the local capital market.

The change in the real interest rate regime entailed modifications neither in the persistent internal segmentation in terms of access to financing, nor in the discrimination that particularly affected the smaller companies. This segmentation was not neutral even for the financial administration of the larger companies since these companies interacted with the small and medium-sized enterprises that were their suppliers and clients and often acted as their financial and capital market substitutes for the purpose of overcoming the above mentioned imperfections. The participation of large firms in reciprocal collateral systems, for example in the steel and aluminum sectors, is representative of this situation.

Credit rationing is a direct result of the effects of the information asymmetry in these markets. In the case of smaller firms, these effects are aggravated by the accounting and administrative structures that characterize them. In a case often presented in economic theory, the combined effects of interest rates on the interests charged on credit and on loan portfolio risks (originating in problems of moral hazard and adverse selection) result in a supply curve for credit institutions that does not always coincide with increases in the interest rate and that can therefore lead to credit rationing (STIGLITZ; WEISS, 1981). One way to reduce these problems (though not eliminate them completely) is to introduce high requirements in terms of real collateral. In addition, in the case of Argentina, the banks displayed a notable lack of ability to correctly evaluate projects. Thus, to a considerable extent, efficiency problems in risk assessment impacted directly on productive processes.

During the transition from a semi-closed to an open economy, the degree of access to financing placed the local offices of the transnational corporations and the large local economic conglomerates in very different positions. The former had better access to international capital markets than the latter, as shown by the empirical evidence. In some cases, the problems faced led large locally owned companies to sell their market positions due more to the imperfections of the capital market than to their own technical and productive limitations. In other cases, local companies found it impossible to dissociate their national origin from the sovereignty risk of the country. This distortion was one of the factors that motivated the purchase of the American oil company Maxus by the company known at the time as simply YPF.

It is also interesting to corroborate the association that existed between financing and the process of internationalization. Financing restrictions were among the most important factors limiting the internationalization success of Argentine companies. This phenomenon and its consequences were analyzed by Kosacoff (1999). The experience of the telecommunications company IMPSAT is revealing concerning the central role played by financing in internationalization.

In an early stage, the firm sought a technological alliance in order to increase its capabilities and earn a reputation in the international market. For this purpose it partnered - with a participation of 25% of the capital - with the Italian firm STET. To the degree that it positioned and acquired prestige, the limiting factor for international growth became financing at international rates. Therefore, in a second stage, it switched from its technological partner to the investment bank Morgan Stanley. Such cases illustrate that, while a business strategy that does not consider a complementary financing plan is unthinkable, it is undeniable that financial aspects assume magnified dimensions in projects associated with international expansion.

In Argentina, the hyperinflationary episodes of the late eighties and early nineties shrank the financial markets almost to the point of disappearance. Due to the conditions prevailing during the convertibility regime, there was a substantial rise in the demand for financial assets (usually denominated in foreign currency) and in financial deepening.[15] Moreover, the increase in the supply of financial assets and the initial decrease in the sovereignty risk allowed certain firms access to the voluntary market for international credit, which had been inaccessible to them in the eighties. This access was further facilitated in the nineties by international markets characterized by greater liquidity, a fall in rates and the appearance of new instruments. A tendency therefore arose to increase the levels of leverage.[16] Argentina became a learning laboratory for the business management of operations in international capital markets. As a result of this process, finance departments developed sophisticated capabilities for managing the various options arising from the opening of markets. The majority of these companies opted for new instruments, which included negotiable obligations launched in local and international markets; credit lines originating in international financial organs; participation in stock and derived instrument markets; and so forth. These types of operations required greater company transparency, among other elements, due to the stricter rules of the international stock exchanges and regulations aimed at protecting stockholders.

During the convertibility regime, the volatility of capital flow and its effect on the credit supply and the level of activity was a source of potential financial fragility. Also, industrial firms absorbed the fall in profit margins owing to competition from imported products by commercializing greater volumes. Placing products on the market implied credit transactions with terms of from 150 to 180 days. This process occurred within a payment chain that was sensitive to economic

15. Whereas in 1991 the total value of credit in the economy had been around 5% of GDP, towards the end of the nineties it reached values of approximately 25%. Also, the dollarized credit portfolio in the financial system increased from less than 40% to almost 70% of the total.

16. Bebczuk, Fanelli and Pradelli (2002) calculated that between the quarters 1992:I and 2000:III the net wealth of a certain set of companies listed on the stock exchange increased 22% in real terms, while the total debt of these firms rose 221% over the same period.

fluctuations. Consequently, in order to offer such commercial credit operations, industrial firms increased their levels of debt in dollars. Along the same lines, the relationship between firms' long-term debt (in dollars) and short- term debt varied in a procyclic fashion. Although it made longer terms possible, the dollarization of debt caused a substantial rise in the devaluation risk, given a financial structure with income flow in local currency. Thus, negative shocks reduced leverage as well as the duration of debt, for as the equity of a company shrinks, creditors transfer their demand towards less mature debt. This increases the vulnerability of the firm since it has to finance longer term assets with short-term liability. This process continued given that it encouraged creditors to cut terms even shorter.

After the collapse of convertibility, starting in mid-2002 the progressive normalization of markets and the attenuation of uncertainty were related to the activation of domestic demand. Due to the dramatic reduction in labor costs and the postponement of increases in the prices of public services, larger business margins came to be the source for financing production. In summary, although physical volumes fell nearly 20%, this coincided with an abrupt recovery of operating flows. Companies markedly reduced the terms of their commercial operations, arriving at a situation of nearly exclusive cash sales. For a long time, firms' operating costs (wages, public utility fees, taxes, rent, etc.) remained practically unchanged in nominal terms. In contrast, the prices of tradable goods increased significantly. The result was a marked improvement in profit margins which, along with the cash flow recovery, allowed for the self-financing of investment and the restructuring of debt. Business self-financing is an extended characteristic that will most probably continue. However, in order to grow in a sustained fashion, Argentina needs a new spurt in the investment rate because this greater accumulation of capital has to be financed. The creation of long-term financial markets and a more explicit orientation of the credit system towards the selection and financing of investment projects therefore seem inevitable.

5 TECHNOLOGICAL CAPABILITIES AND THE SUPPLY OF SKILLS

The industrial structure that emerged with ISI was characterized by small-sized production plants; high vertical integration; the application of design, process and organization technologies far behind the international state of the art; "short series" production along with a ample mix of manufactured products; and internal technological efforts aimed at copying or adapting foreign technologies through minor changes.

During ISI, the size of a typical industrial facility was not even a tenth of the scale of a similar production plant in a developed country. In addition, given the immaturity of the productive structure and the absence of independent parts and spares suppliers, the degree of vertical integration of these companies was much higher than the prevailing level in the industrialized world. The production of "short series" of various products caused local companies to suffer considerable losses in terms of economies of scale. Similarly, layout and organization technologies had a rudimentary character that increased the incidence of dead time (KATZ, 1986).

The technological challenge for industrial firms was to adapt and assimilate knowledge of foreign origin in a local environment with different relative prices, less division of labor and high transaction costs. These conditions induced companies to search for incremental improvements in their productive performance. However, in order to incorporate knowledge (and at the same time generate new knowledge), it is necessary to master additional know-how. Numerous companies therefore aligned their efforts to the features of the local context by creating engineering departments within the firms themselves for the purpose of improving product design, the manufacturing process itself or the organization of labor. Because they faced the same incentives as domestic firms, this behavior was displayed even by local subsidiaries of transnational companies, which, from the technological point of view, followed the same path despite the fact that they claimed to possess know-how applied by the company in the developed world.

From the perspective of static efficiency, as well as from that of the dynamics of the technological learning path, this set-up resulted in an accumulation of knowledge and idiosyncratic characteristics that did not converge with the international technical frontier. For this reason, it is difficult to label this set of activities as immature industry, given that its evolution implied a final result that would not be arrived at by other societies. Despite the fact that it gradually diminished the productivity gap and allowed for import substitution in a protected market, the "evolution dynamics" of ISI did not aim to increase either the international competitiveness or the export capacity of firms in a systematic fashion until far into the seventies (KATZ; KOSACOFF, 1998).

Similar to what happened in the semi-closed substitution economy, the knowledge and technology employed during the nineties were of foreign origin. However, the sudden opening of the economy and the exaggerated overvaluation of the real exchange rate imposed ferocious competition with state-of-the-art products. These conditions, which provided the framework for the economy, introduced new technological dynamics that were very different from the pattern observed during ISI. From a technological perspective, the increasing internationalization of production required specialization in products that were technically compatible with international standards. Thus, through progressive foreign supply, the process tended to reduce the pre-existing gap in product technology while, at the same time, efforts to develop new products or processes or to adapt foreign technologies were minimized. In addition, this process occurred within a context of a continuous weakening of the domestic supply chain.

In this way, the processes of integration into international commerce networks were intensified for a wide range of firms. This led to progress in specialization and simplification of the production mix, both of which coincided with productive disintegration and a stronger reliance on commercial chains (CIMOLI, 2005). As mentioned above, from the perspective of international comparison, the typical plant of the seventies had, among other characteristics, a relatively small production scale and a significant productivity gap. In the nineties, although some modifications were introduced, it can be said that, in essence, those features were maintained. Some studies have shown that most of the industrial plants substantially differed in size compared to their competitors in Brazil as well as in the rest of the world.[17]

With regard to the direction of the innovation processes, it can be said that, driven by the signals in relative prices, the innovation activities of local companies were mainly concentrated in the purchase of technology embodied in capital goods.[18] Along the same lines, other internal and external sources of knowledge and capacity building such as investment in research and development (R&D),[19] transfer of technology, industrial engineering, management, training and consulting, displayed relatively little importance. The resulting imbalance threatened the development of important capabilities, even those necessary for taking full advantage of the equipment introduced. Taken together, investment by manufacturing companies on innovation activities (particularly R&D) was limited in absolute terms and inferior to that of other countries in the region as a proportion of turnover. According to the Second Innovation Survey, expenditures on innovation activities by Argentine industrial firms varied from 2% of total turnover in 1998 to 1.6% in 2001, while the corresponding index for R&D outlays was between 0.2% in 1998 and 0.3% in 2001.[20]

In other words, with little investment in R&D in absolute as well as relative terms, industrial companies tended to increasingly rely on sources external to the firm for their technological endowments, mainly through the purchase of capital goods and information technology. This complemented the fact that imports became the most dynamic factor for technology supply, especially in

17. In a comparative study of scales of production, it was shown that local plants were smaller in 78% of the 408 cases analyzed. In those cases in which larger or equal scales existed, it was observed that 35% corresponded to the food sector, followed by chemicals and petrochemicals with 30% (DEPARTMENT OF ECONOMIC PROGRAMMING, 1994).

18. Purchase of capital goods and hardware accounted for more than 70% of the expenditures on innovation activities (INDEC; SECYT; ECLAC, 2003). Also see Anlló and Peirano (2005).

19. The Argentine private sector displays scant participation in R&D (between 20 and 25%) within a domestic outlay (0.4% of GDP in 2003) that in itself is lower than average for the region and very low when compared to that of other newly industrialized countries (SECYT-MINISTRY OF EDUCATION, 2005).

20. In 2000, in the cases of Brazil and Uruguay, expenditures by companies on innovation activities in relation to sales were 3.8% and 2.9%, respectively, while the R&D indicators were 0.7% and 0.4%.

the case of embodied technology but also in that of disembodied technology (YOGUEL; RABETINO, 2002).

In addition, stronger international competition forced a reaction that led to greater concern with the acquisition of organizational technologies. In particular, due to the modification of production systems incorporating new criteria based on flexibility and specialization (subcontracting, quality management, just-in-time, etc.) and to the consolidation of forms of production organization that were unusual in the seventies (national economic conglomerates, alliances between local and foreign companies, complementation agreements, etc.), large national and international consulting companies displayed high levels of activity during part of this period (FUCHS, 1994), mainly through the introduction of quality certification (RAMOS, 1995).

Another characteristic of this period was the productive retreat of "technology intensive" sectors, considered the engine of the most successful newly developed economies. In fact, the drop in output in local chemicals and pharmaceuticals, some capital goods, and electronics and telecommunications, deprived the local economy of the spillover effects that their development normally produces. Although different business strategies for the introduction of technological and organizational innovations coexist, recent studies suggest that those that dominate Argentine industry are not those that offer a greater probability of reaching solid and extensive competitive improvements in international markets. In general, there is an absence of strategies aimed at conquering new markets in higher tech productive sectors. The economic scheme prevalent since the collapse of convertibility does not yet seem to have induced significant changes in business innovation strategies. The "wait and see" attitude continues to be the rule.

Finally, the modernization and expansion of agri-food production during the nineties (resulting in double the annual tonnage of oil seeds and cereals in relation to the previous decade, among other effects) allowed one of the main restrictions of the substitution system to be overcome. This development arose from the introduction of a set of innovations and of a complementary capitalization process in the primary sector that brought about a radical change in its productive structure. The widespread use of technologies originating in the developed world and commercialized in Argentina by transnational corporations led to the expansion of the agricultural frontier. Some examples are the incorporation of genetically modified soybean, corn and cotton seeds; a greater use of fertilizers and agrochemicals; the proliferation of direct seeding and double cropping; improvements in animal genetics; the development of feedlots in beef production and of new dairy techniques; and the use of new field storage technologies (IADB; ECLAC; MINISTRY OF ECONOMICS, 2003; BISANG, 2003).

In summary, within a framework of heterogeneous measures, industrial firms tended to display technological behavior associated with foreign supply, the dismantling of equipment for projects with greater local participation and an appreciation of organizational aspects, not only in production, but also in marketing and finance. The growing tendency towards the adoption of product technology of foreign origin at levels close to the best international practices went against the generation of local adaptive efforts. This tendency implied a smaller gap in terms of product technology, but a significant loss in the acquisition of domestic capabilities through research and development activities. However, the massive incorporation of imported machinery and equipment was necessarily accompanied by organizational changes and by greater investment in training. Also, the trend towards deverticalization of production was consolidated, basically through the use of imported parts and spares, reducing the probability of creating production networks based on local subcontracting and having pronounced negative effects on the labor market (due to lower direct and indirect labor requirements, as well as the loss of the "learning by doing" qualification of human resources).

6 HETEROGENEITY AND ECONOMIC AGENTS

Perhaps the most salient aspect of the shape of production during the nineties was heterogeneity. It is undeniable that the various economic agents responded in various ways to the challenges involved in the transition to new productive strategies that combined local production with the importation of inputs and final goods to take advantage of the new economic rules of the game.

Within an overall industrial apparatus of lesser size, a set of companies has grown that has surpassed not only their own previous productivity levels but has also achieved international efficiency and best practice standards. Pre-eminent in this group are activities in the agro-food and basic sectors, the latter having been significantly restructured in relation to the public policies of the past. The most representative examples are the large steel and aluminum plants, oil refineries and petrochemical complexes. At their current levels of efficiency, these operations are capable of generating excess supplies that are sold abroad. Also in this group are various facilities in the automotive complex and several firms that have expanded in the mass consumption market. This group is characterized by its "offensive" restructuring, and a significant portion of its production is exported. Exposure to international markets has motivated these firms to increase their efforts to achieve higher productivity levels. Although the whole group consists of no more than 400 establishments, it represents approximately 40% of total industrial output.

In contrast, the rest of the productive network is characterized by having responded with so-called "defensive" behavior. These companies, despite their advances in productivity relative to their own pasts, are still far from the international technical frontier and continue to display certain features of the substitution strategy, such as small scales of production and limited economies of specialization (KOSACOFF, 2000).

In some cases, activities based on natural resources have generated downstream effects that have also resulted in the attainment of high levels of competitiveness. Such are the cases of the candy industry, fine wines, oils, dairy products and lemons, among others. However, the aggregate behavior of these dynamic areas has not been strong enough to exert a macroeconomic impact and spread to the remaining activities. Within the framework of the recent structural changes in the Argentine economy, modifications in business strategies and behavior have proven to be highly complex processes, far removed from instantaneous adjustments and strongly influenced by history, context and the firms' own perceptions of the future. If there is one factor that emerges as a distinguishing feature of business strategies and decisions, it is heterogeneity. Firms have not followed a common pattern; rather, based on their own specific assets and advantages, they have taken different directions and postulated disparate long-term visions and objectives.

Although it does not yet attest to a pattern of specialization, in recent years a body of evidence has evolved that shows the economy in conditions to develop more sophisticated productive processes based not only on natural resources but also on human capital and technology. There are notable cases such as those of the firms EDIVAL and BASSO (engine valves) in the district of Rafaela or TRANSAX (gear boxes) in Cordoba, the production of fine wines in various provinces, ARCOR (candies), the Santa Fe Province dairy complex and INVAP (nuclear reactors), among others. These success stories unquestionably coexist alongside many instances of failure, hence the significance of undertaking case studies that give due importance to the vital role played by historical evolution.

An analysis of firm behavior based on the concept that holds companies to be complex organizations that evolve over time through an interactive process with the market and institutions requires an approximation that simultaneously includes a large number of determinants. For example, EDIVAL was created in the mid-fifties in the city of Rafaela as a family-owned company that produced engine valves using rudimentary methods. Initially, it sold in the spares market and benefited from the passion for the sport of car-racing that existed in that city and its surroundings. Then, at the outset of the sixties, its founders traveled to Europe with the intention of obtaining quality materials and learning how their product was made in industrialized countries in order to reproduce these methods in Argentina. After developing machinery and operations similar to those in Europe and making enormous efforts to meet technical standards, EDIVAL began to conquer the finished product industry established in Argentina at the end of the sixties. In the mid-seventies, aided by a locally earned reputation, the company decided to enter the U.S. market with its competition valves and road cars. It thus discovered a difficult but profitable market niche: the high performance competition market, which allowed it to advance during almost a decade until it was able to enter the international market for standard valves. This latter achievement was attained only in the mid-eighties, when it signed a sizable contract in the United States that marked the transformation of the company into an exporter of original equipment in some cases, and, in others, into an alternative in the spares export market.

Thus, EDIVAL evolved with the needs of the world market while most Argentine companies continued to operate in an almost totally captive market. During the nineties, trade liberalization and the appreciation of the local currency, combined with a generational change in management, complicated the evolution of the company. Even within this context, a decision was made to undertake a risky project: to become a global player in the original equipment supply market. In 2002, once the company leadership had been thoroughly professionalized, EDIVAL purchased a plant in Portugal with a view to increasing its production capacity and "getting closer" to European clients. Today, EDIVAL is the fourth ranked producer and exporter of valves in the world and supplies automotive producers at their headquarters worldwide despite the distance that separates them from the city of Rafaela.

As Ascúa pointed out in his study of the company,[21] "the case of EDIVAL is interesting not only from the historical point of view, but also from the academic stand, especially in order to better understand globalization processes and their impact on developing countries. For fifty years, this company of humble beginnings has shown that it is possible to build a business model that generates dynamic competitiveness, competing first with other domestic firms and later with dominant transnational ones." Despite the fact that each company unquestionably has its own characteristics, its own limitations and its own history, the evolution of EDIVAL provides lessons for other companies by teaching the importance of staying on the growth path by constantly adapting business strategies; of enhancing the ability to identify and take advantage of opportunities; and of emphasizing the development of technical capabilities and continuous learning

INVAP is another such example. It was created through an agreement between the National Atomic Energy Commission (CNEA) and the government of the Province of Río Negro. It is well known as an exporter of nuclear facilities, together with control systems and equipment for nuclear technology. It has also exported cobalt-therapy machines, automation systems and equipment for industrial projects.

The story of INVAP began in the late forties with the Huemul Project for the construction of an atomic assay lab. The failure of this project resulted in reorganization of the company in the early fifties and the taking on of a new task,

21. Ascuá (2003).

that of developing knowledge and technologies for an Argentine nuclear complex. It is thus that the Bariloche Atomic Center (CAB) was created to pursue the study of certain fields of knowledge in response to the specific demands of CNEA. At the end of the fifties, CNEA launched the first experimental reactor built in the country. Then, in the early seventies, CAB created a Department of Applied Research to take advantage of the experience acquired in the field of experimental research in order to work on problems of a practical nature. This step was associated with the decision to build the first nuclear plant in the country.

In the middle of the seventies, INVAP was created from a division of the Applied Research Department. Within an international setting of strong restrictions on the acquisition of nuclear technology, INVAP initiated its activities when contracted by CNEA to manufacture equipment to supply combustible elements for a second nuclear plant. In the eighties, the technological progress made by INVAP allowed it to obtain its first turnkey-plant export contracts. When the crisis of the late eighties diminished resource availability, the company drastically reduced its staff. Some of its former employees created their own companies and became its suppliers. INVAP entered new fields related to space activities and communications and information technology. Finally, the nineties were the decade in which INVAP consolidated its take-off. During this period, it deepened its penetration of foreign markets as a supplier of nuclear technology, a trend that culminated in 2000 with its winning a contract for the construction of a research nuclear reactor for Australia (LUGONES; LUGONES, 2004).

Thus, any effort to explain the complexity of such phenomena is necessarily partial and subject to limitations. The perspective provided by evolution theory is a key element to understanding these long-term processes with their ups and downs and their co-evolution with macroeconomic dynamics. Despite the striking dearth of company case studies, there are some works that merit mention, such as Gutiérrez (1999), who analyzed the evolution of IMPSA; Kosacoff *et al*. (2001), who studied the ARCOR group; Ordóñez and Nichols (2003) and the Grobo case; Vispo and Kosacoff (1991) for the analysis of IBM Argentina; Schvarzer (1989) and the experience of Bunge and Born; Artopoulos (2004) and the Teching group; and Barbero (1998).

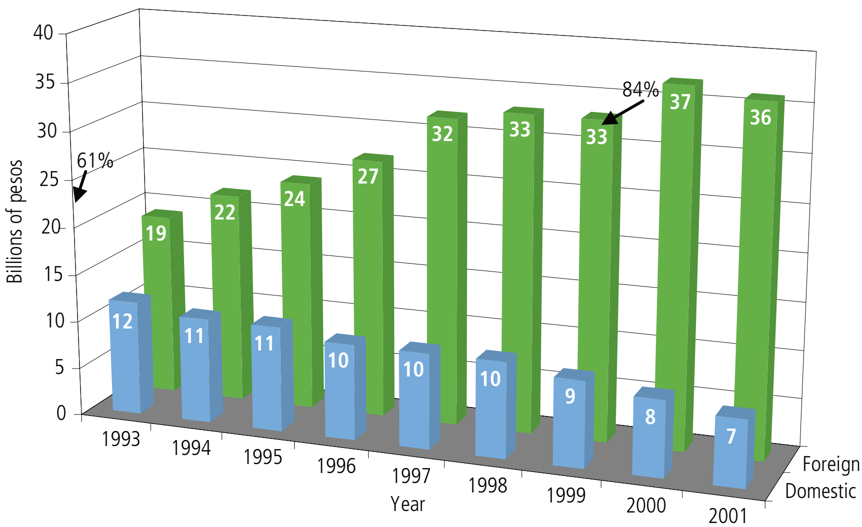
During the nineties, as State-owned companies disappeared and the presence of large independent local companies was reduced, the presence of foreign companies increased remarkably.[22] Although business structure had already changed considerably by 1995, given the active participation of foreign investors in the

22. According to official estimates, between 1990 and 2000 seventy-eight billion dollars entered the country in foreign direct investment (FDI); thus, the amount of foreign capital grew at annual rates above 20% and surpassed eighty billion dollars in 2000. (KULFAS; PORTA; RAMOS, 2002).

privatization process, it has been since then that the extraordinary growth in the transfer of private sector industrial firms has taken place. While the presence of foreign capital in manufacturing is not new, it has increased substantially[23] since that date.

Notwithstanding the importance of the Argentine endowment in natural resources as a locational advantage for investments in agro-industrial, mining and petroleum commodities, foreign direct investment (FDI) has concentrated on the sectors most stimulated by dynamic demand. Despite the fact that the opening of the economy – within the framework of an exchange rate misalignment – generated an unfavorable bias against the domestic production of tradable manufactures, the dynamism displayed by domestic and regional demand during the greater part of the nineties became a decisive factor for the investment decisions of transnational corporations (TNCs), whether for established firms or "newcomers".

FIGURE 8
Value added of the 500 largest companies by origin of capital (1993-2001)



Source: Elaborated by the authors on the basis of official figures.

The imperfections of the financial and capital markets, coupled with interest rate differentials between the local and international markets, assisted in furthering the transnationalization process. For the local entrepreneur selling his company, the flow of future returns was discounted at the interest rate existing in the local market, which was on average no less than two to three times higher than the international rate at

23. While in 1994 there were 69 foreign owned companies among the largest 200 industrial firms in the country, their participation in this group grew in a sustained fashion, increasing from 87 in 1995 to 129 in 1998. In 1994, sales by foreign companies concentrated 43.4% of total sales by the largest 200 firms, while in 1998 such participation was remarkably higher, reaching 69.2% (CEP, 1999). In 2002, 325 of the largest 500 companies were subsidiaries of TNCs and generated more than 80% of the value added of this business elite.

which the TNC buyer operated. Furthermore, in certain cases, a technological factor came into play. In sectors that experienced technological progress at an intense pace beginning in the 1980s (information technology, telecommunications, machine-tools), or where access to innovations was limited (pharmaceuticals), local firms faced greater constraints to their performance. In summary, besides the tenders for foreign operators in privatized public services, the set of incentives implicit in the new rules, and the financial valorization strategy adopted by the large local agents, favored the attainment of the transnationalization coefficients reached.

In the production area, the main concerns of the new investments were specialization and increased scale, which were decisive factors under the new conditions of competition. In cases of growth by merger or purchase of local companies, the tendency was to dismantle facilities vertically, outsourcing certain sections, rationalizing activities, downsizing administrative areas and maximizing corporate synergies. It is important to note that, while a firm's previous history and some of its tangible and intangible assets were attraction factors and a good basis for the restructuring operations undertaken, in some cases the accumulated equipment imposed technical restrictions when defining new projects. As a rule, it was only in these cases, and particularly if new investors were involved, that new plants or greenfield investment projects were developed.

TABLE 2
TNC strategies in the nineties

Sector	Share in FDI flow	Locational advantages or attraction factors	Type of investment	Market
Public services	37%	Regulation Captive market, monopoly, guaranteed profitability	Market seeking Rent seeking	Internal
Private services (financial and commercial)	11%	Regulation Expectation concerning internal market	Market seeking	Internal
Foods Beverages Chemicals	6%	Expectation concerning internal market Market position Natural protection	Market seeking Efficiency seeking	Internal and some Mercosur
Automotive and auto-parts	5%	Regulation Expectation concerning regional market	Efficiency seeking Market seeking	Mercosur
Agro-industrial commodities Petroleum Mining	28%	Natural advantages (expanding frontier) Privatization Regulation	Resource seeking	World Mercosur

The marked increase in the degree of transnationalization of the Argentine economy was also reflected in the participation of TNCs in foreign trade, where they dominated the import flow and substantially contributed to the export flow. The great majority of these exports were concentrated in a reduced number of sectors based on natural resources, with the exception of the automotive industry. Two other facts make the Argentine case strikingly singular: the TNCs accounted for a comparatively high share of international trade, while at the same time their operations were more oriented to the internal market than those of TNCs in other FDI-receiving countries.

Only the FDI strategies intensive in the use of natural resources generated a positive balance of trade. This occurred as a result of the strong orientation of these activities towards the export market due to their natural advantages and their very low import propensity. In contrast, among the companies that adhered to predominantly market seeking strategies – as in the greater part of the manufacturing sector – there was a generalized trade deficit, even among those firms having export coefficients above the national average due to their particularly high reliance on final or intermediate imports. Moreover, this group displays a pattern of integration into the foreign market in which exports to Mercosur and imports from outside the region prevail, combined with a strong component of intrafirm trade. Insofar as access to international trade channels may be a significant ownership advantage for a TNC, an important expected effect of FDI is its potential contribution to the net generation of foreign currency through exports. However, in the case of Argentina, the evidence does not support this argument, for the export performance of TNCs seems to be associated with specialization strategies and complementarity among subsidiaries in accordance with regional commercial preferences.

In summary, despite their predominance in the country's commercial flows (except for the singular case of the development of the automotive complex within the framework of the sectoral integration of Mercosur), the strategies displayed by theTNCs in the nineties do not appear to have contributed to modifying or diversifying the traditional pattern of Argentine exports. To the extent that these subsidiaries clearly show a stronger propensity to import than to export – except in the obvious case of sectors based on natural resources – their actions are the main source of the trade deficit and therefore aggravate external restrictions. In addition, they reinforce a "dual" process of productive internationalization, which combines a pattern of intersector trade with markets in developed countries and a pattern of essentially intrasector trade with regional markets. Lastly, according to available estimates, probably no less than 25% of Argentine international trade corresponds to intrafirm flows. If so, management of transfer prices may be a common practice among firms and a serious economic policy problem.

In recent years, a significant contraction in FDI flows has been experienced. Although it is still hard to differentiate temporary and permanent changes, a boom similar to that of the nineties seems unlikely to occur.[24] Furthermore, the possibility

24. Since the 2001-2002 crisis, the purchase of Argentine companies by Brazilian firms suggests a certain ability by regional firms to take advantage of opportunities that emerge in high instability contexts in which the TNCs of the developed world are either absent or prefer to be absent.

of a reduction in the participation of foreign companies cannot be discarded. In addition to volume, there are also questions as to what strategies they will follow: in general, subsidiaries have high import coefficients and low export coefficients. Based on the higher real exchange rate, a gradual increase in export coefficients may ensue: the challenge consists in developing "global products." If so far the contribution of the TNCs to capital formation, to the accumulation of local technological capabilities, to the development of suppliers and to the opening of markets has been poor, it is still undeniable that these corporations will be key actors in any strategy for sustained growth. In the future, the goal should be not to attract simply a greater number of capital investments, but to procure better quality foreign investments in the context of a highly transnationalized economy – investments that assure that the FDI flows have favorable spillover effects on other economic activities.

Writers have long been stressing the importance of the quality of management for company performance. However, only recently have empirical studies appeared containing detailed information in support of this hypothesis. These studies attempt to quantify the contribution of executives and their practices to the productivity gaps observed among firms[25] (and that cannot be explained by differences in location, sector, technology or labor). Thus, evidence has been produced that confirms the existence of a correlation between best practices in management and greater returns on capital, sales per employee and growth of market share. Similarly, it has now been substantiated that the heterogeneity of "styles" among executives explains differences in investment, financial and organizational practices.

An aspect not covered by the above mentioned literature but is interesting to note in the case of Argentina is how the idiosyncratic knowledge gained by management during years of volatile economic behavior can affect a firm's path and performance. In particular, the latest crisis clearly demonstrated that knowledge accumulated over the years concerning how to act in the face of changing economic scenarios provided some local companies with a better understanding of what might happen once the crisis accelerated and became a depression.

These management capabilities can be associated with the economic literature that views entrepreneurial actions as decision-making under high uncertainty, a process in which the individual attempts to anticipate and actively take advantage of changing conditions.[26] This refers to those business decisions in which the individual contemplates a range of unknown future results without even reflecting on the

25. It is worth mentioning, among others, Bertrand and Schoar (2003), who analyzed the impact on the development of US companies of changes in style and strategies resulting from the incorporation of new CEOs and CFOs, and Bloom *et al.* (2005), who measured the effects of the quality of practices applied by middle management in US, UK, French and German companies.

26. Other concepts related to the entrepreneurial spirit that have been emphasized are the management of small and medium-sized companies or start-ups characterized by certain personal and psychological features that result in greater creativity and imagination, Schumpeterian innovation in products and processes, a constant search for profit opportunities or a capacity for charismatic leadership (FOSS; KLEIN, 2004; IBRAHIM; VYAKARNAM, 2003).

probability of their actually occurring. It is what Knight (1921) called "uncertainty" to differentiate it from mere probabilistic risk. The ability to make such entrepreneurial judgments is learned through experience and tends to involve components that are not explicitly acknowledged.

These past experiences provide local management with greater flexibility for adapting adroitly, whether from the financial perspective or the commercial standpoint. In times of crisis, when the decision horizon suddenly shortens, certain business mistakes in short- term decision-making related to daily operations can irreversibly lead to forced company sales or mergers, or even to permanent closures. These same mistakes, in other contexts, may only translate into reductions in annual profitability, into economic losses, or into changing the manager of the subsidiary located in a country that represents less than one percent of the total sales of the corporation. Therefore, the entrepreneurial capacity for day-to-day crisis management must be added as an asset to the structural strengths possessed by a company.

A strategy that was successfully applied by several local companies during the crisis was to protect the company's working capital, which generally meant selling goods and services "cash only." Implicitly, this involves reducing sales volumes and losing part of the market to the competition. Whatever the reason, the acceptance of losses in market share can lead to situations that may be difficult to revert in the future. Decisions of this type, made in an attempt to maintain an adequate balance between the financial and commercial aspects of a business, generate strong internal tension (KOSACOFF *et al.*, 2001).

7 FINAL CONSIDERATIONS

During turbulent times for Argentina, when horizons were shrinking and the lens of analysis was focused on the short term, a macroeconomic approach to the problems of the economy was the absolute rule. As a result, the microeconomic foundations of these problems went unattended. In various articles it was suggested that the responses of economic agents to the macroeconomic policies and shocks could be considered, with no risk of oversimplification, as homogeneous and automatic. It was not noticed that to a certain extent the weaknesses of the microeconomic foundations and some of their operational features could in turn generate macroeconomic problems and contribute to the persistence of these problems over time. In fact, a review of the papers written on the recent Argentine crisis reveals that the great majority contain no direct consideration of microeconomic foundations among their explanatory arguments.

The connections between modes of productive organization, of human resource capacitation and of measures aimed at productivity and competitive gains are all affected by real volatility and financial fragility, which, in turn, disrupt investment and growth through a feedback process. Therefore, consistency between macro and microeconomic schemes provides a solid basis for long-term growth. The development of productive capacities is a complex process that advances in uneven fashion and takes on specific characteristics according to the sector, region and country. As such, it involves causalities and interactions that are yet to be completely understood. The above notes have sought to contribute some elements for a better understanding of these phenomena based on the Argentine case.

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CHAPTER 3

TECHNOLOGICAL CHANGE IN THE MANUFACTURING SECTORS OF ARGENTINA AND BRAZIL: AN ANALYSIS BASED ON THE INNOVATION SURVEYS

Fernando Peirano

1 INTRODUCTION

The purpose of this study is to compare the Argentine and Brazilian manufacturing sectors from the standpoint of technological change on the basis of data generated by the innovation surveys conducted by the National Statistics and Census Institute in the former (INDEC, 2003) and the Brazilian Geographical and Statistical Institute in the latter (IBGE, 2002) and subsequently compiled by IPEA.[1] The proposal consists in organizing the evidence around four points that are often themes of debate and that allow for an initial classification of the innovation processes underway in the two principal members of Mercosur.

First, the innovation capacities of the manufacturing sectors are contextualized by taking a group of European countries as a reference. In this way, it is possible to ascertain the gap that exists between these two Latin American economies and their European counterparts with regard to resources earmarked for promoting technological change.

Second, the epicenter of technological change in each of the manufacturing sectors surveyed is defined. This allows for more accurate weighing of the causes behind the differences between Argentina and Brazil. The policy implications vary widely depending on whether these differences are explained by asymmetries in the industrial framework (the relative importance of technologically sophisticated sectors) or by divergences in the intensity of expenditure on innovation activities across sectors (a factor indicative of prevailing business strategies).

The third point concerns the existing infrastructure for conducting research and development activities (R&D) and the tasks the research centers actually perform. For this purpose, the number of R&D laboratories housed by industrial firms in each country is estimated. Moreover, indicators are selected for characterizing these specialized centers and deducing the tasks they fulfill.

1. The author wishes to extend special thanks to Fernando Freitas of IPEA for his collaboration in compiling and processing the statistical data used in this work. It should be stated, however, that the final presentation and conclusions are solely the responsibility of the author.

Lastly, an attempt is made to outline the innovation profiles of the manufacturing sectors of the two economies. Based on the proportion of innovating firms within each sector, the sectoral path is appraised with regard to product versus process innovation, as well as innovation for the market versus innovation for the firm.

The period surveyed covers the years 1998-2001 for Argentina and 1998-2000 for Brazil, corresponding in each case to the reference years for the innovation surveys utilized. The data arising from the surveys have been compiled by IPEA, thereby allowing for additional processing in order to standardize the analytical categories employed. Furthermore, some of the Argentine indicators have been expanded to yield results representing not only the firms surveyed, but the manufacturing sector as a whole. These tasks having been performed, it is now possible to make a more precise and direct comparison of the two economies.

2 INDUSTRIAL INNOVATION CAPACITIES IN ARGENTINA AND BRAZIL: A COMPARATIVE APPROACH

In this section, the basic features of the Argentine and Brazilian manufacturing sectors are described in relation to their innovation capacities. To better appraise these features, a group of European countries has been included to allow for more precise evaluation of the data gathered.

TABLE 1
Expenditures on innovation activities by Argentine and Brazilian industry in the European context: values for sets of manufacturing firms covered by innovation surveys (2000)
(Million Euros and %)

	Revenue (A)	Selected innovation activities (B)		R&D (C)	Machinery & equipment (D)		Other external knowledge (E)		Training, marketing and technical preparation (F)	
		(C+D+E+F)	(B/A) (%)			(D/A) (%)		(E/A) (%)		(F/A) (%)
Germany	1,238,953	65,795	5.31	36,216	18,519	1.49	1,142	0.09	9,918	0.80
Italy	494,207	20,474	4.14	7,242	10,261	2.08	809	0.16	2,162	0.44
Brazil	297,638	13,101	4.40	2,566	6,821	2.29	689	0.23	3,025	1.02
Spain	272,691	6,937	2.54	2,795	2,866	1.05	432	0.16	844	0.31
Holland	163,749	5,878	3.59	4,374	805	0.49	370	0.23	329	0.20
Belgium	146,250	8,076	5.52	3,638	2,469	1.69	305	0.21	1,664	1.14
Portugal	68,793	2,371	3.45	421	1,634	2.38	64	0.09	252	0.37
Argentina(2001)	94,858	1,532	1.62	238	1,005	1.06	99	0.10	190	0.20

Sources: Prepared on the basis of data from IPEA, IBGE, INDEC and EUROSTAT.

The first point that should be stressed refers to the share of innovation activities as a percentage of total industrial revenue (Table 1).[2] With respect to this share,

2. The exchange rates used throughout this study are as follows: US$=1; R$/US$=1.82; Euro/US$=0.93. If the comparisons presented were at the rates of exchange in effect in 2006, the gap between Argentina and the other countries would be wider yet.

Argentina is at the bottom among the group of countries selected, whereas Brazil occupies third place together with Italy, thus coming only after the countries at the top of the list: Belgium and Germany. However, on analyzing the composition of innovation expenditures, the patterns are found to be very different, leading to a reconsideration of the relative position of Brazil.

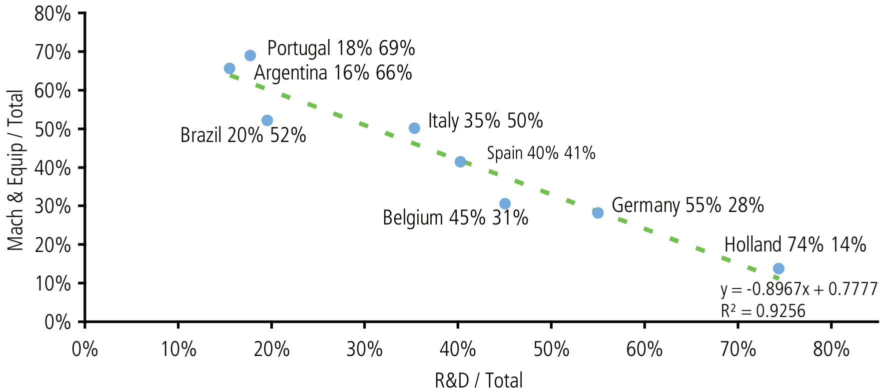
As a general rule, an average 82% of innovation expenditures is explained by R&D and acquisition of machinery and equipment (Figure 1). Thus, despite structural differences in the countries selected, it seems valid to affirm that industrial technological change basically ensues from these two antecedents. Due to its being consistently observed, this point deserves more attention than it usually receives. Although training, engineering activities and the acquisition of unincorporated knowledge apparently have leading roles in differentiating the impact of technological change on the performance of the players at the aggregate level, they are relegated to supporting roles in relation to R&D and the acquisition of machinery and equipment.

By nature, these activities are distinct and each has its own way of conditioning the dynamics, and above all, the externalities involved in the process of technological change. In the cases of Holland and Germany, the predominance of R&D expenditure as the principal innovation effort is in accord with manufacturing sectors comprised of trend-setting firms that operate on the technological and productive frontiers. In such a context, technological change depends on the capacity to generate and apply scientific knowledge within the production sphere.

At the other end of the spectrum lies Portugal, where the relative importance of the acquisition of machinery and equipment is consistent with an industrial complex fed mainly by external sources insofar as technological innovation is concerned. At the same time, the more open the foreign-trade channels, the more likely that sources exogenous to firms will also be noticeably exogenous to the developing countries. Moreover, from the outset, technological progress based on the changes incorporated in capital goods offers both advantages (less uncertainty and frustrated effort) and disadvantages (a "follower" market position and difficulties in finding technical solutions to isolated problems) that must be weighed in accordance with the shape of the industrial sector and the degree of development of the country in question.

Based on these considerations, it is clear from the innovation profiles of Argentina and Brazil that sources external to the firms play a dominant role. However, two elements lead to speculation as to the possibility that this shared characteristic affects the two systems in different ways, with the outcome being more favorable to Brazil. To start with, the slight relevance of the machinery and equipment sector in Argentina compared with that in Brazil (as seen in the next section) indicates that the coincidence between sources external to the firms and external to the economy as a whole is more accentuated in the Argentine case. It is necessary to add that training, engineering and technical adaptation activities are highly relevant in Brazil, surpassing R&D activities in importance. This is peculiar to the Brazilian case and allows one to hypothesize concerning the existence of a stronger absorption process based on significant adaptive innovations.

FIGURE 1
Composition of innovation expenditures (2000)



Sources: Prepared on the basis of data from Eurostat, IPEA, IBGE, INDEC.

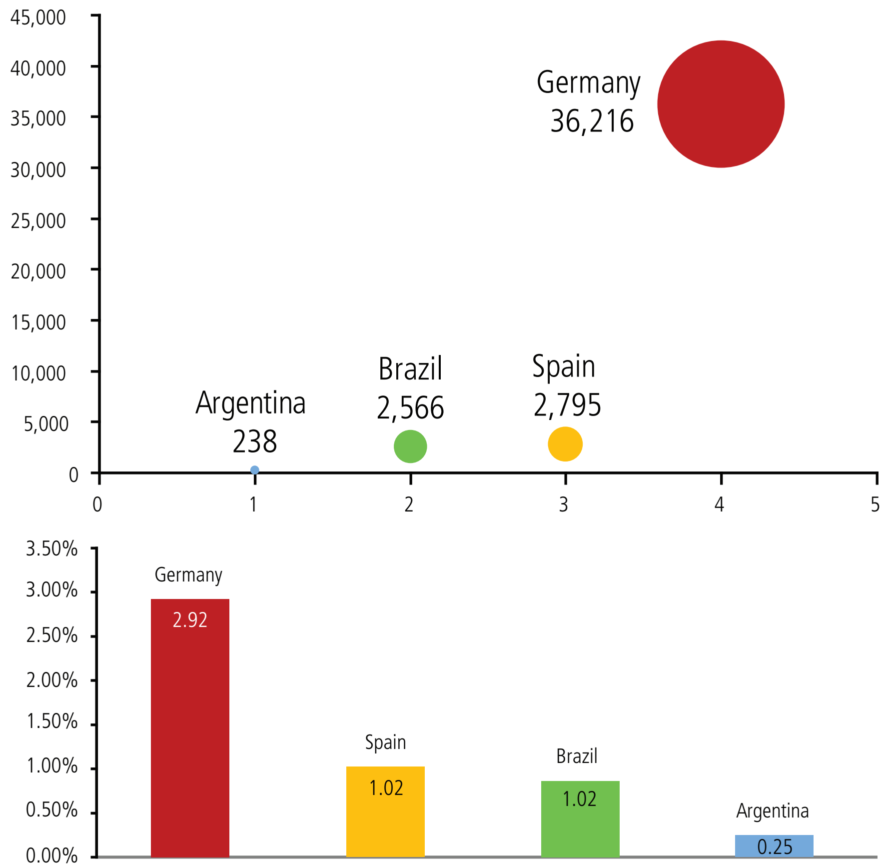
With reference to R&D expenditure, Argentina and Brazil have in common that they are both in the lowest segment.[3] Only Portugal, among the European countries studied, shares this "under 1%" condition, while Germany, Belgium and Holland register between 2.5% and 3%. Nevertheless, as already discussed, this is not the determining factor behind technological change in these countries. What are significant are the differences in the purchase of machinery and equipment that endow Brazil with a vigor considerably different from that exhibited by the Argentine manufacturing industries.

These disparities become even more evident when the analysis takes into account that innovation processes are strongly influenced by economies of scale, reach and learning. Hence, to respect the theoretical premises, efforts should be measured not only as percentages of total available resources, but also in terms of absolute values and values accumulated over time. Consequently, it must be remembered that differences in terms of impact should be greater than differences in terms of effort (Figure 2).

3. Between 1998 and 2001, the Argentine economy underwent a strong recession that worsened in 2002 when the convertibility regime terminated and the currency devalued substantially. However, R&D expenditures continued relatively stable, so the drop in revenue raised the indicator R&D Expenditure/Revenue. According to the data furnished by INDEC, the R&D share was 0.15% in 1992; 0.16% in 1996; 0.16% in 1998; 0.26% in 2001; and 0.17% in 2004 (estimate). The series shows the 2001 figure to have been exceptionally high, and when taken as a whole for the period, improves the relative position of Argentina in the context of a long-term analysis.

Observation of the absolute magnitudes reveals a panorama with even wider gaps than those noted when considering only expenditure shares and structural differences. Amongst the innovation activities, research and development, training, technical preparation and engineering tasks are types of efforts in which external factors associated with learning by doing and size of investment strongly influence outcomes. In turn, the acquisition of machinery and equipment and the transfer of unincorporated technologies, though exogenous to the firm, are subject to the same external factors but to a much higher degree (Figure 3).

FIGURE 2
R&D expenditures of Argentine and Brazilian versus European manufacturing complexes — selected countries and indicators
(Million Euros in 2000)

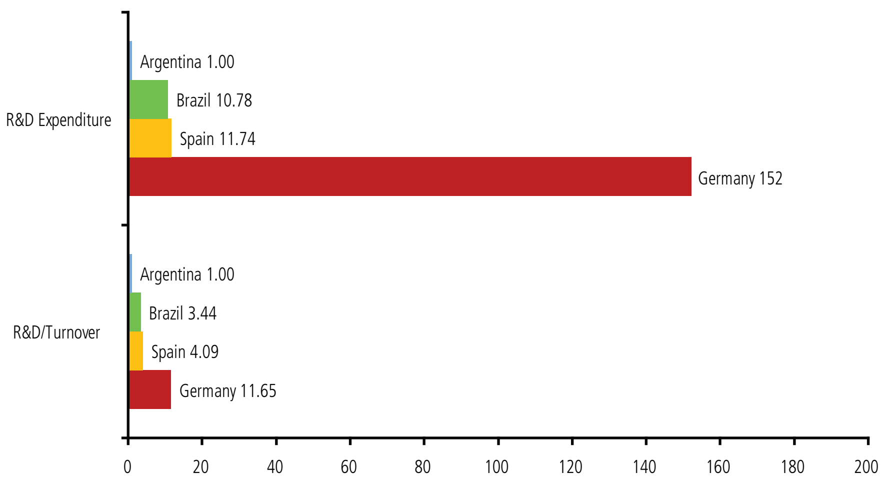


Sources: Prepared from data computed by IPEA based on information from IBGE, INDEC, EUROSTAT.

Reviewing the available data from this angle further broadens the distances between the Argentine manufacturing sector and the manufacturing sectors of the other economies analyzed, as well as re-emphasizing the weakness of the internal innovation capacities of the country. Although the gaps are also seen to be wider in Brazil with regard to the categories that represent internal capacities, the differences in resources when compared to those of the major production centers are within a relatively narrow range. Moreover, the total volume of resources that Brazil allocates to innovation activities surpasses those of most of the less developed European countries. However, the gaps become relevant when the types of outlay are considered.

In contrast, the 238 million euros that Argentina earmarked for innovation activities is seen to be a very low figure when appraised in context. While it is hard to establish a minimum threshold, this sum is probably less than the "critical mass" needed to generate the series of ties and connections required to form a network of sustainable relations across firms and between the industrial complex and scientific institutions. Thus, the scant amount allocated is strong proof against the existence of anything similar to what the literature terms a National Innovation System (NIS).

FIGURE 3
Gaps across manufacturing complexes
(Argentina = 1)



Country	R&D expenditure (million euros)	Gap	R&D/ Turnover	Gap
Germany	36,216	152.17	2.92%	11.65
Spain	2,795	11.74	1.02%	4.09
Brazil	2,566	10.78	0.86%	3.44
Argentina	238	1.00	0.25%	1.00

Sources: Prepared from data supplied by IPEA based on information from IBGE, INDEC and EUROSTAT.

In Brazil, the scenario appears to be different, for there are sufficient funds available for extenuating the problems associated with economies of scale in R&D activities and for assuring a significant demand for specialized services, which, in turn, permits the formation of markets and the establishment of other ties among the players. Clearly, lack of funds for innovation activities is not the only obstacle to shaping an innovation system. Cultural and institutional factors are also decisive; and the complexity of these determinants may grow at a faster rate than the increase in investments. In turn, the fragmentation and dispersion of R&D expenditures may eliminate any advantages associated with higher scales of investment.

The evidence presented thus far justifies deeper reflection on the challenges facing Argentina and Brazil when shaping their innovation systems, as well as on the degree to which the priorities of the two countries coincide. Despite their having much in common, the differences between the two economies are apparently more relevant than generally supposed. Even so, the importance of the absolute magnitudes involved reaffirms the benefits of regional integration for the purpose of generating and applying knowledge. To date, this is a scarcely explored dimension within the sphere of Mercosur.

3 THE NUCLEUS OF THE INNOVATION PROCESS IN ARGENTINA AND BRAZIL

In this part of the article, the aim is to verify the degree of sectoral concentration of innovation activities and to identify which sectors form the nucleus or central core in Argentina and which in Brazil. These sectors are described and compared with a view to improving the diagnosis and rendering the discussion more specific with regard to the relevant government policies

The data arising from the innovation surveys conducted in the two countries confirm that the activities related to technological change are highly concentrated. In both cases, more than 75% of the R&D activities are accounted for by merely eight sectors. In fact, in Argentina it would be sufficient to consider only four. Moreover, it should be emphasized that the sectors at the forefront of the process coincide in the two countries under analysis.

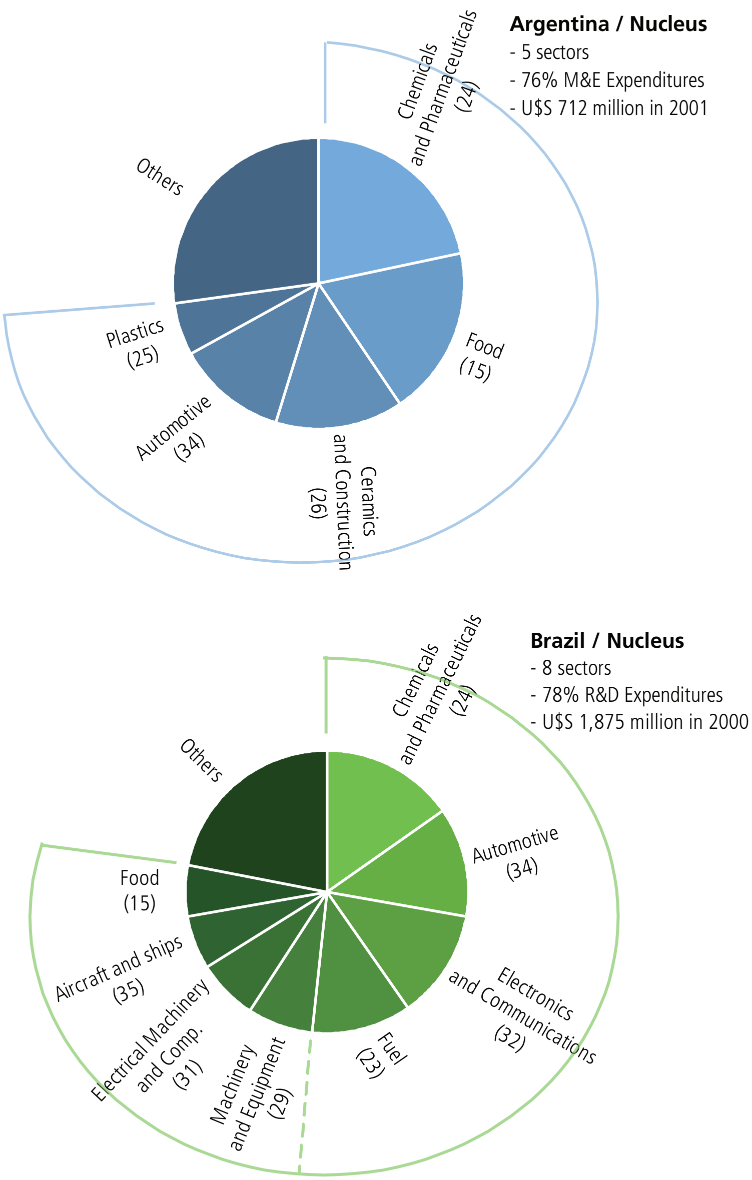
In the case of Argentina (Figure 4 and Table A1 in the Appendix),[4] the research and development nucleus is comprised of firms in the food (15), chemical and pharmaceutical (24), plastics (25) and automotive (34) sectors. These sectors explain 76% of the R&D expenditures, with the remaining 24% being equally distributed across the eighteen sectors that complete the Argentine manufacturing complex.

In the case of Brazil, it is also possible to identify a limited number of sectors that are responsible for the greater part of R&D expenditures. In fact, fuel (23), chemicals and pharmaceuticals (24), electronics and communications (32) and the automotive industry (34) account for 52% of R&D expenditure. Thereafter

4. The 1998-2001 recession exerted a differentiated impact on Argentine manufacturing activities. The automotive sector was among those affected. In 1998, the composition was as follows: food (15) at 9%, chemicals and pharmaceuticals (24) at 39% and the automotive sector(34) at 14%. Nonetheless, the prime nucleus was not altered.

comes a secondary group comprised of machinery and equipment (29), electrical machinery and apparatus (31), food products (15) and aircraft, ships and other transport equipment (35).

FIGURE 4
R&D Expenditures - Leading Argentine and Brazilian sectors



Sources: Prepared from data supplied by IPEA based on information from IBGE and INDEC.

As to similarities, the chemical and pharmaceutical (24) sector, together with the automotive industry (34), is outstanding in the matter of R&D in both countries. Food and food products (15) is another outstanding sector in both, forming part of the primary core in Argentina and of the secondary core in Brazil. When taken together, these three sectors are responsible, respectively, for 54% and 42% of Argentine and Brazilian industrial revenue.

Concerning the differences, whereas the plastics sector (25) is important in Argentina, it is not among the more prominent sectors in Brazil. At the same time, while fuel (23) and electronic and communication equipment (32) are two of the most relevant in Brazil, they are among the least relevant in Argentina. Another sector that differentiates Argentina from Brazil includes the manufacture of aircraft, ships and other transport equipment (35).

In many instances, the fact that sectors do not appear is owing not to absence of economic activity, but rather to low levels of R&D expenditure. Thus, in terms of the arguments presented in the first section, what is being observed is not a question related to the intensity of sector expenditures, but one linked to specialization within the production sphere. For example, the available data indicate that the plastics sector (25) accounts for a similar share in the two countries with 4% of the total revenue in each. Likewise, fuel (23) represents 9% of industrial sales in Brazil and 11% in Argentina.

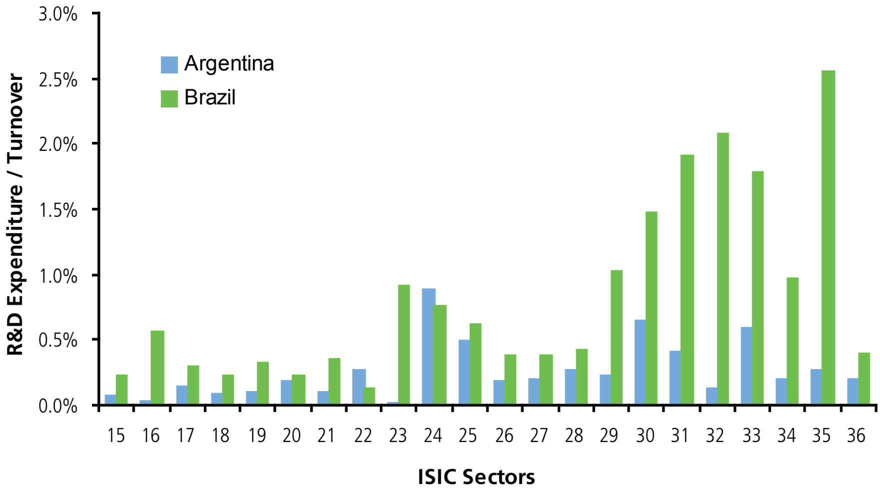
However, it is justifiable to speak of specialization differences when referring to the manufacture of aircraft and ships (35), which stands at nearly 2% in Brazil and under 0.5% in Argentina. The gap is even wider for electronic and communication equipment (32), attaining 4.25% of the industrial revenue in Brazil and barely surpassing 1% in Argentina.

These differences may in great part be explained by the research and development activities carried out by Petrobras and Embraer. At the same time, differences in industrial policy and in the denationalization of the telecommunications sector may well be keys to understanding the other determinant responsible for shaping the prime cores. In other words, the role of the state in the configuration of these cores appears to be a highly significant factor.

3.1 Re-evaluation of aggregate differences in the intensity of R&D expenditures

As already mentioned, the differences in sectoral intensity of R&D expenditures are striking. On analyzing Figure 5, it becomes clear that the two countries do not share the same intensity pattern. Whereas sectors 29 to 35 correspond to the highest points for Brazil, the highest for Argentina is chemicals and pharmaceuticals (24), this branch being an exception in that it is the only Argentine sector that surpasses its Brazilian counterpart. In the remaining sectors comprising the respective main nuclei, the differences are strongly in favor of Brazil: for plastics (25) and food (15) they are substantial and become highly significant for the automotive (34), fuel (23) and electronic and communication equipment (32) industries.

FIGURE 5
Sectoral intensity of R&D expenditures



Sources: Prepared from data supplied by IPEA based on information from IBGE and INDEC.

Evaluation of these data reveals that the low sectoral intensity of R&D expenditures is the main cause underlying the marked differences that separate the two countries. In other words, the Argentine manufacturing firms apparently have a lower degree of compromise with this type of investment than their Brazilian counterparts. At the same time, the evidence gathered goes against the idea that Brazil spends more than Argentina in consequence of a more sophisticated and specialized productive framework. The two exceptions are electronic and communication equipment (32) and aircraft, ships and other transport equipment (35). Hence, there is no question that sectoral intensity is the factor that best explains the differences between the two economies.

With regard to this issue, the following simulation exercise can be used to confirm this conclusion. If we apply the values corresponding to the spending intensity of their Brazilian counterparts to the Argentine sectors, without altering the sectoral composition of the manufacturing industries, total R&D expenditure climbs to 490 million dollars, or 269 million more than the 221 million actually spent in Argentina in 2001. In other words, the ratio between R&D expenditure and revenue rises from 0.25% (2001) to 0.56%. Therefore, if the current sectoral structure of the Argentine manufacturing complex were maintained but the firms were to assume a stronger compromise with R&D activities – emulating the parameters of their Brazilian counterparts – expenditures on this highly significant activity would increase by 122%.

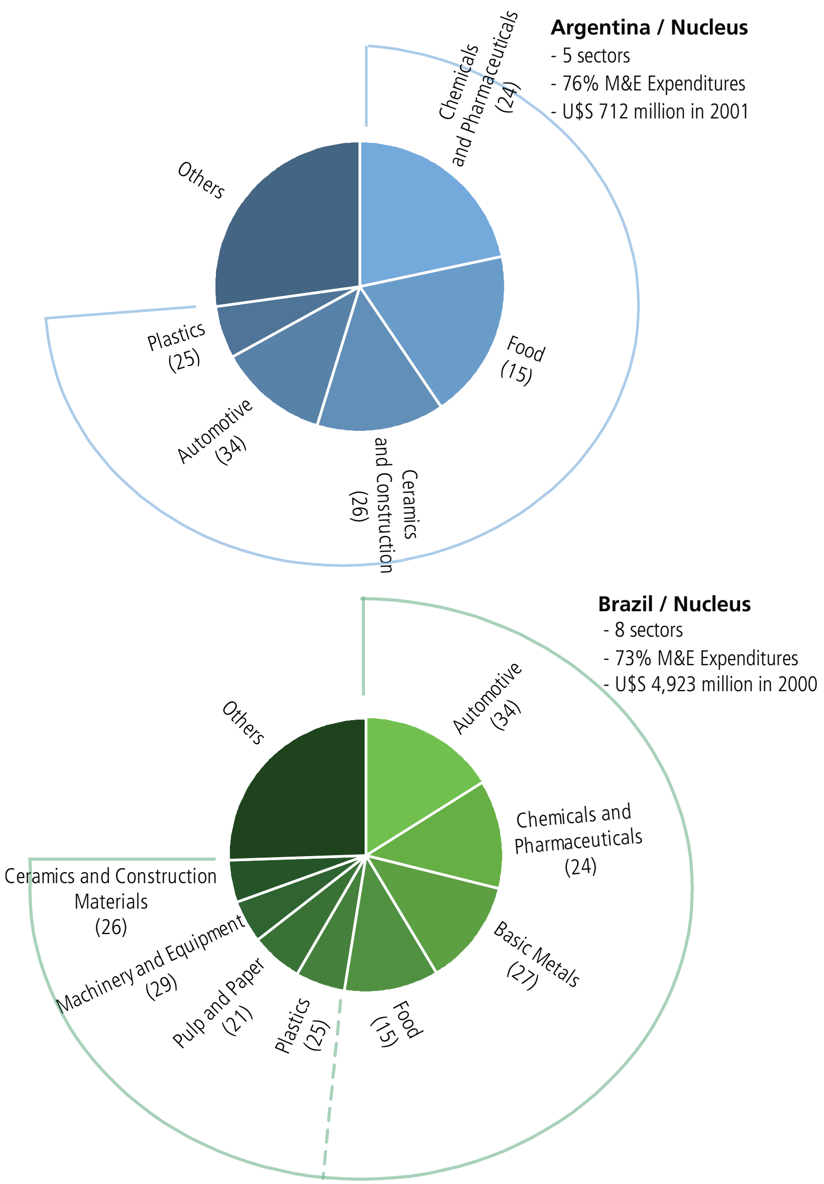
3.2 Expenditures on machinery and equipment

In Section 2, it was shown that, as a general rule, 82% of the amounts allocated to innovation activities were spent on R&D and the acquisition of technologically improved machinery and equipment. In the Argentine and Brazilian industrial parks, the sum totals corresponding to these categories are 82% and 72%, respectively. Considering the lesser share of R&D in these expenditures in monetary terms, the greater share is earmarked for the purchase of machinery and equipment, with the percentages being 66% for Argentina and 52% for Brazil. It is therefore justifiable to apply the methodology used to analyze R&D expenditure to this item as well.

For Brazil, a similarity is also confirmed between the core that accounts for most R&D expenditures and the core that answers for the bulk of machinery and equipment outlays. In this case, there are two cores: an inner core comprised of four sectors that respond for 52% of the purchases; and an outer, or complementary, core constituted of four other sectors that respond for an additional 21%. Taken together, these eight sectors cover 73% of the total spent by the Brazilian manufacturing industries in 2000. With regard to the type of capital goods in question, the automotive industry (34), with an expenditure of 1,000 million dollars, is the principal buyer. Also included in this select group are the chemical and pharmaceutical (24) and food (15) sectors. In this case, the new element that now appears with reference to R&D is the basic metals sector (27) with 12% of total expenditures.

The outer core includes plastics (24), pulp and paper (21), machinery and equipment (29) and ceramics and construction materials (26). The annual expenditure of these sectors lies between 328 and 415 million dollars. As for R&D expenditures, neither the pulp and paper (21) nor the ceramic and construction materials (26) sectors figure among the select.

FIGURE 6
Machinery and equipment expenditures - Leading Argentine and Brazilian sectors



Sources: Prepared from data supplied by IPEA based on information from IBGE and INDEC.

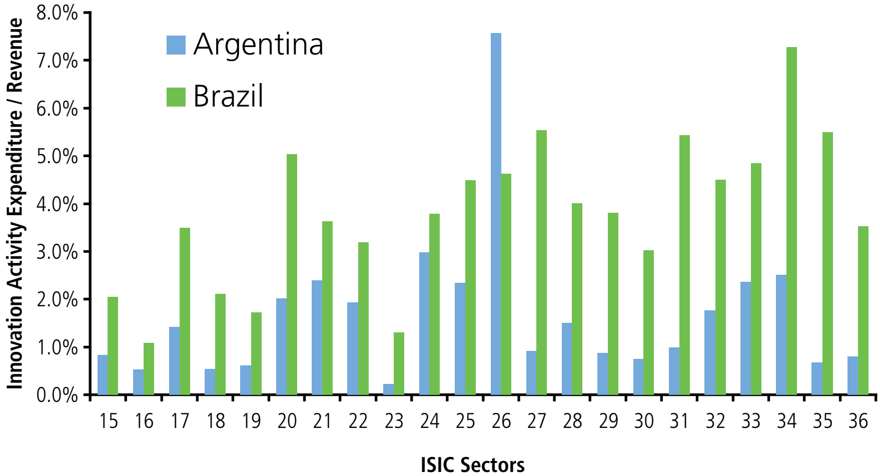
In Argentine industry, the aforementioned 76% of total expenditure is equivalent to 712 million dollars; while in Brazilian industry, 73% of industrial outlays corresponds to 4,923 million dollars. This means that the Brazilian core, or nucleus, is nearly seven times larger. At the sectoral level, the narrowest gap, in terms of amounts, is in ceramics and construction materials (26) and the widest is between the expenditures of the Brazilian and the Argentine automotive industries (34).

Thus, the sectors that form the core for machinery and equipment expenditures are seen to strongly coincide with those that comprise the core for R&D expenditures. Furthermore, the chemical and pharmaceutical (24), food (15) and automotive (34) sectors can be identified as the industries in which most of the activities linked to innovation and technological change are developed in the two most important Mercosur economies.

3.3 Sectoral intensity of expenditures on innovation activities

When the intensity of innovation expenditures is surveyed from a sectoral perspective, it is evident that, on the whole, Brazilian industry operates at a higher average investment level than Argentine industry. (Figure 7). The differences are especially visible in the range that extends from sectors 29 to 35. The gap narrows in sectors 24 to 26, where the strongest Argentine sectors are located. However, only in the exceptional case of ceramics and construction materials (26) does an Argentine industry surpass its Brazilian counterpart. This pattern confirms the already observed trend toward sectoral intensity in R&D expenditures.

FIGURE 7
Sectoral intensity of expenditures on innovation activities



Sources: Prepared from data supplied by IPEA based on information from IBGE and INDEC.

Once again, the larger size of the Brazilian sectors in terms of revenue, coupled with their stronger inclination to allocate a higher percentage to the financing of activities linked to technological change, explains why they are so distant from the Argentine sectors.

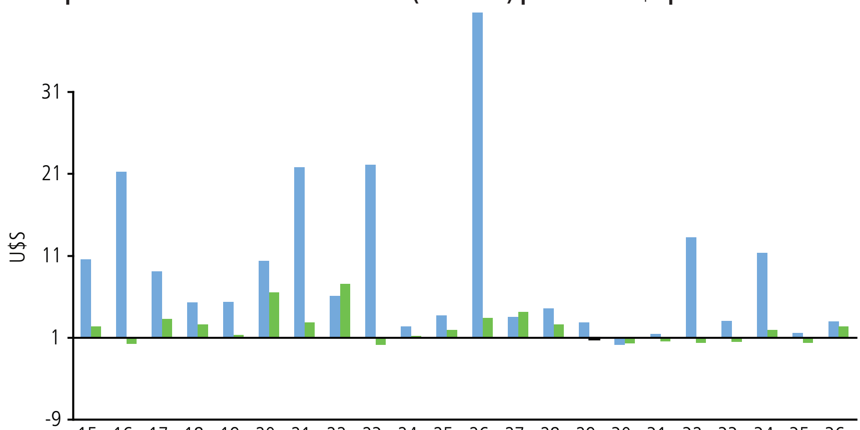
Having analyzed the data for the two major items that comprise innovation activities, it would be interesting to determine how these factors interact. Consequently, an attempt has been made to detect some regularity in the composition of innovation efforts at the sectoral level (Figure 8). According to the hypothesis of sectoral technological regimes, the composition of expenditures on innovation activities should be ruled by technical relationships. Therefore, the innovation process observed at the sectoral level should be relatively homogeneous and the firms that do not follow the rules should sooner or later face serious competitive problems.

The results obtained show that the Brazilian sectors have a stronger propensity to spend on R&D than the Argentine sectors. Thus, Argentine firms tend to center their innovation efforts on the purchase of machinery and equipment in greater measure than their Brazilian colleagues. This difference is even significant in two sectors belonging to the central core in both economies. In the Argentine food sector (15), for each dollar spent on R&D, 10.5 dollars go to other innovation activities while in Brazil the ratio is 1 to 2.4. In the automotive industry (34), the ratios are similar. Once again, it is in the chemical and pharmaceutical sector (24) that the closest similarity is observed.

It is also revealing that in several manufacturing sectors in Brazil, R&D expenditure is the outstanding item among the innovation activities. It can therefore be asserted that Brazilian industry has eight sectors that promote technological change through intensive R&D efforts. One of the most outstanding cases is the electronic and communication sector (32), where for each dollar earmarked for R&D, only 0.4 is spent on other innovation activities.

Finally, though the preceding comparison is extremely rudimentary, it brings facts to light which justify closer examination of the innovation processes unfolding in parallel sectors in Argentina and Brazil, with special emphasis directed to whether or not they have similar features and similar goals. Apparently, even when the opportunities and technological regimes are the same, the composition of the innovation efforts is not. Other factors of a non-technological nature are apparently more relevant, and it would be interesting to decipher if they are tied to strategic decisions made by firms in their differentiating efforts, or if they are linked to structural causes such as size of market, type of competition, economic cycle, access to long-term financing and so forth.

FIGURE 8
Expenditure on innovation activities (less R&D) per each US$ spent on R&D



	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Argentina	10,5	21,3	09,1	05,3	05,4	10,3	21,8	06,1	22,1	02,3	03,7	40,6	03,5	04,6	02,9	00,2	01,4	13,2	03,0	11,4	01,5	02,9
Brazil	02,4	00,3	03,3	02,6	01,3	06,5	02,8	07,5	00,1	01,2	01,9	03,4	04,1	02,6	00,8	00,3	00,6	00,4	00,5	02,0	00,3	02,4

ISIC Sectors

Sources: Prepared from data supplied by IPEA based on information from IBGE and INDEC.
Reference years: Brazil: 2000; Argentina: 2001.

At any rate, the conclusions reached are disturbing for Argentina considering that the innovation process is relevant to explaining long-term competitive. In this case, there are clear signs of a marked and generalized weakness and it is not evident which factors might be capable of offsetting the asymmetry observed.

4 R&D LABORATORIES IN ARGENTINE AND BRAZILIAN MANUFACTURING FIRMS

At this point, attention should be directed to the infrastructure figures on R&D laboratories housed in the Argentine and Brazilian manufacturing complexes, with the term “laboratory” being broadly defined to include all facilities and departments essentially dedicated to research and/or development. The data point to the distance between the two countries being more in terms of monetary resources than in terms of infrastructure. There are also strong indications that R&D activities are somewhat more diffused in Argentine firms; however, though less diffused in Brazilian firms, the activities themselves tend to have a greater span. This prevalence of the extensive in the case of Argentina and the intensive in the case of Brazil justifies a deeper inquiry into the kind of R&D performed in each country. In this analysis, the use of three complementary indicators makes it possible to outline some hypotheses concerning this question.

TABLE 2
R&D laboratories in Argentine and Brazilian manufacturing firms
(Argentina: 2001/ Brazil: 2000)

	Argentina		Brazil	
Number of firms with R&D laboratories	1,375	11.7%	3,146	4.5%
Number of workers in R&D laboratories	5,847	0.7%	31,223	0.6%
Internal R&D expenditure per laboratory (US$ thousand)	123	68.7%	1,835	90.0%
Average internal R&D expenditure per laboratory	89,736	-	583,401	-
Average number of workers per R&D laboratory	4.25	-	9.93	-
Average internal R&D expenditure per worker (US$ thousand)	21,108	-	58,778	-

Sources: Prepared from data supplied by IPEA based on information from IBGE and INDEC.

In fact, the ratio between the number of firms conducting internal R&D activities and expenditure per worker employed, as well as that between the number of firms doing R&D and the monetary resources per laboratory, leads to doubts concerning the tasks performed by these specialized units. For both countries, overall analysis of the chosen indicators supports the idea that the tasks of these work teams are centered on supporting production activities and controlling the quality of inputs and outputs. Experimental development and basic research are therefore secondary and, in the case of Argentina, are apparently exceptions to the rule.

20% of the Argentine firms and 10.5% of the Brazilian firms claim to have invested in internal R&D activities during the period covered by the innovation surveys used in this study. These figures correspond to 2,347 firms in Argentina and 7,343 in Brazil. Since nearly half have been performing these tasks continuously, they presumably have permanent teams available and a regular flow of resources for financing their R&D activities. Accordingly, there should be 1,375 R&D laboratories in Argentina and 3,146 in Brazil (Table 2). In other words, one out of every 10 firms in Argentina has a stable internal structure dedicated to fulfilling R&D tasks. For Brazil, the proportion is only one in every 20 manufacturing firms.

These labs account for 68.7% of internal expenditures on R&D activities in Argentina and 90% in Brazil. These units employ, respectively, 5,847 and 31,223 workers. The ratio between the personnel attached to these laboratories and industrial personnel is similar in the two countries at nearly 6 per 1,000. In general, the Brazilian laboratories are larger. Whereas an average Argentine lab employs 4.25 workers, on the other side of the border the average is approximately 10 per lab. This larger average size is confirmed by the expenditure figures, which strongly accentuate the differences. While a typical Argentine lab spends 90,000 dollars per year, an average Brazilian lab spends an annual 583,000. The expenditures per employee underline the difference in magnitude, for a worker employed by an Argentine lab earns an average 21,000 dollars a year, compared to the average 58,000 received by an R&D worker in Brazil.

It should be taken into account that an engineer's salary easily represents an expense to the laboratory of 18,000 dollars per year (or 1,500 per month). This is one of the clues that leads to suspicions concerning the type of activities performed in the Argentine laboratories, given that the margin for financing expenditures other than those related to personnel seems quite narrow. Since quality control and production support consume mainly wages, different from experimental development and basic research, there is a certain basis for the hypothesis formulated.

TABLE 3
R&D laboratories in Argentine and Brazilian manufacturing firms
(Argentina: 2001/ Brazil: 2000)

Sector		R&D laboratories		Average expenditure per lab (US$)		Average expenditure per lab worker (US$)	
		Arg	Br	Arg	Br	Arg	Br
15	Food	170	336	60,531	323,723	18,823	50,479
24	Chemicals and pharmaceuticals	175	500	287,240	509,473	29,893	69,482
34	Automotive	103	113	115,223	2,201,462	28,276	87,353
35	Aircraft, ships and other transport equipment	14	75	23,481	1,871,868	16,120	65,091
25	Plastics	121	250	132,891	137,219	37,732	49,369
23	Fuel	3	6	588,334	42,069,255	17,650	138,696
32	Electronics and communications	6	123	143,931	1,650,971	7,046	106,648
31	Electrical machinery and comp.	46	159	42,652	821,684	10,773	84,703
29	Machinery and equipment	196	353	30,823	374,981	11,880	50,340

Sources: Prepared from data supplied by IPEA based on information from IBGE and INDEC.

The sectors that comprise the primary and complementary cores are also home to most of the laboratories (Table 3). In both countries, a group of nine sectors responds for 60% of the firms with R&D laboratories, 80% of the expenditure of all laboratories and 69% of the workers employed at these units. At the sectoral level, analysis of the data on average expenditure per laboratory reveals that the largest amounts are invested in the fuel sector (23). In the case of Brazil, this average is truly exceptional at 42 million dollars. The figures are also strikingly high in the automotive (34), aircraft and ships (35) and electronic and communication (32) industries.

As to other sectors that most contribute to R&D expenditures in Argentina, the differences are more moderate. In the plastics sector (25), the average size of the laboratories is similar whether measured by expenditures or number of workers. In the other outstanding sector, chemicals and pharmaceuticals (24), Brazil enjoys a size advantage at twice the Argentine parameters. Even so, in terms of the overall average, the differences are of relatively slight significance.

The indicator "average expenditure per employee" shows that, in three of the sectors forming the primary nucleus in Argentina, the value is over the reference figure of 18,000 dollars a year. Therefore, in the plastics (37,000 dollars), chemical and pharmaceutical (29,900 dollars) and automotive (28,300 dollars) industries, there are enough funds to finance more sophisticated activities. In the remaining Argentine sectors, the expenditures are below the reference point. At the same time, in Brazil, the averages per worker in the sectors under analysis easily surpass this point. Furthermore, the two sectors that mark the difference between the prime nuclei of the two countries have the highest averages: fuel (138,700 dollars per worker) and electronics and communications (106,600).

5 INNOVATION TRENDS IN ARGENTINA AND BRAZIL

In the Argentine manufacturing complex, the rate of innovative firms is 41%[5] (Table 4 and Table A3 in the Appendix), close to that registered by countries such as Portugal (42%) and Spain (37%), but well under the German rate of 60%. Brazil displays a 32% rate, slightly higher than those of Uruguay (30%) and Greece (26%), the European country with the lowest share of innovative firms.

It should be emphasized that in the majority of sectors, in Argentina as well as Brazil, innovation tends to be the exception, not the rule. After all, the mere purchase of any equipment that is more technologically advanced leads the firm to be classified as innovative. Moreover, despite the laxity of the definitions, most of the firms significantly modified neither their products nor their processes during the period under analysis.

TABLE 4
Innovative firms in Argentina and Brazil - sectoral distribution
(Argentina: 1998-2001 / Brazil: 1998-2000)

Rate of innovative firms	Number of ISIC sectors	
%	Argentina	Brazil
0-20	2	1
20-40	8	14
40-60	6	5
60-80	4 (18/19/20/23)	2 (35/36)
80-100	2 (35/36)	0
Total	**16**	**20**

Sources: Prepared from data supplied by IPEA based on information from IBGE and INDEC.

5. The combined product plus process innovation rate for the 1,688 firms surveyed is 56% (INDEC, 2003). However, when expanded to cover the Argentine manufacturing complex as a whole, the rate drops to 41%. Being considerable, this difference merits explanation. Firstly, this indicator is an unweighted sum of the number of firms that claimed to have innovated product or process. Secondly, the sample of firms actually interviewed is biased in favor of the large corporations, thereby serving to better capture expenditures on R&D and other innovation activities. However, the expansion corrects this bias by taking into account the share of the smaller firms in relation to the larger. As for R&D expenditure in relation to revenue, the proportional change is insignificant because the smaller firms make only minor contributions to both sides. With regard to the indicators based on the number of firms, the situation is different. In general, the large corporations display an expansion factor of close to one, whereas each small firm interviewed represents 10 to 20 firms with similar characteristics. Since the rate of innovative firms is far from homogeneous when gauged by size of firm—and even lower among the SMEs—when expanded, the numerator increases far less than the denominator. Thus, for calculating the rate of innovative firms presented in this study, the sample of firms surveyed was expanded in accordance with factors determined as functions of the number of workers employed.

In only two Brazilian and six Argentine sectors are there more innovative than non-innovative firms and none of these sectors is part of the main core with respect to R&D expenditures or innovation activities. Rather, these appear to be sectors in which short runs prevail, with products adapted to the requirements of individual clients and influenced by fashion trends.

In contrast, in those sectors that concentrate most of the R&D and innovation expenditures, approximately half the firms innovate. This is an important clue, for it indicates that these expenditures, already concentrated within few sectors, are actually accounted for by a limited number of firms.

By way of tracing a profile of the innovation processes in Argentina and Brazil, five sectoral indicators have been constructed on the basis of the firms' declarations concerning the innovations they achieved. These indicators cover both the degree of innovation (new to the market or only to the firm) and the type of innovation (product, process or combined product/ process innovation).

First, the type of prevailing innovation is analyzed (Table 5). The indicator constructed for this purpose gives the coefficient between the number of firms that declared product innovations and those that declared process innovations. The value of the indicator is greater than one when product prevails over process. Also, the higher the value, the more intensive the sector in terms of product innovation. The results show that, at the sectoral level, what predominates in both countries is process innovation, a tendency that is slightly more accentuated in Brazil. Although there are several exceptions, they are all in sectors where this might be expected.

Project or short-run production favors change in product over change in process. As examples of project production, the manufacture of machinery and equipment (29) and aircraft and ships (35) can be cited. Instances of short-run production are observed in the Argentine textile (17), wearing apparel (18), leather and footwear (19) and furniture (36) industries, all of which are characterized by having a large number of small and medium-size firms that manufacture in small lots. The assembly of components, such as in the electronic and communication (32) sector, also stands out as an activity in which product modification prevails over process modification. Curiously, the Argentine pulp and paper sector (21) turns up among the industries in which product innovation is more important than process innovation.

The second indicator refers to the degree of newness in product innovation. In this case, there is indeed a considerable difference between the Argentine and Brazilian industries, for whereas the former has more firms that innovate for the market, the efforts of the enterprises in the latter have been far more modest and limited to the sphere of the firms themselves. In other words, known market innovations have been reproduced or adapted by the firms.

Once again, production scale may be relevant when explaining these differences. Since many Argentine firms manufacture in shorter runs than their Brazilian counterparts, they may be competing through product differentiation. In turn, since more Brazilian firms manufacture standardized goods, they may be less inclined to alter the characteristics of their products. The size of the market and the number of competitors can also affect the feasibility of creating a wholly new product for the market, especially if the innovation consists in introducing goods that already exist in developed countries to the local market.

It could also be argued that the ambiguity of the term "market" may be influencing these results. However, if the term implies that the conditions are more demanding in Brazil than in Argentina, it is curious that when it comes to process innovations, entrepreneurs demonstrate a completely different response.

Hence, the third indicator attempts to verify which process innovations are most common: those new to the market or those new to the firm. It is the second alternative that characterizes process innovation in both Argentina and Brazil. To weigh this result correctly, the reasoning should be clarified. Depending on how the questions are posed, and taking into account the characteristics of innovation processes in developing countries, the acquisition of machinery and equipment comes to be designated an innovation. This type of innovation leaves its mark not only by raising the expenditures referring to this category, but also by placing firms in the process innovation category. Since it is reasonable to assume that the equipment purchased by a firm can also be bought by a competitor, it is understandable that many entrepreneurs consider this type of innovation to be limited to the sphere of the firm.

The results obtained for the Argentine textile sector (17) therefore suggest a hypothesis that should be confirmed through more detailed studies. For each enterprise that declared a process innovation for the firm, there are 1.62 cases of process innovation for the market. This opens the way to speculation given that this is a sector in which the incorporation of new equipment allows a firm to make the adaptations necessary to assuring the originality of the enterprise in the marketplace.

The purpose of the last two indicators is to ascertain whether product and process innovations occur in a coordinated or isolated manner. In other words, does product innovation usually imply a necessary process modification? Or, at the sectoral level, are processes improved (efficiency efforts, for example) even when the products remain the same?

The indicator referring to the ratio between process innovation and process/product innovation reveals that, in Argentina, process improvements are highly correlated with product improvements. In Brazil, however, processes advance independent of products in the majority of sectors. Nonetheless, most product innovations apparently demand accompanying process innovations, as shown by the fifth indicator.

The evidence brought forth by the five indicators signals that Argentine innovation efforts are aimed at differentiating products, while those of Brazilian firms are targeted at developing new processes. In-depth studies of the competitive frameworks of the more relevant sectors may well provide a valuable complement to these conclusions.

TABLE 5
Innovation paths in Argentina and Brazil — coefficients by type and degree of innovation
(Brazil: 1998-2000 / Argentina: 1998-2001)

ISIC	Product innovation versus process innovation		Product new to the firm versus new to the market		Process new to the firm versus new to the market		Process innovation versus process and product innovation		Product innovation versus process and product innovation	
	Greater than 1: Product prevails over process		Greater than 1: Product new to the market prevails		Greater than 1: Process new to the market prevails		Greater than 1: Process innovation alone prevails		Greater than 1: Product innovation alone prevails	
	Argentina	Brazil	Argentina	Brazil	Argentina	Brazil	Argentina	Brazil	Argentina	Brazil
15	0.90	0.66	2.61	0.15	0.32	0.14	0.49	1.10	0.34	0.38
16	1.00	1.64	ND	0.41	0.00	0.77	0.36	1.39	0.19	2.92
17	1.47	0.72	2.72	0.18	1.62	0.14	0.09	0.97	0.60	0.42
18	2.09	0.55	7.40	0.04	0.02	0.04	0.26	2.22	0.18	0.76
19	1.89	0.63	1.42	0.08	0.59	0.05	0.12	1.40	0.19	0.51
20	0.75	0.54	0.31	0.09	0.59	0.06	0.35	1.28	0.31	0.23
21	1.23	0.52	1.95	0.44	0.58	0.19	1.86	1.38	4.98	0.23
22	0.74	0.27	2.62	0.21	0.48	0.06	0.64	2.74	0.22	0.02
23	0.73	0.60	1.00	0.04	0.38	0.04	0.17	1.04	0.95	0.22
24	0.93	1.22	1.73	0.58	0.24	0.31	0.13	0.38	1.14	0.68
25	0.97	0.67	2.76	0.24	0.40	0.14	0.52	1.11	0.14	0.42
26	0.89	0.53	4.69	0.24	0.59	0.11	0.17	1.57	0.05	0.36
27	0.98	0.69	0.82	0.62	0.26	0.18	0.69	2.23	0.38	1.22
28	0.88	0.51	1.10	0.19	0.37	0.06	0.19	2.18	0.16	0.62
29	1.06	1.19	7.17	0.68	0.65	0.18	0.23	0.64	0.46	0.95
30	ND	2.02	ND	0.55	0.00	0.13	0.11	0.02	0.36	1.07
31	1.18	1.03	1.05	0.56	0.67	0.17	0.31	0.45	0.66	0.49
32	2.32	1.33	2.58	0.55	0.27	0.49	0.45	0.51	0.04	1.01
33	0.72	1.18	6.25	0.51	1.53	0.22	0.00	1.21	1.32	1.60
34	0.82	0.76	2.42	0.92	0.45	0.29	0.00	1.04	0.00	0.55
35	1.26	2.48	11.52	0.68	0.23	0.29	0.57	0.48	0.14	2.68
36	1.67	0.71	1.29	0.12	0.25	0.06	0.00	1.15	0.00	0.52
		Greater than 1		Greater than 1		Greater than 1		Greater than 1		Greater than 1
	Maximum Value		Maximum Value		Maximum Value		Maximum Value		Maximum Value	

Sources: Prepared from data supplied by IPEA based on information from IBGE and INDEC.

6 OVERVIEW AND CONCLUSIONS

The main purpose of this article has been to delineate the principal structural features of the innovation process as developed in the Argentine and Brazilian manufacturing sectors. The profile is based on data arising from innovation surveys and the compilation prepared by IPEA has made it possible to use homogenous categories for the two countries, an essential requirement for a comparative analysis such as the one presented in this study.

As mentioned in the introduction, the research has centered on four issues. The first refers to the innovation capacities of the Argentine and Brazilian manufacturing industries and the gap that separates them from their European counterparts. The second has aimed to identify the sectoral nuclei that form the epicenters of the innovation processes in the two countries. The third question has been to ascertain the extension and framework of the industrial R&D laboratories. The fourth and final objective has been to outline a profile of the innovations actually achieved within each manufacturing complex.

An overview of the results shows that R&D expenditures are extremely low in Argentina, especially in absolute terms–a relevant dimension considering that economies of scale are significant in this kind of activity. This limits the possibility of gathering the "critical mass" of resources necessary to sustaining a dynamic flow between manufacturing firms and scientific institutions, which, in turn, weakens the feedback mechanisms. Under these circumstances, it is extremely difficult for the National Innovation System to take shape and provide the foundations for a competitive framework.

Brazil is different from Argentina in this respect since its position approximates those of the less developed European countries, especially with regard to absolute R&D expenditures. However, when the overall composition of expenditures on innovation activities is analyzed–wherein the acquisition of machinery and equipment predominates–Brazil is seen to approach Argentina and the other Latin American countries.

R&D expenditures, as well as outlays on machinery and equipment, are highly concentrated in both Argentina and Brazil. The chemical and pharmaceutical (24), automotive (34) and food (15) sectors comprise part of the nucleus for R&D expenditures in both countries. These three sectors also stand out as the industrial R&D epicenter of Mercosur. The principal differences in the composition of the nuclei are the plastics sector (25), which enters only in Argentina, and fuel (23) and electronic and communication equipment (32), which participate only in Brazil.

Different from what is often believed, variations in specialization within the production framework do not appear to be the main reason for the gap between the Argentine and Brazilian manufacturing industries. Instead, asymmetric sectoral intensities with regard to expenditure seem to be the most significant explanatory factor. If the Argentine manufacturing sectors were to allocate resources similar to those invested by their Brazilian counterparts in the activities that drive technological change, the total amount would increase by 122%, thereby raising the aggregate indicator "R&D/Revenue" from the 0.25% observed in 2001 to 0.56%.

From the standpoint of R&D laboratories, the Argentine infrastructure is more extensive than the Brazilian. The density is one laboratory for every 10 firms (1,375 units) in Argentina, compared to only one for every 20 firms (3,146 units) in Brazil. However, when measured by employment, the average size of the Brazilian laboratories (9.93 workers) doubles that of the Argentine research facilities (4.5 workers). Likewise, expenditures per employee and per laboratory are significantly higher in Brazil.

This set of evidence allows for the conclusion that more sophisticated tasks are being performed in the Brazilian R&D labs than in the Argentine labs, where, in most cases, the presumed budgets are sufficient to cover only wages and salaries. It should also be mentioned that the Brazilian research facilities in the fuel (23), electronic and communication (32), automotive (34), aircraft and ship (35) sectors are the most important in the region.

In the majority of the Argentine and Brazilian manufacturing sectors, there are more non-innovative than innovative firms. The resulting difficulties in improving products and/or processes have led to the serious competitive disadvantages shared by the two countries.

At the sectoral level, more firms claim to have innovated with respect to process than to product in Argentina as well as Brazil. This is hardly surprising considering that the acquisition of machinery and equipment is the major innovation activity in both economies and that the mere purchase of more technologically advanced equipment places the firm in the process-innovation category. The fact that entrepreneurs themselves describe process innovation as being for the firm alone indicates that absorption of technology prevails over the creation of new knowledge.

With regard to product innovation, Argentine firms tend to develop products new to the market. In most Brazilian sectors, however, the majority of firms that alter their products incorporate features already known to the market. Whereas product and process innovations are often independent of one another in Brazil, the two types of innovation tend to develop alongside in Argentina.

The resulting innovation paths lead to the following hypotheses. In Argentina, innovation is related to competition strategies linked to product differentiation. In Brazil, it is associated with strengthening competitivity through more efficient processes and therefore lower costs. These strategy options are compatible with the scales of production in the two countries, scales which are significantly larger in the Brazilian manufacturing sectors.

APPENDIX

TABLE A1
R&D expenditures of leading sectors in Argentina and Brazil
(In US$ - Argentina: 2001 / Brazil: 2000)

Argentina				Brazil			
Sector	ISIC	US$	% of total	Sector	ISIC	US$	% of total
Chemicals and pharmaceuticals	24	118,922	**54%**	Automotive (expanded)	34	303,738,210	**13%**
Food	15	20,207,223	**9%**		35	144,403,891	**6%**
Plastics	25	15,863,892	**7%**	Chemicals and pharmaceuticals	24	365,498,548	**15%**
Automotive	34	12,254,810	**6%**	Electronics and communications	32	298,495,228	**12%**
				Fuel	23	274,102,520	**11%**
Total R&D expenditures: primary nucleus				**Total R&D expenditures: primary nucleus**		**1,386,238,397**	**58%**
				Machinery and equipment	29	179,527,611	**7%**
				Electrical machinery and comp.	31	165,863,116	**7%**
				Food	15	143,807,902	**6%**
				Total R&D expenditures: secondary nucleus		**489,198,629**	**20%**
				Total: 8 sectors selected		**1,875,437,026**	**78%**

Sources: Prepared from data supplied by IPEA based on information from IBGE and INDEC.

TABLE A2
M&E expenditures of leading sectors in Argentina and Brazil
(In US$ - Argentina: 2001 / Brazil: 2000)

Argentina				**Brazil**			
Sector	ISIC	US$	% of total	Sector	ISIC	US$	% of total
Chemicals and pharmaceuticals	24	212,530,766	**23%**	Food	15	754,548,120	**11%**
Food	15	189,267,141	**20%**	Chemicals and pharmaceuticals	24	855,093,024	**13%**
Ceramics and construction materials	26	135,838,517	**15%**	Basic metals	27	825,141,687	**12%**
Automotive	34	119,431,756	**13%**	Automotive	34	1,052,026,724	**16%**
Plastics	25	54,898,886	**6%**				
Total M&E expenditures: primary nucleus		**711,967,066**	**76%**	**Total M&E expenditures: primary nucleus**		**3,486,809,555**	**52%**
				Plastics	25	414,699,404	**6%**
				Pulp and paper	21	359,914,890	**5%**
				Machinery and equipment	29	333,841,417	**5%**
				Ceramics and construction materials	26	327,867,256	**5%**
				Total M&E expenditures: secondary nucleus		**1,436,322,967**	**21%**
				Total: 8 sectors selected		**4,923,132,523**	**73%**

Sources: Prepared from data supplied by IPEA based on information from IBGE and INDEC.

TABLE A3
Number of firms by type of innovation
(Argentina: 1998-2001 / Brazil: 1998-2000)

	Non-innovative firms	Innovative firms			Rate of innovative firms
		Product	Process	Product and process	
Argentina	6,403	948	849	2,713	41%
Brazil	47,767	4,526	9,821	8,037	32%

Sources: Prepared from data supplied by IPEA based on information from IBGE and INDEC.

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CHAPTER 4

A COMPARISON OF THE TECHNOLOGICAL STRATEGIES OF THE LESS PRODUCTIVE ARGENTINE AND BRAZILIAN FIRMS

Victor Prochnik
Rogério Dias de Araújo

1 INTRODUCTION

This chapter compares the technological strategies of the less productive firms in Argentina and Brazil on the basis of the innovation surveys conducted in the two countries. The purpose of the comparison is to contribute to the industrial and technological policies of these countries and, above all, to their joint endeavors.

The relevance of the economic integration of South America stands out when compared to other parts of the world. In the European Economic Community, NAFTA and other regions, populations as well as enterprises have benefited from the growing cooperation among nations. Meanwhile, in South America, the integration of economic activities and policy measures has been progressing at a far slower pace. The approximation of Brazil and Argentina is therefore of great interest.

In this process, the less productive firms have much to gain, but also much to lose. Specifically, increases in the scale of markets may lead to economic concentration should it become harder to defend the niches in which the less productive companies are currently protected.

For this reason, when formulating economic policies, ways need to be found to support these firms without reinstituting protective barriers to guarantee their markets. With regard to this issue, one of the solutions most frequently proposed in the technical literature is to stimulate innovation. Following this line of thought, this chapter considers how to spur innovation among the less productive enterprises in Argentina and Brazil.

2 CLASSIFICATION SCHEME

This chapter is based on the same methodology followed throughout the rest of the book, succinctly explained below. It also makes use of the taxonomy proposed by Prochnik and Araújo (2005), also outlined below.

It should be underlined that the databases of the Argentine and Brazilian innovation surveys are organized following the same classification scheme, which distributes firms according to their competitive strategies:

X firms: firms that innovate and differentiate products for the market, export and have above average R&D/turnover ratios within their industrial sectors.

Y firms: export firms specialized in standard products and non-export firms that have above average work productivity within their industrial sectors.

Z firms: firms included in neither of the above categories (DE NEGRI, 2005, p. 2).

This study focuses on the Z firms, those that neither innovate nor differentiate products, direct their efforts to local markets and have lower productivity levels.

Since the X firms are the most competitive and operate according to international standards, R&D expenditures are probably an accurate indicator of their product differentiation efforts. In contrast, Y firms specialize in standard products having lower value added. Z firms, though also specialized in standard products, operate at lower productivity levels and have efficiency problems. They are therefore the least competitive.

To help understand the dynamic of the non-differentiating, lower productivity Z firms, a taxonomy having four technological strategy classes, as proposed by Prochnik and Araújo (2005), is adopted in this text. As Chart 1 shows, the combined product and process strategy tends to be more ambitious than the product only or process only innovation strategies.

CHART 1
Competitive strategies by type of innovation

Technological strategy	Aim of strategy	Cumulative competitive advantages linked to strategy
I No innovation (NIS)	Cost rationalization	Increased production capacity through use of capital goods similar to those already employed, marginal cost reductions and/or quality improvements
II Process innovation only (PcS)	Cost leadership	Increased production capacity through technical efficiency gains, significant cost reductions and/or quality improvements
III Product innovation only (PdS)	Greater variety	Product innovation and/or differentiation for new market with current technical base
IV Product and process innovation (PPS)	Differentiation and efficiency	Product innovation and/or differentiation for new market through technical efficiency gains, cost reductions and/or quality improvements

It should be noted that only domestic firms were considered since there are few foreign enterprises in the non-differentiating, lower productivity category and their technological standards are far different from those of the domestic firms. Taking this into account, it was decided not to consider these enterprises in the analysis. Likewise, for the sake of comparison, foreign and mixed capital firms in the other categories were also excluded.

Finally, it should be observed that both the tables and the econometric model follow the sectoral classification found in Abramovsky *et al.* (2004).

3 RESULTS OF THE DESCRIPTIVE ANALYSIS

3.1 Distribution of firms according to category, sector and size

Table 1 and Table 2 show the distribution of firms by economic sector in Argentina and Brazil, respectively. The aggregate analysis reveals strong similarities between the industrial structures of the two countries. However, Argentina has proportionally more firms in the high-tech sectors, primarily in the chemicals sector. The most striking difference refers to the product and process strategy, for Brazil has a larger share of capital goods firms, an issue relevant to this chapter.

Among the low-tech sectors, Argentina has a higher share of firms in the food industry, a sector in which many firms innovate only processes, not products. At the base of the food chains, where often homogeneous inputs are produced for future industrialization, process innovation is more common than product innovation. Thus, the data indicate a larger share of firms at the base of the chains where the raw materials are processed. The textile and footwear chains operate in a different manner since product innovations tend to be incremental. For this reason, in these cases as well, the tables suggest that the Argentine firms are less competitive in terms of innovation.

TABLE 1
Argentina: percentage distribution of firms by technological strategy and sector

Sector	**Total**	Firms that innovate and differentiate products (X)	Firms that specialize in standard products (Y)	Firms that do not differentiate products and have lower productivity (Z)	PPS	PcS	PdS	NIS
Transport equipment	**4.6**	11.3	6.3	2.7	4.6	n.a.	5.6	2.1
Chemicals	**9.2**	30.6	11.5	5.6	17.1	10.8	n.a.	2.8
Machinery and equipment	**3.4**	5.9	3.0	3.5	9.0	n.a.	5.6	2.2
Electrical/Electronic machinery	**4.0**	13.9	1.9	5.0	2.8	n.a.	7.7	5.7
High technology sectors	**21.1**	**61.7**	**22.7**	**16.9**	**33.6**	**10.8**	**18.8**	**12.8**
Food/Beverages	**19.5**	13.6	23.5	16.7	10.0	34.2	9.3	17.8
Textiles/Footwear	**21.8**	4.7	24.8	20.6	7.9	1.4	55.3	21.5
Wood/Paper/Publishing	**11.6**	5.6	8.1	14.9	12.9	23.7	n.a.	16.4
Rubber/Plastics	**6.9**	n.a.	8.3	6.2	9.3	19.1	n.a.	5.0
Non-metallic minerals	**2.9**	7.4	1.4	3.9	10.5	n.a.	n.a.	3.0
Basic metals	**11.3**	6.8	7.7	14.6	10.4	10.8	n.a.	17.7
Furniture/Miscellaneous	**4.8**	n.a.	3.5	6.3	5.3	n.a.	16.7	5.9
Low technology sectors	**78.9**	**38.3**	**77.3**	**83.1**	**66.4**	**89.2**	**81.2**	**87.2**
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Number (10,000)	**9.1**	0.3	4.0	4.7	0.8	0.3	0.4	3.2

Source: INDEC (2003).

TABLE 2
Brazil: percentage distribution of firms by technological strategy and sector

Sector	Total	Firms that innovate and differentiate products (X)	Firms that specialize in standard products (Y)	Firms that do not differentiate products and have lower productivity (Z)	Strategy			
					PPS	PcS	PdS	NIS
Transport equipment	**2.9**	6.9	5.2	2.4	1.9	1.6	6.4	2.3
Chemicals	**4.2**	15.4	4.6	3.9	7.0	2.0	7.8	3.6
Machinery and equipment	**5.2**	14.6	9.2	4.3	5.4	4.4	9.4	3.8
Electrical/Electronic machinery	**3.7**	18.9	5.4	3.1	6.7	2.9	11.7	2.1
High technology sectors	**16.0**	**55.7**	**24.4**	**13.7**	**20.9**	**10.9**	**35.3**	**11.7**
Food/Beverages	**14.8**	8.8	11.4	15.6	17.8	15.2	12.6	15.6
Textiles/Footwear	**21.9**	13.2	23.2	21.8	18.1	22.0	18.4	22.4
Wood/Paper/Publishing	**13.6**	4.7	10.1	14.4	9.4	14.6	2.2	15.9
Rubber/Plastics	**6.0**	5.1	6.9	5.8	9.4	7.2	6.4	5.0
Non-metallic minerals	**8.7**	1.5	5.4	9.6	6.6	7.7	3.9	10.7
Basic metals	**10.1**	7.0	10.2	10.2	7.2	13.4	9.5	10.0
Furniture/Miscellaneous	**8.8**	3.9	8.4	9.0	10.6	9.0	11.6	8.6
Low technology sectors	**84.0**	**44.3**	**75.6**	**86.3**	**79.1**	**89.1**	**64.7**	**88.3**
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Number (1,000)	**68.0**	0.7	11.9	55.4	5.0	7.3	2.9	40.2

Source: IBGE (2002).

Both Argentina and Brazil have higher shares of firms in the low technology sectors. The same is true of the Z firms that innovate products (columns PcS and PPS). This frequent product innovation by low-tech firms is a relatively recent phenomenon. In Pavitt's (1984) classification, for example, firms in the supplier dominated category, which roughly corresponds to the low technology category in the above tables, were not characterized as product innovators. This indicates that the database used by this author did not report these firms as product innovators.

The innovations of low technology firms tend to be different from those of high technology firms. While less influenced by scientific knowledge, the low-tech industries face increasing pressure to innovate due to low income elasticity of demand (which drives the search for differentiation of products and diversification of the more successful firms); to changes in market composition (demographic variations, habits and preferences); and to pressure for products that are safe and comply with environmental requirements (TUNZELMAN; ACHA, 2004).

Another point emphasized by analysts of low technology industries (HIRSCH-KREINSEN *et al.*, 2003; TUNZELMAN; ACHA, 2004; BENDER, 2004) is the diversity of organizational structures and learning processes underlying innovation in these sectors. This leads to highly varied and specific demands for technological policies, making it hard to implement generic measures. For this reason, numerous Brazilian authors, such as Diniz (2001); Cassiolato and Lastres (2005) and Prochnik (1990) have suggested the adoption of local policies.

TABLE 3
Argentina: percentage distribution of firms by research category and sector

	Firms that innovate and differentiate products (X)	Firms that specialize in standard products (Y)	Firms that do not differentiate products and have lower productivity (Z)	**Total**	Number (10,000)
Transport equipment	9.2	60.0	30.8	**100.0**	0.4
Chemicals	12.4	55.4	32.2	**100.0**	0.8
Machinery and equipment	6.6	38.7	54.8	**100.0**	0.3
Electrical/Electronic machinery	13.0	21.0	66.0	**100.0**	0.4
High technology	**10.9**	**47.2**	**41.9**	**100.0**	**1.9**
Food/Beverages	2.6	52.7	44.7	**100.0**	1.8
Textiles/Footwear	0.8	49.8	49.4	**100.0**	2.0
Wood/Paper/Publishing	1.8	30.7	67.5	**100.0**	1.0
Rubber/Plastics	n.a.	52.9	47.1	**100.0**	0.6
Non-metallic minerals	9.4	21.3	69.3	**100.0**	0.3
Basic metals	2.3	30.1	67.7	**100.0**	1.0
Furniture/Miscellaneous	n.a.	31.9	68.1	**100.0**	0.4
Low technology	**1.8**	**43.0**	**55.2**	**100.0**	**7.1**
Total	**3.7**	**43.9**	**52.4**	**100.0**	**9.1**

Source: INDEC (2003).

TABLE 4
Brazil: percentage distribution of firms by research category and sector

	Firms that innovate and differentiate products (X)	Firms that specialize in standard products (Y)	Firms that do not differentiate products and have lower productivity (Z)	**Total**	Number (1,000)
Transport equipment	-	31.4	66.2	**100.0**	1,979
Chemicals	3.7	19.4	76.9	**100.0**	2,823
Machinery and equipment	2.8	30.6	66.6	**100.0**	3,568
Electrical/Electronic machinery	5.1	25.5	69.4	**100.0**	2,510
High technology	**3.5**	**26.7**	**69.8**	**100.0**	**10,880**
Food/Beverages	0.6	13.5	85.9	**100.0**	10,063
Textiles/Footwear	0.6	18.5	80.9	**100.0**	14,915
Wood/Paper/Publishing	0.3	13.0	86.7	**100.0**	9,212
Rubber/Plastics	0.9	20.2	78.9	**100.0**	4,058
Non-metallic minerals	0.2	10.7	89.1	**100.0**	5,944
Basic metals	0.7	17.6	81.7	**100.0**	6,899
Furniture/Miscellaneous	0.4	16.6	83.0	**100.0**	6,001
Low technology	**0.5**	**15.7**	**83.8**	**100.0**	**57,092**
Total	**1.0**	**17.5**	**81.5**	**100.0**	**67,971**

Source: IBGE (2002).

Tables 3, 4 and 5 show the distribution of firms according to the categories researched. Moving from firms that innovate and differentiate products (X) to those that do not differentiate and have lower productivity (Z), the share of Brazilian firms in relation to Argentine firms increases, while average firm size decreases in both countries. Within the Z category, more Brazilian than Argentine firms adopt non-innovation strategies (NIS). Among the low-tech firms, this asymmetry becomes so evident that the Argentine firms are seen to employ 2.6 times more workers than their Brazilian counterparts.

This has two consequences: (1) the average difference between small and large enterprises is less marked in Argentina than in Brazil and (2) small businesses hold a more prominent position in the Brazilian than in the Argentine industrial framework.

TABLE 5
Argentina and Brazil: percentage distribution of non-differentiating, lower productivity firms by research category and technological strategy

Argentina: percentage distribution of Z firms according to technological strategy						
Sectoral aggregates according to technological intensity	PPS	PcS	PdS	NIS	**Total**	No. of firms
High technology	35.0	2.0	11.7	51.4	**100.0**	812
Low technology	14.0	6.2	9.3	70.5	**100.0**	4,013
All firms	17.5	5.5	9.7	67.3	**100.0**	4,825
Brazil: percentage distribution of Z firms according to technological strategy						
Sectoral aggregates according to technological intensity	EPP	EPC	EPD	ENI	**Total**	No. of firms
High technology	13.7	10.5	13.7	62.1	**100.0**	7,599
Low technology	8.2	13.6	4.0	74.2	**100.0**	47,819
All firms	8.9	13.2	5.3	72.5	**100.0**	55,417

Sources: INDEC (2003) and IBGE (2002).

Finally, Table 6 compares the size of firms in the two countries, measured in terms of the number of workers employed. Insofar as firm size is a key variable when determining the feasibility of innovating, as Chudnowsky (2005) has pointed out for Argentina and Prochnik and Araújo (2005) for Brazil, Argentina appears to be in a better position. This may partly explain the greater intensity of innovation efforts in Argentina despite lower expenditures on research and development. This issue will be discussed further on in this paper.

TABLE 6

Argentina and Brazil: average number of workers employed in innovative firms by sector and technological strategy

Argentina (2001)							
Sectoral aggregates according to technological intensity	Firms that innovate and differentiate products (X)	Firms that specialize in standard products (Y)	Firms that do not differentiate products and have lower productivity (Z)	PPS	PcS	PdS	All firms
High technology	120	92	40	43	59	42	68
Low technology	157	123	61	61	71	44	86
All firms	136	115	56	55	70	43	81
Brazil (2000)							
Sectoral aggregates according to technological intensity	Firms that innovate and differentiate products (X)	Firms that specialize in standard products (Y)	Firms that do not differentiate products and have lower productivity (Z)	EPP	EPC	EPD	All firms
High technology	276	124	54	64	54	44	107
Low technology	746	151	45	52	44	36	102
All firms	484	145	47	54	45	39	103

Sources: INDEC (2003) and IBGE (2002).

3.2 Intensity of research and development

3.2.1 Expenditures on R&D

The ratio of R&D expenditures to turnover is lower for the non-differentiating, lower productivity Argentine firms than for their Brazilian counterparts. Whereas the Brazilian Z firms spent an average 0.53% of their net sales on R&D in 2001, the Argentine Z firms spent an average 0.13% in 1998 and 0.18% in 2001. Likewise, expenditures on extramural acquisition of R&D were higher in Brazil (0.10%) than in Argentina (0.05% in both years).

However, as the next section shows, the average number of workers engaged in R&D is higher in Argentina than in Brazil. At the same time, the rates of innovation are also higher in the former than in the latter. These data suggest that the two countries have different patterns of innovation. Whereas Argentina advances via a modernization process in which it seeks to broaden its range of manufactured goods, innovation in Brazil is of a more radical nature and places heavier emphasis on increments in technical efficiency. The data on the non-differentiating, lower productivity firms support this interpretation since, contrary to what occurs in the X and Y categories, the Argentine Z firms are larger than the Brazilian Z firms. Even so, they spend less on R&D and on the acquisition of machinery and equipment geared to the innovation process.

TABLE 7
Argentina and Brazil: average expenditures on R&D by innovative firms

Argentina (2001)							
Sectoral aggregates according to technological intensity	Firms that innovate and differentiate products (X)	Firms that specialize in standard products (Y)	Firms that do not differentiate products and have lower productivity (Z)	PPS	PcS	PdS	All firms
High technology	179	22	8	5	4	16	35
Low technology	64	16	6	11	1	2	10
Average R&D expenditure	130	18	6	9	2	5	17
Brazil (2000)							
Sectoral aggregates according to technological intensity	Firms that innovate and differentiate products (X)	Firms that specialize in standard products (Y)	Firms that do not differentiate products and have lower productivity (Z)	PPS	PcS	PdS	All firms
High technology	1,446	230	49	83	43	20	146
Low technology	696	34	10	16	8	3	17
Average R&D expenditure	1,114	82	16	30	5	20	38

Sources: INDEC (2003) and IBGE (2002).

The main differences are in expenditures on the acquisition of machinery and equipment used for innovation. The Argentine Z firms spent only 0.95% of their net sales in 1998, and 0.80% in 2001, on the purchase of capital goods for innovation. In contrast, the Brazilian Z firms spent 8.57% of their net sales on the purchase of such goods.

The lower expenditure on capital goods in relation to the turnover of the Argentine Z firms may be related to the frequent cyclical instabilities observed in the country. It may also be linked, however, to the smaller size of the domestic capital goods sector. For a small firm, the supply of imported capital goods may not be compatible with its needs, that is, such goods may not be suited to meeting the requirements of the local market.

This issue becomes especially evident in the case of innovation. While imported capital goods are expected to bring significant technical advances, and therefore to serve as effective instruments for introducing radical process or product innovations, they do not necessarily support incremental product innovation. Since capital goods can be separated according to domestic or foreign origin in the case of Argentina, the next section will approach this question.

3.2.2 Expenditures on domestic and imported capital goods for innovation in Argentina

The Argentine survey shows that among the non-differentiating, lower productivity firms, there is a correlation between the innovation strategy adopted and the origin of the capital goods acquired for innovation. This is verifiable due to the Argentine survey containing information on the domestic or foreign origin of the capital goods purchased. Table 8 shows the relations between the purchase of domestic and imported capital goods and the four technological strategies.

TABLE 8
Argentina: purchase of domestic and imported capital goods by non-differentiating, lower productivity firms according to technological strategy
(US$ 1,000)

Strategy	Purchase of domestic capital goods	%	Purchase of imported capital goods	%	Total purchase of capital goods	%
PPS	55,812	84.2	10,502	15.8	66,313	100.0
PcS	10,446	18.9	44,844	81.1	55,290	100.0
PdS	17,073	91.0	1,681	9.0	18,754	100.0
NIS	106,151	94.9	5,670	5.1	111,820	100.0
Total	**189,481**	**75.1**	**62,697**	**24.9**	**252,178**	**100.0**

Source: INDEC (2003).

As the table shows, process innovation only (PcS) is related to the acquisition of imported capital goods, while product innovation only (PdS) and combined product and process innovation (PPS) are tied to the purchase of domestic capital goods. Firms that did not innovate also purchased mainly domestic capital goods. Since the latter did not innovate, their purchases are likely to have been merely for replacement purposes, thus implying no technological advances.

Why do product innovators prefer domestic capital goods? The answer may be pointing to a strategy implemented by capital goods manufacturers, one based on their knowledge of the domestic market and aimed at introducing new processes capable of manufacturing innovative products.

This hypothesis would also partly explain the low average cost of the innovations introduced by Argentine firms compared to those developed by Brazilian firms (i.e., lower absolute and relative R&D expenditures). To the extent that the new machinery is already prepared to manufacture new products, additional R&D becomes minimal. In addition, if the improvements in the machinery are incremental, the product innovations made possible through its acquisition also tend to be incremental. The low expenditures on R&D on the part of both machinery manufacturers and other firms suggest that suppliers and consumers progress in step and interact via adaptive rather than radical strategies.

The firms that innovated processes only took the opposite path, importing most of their capital goods for innovation. This is consistent with the type of innovation undertaken, since it indicates production planning directed basically to technical efficiency rather than to product differentiation.

Another aspect of the issues discussed in this section refers to the exchange of information between firms and their suppliers. In the case of new machinery and equipment, firms tend to maintain regular contact with the manufacturers of the capital goods they purchase because the new equipment is different from what they used before, thus requiring learning for operation and maintenance purposes, as well as for production planning. Suppliers, in turn, are primarily interested in use and quality statistics on the equipment sold in order to optimize their own products.

TABLE 9
Argentina: relevance of suppliers as sources of information for the innovation efforts of non-differentiating, lower productivity firms

Strategy	Purchase of domestic capital goods	Purchase of imported capital goods	Total purchase of capital goods
PPS	6,381	1,725	8,105
PcS	5,334	170	5,504
PdS	4,271	0	4,271
NIS	1,455	309	1,764
Total	17,440	2,203	19,643

Source: INDEC (2003).

In the exchange context, an especially important type of information is that capable of leading to innovation, a question explicitly addressed in the Argentine survey. Although Argentine firms rarely have recourse to capital goods suppliers as sources of information for innovation, there is a correlation between firms that appeal to suppliers and the purchase of domestic capital goods. In fact, 9.2% of the firms that acquired domestic capital goods for innovation indicated that their suppliers were an important source of information, whereas only 3.5% of the firms that purchased foreign capital goods replied in the affirmative.

The most interesting case is that of process innovation only. Among firms that innovated and depended on information from suppliers, 96.3% of the capital goods purchases were effected in Argentina. In marked contrast, among those that innovated but did not take advantage of this source of information, only 10.3% of the capital goods purchases were made in Argentina.

Lastly, it must be underlined that the above discussion is valid only for the less productive Argentine firms. The more productive firms, those that innovate and differentiate products or specialize in standard goods, are responsible for the majority of expenditures on incorporated technology. Among these firms, the importation of capital goods prevailed, as already observed by Chudnovsky *et al.* (2005).

3.3 Rate of innovation in Argentina and Brazil

The rate of innovation of a given set of firms is the share of firms in the set that innovates. Since the number of non-differentiating, less productive firms (Z firms) is far greater than the number of firms in other categories (X and Y firms), the innovation rate of a country is heavily influenced by the innovation of its Z firms.

The tables below, which refer to domestic firms only (as throughout this study), present the innovation rates for the different strategies and categories. On comparing Argentina and Brazil, combined process and product innovation (PPS) is seen to be far more common in Argentina (an average 25.3%) than in Brazil (11.0%) in all categories and sectors. With respect to product innovation only (PdS), the Argentine rate is also higher than the Brazilian, except for the non-differentiating, lower productivity Z firms. However, with regard to process innovation only (PcS), the Brazilian rate is superior.

TABLE 10
Argentina and Brazil: rates of process and product innovation for firms X, Y and Z

Sector	Argentina			Brazil		
	Firms that innovate and differentiate products (X)	Firms that specialize in standard products (Y)	Firms that do not differentiate products and have lower productivity (Z)	Firms that innovate and differentiate products (X)	Firms specialized in standard products (Y)	Firms that do not differentiate products and have lower productivity (Z)
Transport equipment	92.1	11.7	30.5	75.5	8.4	7.1
Chemicals	80.6	27.0	54.3	46.6	28.2	16.1
Machinery and equipment	75.0	45.8	45.5	63.2	21.0	11.2
Electrical/Electronic machinery	70.2	85.5	10.0	71.3	18.3	18.9
High technology	**79.7**	**31.0**	**35.0**	**62.9**	**19.1**	**13.7**
Food/Beverages	93.5	24.4	10.8	88.8	16.9	10.2
Textiles/Footwear	93.8	18.4	6.9	75.5	12.4	7.4
Wood/Paper/Publishing	42.1	32.0	15.4	65.4	14.0	5.8
Rubber/Plastics	n.a.	40.9	26.9	68.4	16.1	14.5
Non-metallic minerals	100.0	14.0	48.1	90.4	10.3	6.2
Basic metals	91.3	42.0	12.7	76.8	11.0	6.3
Furniture/Miscellaneous	n.a.	30.7	15.05	90.7	20.4	10.5
Low technology	**81.8**	**26.9**	**14.0**	**78.3**	**14.2**	**8.2**
Total	**80.6**	**27.8**	**17.5**	**69.7**	**15.4**	**8.9**

Sources: INDEC (2003) and IBGE (2002).

These trends can be accounted for by at least four, not necessarily mutually exclusive, explanations: (1) the higher level of qualification of the Argentine labor force; (2) the greater share of high technology firms in the Argentine industrial structure; (3) a different innovation pattern, one directed to modernization based on the introduction of numerous incremental innovations; and (4) the elimination during times of economic crisis of inefficient Z firms that compete solely via price. While analysis of the latter lies beyond the bounds of this study, the other alternatives are supported by the data and econometric models presented.

TABLE 11
Argentina and Brazil: rates of process innovation for firms Y and Z and product innovation for firms X, Y and Z

Sectoral aggregates according to technological intensity	Process innovation strategy					
	Argentina			Brazil		
	Firms that innovate and differentiate products (X)	Firms specialized in standard products (Y)	Firms that do not differentiate products and have lower productivity (Z)	Firms that innovate and differentiate products (X)	Firms specialized in standard products (Y)	Firms that do not differentiate products and have lower productivity (Z)
High technology		5.7	10.1		14.9	10.5
Low technology		7.2	11.3		20.4	13.6
Total		**7.0**	**11.0**		**19.0**	**13.2**
Sectoral aggregates according to technological intensity	**Product innovation strategy**					
	Argentina			Brazil		
	Firms that innovate and differentiate products (X)	Firms specialized in standard products (Y)	Firms that do not differentiate products and have lower productivity (Z)	Firms that innovate and differentiate products (X)	Firms specialized in standard products (Y)	Firms that do not differentiate products and have lower productivity (Z)
High technology	20.3	8.4	11.7	37.1	16.7	13.7
Low technology	18.2	8.2	9.3	21.7	6.2	4.0
Total	**19.4**	**8.2**	**9.7**	**30.3**	**8.8**	**5.3**

Sources: INDEC (2003) and IBGE (2002).

4 ECONOMETRIC MODEL FOR INNOVATION AMONG NON-DIFFERENTIATING, LOWER PRODUCTIVITY FIRMS

4.1 Methodology

As most of the non-differentiating, lower productivity firms (Z firms) did not innovate, it is important to analyze what prompted those that did. Thus, three probabilistic econometric models were estimated in order to study innovative strategies in relation to non-innovative strategies. The basis of the three models is the same, with innovative firms being compared to non-innovative firms. Thus, the dependent variable is the same binary variable in all three cases, the innovative firms having a value of 1 (one) and the non-innovative firms a value of 0 (zero).

1. MODEL 1 (PcS model) - compares Z firms that innovated processes only to firms that did not innovate

2. MODEL 2 (PdS model) – compares Z firms that innovated products only to firms that did not innovate
3. MODEL 3 (PPS model) – compares Z firms that simultaneously innovated processes and products to firms that did not innovate

The models employ independent variables used in similar models in other countries as well as in Brazil and Argentina, with emphasis placed on those that may become the object of industrial policy. Specifically, the models are based on two branches of the neo-Schumpeterian school: that referring to technological regimes (MALERBA; ORSENIGO, 1996 and 1997) and that referring to technological strategies (PIANTA, 2004). Finally, they were partially inspired by the model developed by Castellacci (2004), which also uses variables based on the same two neo-Schumpeterian branches.

Among the variables, some are sectoral (ISIC at the 2 and 3-digit levels), reflecting the general conditions faced by all non-differentiating, lower productivity firms in the same sector, and designed to identify the prevailing technological regime. Two examples of such variables are the "technological level" and "degree of imitation" prevalent in the sector. The degree of imitation indirectly measures the degree of innovation because the two are complementary.

Other variables differ across firms and are targeted at capturing disparities in the technological and competitive strategies of related firms. Among these can be cited "expenditures on incorporated technology," "expenditures on unincorporated technology" and the relevance of suppliers as sources of information.

Another variable related to industrial structure is the concentration ratio (CR4). In a neo-Schumpeterian model, market concentration is essentially a dependent variable because innovation activities are assumed to dynamically determine the degree of concentration. In the case of smaller firms, however, concentration can be an obstacle to innovation since innovative activities require substantial resources and tend to be quite risky.

The variables, calculation methods and selection criteria are described as follows:

Concentration ratio (CR4): The sectoral values are estimated at the three-digit level. On the one hand, expenditures on technology are immediate and constitute sunk costs. On the other, the benefits of investing in innovation are uncertain and generally bring returns only in the long run. Thus, given that costs are certain and immediate and returns are spread over time, the uncertainty regarding expected returns is a key explanatory variable underlying innovation processes and the adoption of new techniques. In addition, the higher the degree of concentration, the more easily larger firms can block the access of smaller innovative firms to the market and/or imitate their innovations within a short space of time. The larger firms can also protect their competitive advantages through other means, including by once again innovating. Thus, from the standpoint of less competitive firms, market concentration may be seen as a barrier to the adoption of new technologies since it increases the uncertainty as to expected returns. Under these conditions, net returns on technological investments are relatively limited.

Degree of imitation: The degree of imitation is calculated as the ratio of firms that absorb innovations to the total number of innovators. The degree of imitation is therefore the inverse of innovation by the firm itself. This variable is also defined at the sectoral level, in which case the values reflect the characteristics of the entire sample, that is, not only of the Z firms, but also of the X and Y firms.

Ratio of expenditures on incorporated technology to net sales: This ratio stands for the percentage of net sales revenue spent on the acquisition of machinery and equipment for innovation purposes.

Ratio of expenditures on unincorporated technology to net sales: This ratio covers all expenditures on unincorporated technology (internal R&D, external R&D, other external knowledge, training, industrial design and marketing), not only those on R&D. The procedure is valid because such costs are an integral part of the innovation process. In the case of process innovation, the need to train personnel to operate new equipment, as well as the need to pay manufacturers for the right to use proprietary technology, increases the cost of adopting new processes. In the case of product innovation, post-innovation expenditures such as industrial design and marketing tend to be more relevant. The true cost of innovation therefore involves a series of complementary expenditures on unincorporated technology.

The expenditure data on both incorporated and unincorporated technology refer to the year 2000 in the case of Brazil and to the year 2001 in the case of Argentina. In the surveys, the Brazilian questionnaire requested innovation information for the period 1998-2000, while the Argentine questionnaire solicited information for 1999-2001. Due to this difference, the models were tested without cost variables. In the results, the signs of the variables remained the same and the values of the coefficients were similar.

Share of workers with higher education: This statistic is the ratio of workers with higher education to the total number of workers. The variable was included in an attempt to verify if the skill level of the labor employed affects the probability of a non-differentiating, lower productivity firm choosing to innovate or not depending on the strategy it adopts.

Number of workers: Firm size corresponds to the natural logarithm of the variable "number of workers employed." Size is a classic variable for explaining the propensity of a firm to innovate. The costs of innovating or incorporating new technologies are nearly all fixed. While larger firms expect to transform these costs into higher sales, smaller firms often view their own size and market concentration as potential barriers to innovation.

Cumulativity: This binary variable indicates whether R&D activities were performed regularly (value = 1) or occasionally (value = 0) during the period 1998-2000. "The cumulativeness conditions, which define the extent to which current innovative activity builds upon the experience and results obtained in the past." and " Cumulativeness conditions persistently differ across industries, thus affecting the intensity and direction of technological change in each sector." Castellacci (2006, p. 5-6).

Market guidance (customers): This binary variable indicates whether or not the firm attributed average or above average importance to "clients or customers as sources of information for the development of technologically new or significantly improved products and/or processes in the period 1998-2000" (PINTEC, 2004, p. 8 of survey questionnaire).

Market guidance (suppliers): This binary variable indicates whether or not the firm attributed average or above average importance to "suppliers of machinery, equipment, materials, hardware and/or software as sources of information for the development of technologically new or significantly improved products and/or processes in the period 1998-2000" (PINTEC, 2004, p. 8 of survey questionnaire).

Technological intensity of sector: This binary variable has a value of 1 (one) if the firm belongs to one of the high technology sectors listed in the tables presented in this paper and 0 (zero) if not.

All three models were estimated using the *probit* technique. When using this technique, certain estimation problems must be taken into account. The first is heteroscedasticity, for the estimators are not only inefficient, but also inconsistent. Even so, the values of the marginal probabilities calculated from the coefficients estimated are similar for homoscedastic and heteroscedastic models (see GREENE, 2000, p. 830).In addition, it is hard to determine which variable is heteroscedastic and precisely what form it takes in the models estimated so as to be able to implement corrective procedures.

To calculate the marginal probabilities, the value of the probability density function at estimated point Yi is multiplied by the estimated value of the coefficient. This yields marginal probabilities for each Yi estimated. However, two methods are cited in the literature for obtaining a single marginal probability for each coefficient: (1) use a mean (an average non-differentiating, low productivity firm) to estimate the marginal probabilities or (2) estimate the marginal probability of each firm and then calculate the mean marginal probability. For the purposes of this analysis, the first alternative was chosen.

The second problem related to the *probit* technique is multicollinearity. This is of little concern, however, because the problem diminishes as the number of observations in the sampling frame rises. Moreover, the partial correlations did not surpass 0.8.

Tables 12 and 13 present the results of the models estimated for the process only, product only and combined process/product strategies in Argentina and Brazil.

TABLE 12
Innovation probabilities for non-differentiating, lower productivity firms: Argentina (2001)

Independent variable	PPS model – probit Product and process		PcS model - probit Process only		PdS model – probit Product only	
	In all three models, the dependent variable is binary: 1 = innovated and 0 = did not innovate					
	Coefficient	Marginal probability	Coefficient	Marginal probability	Coefficient	Marginal probability
Concentration ratio (CR4)	1.474**	0.534	-0.980**	-0.169	0.4594*	0.06045
Degree of imitation	0.261*	0.095	-0.830**	-0.143	0.661**	0.087
Expenditures on incorporated technology/ net sales	0.013**	0.005	0.009**	0.002	0.010**	0.001
L Workers with higher education	1.766**	0.640	1.556**	0.268	1.609**	0.212
Expenditures on unincorporated technology/net sales	0.035**	0.013	0.066**	0.011	0.016*	0.002
L Number of workers	0.371**	0.135	0.118**	0.020	0.253**	0.033
Cumulativity	3.414**	1.237	1.929**	0.333	3.130**	0.412
Market guidance (consumers)	2.031**	0.736	2.094**	0.361	2.005**	0.264
Market guidance (suppliers)	0.990**	0.359	0.650**	0.112	-0.104^{NS}	-0.014
Technological intensity	0.620**	0.225	0.223*	0.038	0.085^{NS}	0.011
Statistics	Inter.: -3.486** / -1.264		Inter.: -1.325** / -0.229:		Inter.: -3.245** / -0.427	

Source: INDEC (2003).
Notes: * Significant at 10%; ** Significant at 5%; *** Significant at 1%; NS = not significant.

TABLE 13
Innovation probabilities for non-differentiating, lower productivity firms: Brazil (2000)

Independent variable	PPS model – *probit* Product and process		PcS model - *probit* Process only		PdS model – *probit* Product only	
	In all three models, the dependent variable is binary: 1 = innovated and 0 = did not innovate					
	Coefficient	Marginal probability	Coefficient	Marginal probability	Coefficient	Marginal probability
Concentration ratio (CR4)	-0.4193**	-0.0792	-0.1748*	-0.0424	-0.4323**	-0.0380
Degree of imitation	-0.4201*	-0.0793	0.8792**	0.2136	-0.8874**	-0.0780
Expenditures on incorporated technology/ net sales	0.4665**	0.0881	1.2485**	0.3033	-0.2929**	-0.0258
Expenditures on unincorporated technology/net sales	1.3299**	0.2512	-0.3211**	-0.0780	1.0756**	0.0949
L Workers with higher education	0.1114*	0.0210	-0.0100*	-0.0020	0.0055*	0.0005
L Number of workers	0.2508**	0.0474	0.2531**	0.0610	0.1206**	0.0106
Cumulativity	1.3346**	0.2520	-0.1121*	-0.0270	0.6769**	0.0597
Market guidance (consumers)	1.5101**	0.2852	1.3575**	0.3290	1.8457**	0.1629
Market guidance (suppliers)	1.2250**	0.2313	1.4002**	0.3402	0.8061**	0.0711
Technological intensity	-0.0339*	-0.0064	-0.0284*	-0.0069	0.3288**	0.0290
Statistics	Inter.: -2.2050		Inter.: -3.1282		Inter.: -1.6223	

Source: IBGE (2002).
Notes: * Significant at 10%; ** Significant at 5%; *** Significant at 1%; NS = not significant.

4.2 Analysis of econometric results

Concentration ratio: In all three models for Brazil, concentration is a significant variable with a negative value, supporting the existence of intra-sectoral technological barriers. This probably reflects the fact that innovative firms and firms specialized in standard products retain substantial market shares in certain sectors, thus discouraging the non-differentiating, lower productivity firms from innovating. In Argentina, contrary to Brazil; the results were negative for process innovation alone and positive for the combined process/product strategy, while the findings for product innovation alone were non-significant. This may be due to there being relatively fewer firms in the non-differentiating category in relation to the other categories in Argentina, as well as to their average size being larger than that of their Brazilian counterparts.

Degree of imitation: The degree of imitation is linked to the distribution of Schumpeterian returns. Whereas a firm that innovates for the market wants to assure expected returns, one that innovates for itself alone (in other words, produces goods already on the market) hopes to secure a share of the Schumpeterian returns that firms that previously innovated are now earning.

In the case of the PdS and PPS models for Brazil, the marginal probabilities were negative and significant. This suggests that the non-differentiating, lower productivity firms, compared to firms that do not innovate, are searching for market niches in response to their relatively weak competitive positions, as already pointed out in the analysis of the concentration ratio. This strategy is most often observed in the high-tech sectors because the opportunities for technological advance are greater in these sectors. In the PdS model, a ten-percent increase in the number of firms that imitated represented a 0.78% decrease in the probability that a firm would innovate; in the PdS model, the corresponding figure was 0.79%.

In contrast, the marginal probability margin was positive and significant for the PcS model, indicating that one of the reasons less productive firms innovate is to offset the competitive advantages held by more productive firms.

For Argentina, the results were the opposite of those for Brazil, the values being positive for product innovation only and combined process/product innovation and negative for process innovation only. These results concur with the coefficients obtained for the first variable, the concentration ratio, showing that the non-differentiating, lower productivity Argentine enterprises innovate in the same sectors in which the innovation for the market occur.

Ratios of expenditures on incorporated and unincorporated technology to net sales: For Brazil, both variables are positive and significant in the PPS model, indicating that these two types of innovation expenditure are complementary. As expected, the PdS model shows that product innovation alone is negatively related to expenditures on incorporated technology.

The PcS model reveals that expenditures on unincorporated technology are significant and negative. On the one hand, this indicates that equipment purchases are not as a rule accompanied by efforts to improve processes, develop projects or train personnel. On the other, it points to process innovation alone being aimed merely at replacing machinery and the goods it is capable of producing and not at engaging in joint creative efforts on the part of suppliers and consumers. Other data point in the same direction, among which might be cited limited levels of cooperation for the purpose of innovation and the non-significance of the share of workers with higher education and of the degree of cumulativity. In this model, a ten-percent increase in expenditures on unincorporated technology resulted in a 3.03% increase in the probability of a firm innovating.

For Argentina, expenditures on incorporated technology are positively correlated with innovation in all of the models. Thus, despite total expenditures being relatively lower than in Brazil, they are important for Argentine firms. In the case of product innovation only, the positive coefficient may indicate that some firms had purchased equipment that was not yet in operation. This might explain why some firms declared to have purchased new equipment for the purpose of innovation but not to have engaged in innovation.

Share of workers with higher education: In the case of Argentina, the values are positive for all three models, this being the most important variable for explaining the probability of process only innovation among the less productive Argentine firms. In the other innovation categories, cumulativity is more important. This finding is strengthened by the larger number of R&D workers per firm, the higher percentage of firms in high-tech sectors and probably higher overall educational levels in Argentina than in Brazil. In the case of Brazil, it is important to note that the sign is negative in the PcS model and positive in the other two models. The negative sign indicates that the level of process innovation is linked to the lower proportion of skilled labor. The marginal probabilities are lower in Brazil than in Argentina, possibly due to the lower share of workers with higher education in Brazilian firms.

Number of workers: All the coefficients are positive for both Argentina and Brazil, in accord with all innovation studies performed to date. It should be highlighted that the estimated marginal probability was lower for the PdS model than for the PcS and PPS models, both for Argentina and for Brazil.

Cumulativity: With regard to Brazil, the sign is positive in the models involving product innovation and negative in that referring to process innovation only. This supports the hypothesis that, more often than not, process innovation only involves equipment purchases from capital goods manufacturers and implies no continuous R&D effort on the part of consumers. This interacts with the negative coefficient of expenditures on unincorporated technology.

With respect to Argentina, all three probabilities are positive and significant, with product innovation only and combined product/process innovation standing out. As to process innovation only, the difference in relation to Brazil may be explained by the Argentine economic crisis, for in a crisis scenario, only firms with histories of innovation continue to innovate to strengthen their ability to compete, which, in turn, increases their marginal probabilities.

Market guidance (consumers and suppliers): While all the marginal probabilities were positive and significant for Brazil, it should be noted that consumers were a more important source of information than suppliers for firms that followed PdS strategies. When these firms used consumer information, the probability of their innovating rose 16.3%, compared to 7.1% when they were guided by supplier information.

In Argentina, recourse to consumers as a source of information for innovation is positively correlated with all three strategies. However, recourse to suppliers for such information is non-significant with respect to product innovation only, a result which is consistent with previously mentioned findings on Brazil.

Technology intensity of sector: Whereas more firms in high technology sectors follow PPS strategies in Argentina, more adopt PdS strategies in Brazil. For this reason, these firms have the highest marginal probabilities. In the case of Brazil, this supports the hypothesis that the non-differentiating, lower productivity firms that innovated product only were searching for market niches, probably high-tech niches, in which they could reap economic benefits. In the model, a firm in a high-tech sector has a 2.37% stronger propensity to innovate than one in a low-tech sector.

For the PcS and PPS strategies, the marginal probabilities in the models estimated were higher for Argentina since the composition of the non-differentiating, lower productivity firms favors the high technology firms.

5 CONCLUSIONS

This study has compared the less productive firms in Argentina and Brazil on the basis of data from innovation surveys conducted in the two countries. The initial conclusion confirms that limited size is the main problem faced by the less productive firms, as previously suggested by Prochnik and Araújo (2005) for Brazil and Chudnovsky (2005) for Argentina. No other structural obstacle to their engaging in innovation was identified.

However, only when macroeconomic conditions are normal, and mainly when sufficient credit is available, are less productive firms inclined to innovate. It should therefore be recalled that Brazil has one of the highest interest rates in the world and that credit is offered on harsh terms, while Argentina has often experienced strong macroeconomic instability. Katz (2005) reported that thousands of small and medium-size Argentine firms exited the market in the context of the recent economic reforms. In the econometric models, this is reflected in the positive coefficients of the log for the "number of workers" variable.

It should also be mentioned that the international literature suggests that not only industrial structures, but also innovation patterns vary substantially across European countries (SANDVEN *et al.*, 2005). Such differences are also observed when Argentina and Brazil are compared to one another, as well as to more developed countries.

On the one hand, in the more developed countries, it has been noted that: (1) the rates of innovation are high, indicating that smaller firms also innovate; (2) innovation is mainly in accord with simultaneous product/process strategies; and (3) the ratios of expenditures on R&D and incorporated technology to net sales are relatively high.

On the other hand, the innovation rate is low in Brazil, process innovation prevails and expenditures on R&D and on incorporated technology in relation to sales are lower than in the developed countries, primarily among the less productive firms. In Argentina, despite the relatively high rates of innovation, with strong emphasis on combined product/process innovation, expenditures on R&D and on incorporated technology, whether measured in absolute terms or as a share of net sales, are even lower than in Brazil, thus indicating the predominance of incremental innovations with limited economic impact.

Among the Brazilian non-differentiating, lower productivity firms, innovation is mainly of the process only variety and is essentially supplier dominated (PAVITT, 1984), the supplier being the capital goods producer in most instances. Since firms innovate by merely purchasing equipment and spend barely 5.7% of their net sales on ongoing research and development, they fail to accumulate knowledge. Among Argentine firms in the same category, product innovation assumes greater relevance, possibly due to the strong economic oscillations and higher educational levels of the country.

Thus, to produce the desired results, technological policies should be targeted at encouraging product innovation in Brazil and at stimulating investment in research and development in Argentina.

These proposals can be achieved in various ways. For instance, since less productive firms tend to cluster in specific regions or locations, they are the theme of a significant part of the extensive technical literature on local and regional productive systems. This literature, in turn, stresses the importance of decentralization via measures such as the creation of local institutions for generating and diffusing technology, the establishment of small business credit and the joint efforts of local entities. In this context, investment in intangible assets such as collective values, professional training and the marketing of local brands performs a key role in maximizing the potential synergies of the players involved.

Such approaches usually ascribe significant value to the product and process innovations (improvements) performed by local and regional entrepreneurs. The relevance of this trend, as emphasized throughout this study, lies in the fact that more frequent product innovation on the part of firms in lower tech sectors may serve to offset the supplier dominated innovation observed to date.

However, even from the standpoint of local and regional approaches, the supply of machinery and equipment is not generally the issue at stake. What is in evidence is that there has been intense technical progress over the past twenty years and that a new, highly transformed generation of machinery and equipment is now available, especially due to the appearance of digital technology. With the new equipment, it is simply easier to innovate products.

In an earlier study of the less productive firms in Brazil, Prochnik and Araújo (2005) showed that the process innovation only strategy (PcS) is relevant insofar as it apparently leads to the more embracing combined product and process innovation strategy (PPS). This occurs because the new equipment, usually intensive in software, is capable of producing a broader range of products. Its introduction therefore fosters product innovation. Thus, given the relatively limited technical capacity of the firms that adopt PcS strategies, such strategies may open the path to innovation for firms that are technologically farther behind.

The same does not occur in Argentina, possibly due to considerably lower total expenditures on innovation activities and to a stronger propensity to engage personnel in R&D activities.

The Argentine survey differentiates capital goods by domestic and foreign origin. Owing to the availability of this information, it was possible to determine that non-differentiating, lower productivity firms mainly innovate products by acquiring domestic capital goods and processes via acquiring imported capital goods. However, despite the fact that the total purchase of imported goods was more substantial than that of domestic goods for process innovation only, firms that performed this type of innovation declared that their domestic suppliers were more important than their foreign suppliers as sources of information for innovation. Thus, to accelerate the rate of innovation of the non-differentiating, lower productivity firms Argentine firms, the domestic production of capital goods is apparently a relevant factor. As can be readily seen, this argument is essentially a neo-Schumpeterian revival of an earlier thesis—that of Fajnzylber (1983), for example—as to the importance of the geographical proximity of institutions for innovation purposes.

Hence, the capital goods sector stands at the center of any discussion of innovation policies for the lower productivity firms. This conclusion points to the need for closer examination of the issue of domestically produced versus imported capital goods and the concomitant modernization of the capital goods sector, as well as the question of the relations between strengthening the production of the capital goods and software sectors and achieving overall economic integration.

Finally, it should be noted that the preceding conclusions with regard to the size limitations and credit needs of lower productivity firms and the relevance of the capital goods sector for innovation are interrelated. In fact, since the purchase of machinery and equipment is the most costly factor in innovation efforts, improved terms of credit would increase the demand for equipment. The other side of the issue refers to incentives for enhancing the supply of machinery, equipment and software.

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CHAPTER 5

NATIONAL INNOVATION SYSTEMS IN BRAZIL AND ARGENTINA: KEY VARIABLES AND AVAILABLE EVIDENCE

Gustavo Lugones
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1 INTRODUCTION

In recent years, the consensus as to the importance of Science and Technology (S&T) to growth and development has been considerably strengthened. This has led to changes in the way of understanding the determinants of economic development, the search for competitivity and the insertion of a country or region into the global markets. Among the approaches that have contributed to broadening this consensus is the concept of a National Innovation System (NIS).

The NIS concept provides the basis for overall analysis of the vast set of factors that interact during processes of technological and organizational transformation. It also makes it possible to gauge the influence the resulting changes exercise on the pace of growth and the path of development (LOPEZ, 1998).

Broadly defined, the concept embraces all the elements leading to the development, introduction, diffusion and utilization of innovations (LUNDVALL, 1992). It therefore includes firms that produce goods and services, the educational system (particularly universities and technical institutes), public and private laboratories and research centers and the financial system, as well as institutions and government agencies for the promotion of science, technology and innovation.

Interest in innovation analysis is on the rise, for innovation is coming to be acknowledged as the main source of the genuine, cumulative and sustainable competitive advantages that drive growth, together with economic and social development, in a positive manner. However, measuring and evaluating the characteristics, dimensions and operational facets of an NIS, and above all comparing it to the systems of other nations, is a complex task.[1] After all, there is no ideal by which to compare the various trajectories. Moreover, each NIS has specific features that must be taken into account, features that can lead to different, yet equally "virtuous" evolutionary paths.

The approach adopted in this analysis follows a minimalist and pragmatic criterion, insofar as possible restricting the data to those obtained through the

1. A methodology for measuring and comparing NISs has been proposed by Mira Godinho, Mendonca and Santos Pereira (2004), who use eight analytical dimensions and a total of 30 indicators aggregated in such a way as to obtain composite indicators for each of the dimensions.

innovation surveys conducted in Argentina and Brazil and only occasionally resorting to other data or sources of information.

However, the intention is not to "measure" the NISs with a view to obtaining aggregate indicators that "synthesize" the relative weights of chosen variables in the two systems for subsequent comparison; rather, the approach is oriented to qualitative analysis of selected indicators that are compared and contrasted, with special interest directed to the dynamic factors that interact with the structural determinants. In other words, the primary focus of this study is on the roles that the various actors are performing in the generation and transformation of the innovation processes and the obstacles or difficulties they are facing in the two countries under consideration.

1.1 Key variables

One way to evaluate an NIS is to consider a set of key variables, analysis of which allow for characterization of the structure of the system, of the links between its components and of the innovations undertaken by the firms, particularly with regard to their direction and impact on changes in competitiveness levels and in the evolutionary process of economic and social development.

Adopting an analytical perspective that strongly centers the NIS at the level of the firm and in its relations with the other components of the system, the following stand out as the most relevant variables:

- The shape of the NIS, especially the degree to which the framework is relatively complete and the development of its components balanced, for the absence or weakness of any single component may cause discrepancies between the supply and demand of knowledge (absence or weakness on the supply side or insufficient stimulus on the demand side), or else create problems in the relations between these dimensions. In this manner, two components play crucial roles in consolidating the NIS and stimulating innovative processes:
  - ⇒ firms (whether producers or users of knowledge)
  - ⇒ universities and research centers, institutes and laboratories (generators of new knowledge and new applications)
- The efforts displayed (in terms of human and material resources) to generate, acquire and adapt new knowledge or to enhance research capacities, as well as technological and organizational innovation capacities[2] given that the learning curve and increased absorption capacities play critical roles not only in the growing importance of knowledge to the performance of firms and

2. Throughout this study, technological innovation means the market insertion of new or significantly improved products and/or processes, according to the definition offered in the OECD Oslo Manual and adopted in the Bogotá Manual. When organizational innovations are mentioned, reference is being made to changes in the organizational structures of firms. Such administrative changes are not covered by the previous definition.

organizations, but also to the strong path dependency typical of technological and organizational transformation. Thus, the proportions of such efforts in relation to national aggregates (GDP, EAP and total population, among others) are variables that indicate the relative weights of R&D and innovation activities and make it possible to infer the size and scope of the NIS. Among the indicators used are the ratios R&D expenditure to GDP; innovation activity (IA) expenditure to GDP; and number of research workers to total population or EAP.

- The concrete results of the activities of the various players in the NIS (true innovations and registered patents, for example), together with the interactions among the players within the framework.
- The direction that processes are taking within the NIS, that is, the focus of efforts and relations since there is growing evidence that different innovation strategies (specifically, distinct combinations of efforts and relations) lead to different impacts in terms of results. The structure or composition of expenditures on innovative activities[3] can be a revealing indicator, especially if it conforms to the network of ties and relationships and their goals.
- The pattern of ties and relations between the distinct components of the NIS, given the social and interactive nature of innovative processes.
- The micro and macroeconomic determinants and conditions, including the financing of innovation efforts and the institutional framework of incentives to innovation.

The explanatory wealth of these variables becomes stronger, of course, if in the analysis they are combined and weighed against each other and against other variables and indicators that may offer clues as to the true role and significance of the NIS in economic and social development. As shown later in this study, it may become necessary, for example, to compare the evolution of the indicator for innovative firms as a proportion of total firms to other data capable of shedding light on the depth and reach of the innovations introduced. Likewise, the indicators referring to the technological content of production and commerce, or to expenditures on R&D or other IA, may contribute to placing in perspective any conclusions extracted from isolated analysis of the percentage of innovative firms.

1.2 Objectives of the study

The purpose of this work is to further the understanding and describe the features of the innovation dynamics of two countries that exhibit many similarities but also

3. Innovation activities include R&D, engineering and design, acquisition of incorporated and unincorporated technologies, training and consulting.

important differences in their productive structures and economic development. In other words, the intention is to characterize and compare the composition, dimensions and operations of the National Innovation Systems in Brazil and Argentina. Attention is also directed to the challenges that must be faced to assure their more effective development.

The two systems will be analyzed using the above mentioned key variables divided into six blocks. Five of these blocks can be manipulated using a set of indicators (Table 1) based on data obtained from national surveys (especially innovation surveys), together with information provided by official organs and other institutions dedicated to gathering data and performing statistical analyses, particularly the Ibero-American and Inter-American Network on Science and Technology Indicators (RICYT).

The sixth block comprises the micro- and macroeconomic determinants. While these variables can also be analyzed employing a set of indicators, it was considered more practical to perform a qualitative analysis (systemic, historical and coevolutive) of the impact these determinants have exercised on the paths taken by the respective NISs.

TABLE 1
Variables and indicators

Blocks		Indicators
1. Shape of NIS	S&T centers, laboratories and institutions	R&D expenditures Research workers Expenditure per research worker Concentration per institution Concentration per discipline
	Firms	Production framework Performance growth (sales, exports and employment)
2. S&T efforts		R&D expenditure/GDP IA expenditure/Revenue Training of human resources RH in S&T RH in private sector R&D
3. Results of innovation activities		TPP and non-TPP innovations Patents
4. Path of innovation efforts		Structure of innovation expenditures
5. Network of ties and relations		Links and cooperation agreements with NIS Sources of information
6. Micro and macroeconomic framework and determinants		

Following the presentation of the six blocks, the principal observations are summarized and final considerations offered in the seventh section. Lastly, to complement the information presented throughout the study, a statistical appendix containing data on Argentina and Brazil has been included.

2 SHAPE OF THE NIS

Argentina and Brazil are two of the largest countries in Latin America. Together, they account for 36.5% of the GDP and 41.5% of the total population of the region. Brazil is considerably larger with nearly 179 million inhabitants and a GDP of 505,670 million dollars, whereas Argentina has a population of approximately 37 million and a GDP of roughly 127,000 million dollars. However, the GDP per capita is higher in the latter (nearly 3,400 dollars in Argentina compared to 2,800 dollars in Brazil) (see Table A1 in the appendix).

During the 1990s, the economies of the two countries opened and became the destination for foreign capital flows. The changes in the macro and microeconomic environments led firms to redefine their business strategies and consequently modify their productive structures. The outcomes were the consolidation of the specialization in natural-resource-based products and the adoption of more open production models, with imports taking on growing weight in the total purchases of the private sector (CASSIOLATO, 2001; PORTA; BONVECCI, 2003).

Both countries underwent strong fiscal crises that led to diminished public financing of S&T activities that failed to be offset by private investment in these activities. S&T financing recovered once the crisis had been overcome, but within the framework of production structures that demanded only limited knowledge and were specialized in low- and medium-tech goods.

2.1 S&T centers, laboratories and institutions

One of the main characteristics of the S&T system in Latin America is the preponderance of public over private S&T investment. This is reflected in the high proportion of public research centers, laboratories and institutions and the correspondingly low proportion of private R&D laboratories, which unquestionably points to a strong association between the development of the S&T complex and the state of public accounts.

Argentine and Brazilian S&T investments are low by international standards, though with important differences in favor of Brazil. Whereas the Argentine R&D expenditure/GDP ratio is under the Latin American and Caribbean average, the Brazilian ratio is nearly 70% above the regional average. Brazil is also in a relatively better position with regard to expenditure per researcher, at levels 45% higher than the regional average and nearly three times higher than that observed in Argentina.

These differences between the two countries in R&D expenditure per researcher suggest notably different structural characteristics. In Argentina, a low level of R&D expenditure is combined with a high number of research workers in relation to the EAP. In Brazil, the situation is the inverse, for though expenditures are higher, the number of researchers is relatively lower (in Argentina, there are

1.67 researchers for every 1000 in the EAP, whereas in Brazil the ratio goes down to 0.71 and the regional average to 0.64).[4]

TABLE 2
R&D expenditures and number of researchers (2000)

	Argentina	Brazil	Latin America and Caribbean
R&D expenditure/GDP (%)	0.44	0.99	0.56
Researchers per thousand inhabitants	1.67	0.71	0.61
R&D expenditure per researcher (FTE) (thousand international dollars, PPC)	74.68	206.72	143.59

Source: Elaborated on the basis of data from RICYT.

Generally speaking, both countries apparently face serious restrictions with respect to the development of their S&T systems. In the year 2000, 72.6% of the Brazilian researchers and 88.7% of their Argentine counterparts belonged to the governmental or higher education spheres. Thus, increases in expenditures per researcher depend essentially on the evolution of the fiscal framework. This, in turn, may have a negative impact on the feasibility of project development and therefore on the evolution of the system for creating knowledge at the national level.

The high degree of geographic concentration of S&T institutions is another aspect to be considered.[5] A recent report prepared for the Argentine Science and Technology Secretariat (SECyT, 2005a) provides an alert as to the high concentration of research institutes in the city and the province of Buenos Aires. In Brazil, according to the 2004 census of the National Council for Technological and Scientific Development (CNPq), nearly 50% of the institutions are located in the Southwest region, which also accounts for 51% of the research personnel. Although the census does not cover the total number of researchers, it is highly representative since it includes 85% of the national human resources dedicated to research (CARNEIRO; LOURENÇO, 2003).[6]

The concentration by discipline also appears as a problem to be resolved. A national survey conducted in Argentina amongst a group of centers of excellence indicates that, of a total 102 disciplines – as defined according to the UNESCO classification – the 10 most common (in a sample representing 78%), are molecular biology, biochemistry, environmental engineering and technology, genetics, cellular biology, biotechnology, specialized technologies, chemistry, physics and materials technology (GUTTI; PRADOS, 2005).

4. The authorities of the respective countries are not unaware of this. On the contrary, in Brazil as well as Argentina, they have been redirecting government efforts and creating incentives to the private sector as a way of overcoming the deficit, though significant results are yet to be seen (NASSIF, 2003; SECyT, 2005b).
5. See Figure A1 in the appendix.
6. See Table A2 in the appendix.

Although the concentration is lower in Brazil, it still calls attention: in the CNPq census,[7] nearly 30% of the researchers are in the areas of the human and social sciences and almost 20% in the health sciences.

In summary, both Argentina and Brazil should make strong efforts to increase their S&T expenditures so as to approach international standards. In Argentina, the primary aim should apparently be to raise the expenditure per researcher, while in Brazil, it is seemingly more imperative to increase the number of researchers while maintaining the level of expenditure per researcher. At the same time, both countries should strive to improve their distribution of resources by region and discipline in order to better balance their systems and fulfill their potentials.

2.2 Firms

As previously mentioned, the 1990s were marked by an opening of the economies in question, as well as by increases in their importation of inputs, parts and components and technology. Towards the end of the decade, Brazil and Argentina had already made changes in their productive frameworks, now characterized by the relative importance of the industries based on natural resources.

The devaluation of the *real* in 1998 and the *peso* in 2002 represented a change not only in relative prices and in business behavior, but also in the way local business sectors competed on the foreign market.

TABLE 3
Economic performance: selected variables
(%)

	Argentina	Brazil
Manufacturing output[1]	33.55	11.55
Employment[2]	15.40	1.19
Exports[3]	34.39	59.83
High-tech manufactured exports[4]	3.20	11.60

Sources: Elaborated on the basis of Kuwayama and Durán Lima (2003), Centro de Estudios para la Producción (CEP, Argentina), Instituto Brasilero de Geografia y Estatística (IBGE), Ministério de Desenvolvimento, Indústria y Comércio Exterior (Brazil), Banco Central de la República Argentina, Ministerio de Economía (Argentina) and Instituto Nacional de Estadísticas y Censos (INDEC) (Argentina).
Notes: 1. Argentina: output index – Brazil: manufacturing output.
2. Argentina: private sector wage earners – Brazil: employed wage earners.
3. FOB.
4. As percentage of total exports over the period 1999-2001.

Once the crisis ended, the manufacturing sectors in both countries entered into a period of economic recovery as evidenced by a growth in sales, exports and employment (Table 3). In 2005, Argentine manufacturing output continued

7. Available at: <http:// www.cnpq.br>.

on an upward trend led by the reactivation of the automotive sector and the manufacture of non-metallic mineral products (CEP, 2005).

Meanwhile, according to the information provided by IBGE in its Monthly Industrial Survey – Brazil: Output,[8] during 2005 the employment rate as well as industrial activity continued on an upward trend, though on a smaller scale than in previous years. In particular, a decline was observed in the activity of certain traditional sectors (textile, wearing apparel, wood), coupled with an increase in the activity of the mining industries, publishing and printing, and the pharmaceutical industry. As was the case in Argentina, the greater portion of the increase corresponded to the growth in the production of the automotive sector.

In terms of the productive framework, both countries have structures that rely heavily on raw materials and manufactured goods based on natural resources. Nonetheless, Brazil has demonstrated significant growth in high-tech manufactured exports, with the ratio of such exports to total exports being almost four times greater than that of Argentina.

This type of growth coincides with that cited by De Negri, Salerno and Barros de Castro (2005) in relation to the differentiated behavior of Brazilian firms. According to these authors, Brazilian industry is characterized by three types of competitive strategies: firms that innovate and differentiate products, those that also innovate and export but specialize in standardized goods (commodities), and the rest. From the available statistical data, these authors conclude that firms of the first type, which constitute a minority among the manufacturing industries, evidence more robust growth, with higher wages and better export performance. On the basis of a study conducted by David Kupfer and Frederico Rocha (cited in De Negri and Salerno, 2005), the authors observe that this competitive strategy occurs with greater frequency in the mechanical, chemical and electronic sectors, in other words, the mid-tech to high-tech sectors

Having presented this evidence on the Brazilian case, it appears relevant to analyze competitive strategies in the Argentine case so as to verify the existence or inexistence of similar patterns of behavior and in which manufacturing sectors. Although it is probable that if such patterns existed they would be in the same sectors as observed in Brazil, the same article by De Negri *et al*. affirms that given strategies are not necessarily associated with given sectors, but are capable of being successful in any manufacturing sector. Regardless, it would seem valid to assume that, commercially speaking, the impact of technological content would vary depending on the sector.

In summary, although the recovery of economic activity in Brazil is apparently related to a growing sophistication of the productive framework, the trend in both countries is still towards the manufacture of low-tech goods.

8. Available at: <http:// www.ibge.gov.br>.

3 S&T EFFORTS

3.1 S&T Expenditures

3.1.1 Public expenditures on S&T

The efforts displayed in the creation, acquisition and adaptation of new knowledge or in the improvement of capacities are key variables for understanding the dynamics of the NIS. Thus, it is relevant to analyze not only the position of these systems relative to the efforts of other countries, but also relative to the growth tendencies observed in recent years.

Perhaps the two best indicators of S&T efforts are the size of expenditures in this area relative to the GDP and the number of workers employed relative to either the total population or the total work force. In this regard, though Argentina and Brazil are two of the countries with the highest ratios in the region as a whole, the values are of slight significance when compared to the rest of the world since both countries fall below international standards.[9] In Europe, for example, the ratio between R&D expenditures and GDP is about 1.8%. In the United States, the figure is over 2.6% and in Japan it is approximately 3%. In Argentina, on the other hand, it fails to reach 0.5% while in Brazil it is less than 1%, having declined in recent years[10] (Table 4).

These facts are in agreement with those established by De Negri *et al.* (2005), according to which firms that innovate and differentiate their products represent only a small fraction of Brazilian industry. Thus, in spite of the increase in innovative efforts on the part of these firms, the majority of manufacturing firms are most likely allocating proportionally less resources toward the search for the technological innovations that would give them a competitive edge over the rest of the firms. Under these circumstances, the competitive traits of those firms with superior behavior and performance could be generating significant changes in exports in terms of increased foreign sales of high-tech products, but without altering the internal framework of the production system.

9. Between 1994 and 2003, the expenditure of Latin America on S&T equaled only 1.3% of global expenditure. In this period, Argentina, Brazil and Mexico represented 70.6% of the total expenditure of Latin America and the Caribbean (4.1%, 48.45% and 18.11%, respectively).

10. In accordance with the data provided by RICYT, in 2003, Brazilian S&T expenditures reached 6,971.6 million dollars, or 1.38% of the GDP. Regardless, this figure is below those registered in the previous two years (1.44% in 2002 and 1.46% in 2001). The same trend was observed in R&D expenditures: whereas the ratio between these expenditures and the GDP was 0.95% in 2003, it had been 0.98% in 2002 and 1.2% in 2001. In contrast, even though Argentina has not yet returned to the 2000 levels, there has been a rising trend in S&T expenditures since 2002: in 2003, a total of 590.06 million dollars was earmarked for these activities (0.46% of the GDP), an amount greater than that registered in the previous year, when the expenditure was equal to 0.44%. This same tendency was observed with respect to R&D expenditures: while in 2002 they were 0.39% of the GDP, in 2003 the figure rose to 0.42%.

TABLE 4
Expenditures on innovation activities (2000-2003)

	STA	R&D	ACT / PBI	R&D/GDP
	US$ thousand	US$ thousand	%	%
Argentina	3,760.99	3,304.66	0.48	0.42
Brazil	29,667.70	20,473.40	1.43	0.99
Latin America and the Caribbean	59,642.46	37,286.48	0.81	0.51

Source: Elaborated on the basis of data from RICYT.
STA: Science and technology activities.
R&D: Research and development.

Argentina recently began to record significant increases in S&T expenditures (proportionally greater than the increases in GDP). This phenomenon could be due to the existence of more favorable incentives to innovation; in fact, the preliminary results of a recent study made by SECyT show a significant rise in private investment in R&D over the last few years (INDEC, 2005).

In summary, Argentina should sustain the upward trend in its STA expenditures in order to reach the mean levels of the region as well as to achieve world levels. Brazil, for its part, should strive to reverse the downward trend of its S&T expenditures in order to reach levels similar to those of the developed countries.

3.1.2 Private expenditures on S&T

The innovation surveys performed in Brazil and Argentina offer relevant information concerning the efforts made by firms in the area of techno-scientific activities. Although the two surveys are not perfectly comparable,[11] it is possible to extract comparable indicators with respect to innovative efforts.

TABLE 5
IA expenditures as a percentage of revenue

	Year	% AI/Revenue	% AI / Revenue
Argentina	1998	2.05	0.19
	2001	1.64	0.26
Brazil	2000	3.84	0.64
	2003	2.46	0.53

Sources: Elaborated on the basis of data from INDEC (2003) and IBGE (2003).

According to the respective innovation studies (INDEC, 2003; IBGE, 2003), the level of efforts of the Argentine firms is significantly lower than that of its Brazilian peers (Table 5). Nevertheless, a recent survey conducted by SECyT

11. The last Brazilian innovation survey covers the period 2000-2003, when the country was recovering from the crisis that culminated in the devaluation of the *real* in 1998. The most recent Argentine survey encompasses the years 1998-2001, when the economy was moving toward the deep economic recession that led to the devaluation of the *peso* in early 2002.

for INDEC (INDEC, 2005) indicates there has been a significant increase in expenditures on these activities amongst Argentine firms since 2002.

The downward trend in expenditures by Brazilian companies on innovative activities (IA) and research and development (R&D) is not an encouraging sign with respect to the current path of specialization and the possibilities for increasing the technological content of products and exports. Argentina, for its part, needs to register significant and sustained increases in both IA and R&D expenditures so as to foster a strong impact on the pattern of specialization. The improvements in the competitivity levels of Argentine firms since 2002 have apparently rested more on favorable conditions (real devaluation of the *peso*) than on genuine and sustainable increases in the productive capacities of the firms.

> In summary, the available information confirms that both Argentina and Brazil are advancing along a specialization path that requires little investment in science, technology and innovation. It therefore appears necessary to create or reinforce the incentives to private investment in S&T in order to favor the adoption, on the part of the productive sector, of a strategy targeted at improving competitivity through differentiation, innovation and technological change.

3.2 Human resource efforts

3.2.1 Training of qualified human resources

The educational base of a country is a key asset for advancing towards an economy founded on knowledge. As previously mentioned, the existence of discrepancies in the supply and demand of knowledge (absence or weakness on the supply side or insufficient impetus on the demand side) can pose serious obstacles to the functioning of the NIS. The qualified human resources on which an economy relies consists of a labor supply trained to meet the demands of the firms, together with potential researchers and scientists to meet public and semipublic needs. In this respect, analysis of the development of such resources can provide important indicators as to the capacity of the system to create and absorb a qualified labor force.

During the period 2000-2002, the training of qualified human resources registered a growth trend in both countries.[12] However, in both cases the proportional increase was explained by a rise in the number of graduates in social sciences,[13] when what is often needed from the standpoint of technological development is an increase in the number of qualified professionals in the natural and exact sciences and the associated fields of engineering. In this regard, both countries show a significantly less-than-desirable share of graduates in these fields.

12. Between 2000 and 2002, the number of university graduates increased approximately 32% in Brazil and 19% in Argentina compared to 19.5% for all Latin America and the Caribbean.

13. In Argentina, roughly 40% of the overall increase in the number of graduates; in Brazil, over 65%.

In the case of Argentina, even though an increase in the staffing of engineers is plausible, there has been regression in the combined fields of the natural and exact sciences (in the measure that the increase in the number of graduates in these disciplines was less than the increase in the total number of graduates). In Brazil, the increase in the number of graduates in these fields was also less than the total number of graduates.[14]

Among the causes commonly cited in the literature for explaining the evolution and distribution of graduates by discipline is the lack of incentives to study certain fields or a shortage of the resources (human and financial) needed to prepare graduates in these fields. However, to confirm this with any degree of certainty, it would be necessary to conduct more specific studies.

> In summary, two areas of strategic importance to technological development – natural and exact sciences and engineering – evince poor results in both countries when compared to international standards. Although both countries show growth trends in the numbers of university graduates, to arrive at the specialization profile associated with high-tech activities, it will be necessary to increase the number of professionals capable of generating, selecting, and applying such technologies.

3.2.2 Human resources in S&T activities

Another aspect associated with the supply of knowledge and growth of absorption capacities refers to the number of research workers dedicated to S&T. As previously mentioned, Argentina has relatively more researchers, while Brazil is in a better position with respect to expenditure per researcher (Table 2). At any rate, both countries are still far behind by international standards.

In both cases, there has been a decline in the number of researchers in relation to the economically active population. In Argentina as well as Brazil, the rise in the absolute number of researchers was insufficient to compensate for the growth recorded in the EAP.

With reference to the qualification and employment of human resources trained by the manufacturing firms, the Brazilian firms present less-than-favorable indicators for the system as a whole. Not only is the preparation of the personnel weak, but it is showing a tendency to decline even more. This could signify diminishing needs in the levels of qualification required for internal activities linked to technological development or adaptation and change.

In contrast, during a period of heavy reduction in employment levels in Argentina, as was the case in 1998-2001, the number of personnel dedicated to

14. See Table A3 in the appendix.

R&D rose significantly, [15] reflecting a tendency toward placing greater value on activities tied to the creation of knowledge within Argentine firms (Table 6).

TABLE 6
R&D workers in firms

	Argentina	Brazil
Variance (%)	19	-7.10
Number of R&D workers per firm	3.46	1.8
R&D workers/total number of workers (%)	1.70	0.70

Sources: Elaborated on the basis of data from IBGE (2003) and INDEC (2003).
For Argentina, the variances correspond to the period 1998-2001 and the totals to 2001.
For Brazil, the variances correspond to the period 2000-2003 and the totals to 2003.

Although there are no comparable data available for the two countries with respect to the training of personnel, the number of R&D workers has diminished among the Brazilian firms, though this seems to be mainly in response to a decline in the overall number of workers with secondary schooling or less. A similar trend is noticeable in the growth of the total number of workers in Argentine firms, which increased the number of professionals while reducing the number of staff with basic or technical education. In any case, it should be underlined that the SECyT report cited earlier warns of the scarcity of human resources with technical training, as observed by the firms consulted during a field study conducted in 2005 (SECyT, 2005).

In fact, the systematic decline in industrial activity during the 1990s created disincentives for the training of personnel with mid to high-level qualifications or specialized training. The results are being noted with the recovery of economic activity.

> In summary, the number of researchers in each of the countries shows a downward trend when analyzed at the overall level. Moreover, both countries fall unquestionably short of international standards. In Brazil, the decline in the number of personnel dedicated to R&D activities could be a warning sign with respect to the technological behavior of the firms, while in Argentina the concern refers to the relative shortage of personnel with technical education or specialized training.

4 THE RESULTS OF INNOVATION ACTIVITIES

Analysis of the results of innovation activities reflects the achievements of the firms in their efforts to technologically improve their products and processes (innovations) for better market performance at both the national and international levels.

As seen in Table 7.56% of the firms interviewed in the second Argentine Innovation Survey reported having placed technologically improved products

15. Whereas in Argentina there are 3.46 R&D workers per firm (equivalent to 1.7% of total employment), in Brazil the number drops to 1.8 (or 0.7% of total employment).

and/or processes (TPP innovations) on the market during the period considered (1998 to 2001), a proportion markedly superior to the 33% recorded in Brazil between 1998 and 2000 (INDEC, 2003; IBGE, 2003). Even taking into account that the Argentine survey covered one more year than the Brazilian survey (4 years versus 3 years), an earlier Brazilian innovation survey had already warned of a low proportion of innovative companies relative to the total number.

The high proportion of innovative firms reported in the Argentine survey may be indicative of a high failure rate among the non-innovative firms. Comparing the results of the innovation surveys, it was found that the number of non-innovative firms that participated in the first survey but not in the second evidenced a drastic reduction. During the 1990s, Argentina was dominated by a somewhat unfavorable macroeconomic climate (backward exchange rates and the difficulty of accessing financing, together with its high cost) at the same time it was undergoing a process of aggressive commercial expansion. This may have created little chance of survival for the firms that were unable to introduce innovations of some form, even if merely incremental, of limited reach or of little importance or impact.

TABLE 7
Innovation activities by type
(%)*

	Brazil	Argentina
Total number of firms	**100**	**100**
Innovative firms	36	78
TPP innovation	33	56
Product innovation	20	46
Process innovation	27	47
Potential TPP innovation	3	22

Sources: Elaborated on the basis of data from IBGE (2003) and INDEC (2003).
*Brazil: 2003 – Argentina: 1998-2001.

To be precise, the contrast between these results and a productive structure in which the greater portion of products are of low technological intensity (see section 1.2) sheds doubt on the reach of the innovations introduced by Argentine firms.[16]

With regard to the depth or impact of innovations, one form of approximation is to use the indicators that refer to patents. These indicators give the number of firms in which innovation activities led to patent applications or registrations.

Although reasonable debate exists concerning the usefulness of patent indicators for reflecting the quantity and quality of the technological activity of a region, they unquestionably offer insight into the degree to which firms are generating or applying

16. By reach of innovation is meant the degree or measure to which said innovation constitutes a true innovation as defined by the international market, the domestic market or simply the firm that introduces it.

new techniques of real magnitude. They also indicate whether diffusion processes or changes of an incremental or adaptive nature prevail.

In marked contrast to the high proportion of innovative companies, the Argentine innovation survey shows that a very low percentage of firms applied for patents during the period under consideration. In fact, of a total 1,688 firms, only 98 (6%) declared to have obtained at least one patent. In the case of Brazil, only 7% of the innovative firms applied for patents in order to protect their inventions.

> In summary, the data regarding the effectiveness of the innovations introduced in the two countries, combined with the low percentage of firms that applied for and obtained patents, leads to the supposition of low degrees of novelty and reach among the products and processes developed. These conditions obviously do not favor insertion into the more dynamic world markets.

5 THE DIRECTION OF INNOVATION EFFORTS

In both countries, the structure of expenditures on innovation activities appears to weigh heavily towards efforts of an exogenous type, with a higher share applied to the acquisition of capital goods. In fact, in Brazil as well as Argentina, the expenditures earmarked for this area account for over 50% of total expenditures (Table 8).

This disequilibrium in IA, which disfavors other important sources of knowledge and the development of capacities such as R&D, software, technology transfer, industrial engineering, administration, training and consulting, places at risk the development of the endogenous capacities of the firms, capacities that may be indispensable to taking full advantage of the efforts made to acquire incorporated technology (LUGONES *et al.*, 2005).

TABLE 8
Distribution of expenditures on innovation activities*
(%)

	Brazil	Argentina
Internal R&D	22	9
External R&D	3	2
Acquisition of machinery&equipment	50	67
Training	2	2
Others	23	20

Sources: Elaborated on the basis of data from IBGE (2003) and INDEC (2003).
*Brazil: 2003 – Argentina:1998-2001.

In the case of Argentina, there is evidence of a strong positive relationship between balanced behavior with respect to innovation expenditures (in other words, equilibrium between internal and external efforts) and successful economic performance (LUGONES *et al.*, 2005). In particular, amongst a group of firms observed from 1992 to 2001, those that invested in innovative activities and balanced the acquisition of capital goods with investments in R&D, engineering and industrial design and training – among others – achieved the best outcomes in terms of improvements in revenue, employment and export levels. In contrast, weak or negative performance coincided with biased innovation expenditures, for example excessively high or excessively low investment in capital goods.

If these tendencies can also be verified in the case of Brazil, which will require future studies, significant progress will be made in determining the course that technological behavior should take in order for firms to reap the maximum benefits from their innovation efforts and attain higher degrees of international market penetration.

Confirmation of this hypothesis would indicate the advisability of formulating public policies not only to stimulate investment in innovation activities, but also to encourage a proper balance between activities aimed at incorporating technology and activities linked to the endogenous creation of knowledge. It would then be possible "to think about programs or tools in support of an Innovation Activity package, for example, R&D + Training + Acquisition of Technology (or any other combination of innovation activities) as opposed to specific tools to stimulate specific innovation activities" (LUGONES et *al*., 2005).

> In summary, it appears that the prevailing innovation strategies are aimed at defending market positions rather than at strengthening the competitive capacities of the more knowledge-intensive sectors, as would be necessary for firms to gain sustainable and cumulative competitive advantages, as well as for changes to occur in the specialization trends, thereby allowing the productive and commercial structures to contribute to the greater stability of the foreign sector and to significantly higher levels of insertion.

6 THE NETWORK OF TIES AND RELATIONS

The social and interactive nature of the processes of innovation and technological change is widely recognized (LUNDVALL, 1992; FREEMAN, 1995). Hence, one of the key aspects of any analysis of National Innovation Systems is the network of ties and relations established between those who supply and those who demand knowledge.

During the 1990s, state intervention schemes directed toward science and technology focused on both the supply and the demand side. Since neither Argentina nor Brazil was exempt from the world trend, the first funds specifically targeted at stimulating S&T activity in the private sector started to flow at the outset of the decade.

The results of such intervention crucially depend on the existence of institutions capable of supporting the activities undertaken by the productive sector (ECLAC, 2004). Consequently, in both Argentina and Brazil, growing attention came to be given to the interaction between the public and private sectors in the field of S&T.

Reports prepared in the two countries concur as to the existence of institutions capable of meeting the demands of the productive sector (RAPINI, 2004; LUGONES, PEIRANO; GUTTI, 2005). However, with regard to the frequency and kinds of ties established between firms and other players in the NIS, such as R&D centers, educational and training institutes and even other firms, the data gathered by the innovation surveys performed in Brazil and Argentina do not emit encouraging signs.

Studies conducted in Argentina reveal a marked reticence on the part of businessmen to commit themselves to innovation, and especially to the national scientific and technological system (LUGONES *et al.*, 2005). The Brazilian surveys also point to low levels of true cooperation linked to the innovation process.

The ties established and agreements signed show a strong preponderance of commercial relations, that is, relations between customers and suppliers. In fact, of the total number of firms that assumed mutual arrangements in Argentina, approximately 75% did so only with suppliers and over 50% with customers. Although the figures are lower in Brazil, the percentages for such arrangements are still extremely high in relation to other types: among the firms that signed cooperation agreements for the sake of innovation, 50% did so with suppliers and 42% with customers.

Consequently, few firms are seen to have maintained relations with universities and R&D centers in the search for new knowledge.[17] In general terms, obstacles to cooperation and the formation of ties range from bureaucratic red tape to lack of information and even to distrust on the part of the business class. In Brazil as well as Argentina, the growth paths of the manufacturing sector and of the S&T complex have advanced without the advantages to be derived from stricter ties. Cooperation activities are therefore excessively concentrated in the rendering of services of relatively low complexity and the granting of certifications.

Since this question concerns those responsible for the techno-scientific policies of the two countries, various programs aimed at fostering the creation and strengthening of ties have been implemented in recent decades (ECLAC, 2004; KATZ, 2000; RAPINI, 2004). Unfortunately, the results have been less than encouraging.

When comparing the indicators for the two countries, one must bear in mind the difference between gauging ties in Argentina and analyzing cooperation agreements in Brazil, where ties are more formal and therefore of higher quality. Precisely due to this difference in the degree of formalization, numerically speaking there is more data available on Argentina and it serves to justify the less-than-optimistic observation made in the preceding paragraph since most of the ties established are for activities low

17. See Table A4 in the appendix.

in technological intensity and based primarily on tests and experiments (LUGONES, 2004). In Brazil, what has been observed is a decline in the number of firms that develop activities through cooperation agreements.

An alternative yet complementary way to analyze the characteristics of the ties established between firms and the S&T complex is by means of the indicators referring to the sources of information used by firms for their innovation activities. Once again, the data reveal a low level of interaction between firms and universities, laboratories and R&D centers. Taking a set of chosen players, it is seen that more than 60% of the firms denominated innovative obtained information for their innovation activities from other departments within the firm itself. Only 22% of the Argentine firms declared having turned to universities or research centers for information; and among Brazilian firms the figure is a bare 8.4%[18] (Table 9).

TABLE 9
Information for innovation activities by source*

	Brazil		Argentina	
	Number of firms	**(%) Total IA**	Number of firms	**(%) Total IA**
Other areas within firm	17,585	**62.70**	980	**74.10**
Customers and consumers	14,960	**53.40**	581	**43.90**
Suppliers	16,581	**59.10**	578	**43.70**
Universities and research centers	2,345	**8.40**	302	**22.80**
Professional and technical training centers	3,538	**12.60**	n.a.	**n.a.**

Sources: Elaborated on the basis of data from IBGE (2003) and INDEC (2003).
*Brazil: 2003 – Argentina:1998-2001.

Most likely, the feasibility of straightening the ties resides mainly in reappraising the methods for evaluating scientific production and reformulating the incentives designed to encourage cooperation between the creators and the users of knowledge. The current intensification of the pace and extent of technological transformation, together with the growing weight of knowledge in determining competitivity levels, is also making it necessary to change the rules of the game in the sphere of S&T.

> In summary, the main challenge facing the countries under analysis is to better articulate the players within the science and technology framework and to straiten the ties between these players and those in the production sector.

7 MICRO AND MACROECONOMIC FRAMEWORKS AND DETERMINANTS[19]

The last question dealt with in this analysis of the NIS refers to the way micro and macroeconomic determinants influence business behavior and institutional development, in other words, the path of the system.

18. Due to the way the question was posed in the survey, this figure should be considered together with that referring to "professional and technical training centers," for which category 12.6% of the firms replied in the affirmative.

19. This section benefited from the valuable and generous support of Fernando Peirano (Centro REDES).

The structural changes witnessed in Argentina and Brazil in the 1990s — the commercial and financial opening of the economies, deregulation of markets, denationalizations—led to far-reaching changes in the behavior of the economies as a whole. Thus, in order to understand the structural transformations that occurred in the economic, technological and institutional frameworks, a coevolutive approach is required (KATZ, 2000).

At the time of making decisions, a coherent and stable macroeconomic environment plays an undeniably important role, for favorable conditions encourage entrepreneurs to assume risks and make investments. However, it cannot be deduced that the strategic behavior of firms is solely in response to macroeconomic incentives. On the contrary, though macro stimuli may constitute a necessary condition, they are not necessarily sufficient (OCAMPO, 2005), especially when altering or reorienting the current practices and behaviors of the economic agents. In fact, while both countries experienced periods of significant macroeconomic stability, this alone was not sufficient incentive to maintain the economies on the path of sustainable development.

All too often, the risks and uncertainties that halt investment are greater precisely in those activities most capable of generating social benefits such as the diffusion of new knowledge; foreign-exchange earnings through exports (which, in turn, would relieve the foreign accounts); training activities; supply chains; higher local content; and ultimately, the strengthening of the social and productive fabric.

There is also no question that these desirable “side effects” are far more characteristic of certain economic activities than of others. In this regard, the productive activities (especially the manufacturing activities) surpass the commercial and financial activities. It would therefore be advantageous if the macroeconomic framework were to offer a price scheme favorable to the development of activities in which these effects are strong, as well as to the stimulation of private-sector activities consistent with sustainable growth.

Of course the most up-to-date public-policy approaches recognize that attending to the macro dimension alone will not drive structural transformation; and that what is in fact needed is “fine tuning” between the macro and micro dimensions, especially in the less developed economies, which require policies that exert more direct impact on micro behavior. This underlines the strategic importance of coordinating government actions in such a way as to align the stimuli offered by the various policy instruments in order to guarantee their efficacy and extend their reach.

The profuse application of horizontal incentives (financial or fiscal to promote exports, for example) has reinforced the tendency to privilege localization advantages rather than encourage the search for dynamic advantages and the development of new capacities. Especially the latter is an option strongly dependent on the stimulus offered by specific policy instruments that serve to offset the greater implicit risk and inherent difficulty of competing in higher-tech markets. While it is true that such policies have been adopted in both countries, they have had neither the continuity nor the reach necessary for generating palpable results.

Consequently, the output and exports of Brazil, and above all those of Argentina, are predominantly standard low-tech goods, which implies that they are lower-cost, less dynamic items than differentiated products. This clearly limits the possibility of definitively closing the foreign gap, which in great measure exists because of the differences between the prices and dynamics of the goods that Latin America imports and exports.

Another aspect that should be stressed is the weakening of the local framework. Although essentially the direct outcome of the adoption of more open production functions as of the overall commercial opening of the region in the early 1980s, the trend has been reinforced in several ways:

a) by the lowering of duties and taxes on imported inputs, parts and components in order to make it feasible to manufacture world-quality goods at international prices and thereby enhance the competitivity of exports

b) by differences in the costs and possibilities of access to financing for the large export firms (mainly the MNEs) and the SMEs, which prevail in the domestic production chains

c) by backward exchange-rate regimes over long periods of time (especially in Argentina), which made it harder for local firms to compete against imported goods

The resulting damage to the domestic production framework and the weakening of the ties between local suppliers and the export sectors cut transmission of the dynamic impulses that might otherwise have flowed from the external sector to the rest of the economy. At the same time, the problems linked to the structural heterogeneity characteristic of Argentina and Brazil were aggravated, directly leading to poor results in the battles against unemployment, poverty and the poor distribution of income.

It should also be stressed that instruments that act solely or mainly via the financial channel do not offer strong enough incentive for firms to adopt competitive strategies more committed to innovation and learning. Suffice it to say that scarcity of credit is cited by firms as one of the principal obstacles to innovation. It may therefore be necessary to complement such instruments with technological and business goods and services by way of supporting firms in their upgrading efforts.

In terms of technology policy, this points to the advisability of systematically strengthening the ties between the scientific and productive environments. After all, the greater availability of highly qualified human resources is a key, for it is unquestionably they who will find the solutions as the circumstances require.

Given the current macroeconomic conditions in the two countries, new policy strategies need to be formulated with a view to creating assets within the system via reinforcing certain existing instruments and designing others. These policies should place due value on the strengths acquired over recent decades, but also recognize the evident weaknesses that the systems exhibit as a whole. To be explicit, there is an obvious need to produce and export manufactured goods with higher technological content. Moreover, it must be borne in mind that the evolution of a system depends on the coevolution of its members and their relations. In other words, it is of no avail to have an industrial policy, a scientific policy, a technological policy and an educational policy unless they are thoroughly integrated.

In Brazil, the sectoral foundations are clear signs of the political will to advance in shaping a sustainable National Innovation System, for they reveal comprehension of the fact that different sectors have different needs and therefore require differentiated policies. Since the Argentine sectors have much in common with their Brazilian counterparts (although they also exhibit features which are quite distinct, mainly with regard to the scale of the domestic market), they appear to demand a similar strategy, that is, one capable of offering specially designed incentives to each sector.

> In summary, priority, or stronger priority, should be given to issues that have been wholly or partially neglected by the policies followed in recent years. Basically,
>
> - local production frameworks should be consolidated,
> - knowledge should be accumulated through creation, growth, acquisition, adaptation and learning, and
> - specialization trends should be redirected towards higher-tech, higher-value, more dynamic goods.

8 SUMMARY AND CONCLUSIONS

8.1 Key observations

The preceding analysis and comparison have served to bring together a series of observations regarding the operation of the NISs in Argentina and Brazil, the most important of which can be summarized as follows.

- In Argentina as well as Brazil, S&T investment levels should be raised to meet international standards. Whereas the priority in Argentina is to increase the expenditure per researcher, the priority in Brazil is to augment the number of research workers. By attending to these needs, the two countries should advance towards a better regional and disciplinary distribution of resources and thereby contribute to balancing the system.
- While the recovery of economic activity in Brazil initially appeared to be linked to a growing sophistication of the productive framework, what is actually observed in both countries are structures overly biased toward the production of low-tech goods.
- For both Argentina and Brazil, the available data show that these economies are advancing along specialization paths requiring only minimal investment in science, technology and innovation. It is therefore necessary, above all, to create incentives aimed at raising private S&T investment and aligned with a new productive strategy based on innovation and technological change.
- When compared to international standards, two areas of strategic importance to technological development evince shortages: Natural and Exact Sciences and Engineering and Technology. Although there is an upward trend in the number of university graduates in these disciplines in both Argentina and Brazil, in order to achieve a high-tech specialization profile, both countries will have to broaden the base of human resources capable of selecting, adapting and creating the technologies required.
- In both countries, the staffing of research workers displays a downward trend when analyzed over time. Likewise, both are far from international standards with regard to the number of workers dedicated to R&D activities. Whereas in Brazil the decline in the number of researchers may be a warning sign as to the technological behavior of the manufacturing firms, in Argentina the supply (or availability) of personnel with technical and/or specialized training appears to be limited.
- Despite more than a third of the firms claiming to have innovated, the data on the reach of the innovations introduced in the two countries, combined with the small percentage of firms that applied for or obtained patents, leads to the supposition that the degree and extent of process and product innovation were limited and failed to result in the production of the kinds of goods that would favor insertion in the more dynamic world markets.
- The structure of expenditures on innovation activities suggests that the prevailing innovation strategies are targeted at defending market positions rather than at using technological knowledge to raise the competitivity levels of the

manufacturing sectors, as would be necessary to attain sustainable competitive and cumulative advantages for the firms, as well as to change the specialization trends in order to enable the productive and commercial frameworks to offer more solid support to the foreign sector and open the way to substantial increases in foreign-exchange earnings.

- The main challenge facing the countries under analysis is to better articulate the various players within the science and technology system and, in turn, to integrate this system and the productive sector.
- With respect to policy goals, the priorities need to changed and adjusted in such a way as to more strictly align trade policies and technological policies. This basically requires:

  ⇒ consolidation of the local production framework

  ⇒ accumulation of knowledge (generation, development, acquisition, adaptation, learning)

  ⇒ substantial reorientation of the specialization trends in the direction of higher-tech goods (therefore of higher value and more dynamic)

8.2 Final reflections

In this study, a set of variables considered keys to understanding the operations and characteristics of the innovation systems of Brazil and Argentina has been presented. On the one hand, the information gathered has allowed for analysis of the main features and path trends of the central components of the respective NISs: the firms and institutions engaged in the creation and application of new knowledge. At the same time, it has made it possible to assess the relations among these components, identifying the weak points and the strong points of each system.

On the other hand, the data have allowed for comparison of the NISs of the two countries. In turn, the conclusions derived from this comparison have led to reflections and proposals regarding the policies and instruments needed for strengthening the systems so they can contribute to the economic and social development of the respective countries.

Although some of the key variables used refer to resources and potentials that the system can employ to stimulate innovation (structural characteristics or stock variables), the focus has been on features that explain the dynamics of the change underway in each case (flow variables), in other words, the actual efforts and performances that are driving the innovation processes.

Thus, special attention has been directed to the obstacles that hold these processes back, though without disregarding the decisive importance of structural factors capable of halting or slowing the innovation process. Attention has also been given to the impact of the interplay between the current micro and macroeconomic policies, as well as among the commercial, industrial and technological policy instruments, which, when taken together, comprise programs and economic policy instruments that may be subject to adjustment or reformulation.

As to the data employed, the approach has rested on two criteria. The first has been to use mainly information made available through the innovation surveys conducted in the two countries under analysis and to refer as little as possible to other data or interpretative sources. The analysis is therefore a “minimalist” exercise and bypasses a vast set of variables capable of contributing to a more thorough understanding of national innovation systems.

With regard to this point, it should be mentioned that the majority of indicators on which the above considerations are based are readily accessible. While certain questions involved specialized studies or analyses, the greater part of the information arose from data gathered during the innovation surveys and published by the Brazilian and Argentine national statistical institutes (IBGE and INDEC, respectively). Certain of the data employed are available at the RICYT website (<http://www.ricyt.org>).

The first criterion is consistent with the second, according to which the intention has been not to “measure” the NISs to obtain an aggregate indicator reflecting the relative weight of a set of chosen variables that could feasibly be calculated for a group of countries and used for their subsequent comparison; rather, the goal has been to perform a qualitative analysis of a series of quantitative indicators, comparing and contrasting them while focusing on the dynamic factors that interact with the structural determinants.[20]

Lastly, it should be mentioned that this type of analysis stands to benefit from the advances being made in the efforts underway to render the regional innovation indicators compatible (ECLAC/RICYT project), for this will encourage comparative studies capable of providing guidelines for the formulation of policies.

20. Structural potentials and determinants can be incorporated into the analysis using the methods and procedures suggested by Mira Godinho, Mendonça and Santos Pereira (2004).

STATISTICAL APPENDIX

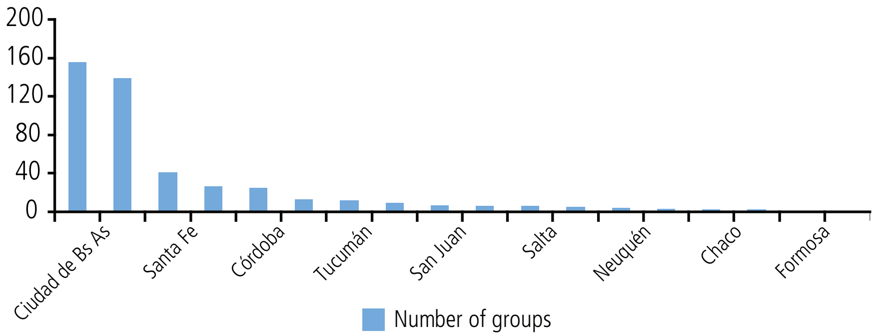
TABLE AI
Brazil and Argentina: Selected variables (2003)

	Argentina	Brazil
GDP (million dollars)	127,000	505,670
Population (million inhab.)	37	179
GDP per capita	3436.69	2824.97

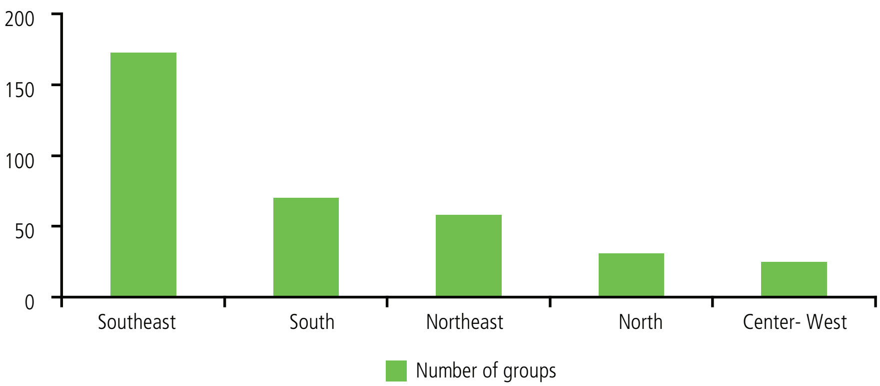
Source: Elaborated on the basis of data from RICYT.

FIGURE A1
Geographic distribution of research groups

Argentina



Brazil



Sources: Gutti and Prados (2005); CNPq. Data available at: <http://www.cnpq.gov.br>.

TABLE A2
Export list by technological intensity
(%)

	Primary goods		Natural-resource-based manufactured goods		Low-tech manufactured goods		Medium-tech manufactured goods		High-tech manufactured goods	
	1985-1987	1999-2001	1985-1987	1999-2001	1985-1987	1999-2001	1985-1987	1999-2001	1985-1987	1999-2001
Argentina	52.8	47.5	25.4	23.4	10.1	8.6	9.5	17.3	2.2	3.2
Brazil	34.3	26.3	23.9	25.6	15.2	11.9	22.6	24.6	4	11.6

Source: Kuwayama and Durán Lima (2003).

TABLE A3
University graduates by discipline (2000-2002)
(%)

	Variance 2000-2002			% Share of total number of graduates 2000-2002		
	Argentina	Brazil	LA and C	Argentina	Brazil	LA and C
Natural and Exact Sciences	13.92	23.50	21.44	9.12	7.88	5.06
Engineering and Technology	20.87	15.97	16.47	12.77	6.38	16.08
Medical Sciences	24.57	31.51	17.15	16.35	13.02	12.52
Agricultural Sciences	7.56	21.34	7.98	3.01	1.97	2.54
Social Sciences	14.92	33.54	20.37	53.54	65.88	60.01
Humanities	63.10	38.86	33.29	5.22	3.35	3.78
Total	**19.05**	**32.35**	**19.52**	**100.00**	**100.00**	**100.00**

Source: Elaborated on the basis of data from RICYT.

TABLE A4
Cooperation agreements for the purpose of innovation by type of agent: Brazil* (2001-2003)

	Number of firms	Distribution of cooperation agreements (%)
Total number of firms	**1,053**	**100**
Customers	447	42.50
Suppliers	584	55.50
Competitors	71	6.70
Other firms within group	239	22.70
Consulting firms	121	11.50
Universities and research institutes	312	29.60
Professional and technical training centers	160	15.20

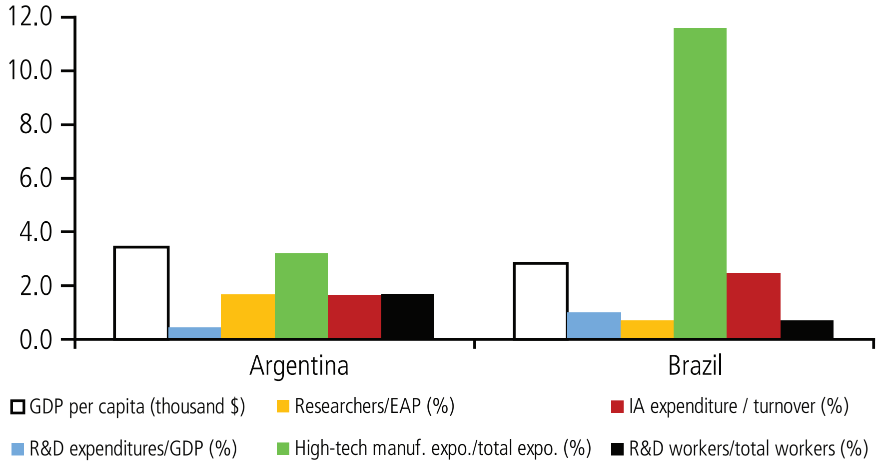
Source: Elaborated on the basis of data from IBGE.
Note: *Firms that declared to have maintained cooperation agreements with other organizations for the purpose of developing innovation activities (and to have given high or average importance to these agreements).

TABLE A4
Cooperation agreements for the purpose of innovation by type of agent: Argentina (1998-2001)

	Number of firms	Distribution of cooperation agreements (%)
Total number of firms	**1,156**	**100**
Universities	429	37.10
Technological centers	410	35.50
Technical training institutes	218	18.90
R&D laboratories/firms	389	33.70
Entities with technological ties	193	16.70
Suppliers	858	74.20
Customers	618	53.50
Home office	243	21.00
Firms within same group	345	29.80
Other firms	317	27.40
Consultants	539	46.60
Government S&T agencies	115	9.90

Source: Elaborated on the basis of data from INDEC.
Note: Firms that maintained relations with other agents and institutions within the NIS.

FIGURE A2
NIS of Argentina and Brazil (selected variables)



Source: Elaborated on the basis of the data presented in this study.

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CHAPTER 6

DRIVERS OF TECHNOLOGICAL INNOVATION IN ARGENTINA AND BRAZIL

Eduardo Gonçalves
Mauro Borges Lemos
João Alberto De Negri

1 INTRODUCTION

Innovation is generally held to be the prime cause of long-term development (ROSENBERG, 1976). Based on this, the underdevelopment of Latin American countries is often associated with the shape of their import substitution industrialization (ISI) processes, which resulted in fragile sectors in their input-output matrixes and marked heterogeneities among industrial firms.

Teitel and Thoumi (1986) contend that the import substitution process followed similar paths in Brazil and Argentina. The first stage of the process, initiated at the beginning of the twentieth century, was well under way in both countries by World War II with the development of non-durable consumer goods industries such as food products and basic consumer goods industries such as furniture, textiles, wearing apparel and footwear, in addition to the manufacture of certain agricultural tools and utensils. This phase was spurred by the growth of the consumer market and by the commodity surpluses generated in the agricultural export sectors of the two countries--coffee being the most important product in Brazil and beef and grain in Argentina.

In the second stage, which lasted until the late 1960s or early 1970s, the industrial complex acquired the capacity to produce durable consumer goods and the sectors linked to metallurgy and metal products gained strength in both Brazil and Argentina, coming to manufacture refrigerators, washing machines, motorcycles, and subsequently automobiles and trucks. Records also attest to the initial production of machine tools and industrial equipment.

The third and final stage extended from the mid-1960s to the late 1970s and was characterized by the insertion and strengthening of the basic chemicals, metallurgical and intermediate goods industries, together with the growth in size and complexity of the capital goods sectors.

However, various analyses have drawn attention to the limited and incomplete nature of this third stage (FURTADO, 1968; TAVARES, 1978; RODRIGUES, 1981), which created sectoral weaknesses in the industrial matrix. Likewise, Bell and

Pavitt (1993) point out that, in Latin America, the development of capital goods and scale-intensive industries was followed by the appearance neither of technical instrument and specialized complex machinery sectors, nor of knowledge-intensive sectors. In turn, such late and incomplete industrialization processes have directly affected the ability of the Brazilian and Argentine economies to innovate.

According to Ranis (1984), adopting import substitution policies can be prejudicial to domestic technological activities for reasons linked to the demand for "ready-made items" available on the world market. In this case, emphasis is placed on physical accumulation rather than on efficiency, which makes it hard to choose appropriate technologies. Moreover, protective tariff systems distort factor and product prices, thus creating extraordinary profits for entrepreneurs, whose interest in seeking local technology opportunities is dampened. Another characteristic of the import substitution model is that it encourages the duty-free entry of capital goods, while protecting domestic intermediate and final goods through tariffs.

It is necessary to point out that this type of recurring criticism of import substitution policies is especially suited to the model adopted by Latin American countries, where the framework for supporting infant industries was generally lax or nonexistent. As pointed out by Okimoto (1989) and Amsden (1989), the experience of Southeast Asia, especially of Japan and South Korea, shows that setting performance targets (innovator and exporter) and timeframes (transitory support and reciprocity rules) allowed for synchronization of the successive stages of import substitution and export substitution, thereby creating structural support for long-term growth.

A lack of such synchronization in the substitution dynamic perpetuates the weakness or absence of capital goods manufacturing sectors in developing countries, thus hindering their industrialization efforts. This translates into a lack of opportunity for generating capital-saving innovations, not to mention a failure to develop the technological skill and knowledge, infrastructure and organizational bases on which all technical progress depends (ROSENBERG, 1976). In this context, the production of machine tools is especially important, for the sector plays a key role in disseminating new skills and techniques throughout the economy. Tools initially designed and perfected to meet the demands of specific customers are subsequently offered to all potential users. In addition, the capital goods sector is responsible for enabling any and all types of innovation because it must produce a new capital good with given specifications capable of producing each new item that the consumer goods sector chooses to manufacture.

When the State fails to take a decisive role in guiding industrialization, countries under import substitution policies become technologically dependent, as evidenced by the incremental nature of the majority of their innovations (FRANSMAN, 1985). In counterpart, most Schumpeterian radical technological changes tend to be performed in developed countries. Thus, to participate in introducing radical innovations, countries in the catching-up process have to implement technology policies specifically aimed at dynamic substitution. This is one of the main factors underlying the difference between the Asian and Latin American experiences with import substitution industrialization.

Due to the pattern of technical change derived from the import substitution model adopted in Latin America, international technology transfer mechanisms have assumed fundamental importance in the region. These mechanisms include foreign direct investment (FDI) and the importation of capital goods, as well as payments for licenses, know-how and technical assistance.

According to Lall (1992), the extent to which the absorption of foreign technology affects the capacity of a country to develop domestic technology depends on the way the technology is imported and the degree of dependence thereon. Technology imports should be channeled so as to reinforce local efforts, never to suppress them. The presence of multinational subsidiaries can therefore have adverse effects due to their tendency to conduct all R&D activities in their home countries. Foreign licensing and consulting can also be damaging if the know-how is not transferred to domestic firms. Under these circumstances, direct intervention is required in order to stimulate the development of local technological capabilities.

Dahlman (1984) takes a similar approach, highlighting the difference between acquiring technology and acquiring technological capacity. Whereas the former is obtained through FDI, licenses, know-how, technical service agreements and capital goods imports, the latter can only be developed by training human capital, which involves formal education, on-the-job training, experience and specific in-house R&D efforts to obtain, assimilate, adapt, improve or create new technology. The degree of commitment to such training reveals the host country's attitude toward the amount of learning to be linked to the technology transfer. Learning is understood as the acquisition of knowledge and additional technical ability by individuals and/or organizations (BELL, 1984).

In Latin American industrialization experiments, the tendency to acquire technology to the detriment of technological capacity was observed even in the cases of large national economies such as Brazil and Argentina (KATZ; BERCOVICH, 1993; DAHLMAN; FRISCHTAK, 1993).

Moreover, even after the import substitution model had been exhausted, the possibility of developing domestic technological capacities was apparently hindered by the institutional transformations of the 1980s and 1990s not only in Brazil and Argentina, but also in other Latin American countries.

Cimoli and Katz (2001) focus on the effects of the Latin American economic adjustments after the recent trade liberalization and market deregulation that followed in the wake of globalization. On the one hand, certain structural changes in the global economy, such as increasing returns to scale in the generation of knowledge, together with the synergy and interdependence among firms and other institutions that globalization tends to produce, led R&D and engineering activities to be concentrated in the more mature economies. On the other hand, developing economies came to specialize in low value-added commodities and assembly or *maquiladora* operations. In the case of Argentina, some of the changes in the production framework actually involved destroying human capital and technological capacity and substituting them with capital that embodied new technology, as well as R&D and engineering services from abroad.

Considering that the current industrial structures of both Brazil and Argentina reflect their import substitution inheritance and the effects of macroeconomic adjustments initiated in the 1990s, the goal of this chapter is to make a comparative assessment of the drivers of the technological innovations performed by manufacturing firms in the two countries. The focus is on the internal determinants of firms' innovation efforts: R&D expenditures, acquisition of R&D from other firms, purchase of machinery and equipment, industrial project expenditures and training expenditures.

The next section describes the databases used and outlines the methodological procedures followed. The third presents the results of the regression analyses performed for both Brazil and Argentina, while the fourth and final section concludes the chapter.

2 DATABASE AND METHODOLOGY

The data on innovation activities in Brazil are from the National Innovation Survey (*Pesquisa sobre Inovação Tecnológica na Indústria–PINTEC, 2002*) conducted by the Brazilian Geographic and Statistical Institute (IBGE). The survey, which covers innovations implemented between 1998 and 2000, includes firms with 10 or more employees. From the methodological standpoint, the PINTEC was modeled according to the Oslo Manual and the third Community Innovation Survey (CIS3). In addition to the PINTEC data, this project employs information from the IBGE Annual Industrial Survey (PIA), the Foreign Capital Census performed by the Central Bank (BACEN) and foreign trade data gathered by the Foreign Trade Secretariat of the Ministry of Development, Industry and Trade (SECEX).

In the case of Argentina, the data are from the Second Innovation and Technological Behavior Survey (*Segunda Encuesta Nacional de Innovación y Conducta Tecnológica de Las Empresas Argentinas--EICT*), which covers the period

1998-2001 and was conducted by the National Statistics and Census Institute (*Instituto Nacional de Estadisticas y Censos–INDEC*). This survey was also performed in line with the Eurostat methodology and suggestions presented in the Oslo, Frascati, and Bogotá manuals (INDEC-SECYT-CEPAL, 2003).

Roughly speaking, the indicators in these databases show that 56% of the Argentine firms conducted some sort of technological innovation between 1998 and 2001, while 31.5% of the Brazilian firms engaged in technological innovation between 1998 and 2000.

One of the advantages of these two surveys is that they take into account types of innovation expenditures other than those on R&D. Table 1 compares and aligns the definitions of innovative activities used in the two questionnaires. Whereas the Argentine survey did not contain questions on market insertion expenses, the Brazilian questionnaire did not cover administrative and consulting costs. The other items correlate, however, as shown in Chart 1.

CHART 1
Definitions of innovative activities in Brazilian and Argentine surveys

Brazil	Argentina
Research and development	Research and development
External acquisition of research and development	External research and development
External acquisition of other knowledge	Technology transfer
Acquisition of machinery and equipment	Acquisition of capital goods, hardware and software
Training	Training
Project design and other technical preparation	Engineering and industrial design
Market insertion of technological innovations	-----------------
-------------------------	Administration
-------------------------	Consulting

Sources: PINTEC (2002); INDEC-SECYT-CEPAL (2003).

In Brazil, machinery and equipment expenditures predominated, representing about 52.1% of total innovation expenditures in 2000. R&D outlays accounted for 16.8% of the total and spending on project design and other technical preparation for 14.8%. The remaining expenses were split between market insertion of technological innovations (6.4%), external acquisition of knowledge other than R&D (5.2%), external acquisition of R&D (2.8%) and training (1.9%).

In Argentina, the share spent on acquiring capital goods was even higher than in Brazil, reaching 75% of total innovation expenditures in 2000. Of the overall amount, 8.6% was allocated to R&D and 6.5% to technology transfers. The remaining expenditures were distributed among engineering and industrial design (3.6%), training (1.8%), consulting (1.7%), administration (1.5%) and the purchase of external R&D (1.3%).

The present study takes into account not only the various types of innovation expenditures and the share of workers engaged in R&D, but also certain structural characteristics of firms that are generally held to influence their propensity to innovate, specifically, foreign insertion (import and export coefficients), productivity and degree of market concentration. In the models, dummy variables were included to obtain the differing sectoral propensities to innovate, the influence of firm size and the impact of capital origin.

The several types of innovation expenditures (internal R&D efforts, purchase of external R&D, knowledge transfer, acquisition of machinery and equipment and project design) were divided by the total innovation expenditures of the firm.

In turn, the "R&D intensity" indicator was built by dividing the firm's R&D expenditures by its total sales revenue. To determine the share of workers engaged in R&D, the number of such workers was divided by the total number employed by the firm.

The import and export coefficients were constructed by dividing the value of imports and exports, respectively, by the firm's sales revenue. The productivity variable arose from the division of total sales revenue by the number of workers employed. The concentration variable was measured as the total revenue of firm *i* in sector *j* divided by the sales revenue of sector *j*, the sectors having been defined according to the Brazilian National Classification of Economic Activities (*Classificação Nacional de Atividades Econômicas--CNAE*) at the two-digit level.

3 DRIVERS OF TECHNOLOGICAL INNOVATION IN BRAZIL AND ARGENTINA

In this study, three types of econometric results are presented. The first are aimed at measuring the importance of the variables related to firms' product innovation efforts and the second at gauging the relevance of these variables to their process innovation efforts. The third series of estimates covers only those firms having 200 or more employees.

3.1 Product innovation

This section contains the results of the regressions for the determinants of product innovation in Brazil and Argentina. In the probit model, the dependent variable has a value of 1 if the firm innovated products new to the domestic market and 0 if not. Five variables were used to measure the relative importance of each type of expenditure.[1]

1. Only training expenses, due to their being strongly correlated with machinery and equipment purchases, were excluded from the regressions for Brazil and Argentina. This correlation is explained by the fact that when a firm purchases new machinery or equipment, it has to train the staff to operate it. For this reason—added to the fact that this capital goods variable is less subject to forms-completion and interpretation errors--only the purchase of such goods was included in the regressions. Moreover, in developing countries, the acquisition of machinery and equipment assumes additional importance because it implies the acquisition of embodied technology.

In addition, two innovation effort variables were included in the specification, one measuring the share of employees engaged in R&D and the other measuring the R&D intensity of the firm. Structural variables that control for the foreign insertion of firms, levels of productivity and degrees of market concentration were also introduced; however, they refer to a period prior to that when the firms claimed to have innovated in order to avoid endogeneity problems. Dummy variables were also included to establish the influence of capital origin, firm size and sectoral technology opportunities.

With respect to innovation efforts on the part of Brazilian firms, Table 1 shows that expenditures on external R&D, on other external knowledge, project design, internal R&D and machinery and equipment constitute, in that order, the major innovation efforts in terms of marginal probability. This brings two features of the Brazilian economy to light in terms of its capacity to innovate: (1) the importance of acquiring foreign technology through licensing, know-how, patents, trademarks, consulting services and technology transfer agreements; (2) the weakness of in-house R&D, given that, measured in terms of marginal probability, outsourcing in this area is four times more significant than in-house R&D efforts.

TABLE 1
Probit regression for product innovation by Brazilian industrial firms (2000)

Explanatory Variable	Coefficient	Standard deviation	Marginal probability
Export coefficient	-0.16 NS	0.1381	0.2300
Import coefficient	0.55 ***	0.2210	0.0579
Productivity	0.00 ***	0.0000	0.0000
Concentration	33.47 ***	5.8200	3.5300
Employees engaged in R&D	0.03 ***	0.0040	0.0028
R&D intensity	0.12 ***	0.0126	0.0122
Internal R&D	1.02 ***	0.0679	0.1076
External R&D expenditures	4.05 ***	0.4871	0.4269
Other knowledge transfer expenditures	1.25 ***	0.3106	0.1318
Machinery and equipment expenditures	0.70 ***	0.0450	0.0738
Project design expenditures	1.17 ***	0.1393	0.1228
Dummy for capital origin	0.38 ***	0.0595	0.0398
Dummy for medium-sized firms	0.20 ***	0.0387	0.0206
Dummy for large firms	0.74 ***	0.0691	0.0775

Source: Prepared by the authors.
Intercept: -2.60***
Log likelihood= -3727.51
N= 6.626
$R^2 = 0.44$
Probability of correct prediction: 88.4%
* Significant at 10%; ** Significant at 5%; *** Significant at 1%; NS= not significant

As Table 2 shows, the importance of foreign technology and weakness of in-house R&D are also significant in Argentina, the difference being the order of importance of the two main types of innovation expenditures. In Argentina, other knowledge transfer and project design expenditures have the greatest impact on the probability of product innovation, with R&D purchases coming next. Whereas in-house R&D efforts are the least relevant in Argentina, machinery and equipment purchases occupy this position in Brazil. This suggests that the in-house capacity to perform R&D, and consequently the capacity to innovate based on internal efforts, is limited in both economies. However, in comparison to other types of innovation spending, the impact of purchasing R&D on innovation is more relevant in Brazil than in Argentina.

TABLE 2
Probit regression for product innovation by Argentine industrial firms (2001)

Explanatory variable	Coefficient	Standard deviation	Marginal probability
Export coefficient	0.51 ***	0.0900	0.1594
Import coefficient	2.14 ***	0.1665	0.6652
Productivity	0.00 ***	0.0000	0.0000
Concentration	5.48 ***	2.5940	1.7030
Employees engaged in R&D	0.05 ***	0.0038	0.0155
R&D intensity	0.26 ***	0.0430	0.0794
Internal R&D	0.73 ***	0.1005	0.2251
External R&D expenditures	1.67 ***	0.3916	0.5185
Other knowledge transfer expenditures	2.63 ***	0.8569	0.8163
Machinery and equipment expenditures	0.73 ***	0.0440	0.2260
Project design expenditures	2.18 ***	0.1690	0.6768
Dummy for capital origin	-0.36 ***	0.0713	-0.1131
Dummy for medium-sized firms	0.22 ***	0.0467	0.0669
Dummy for large firms	0.37 ***	0.1470	0.1153

Source: Prepared by the authors.
Intercept: -1.42***
Log likelihood= -3753.30
N= 1.256
$R^2 = 0.82$
Probability of correct prediction: 74.9%
* Significant at 10%; ** Significant at 5%; *** Significant at 1%; NS= not significant

Exports are included in the regressions in an attempt to determine if this variable encourages innovation, as suggested in the theoretical literature (FRANSMAN, 1985). In turn, imports are theoretically a way to acquire the more advanced technologies embodied in machinery and equipment or in final products—technologies that can eventually be submitted to reverse engineering. Even in the case of countries that simply import products without learning from them, as often observed in Latin America, imports can mean increased competition and consequently force domestic producers to improve their products and processes. With regard to importing capital goods and linking them to capacity build-up, Korea provides a successful example. According to Viotti (2002), Korean imports have been accompanied by complementary strategies that enable absorption, learning, and active incremental innovation.

Tables 1 and 2 illustrate that foreign insertion has a much stronger impact on the probability of innovation in Argentina than in Brazil. For Brazil, the export coefficient is not statistically significant and the import coefficient, in terms of marginal probability, has a positive albeit slight influence on decisions to innovate in Brazilian compared to Argentine firms. For Argentina, both the import and export coefficients are significant, though imports are considerably more relevant than exports in stimulating product innovation, reflecting the fact that capital goods imports continue to promote technical change in Argentine industrial firms.

In relation to the export coefficient, which is negative for Brazil, there are reasons to suspect endogeneity problems in the regression, for some studies link innovation to export capacity (DE NEGRI; SALERNO, 2005; CHUDNOVSKY *et al.*, 2005), while others contend that exports do not affect the decision to innovate (PAMUKCU, 2003).

Probit regressions were run in two stages to introduce instrumental variables for the export regressor. The instrumental variables chosen were (1) the growth rates of the countries to which firms exported, weighted by their shares in the total value of exports and (2) whether or not firms had exported in the previous period (1997). Both instrumental variables had positive signs, were statistically significant and were approved by Hausman and Sargan tests. This procedure indicated that exports have a positive impact on innovation probabilities, in contrast to the findings previously cited, which were marked by endogeneity problems and showed the effect of exports on innovation to be non-significant. These estimates, however, are not presented in the text.

Due to the lack of availability of Argentine data for running such a regression, this procedure could only be applied for Brazil.[2] However, the sign of the coefficient of Argentine exports (Table 2) is apparently compatible with theory and with other empirical evidence indicating the positive effect of exports on innovation.

As to firm size, the larger the firm, the stronger its propensity to innovate. "Large firms" have marginal probabilities of 11.5% and 7.8% for Argentina and Brazil, respectively, while "medium-sized firms" have propensities of 6.7% and 2%. The results for both countries confirm a hypothesis attributed to Schumpeter (1961) that contends innovation should increase at a more-than-proportional rate in relation to firm size. Another Schumpeterian hypothesis, regarding the impact of market concentration on innovation, also confirms for both countries. Although a reverse correlation between

2. With reference to the signs and order of importance of the variables, the other results of the two-stage Probit regression were comparable to those presented in Table 1.

innovation and market concentration would also be consistent with the Schumpeterian view, it would only be valid for a long time span, since a technological breakthrough is the starting point for firm growth and market leadership.

Productivity, a traditional measure of firm performance and efficiency, directly affects the rate of profit, the key performance variable. It was therefore included to test the correlation between performance and innovation efforts, in other words, to ascertain to what extent the efficiency of a firm stimulates its innovative efforts. The evidence reveals that, though the coefficient is statistically significant,[3] efficiency does not have a relevant impact on the probability of a firm innovating.

The dummy variable linked to the origin of capital was aimed at identify differences in the innovative efforts of multinational enterprises vis-à-vis domestic enterprises. This exercise was performed because of divergent views in the literature as to the influence of multinational enterprises on domestic innovation capacity (MANSFIELD, 1974). On comparing Brazil and Argentina, substantial differences are seen to exist in the impact of this variable on innovation.

In Brazil, the presence of multinationals increases the likelihood of innovation by approximately 4%. It should be emphasized that since the reference used in this case was foreign versus domestic ownership, the idea that foreign capital can contribute to enhancing domestic innovation capacities was confirmed. Its importance needs to be qualified, however, by observing the types of efforts made by multinationals and, specifically, by asking if their product innovations are essentially related to the adoption of products developed in their home countries rather than to investment in in-house R&D at their foreign subsidiaries.

At this point, an interesting comparison can be made between the results of this study and those presented by Araújo (2004), who found that the presence of multinationals actually inhibited the probability of a firm investing in R&D. Taking the findings of the two studies into account, it can be concluded that, though multinationals facilitate the transfer of technology from abroad, they make limited contributions to the domestic capacity to innovate because they fail to create the local externalities associated with on-site R&D efforts.

In Argentina, in contrast to Brazil, the presence of multinational enterprises is not only unimportant as a product innovation determinant, but actually diminishes the likelihood of innovation by about 11%. Although these enterprises contributed to domestic technological development by disseminating better global technological practices, Mansfield's (1974) classic hypothesis does not appear to

3. As in the case of concentration, a two-way relation is expected between performance and innovation. In order to avoid endogeneity, the productivity variable was lagged by two years.

be valid for Argentine industry. This evidence is consistent with that presented by Chudnovsky (1999), who called attention to the fact that the multinational subsidiaries located in Argentina generated only minor technological externalities due to the limited scale of their innovative activities and the scarce technological links between these firms and local suppliers and research institutes. These conclusions were further corroborated by Chudnovsky (2006), who found no significant correlation between foreign-owned capital and the performance of innovation activities or the launching of innovations on the market.

According to Pavitt (1984), the propensity to innovate differs among industrial firms because technological opportunities are uneven across sectors. In turn, Scherer (1965) contends that technological opportunity is the main factor responsible for the differences across industries related to product innovation measures such as patents. In order to control for these differences, a dummy for the food and beverage sector, given its importance in the economies of both countries, was included in the study.

In Brazil, the sector dummies that most contributed to the decision to innovate were: wearing apparel (CNAE-18), publishing and printing (CNAE-22), coke and refined petroleum products (CNAE-23), chemical products (CNAE-24), rubber and plastics products (CNAE-25), basic metals (CNAE-27), machinery and equipment (CNAE-29), electrical machinery and apparatus (CNAE-31), motor vehicles, trailers and semi-trailers (CNAE-34) and other transport equipment (CNAE-35). The other 11 sector dummies are not statistically significant in the regression.[4]

The sectors listed above are heterogeneous in terms of technology intensity indicators and patterns of technological efforts. Due to this heterogeneity, the Pavitt taxonomy, originally formulated for developed countries, is not wholly applicable. Among the activities listed, "supplier-dominated" sectors that do not offer the best technological opportunities in developed countries (CNAE 18 and 22) appear alongside sectors classified by the OECD as "low technological intensity" (CNAE 18 and 22), "medium-low technological intensity" (CNAE 23, 25, and 27) and "medium-high technological intensity" (CNAE-34) activities.

The heterogeneity observed across sectors in the capacity of Brazilian industrial firms to innovate reflects not only the origin of capital but also an industrial structure that is biased and favors the natural resource sectors that command the export list. Considering that these sectors are generally "supplier-dominated" or "scale-intensive," private R&D efforts are relatively insignificant because their technological efforts are concentrated on acquiring machinery and equipment. At the same time, domestic sectors that are "science-based," "specialized suppliers," and "information-intensive"

4. Although not included in the tables, these results are available on request.

make relatively limited R&D efforts due to the passive nature of the absorption process, which depends on technology transfers from abroad.

Sectoral technological heterogeneity also reflects weaknesses in Latin American economies owing to their incomplete industrialization processes and subsequent gaps in their technological matrixes. Thus, even sectors with "complete" input-output matrixes - specifically capital goods segments–are under-represented, which compromises the domestic capacity to create new products and processes. In these economies, the very concept of "innovation," as defined in the technological surveys used in this study, differs from that observed in developed economies. In contrast to the developed countries, where introducing a new product usually means placing it on the world market, the range of novelty generally extends only to the domestic market since the underlying innovations are the result of technology transfers and adoptions from abroad.

Sectoral heterogeneity regarding the propensity to innovate also marks Argentine industry, though there are minor differences in the list and order of importance of the sectors when compared to Brazil. The following sector dummies are significant in the regression presented in Table 2: wood products (CNAE-20), publishing and printing (CNAE-22), chemical products (CNAE-24), rubber and plastics products (CNAE-25), non-metallic mineral products (CNAE-26), metal products (CNAE-28), machinery and equipment (CNAE-29), electrical machinery and apparatus (CNAE-31), motor vehicles, trailers and semi-trailers (CNAE-34) and other transport equipment (CNAE-35). The other 11 sector dummies are not statistically significant in the regression.

3.2 Process innovation

In this section, which presents the results of the regressions run for process innovations by Brazilian and Argentine industrial firms, considerable differences are seen to exist between process innovators and product innovators.

In terms of the types of spending on process innovation in Brazil (Table 3), the magnitudes of the marginal probabilities indicate that, as in the case of product innovation, the acquisition of external R&D is the main determinant of the decision to innovate. The order of importance as to this type of innovation only differs with respect to the position of "internal R&D," which, in the case of process innovation, is the lowest ranked. In the case of product innovation, the lowest marginal probability is that referring to machinery and equipment.

Turning to Argentina, Table 4 shows that spending on project design, R&D purchases and machinery and equipment, respectively, are the principal determinants of process innovation. Spending on other knowledge transfers has a negative impact on the decision to innovate processes, while the internal R&D effort, as in the case of product innovation, contributes the least.

In terms of foreign insertion, it is clear that both exports and imports affect the propensity to innovate processes--as opposed to products for Brazilian firms, for which the propensity to innovate was influenced only by imports. This provides important evidence that process innovation, which is closely linked to cost reduction, enters the competitive strategies of Brazilian industrial and agro-industrial commodity exporters, given the weight of these commodities on the export list. Nonetheless, it is important to emphasize that the increase in the likelihood of innovation produced by the import coefficient is approximately five times greater than that produced by the export coefficient, indicating that imports are still the prime driving force behind process innovation in Brazil.[5]

TABLE 3
Probit regression for process innovation by Brazilian industrial firms (2000)

Explanatory variable	Coefficient	Standard deviation	Marginal probability
Export coefficient	0.41 ***	0.1256	0.0294
Import coefficient	2.12 ***	0.2348	0.1509
Productivity	0.00 NS	0.0000	0.0000
Concentration	24.25 ***	5.0200	1.7281
Employees engaged in R&D	0.03 ***	0.0040	0.0020
R&D intensity	0.08 ***	0.0142	0.0058
Internal R&D	0.69 ***	0.0853	0.0490
External R&D expenditures	2.26 ***	0.4800	0.1609
Other knowledge transfer expenditures	1.49 ***	0.3300	0.1060
Machinery and equipment expenditures	1.07 ***	0.0510	0.0765
Project design expenditures	1.17 ***	0.1551	0.0831
Dummy for capital origin	0.14 ***	0.0670	0.0101
Dummy for medium-sized firms	0.45 ***	0.0430	0.0320
Dummy for large firms	1.02 ***	0.0676	0.0728

Source: Prepared by the authors.
Intercept: -2.69***
Log likelihood= -2,862.52
N= 6,626
$R^2 = 0.33$
Probability of correct prediction: 86.9%
* Significant at 10%; ** Significant at 5%; *** Significant at 1%; NS= not significant

In the case of Argentina (Table 4), a different result is observed since only imports raise the probability of firms generating process innovations. This suggests an important difference between the two economies with respect to the relation between foreign insertion and process innovation.

5. In the case of Brazilian process innovators, the two-stage probit regression confirms that the sign of the export coefficient is positive and significant, as shown in Table 3.

Of all the variables, market concentration has by far the greatest relative importance to process innovation for Brazilian industry (Table 3), despite the probability being lower for process than for product innovation (Table 1). For Argentina, however, the so-called "Schumpeterian hypothesis" is not confirmed–at least not in terms of this variable–since its coefficient is not significant for process innovators. This is a source of concern for the Argentine economy because the innovative vitality of a country's industrial sector in great part depends on the strong technological performance of its established leading firms.

TABLE 4
Probit regression for process innovation by Argentine industrial firms (2001)

Explanatory variable	Coefficient	Standard deviation	Marginal probability
Export coefficient	-0.03 NS	0.1192	-0.0042
Import coefficient	1.98 ***	0.1924	0.3028
Productivity	0.00 ***	0.0000	0.0000
Concentration	3.18 NS	3.0345	0.4877
Employees engaged in R&D	0.05 ***	0.0048	0.0083
R&D intensity	0.22 ***	0.0347	0.0341
Internal R&D	0.17 ***	0.1158	0.0256
External R&D expenditures	1.11 **	0.4884	0.1706
Other knowledge transfer expenditures	-0.34 ***	0.8723	-0.0519
Machinery and equipment expenditures	0.71 ***	0.0549	0.1082
Project design expenditures	1.14 ***	0.1861	0.1746
Dummy for capital origin	-0.07 NS	0.0811	-0.0115
Dummy for medium-sized firms	0.23 ***	0.0560	0.0353
Dummy for large firms	0.74 ***	0.1567	0.1130

Source: Prepared by the authors.
Intercept: -1.92***
Log likelihood= -2,206.45
N= 1,256
R^2 = 0.59
Probability of correct prediction: 75.3%
* Significant at 10%; ** Significant at 5%; *** Significant at 1%; NS= not significant

In Argentina, the limited influence of productivity on the process innovation decision (Table 4) is similar to the findings for product innovation (Table 2). In Brazil, productivity is not significant to process innovation (Table 3).

In contrast, the variable measuring the proportion of employees linked to R&D is significant and positive to process innovation, as to product innovation, in both countries.

With regard to R&D intensity, the differences between process innovators in Brazil and Argentina are similar to those observed between product innovators. In other words, R&D intensity increases the likelihood of firms innovating far more in Argentina than in Brazil. Since the dummy for large firms–used as a control variable–is significant and extremely relevant in Brazil, as revealed by its high marginal probability, the explanation for these differences may lie in the fact that relatively more firms are process innovators in Brazil, as reflected in the sample frames used in the two technological innovation surveys. Regardless of occasional problems that may have arisen due to the varying quality of the replies to the questionnaires, it is only natural to expect, statistically and analytically, a higher proportion of innovative firms (as in Brazil) to generate greater heterogeneity with respect to technological capacity, which, in turn, translates into relatively weaker R&D efforts.

In Brazil, capital origin, with foreign capital being favored, affects the probability of a firm innovating processes, though the impact is relatively weaker than that exerted on product innovation. In contrast, this dummy variable is not significant for Argentina despite its having a negative sign, as for product innovation.

The dummies for evaluating the relative importance of firm size confirm that “large companies” have a greater propensity to innovate. The marginal probabilities are 7% for Brazil and 11% for Argentina, similar to the product innovation percentages. Size is important regardless of the type of innovation and the country.

The significant sector dummies for Brazil are those that stand for tobacco products (CNAE-16), wearing apparel and accessories (CNAE-18), leather products (CNAE-19), wood products (CNAE-20), publishing and printing (CNAE-22), coke and refined petroleum products (CNAE-23), machinery and equipment (CNAE-29), office, accounting and computing machinery (CNAE-30), medical, precision and optical instruments (CNAE-33) and other transport equipment (CNAE-35). It should be noted that five of the ten outstanding sectors in terms of product innovation reappear among the most significant sectors with respect to process innovation (CNAE 18, 22, 23, 29 and 33).

The sectors that increase the probability of process innovation in Argentina are: textiles (CNAE-17), wearing apparel and accessories (CNAE-18), pulp and paper (CNAE-21), chemical products (CNAE-24), non-metallic mineral products (CNAE-26), basic metals (CNAE-27), machinery and equipment (CNAE-29), motor vehicles, trailers and semi-trailers (CNAE-34) and furniture and miscellaneous industries (CNAE-36). Four of these sectors (CNAE 24, 26, 29 and 34) were also listed among those most important with regard to product innovation. It should be observed that certain differences exist in comparison to Brazil.

3.3 Product and process innovation in large firms

In this part of the study, regressions were specifically run to analyze samples of Brazilian and Argentine firms with 200 employees or more, given that firm size is an extremely important variable in determining the propensity to innovate. Two dummies were created, one to represent medium-sized firms (assigned the value of one if they had between 200 and 499 employees) and another to represent large firms (assigned the value of one if they had 500 or more employees). Although these firm size dummies were highly significant to product and process innovations in both countries, they were more relevant for Brazil than for Argentina.

Another reason for performing regressions for firms above the 200-employee cutoff point is methodological. By considering only medium-sized and large firms, an attempt was made to minimize any impact the severe Argentine recession may have had on the results of the regression for the complete sample. It is possible that a substantial part of the differences in the innovative performance of firms located in the two countries was related to the failure of a large number of small firms in Argentina during the survey period. In this case, the sample may have been biased due to the questionnaires having been completed mainly by medium-sized and large firms that survived. In Brazil, in turn, the large number of small, non-innovative firms in the PINTEC sample may in great measure explain the low rate of innovation. Analyzing only the medium-sized and large firms therefore provides samples that allow for a better balance between the two countries.

TABLE 5
Probit regression for product innovation by Brazilian industrial firms with 200 or more employees (2000)

Explanatory variable	Coefficient	Standard deviation	Marginal probability
Export coefficient	-0.81 ***	0.2200	-0.1464
Import coefficient	1.61 ***	0.4100	0.2908
Productivity	0.00 NS	0.0000	0.0000
Concentration	52.14 ***	7.7843	9.4202
Employees engaged in R&D	0.09 ***	0.0141	0.0158
R&D intensity	0.11 ***	0.0321	0.0207
Internal R&D	0.90 ***	0.1417	0.1694
External R&D expenditures	2.87 ***	0.7718	0.5190
Other knowledge transfer expenditures	0.89 ***	0.4862	0.1609
Machinery and equipment	0.62 ***	0.0979	0.1118
Project design expenditures	1.06 ***	0.2515	0.1909
Dummy for capital origin	0.33 ***	0.0898	0.0588
Dummy for medium-sized firms	-0.48 ***	0.0759	-0.0869

Source: Prepared by the authors.
Intercept: -1.58***
Log likelihood= -1,027.28
N= 2,503
$R^2 = 0.30$
Probability of correct prediction: 86%
* Significant at 10%; ** Significant at 5%; *** Significant at 1%; NS= not significant

With respect to product innovation in Brazil, the results for the 200-employee-or-more sample are shown in Table 5. As expected, the two variables representing foreign insertion are important determinants of the propensity to innovate. However, the sign of the export coefficient is the opposite of that expected since it indicates that export activities lower the probability of product innovation. This is due to endogeneity problems (as in Table 1) between the export and innovation variables. When a two-stage probit regression is run, the sign of the export coefficient becomes positive and significant (as expected) while the other qualitative results remain the same. These estimates are not presented in the text, however.

The market concentration dummy also exerts a strong impact on product innovation, the coefficient for the partial sample being even higher than that for the complete sample (Table 3). Considering that the dummy for large firms serves as the reference, it is therefore logical for the dummy for medium-sized firms to have a negative sign.

The variable that measures the proportion of employees engaged in R&D activities now contributes more to raising the likelihood of innovation than it did for the complete sample. This is consistent with the fact that the larger the firm, the higher the probability of its having employees who are solely or partially involved in R&D.

The dummy variable standing for capital origin continues to indicate that the presence of foreign subsidiaries is important to the introduction of product innovations by Brazilian industrial firms.

With regard to the types of spending on product innovation, external acquisition of R&D continues to have the greatest impact on the decision to innovate in terms of marginal probability (Table 5), thus reinforcing the previous findings on the importance of outside knowledge to technological innovation on the part of the larger Brazilian firms. The relative importance of the other types of spending is only slightly altered in comparison to the regressions performed using the complete sample.

In this regression, the list of significant sector dummies is similar to that for the complete sample: wearing apparel (CNAE-18), publishing and printing (CNAE-22), chemical products (CNAE-24), machinery and equipment (CNAE-29), office, accounting and computing machinery (CNAE-30), radio, television and communication equipment (CNAE-32), motor vehicles, trailers and semi-trailers (CNAE-34) and other transport equipment (CNAE-35). Once again, as in the case of the complete sample, a fair degree of technological heterogeneity (which increases the propensity of firms to innovate products) is observed across sectors. It is clear that the most innovative sectors are also the most intensive in project design, whether for intra-industry use or the manufacture of goods for final consumption.

In the case of Argentine product innovators with 200 employees or more, certain differences can be noted in relation to the regression employing the complete sample. Only the export coefficient, for example, has a relevant impact on the propensity to innovate, in contrast to the results obtained on running the regression for the complete sample (Table 3). As in the Brazilian case, the negative results may be due to endogeneity problems.

Market structure, represented by the concentration variable, has greater importance than in the regression based on the complete sample, though far less importance than for the larger Brazilian firms. While the same can be said of employees engaged in R&D, the R&D intensity variable is not significant in this sample, as opposed to the results obtained using the complete sample. The sign of the capital origin coefficient is negative but not significant.

As to the types of innovation efforts, certain variables, such as other knowledge transfer and project design expenditures, lack significance. External R&D expenditures have a negative impact on the probability of firms launching new products, meaning that knowledge outsourcing is not relevant to product innovation among the larger Argentine firms. The two types of efforts that are significant and relevant for firms with 200 employees or more are in-house R&D efforts and machinery and equipment expenditures (Table 6). In this regression, the tobacco sector (CNAE-16) has statistical significance.

TABLE 6
Probit regression for product innovation by Argentine industrial firms with 200 or more employees (2001)

Explanatory variable	Coefficient	Standard deviation	Marginal probability
Export coefficient	-1.92 ***	0.4557	-0.7268
Import coefficient	0.67 NS	0.7371	0.2540
Productivity	0.00 *	0.0000	0.0000
Concentration	11.15 *	5.8300	4.2289
Employees engaged in R&D	0.19 ***	0.0395	0.0717
R&D intensity	-0.00 NS	0.1712	-0.0016
Internal R&D	159 ***	0.4236	0.6024
External R&D expenditures	-4.79 **	2.1917	-1.8157
Other knowledge transfer expenditures	1.95 NS	1.6461	0.7391
Machinery and equipment	0.79 ***	0.1943	0.2978
Project design expenditures	0.45 NS	0.6285	0.1719
Dummy for capital origin	-0.55 ***	0.2056	-0.2091
Dummy for medium-sized firms	-0.25 NS	0.1830	-0.0946

Source: Prepared by the authors.
Intercept: -1.12***
Log likelihood= -220.72
N= 283
$R^2 = 0.44$
Probability of correct prediction: 78.4%
* Significant at 10%; ** Significant at 5%; *** Significant at 1%; NS= not significant

In Table 7, the results are shown for process innovators among the Brazilian firms with 200 employees or more. At first sight, the export coefficient is not significant. However, after correcting for endogeneity and running a two-stage probit regression, the sign becomes positive and significant, according to expectations and similar to the result for product innovators. The other results were similar to those obtained for the complete sample. Also, as in the case of product innovators, the import coefficient is relevant; in other words, imports raise the propensity of firms to innovate processes.

Both the market concentration and R&D employee variables have higher marginal probabilities than in the regression based on the complete sample. The order of importance of the types of innovation expenditures, however, is precisely the same as in the regression for all firms (Table 3).

TABLE 7
Probit regression for process innovation by Brazilian industrial firms with 200 or more employees (2000)

Explanatory variable	Coefficient	Standard deviation	Marginal probability
Export coefficient	0,12 NS	0.1879	0.0218
Import coefficient	1.97 ***	0.4041	0.3627
Productivity	0.00 NS	0.0000	0.0000
Concentration	20.62 ***	5.5390	3.7940
Employees engaged in R&D	0.05 ***	0.0136	0.0101
R&D intensity	0.11 ***	0.0334	0.0217
Internal R&D	0.43 ***	0.1566	0.0792
External R&D expenditures	2.76 ***	0.7346	0.5069
Other knowledge transfer expenditures	1.61 ***	0.4670	0.2969
Machinery and equipment expenditures	0.92 ***	0.0959	0.1690
Project design expenditures	1.21 ***	0.2470	0.2227
Dummy for capital origin	0.22 ***	0.0897	0.0401
Dummy for medium-sized firms	-0.54 ***	0.0715	-0.0995

Source: Prepared by the authors.
Intercept: -1.59***
Log likelihood= -1,040.28
N= 2,503
$R^2 = 0.23$
Probability of correct prediction: 82.7%
* Significant at 10%; ** Significant at 5%; *** Significant at 1%; NS= not significant

Although not included in the table, seven sector dummies contributed to increasing the likelihood of firms engaging in process innovation activities: tobacco products (CNAE-16), wearing apparel (CNAE-18), pulp and paper (CNAE-21), coke and refined petroleum products (CNAE-23), office, accounting and computing machinery (CNAE-30), radio, television and communication equipment (CNAE-32) and motor vehicles, trailers and semi-trailers (CNAE-34). The pattern of sectors involved in process innovation is clearer than the pattern for product innovation. Apart from wearing apparel, all are scale-intensive sectors either in the widely used intermediary inputs/ capital goods category or in the consumer goods category.

Table 8 shows the results of the regression run for the Argentine firms with 200 employees or more that conducted process innovations. The findings for both foreign insertion and the concentration variables are the same for the partial as for the complete sample (Table 4).

TABLE 8
Probit regression for process innovation by Argentine industrial firms with 200 or more employees (2001)

Explanatory variable	Coefficient	Standard deviation	Marginal probability
Export coefficient	-0.65 NS	0.4023	-0.1554
Import coefficient	2.53 ***	0.7753	0.6061
Productivity	0.00 NS	0.0000	0.0000
Concentration	7.09 NS	5.8900	1.6968
Employees engaged in R&D	0.12 ***	0.0333	0.0283
R&D intensity	0.10 NS	0.1451	0.0232
Internal R&D	1.47 ***	0.3899	0.3519
External R&D expenditures	-3.76 NS	2.6717	-0.9007
Other knowledge transfer expenditures	2.46 NS	2.0570	0.5888
Machinery and equipment expenditures	0.73 ***	0.2080	0.1736
Project design expenditures	1.24 *	0.6770	0.2969
Dummy for capital origin	-0.61 ***	0.2227	-0.1453
Dummy for medium-sized firms	-0.04 NS	0.1935	-0.0104

Source: Prepared by the authors.
Intercept: -1.38***
Log likelihood= -195.98
N= 283
R^2 = 0.35
Probability of correct prediction: 77.3%
* Significant at 10%; ** Significant at 5%; *** Significant at 1%; NS=not significant

Whereas the variable for employees engaged in R&D has greater importance than in the complete sample, R&D intensity is not as significant as before.

Spending on innovative activities underwent no radical changes in comparison to the findings for the complete sample (Table 4). Expenditures on other knowledge transfers continue to be statistically non-significant and expenditures on external R&D become non-significant. However, those on internal R&D, which were not significant in the regression based on the complete sample, become the most relevant innovation effort in terms of marginal probability, followed by spending on project design and the acquisition of machinery and equipment, in decreasing order.

The larger the firm, the higher the likelihood of innovation, as revealed by the negative sign of the dummy for medium-sized firms. Moreover, the presence of foreign subsidiaries diminishes the probability of process innovation for the partial sample, whereas the presence of such firms was not significant for the complete sample (Table 4). Given the sunk costs of investment in technological innovation, coupled with domestic market bottlenecks due to the limited scale of local R&D, these results confirm a possible risk aversion on the part of foreign companies to long-term investments in Argentina.

Only four sectors statistically increase the likelihood of process innovation in Argentina, namely: textiles (CNAE-17), pulp and paper (CNAE-21), chemical products (CNAE-24), and rubber and plastics products (CNAE-25), all of which are scale-intensive sectors.

4 CONCLUSIONS

In this chapter, the relative importance of the factors that drive innovation in Brazil and Argentina have been analyzed, taking into consideration the features the two countries have in common in terms of technical change owing to similarities in their import substitution industrialization strategies. These features include high expenditures for the acquisition of outside knowledge in relation to total innovation expenditures and the absorption of techniques embodied in machinery and equipment vis-à-vis internal R&D. Other structural and performance characteristics of firms were also taken into account, such as foreign trade patterns, productivity levels, degrees of market concentration, sectoral differences in propensities to innovate, firm size and capital origin.

The results of the regressions underscore the weakness of internal R&D capacities, outsourcing being four times more important than in-house R&D efforts when measured in terms of marginal probability. Complementing this finding, the results also underline the importance of acquiring foreign technology through licensing, technology transfer agreements, consulting services and the purchase of know-how, patents and trademarks.

With respect to the structural variables, market concentration was found to the far most important variable for explaining the decisions of both Brazilian and Argentine firms to innovate products and processes. This finding is consistent with the literature contending that market power and firm size encourage innovation.

Capital origin proved to be an important component underlying the innovation performance of Brazilian firms. Based on the results of this study and evidence presented in other analyses, it can be affirmed that multinational enterprises generally have a stronger propensity to innovate than domestic enterprises. However, since the multinational firms rarely invest in on-site R&D at their overseas subsidiaries, they fail to enhance domestic innovation capacities by creating local externalities. Their contribution is therefore basically limited to international technology transfers.

In contrast, multinational enterprises are not statistically significant to explaining the likelihood of firms innovating in Argentina. This confirms the findings of other studies pointing to the limited technological externalities generated by the multinational subsidiaries located in the country. The reasons lie in the restricted scale of on-site innovative activities and the sparse technological links between these firms and local suppliers and research institutes. As already mentioned, the explanation may lie in the risk aversion of foreign firms, which tends to reduce their long-run innovation investments to a limited number of markets outside their home countries. Thus, the fact that the Argentine domestic market is considerably smaller than those of the two major Latin American markets, namely Brazil and Mexico, may explain this non-innovative behavior.

At the sectoral level, the results attest to the heterogeneous nature of developing countries, as revealed by the technological intensity indicators and patterns of technological efforts. Although there are differences between the two countries regarding the sectors that contribute most to the probability of innovation, activities that are not held to offer technological opportunities in developed countries or considered low or medium-tech by the OECD appear on the lists for both Argentina and Brazil.

This is because the technological dynamic of developing countries is shaped by the strong role of the commodity sectors and linked to low value-added export lists. Likewise, the concept of innovation basically covers products and processes new only to the domestic market, in other words, imitations—that may or may not be adapted to the local market--of products originally introduced in countries on the technological forefront.

No major differences were observed between the determinants of product and process innovation with respect to types of expenditures or other structural and performance characteristics of firms in the two countries.

Whereas firm size is important regardless of the type of innovation, productivity, when significant, has only a modest impact on product and process innovation. The variable that measures the proportion of employees linked to R&D is also significant and positive for both countries and both types of innovation.

Of all the variables, market concentration is the most relevant for Brazilian industry, though the magnitude of its marginal probability is lower for process than for product innovation. Surprisingly, this variable does not present significant coefficients for process innovation among Argentine firms.

In Brazil, capital origin (with foreign capital being favored) also exerts considerable impact on the likelihood of firms innovating processes and, to an even greater extent, products. In Argentina, however, this variable is not significant for process innovation, despite its having a negative sign, as in the case of product innovation.

The findings are as expected, in accordance with the type of good and the technology employed in its manufacture, for the sectors that made the strongest innovation efforts with regard to either product or process.

The regressions based on the samples for Brazilian and Argentine medium-sized and large firms led to results that differed only slightly from those based on the complete samples with respect to the order of importance of the variables that drove decisions to innovate.

Whereas exports had a positive impact on both product and process innovation in Brazil, they affected only product innovation in Argentina. As for process innovation in Argentina, exports had a negative, albeit non-significant effect. In this case, however, additional studies should be conducted to verify the sign of the coefficient.

Imports were generally seen to have positive and significant impacts on both product and process innovation in Brazil as well as in Argentina. This finding is in accord with the import substitution industrialization process and the weight of foreign capital goods purchases in Latin American economies.

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CHAPTER 7

INNOVATION IN BRAZILIAN, ARGENTINE AND EUROPEAN INDUSTRIES: A COMPARISON OF INNOVATION SURVEYS[1]

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1 INTRODUCTION

Innovation lies at the center of the technological and economic development of all nations and, above all, at the core of the development dynamic of each country. For this reason, despite traditional economists having until recently relegated innovation to the condition of an exogenous variable in their models for interpreting reality, understanding the phenomenon is of fundamental importance, as is identifying the factors and policies that shape the innovation dynamics.

In fact, innovation has played a key role in analyses of the nature and causes of the wealth of nations throughout a long and prolific tradition of economic thought. This tradition arose with the founders of the science of economics – the classic economists – continued with Schumpeter, was embraced by many development theoreticians and in recent decades has been consolidating in the Schumpeterian economics of technology and evolutionary tradition. It is therefore unjustifiable that innovation be neglected in efforts to reintroduce the variable "technical change" to traditional economic thought as evidenced in the so-called new growth theories.

In Europe, the importance and influence of economics of technology led the Organization for Economic Co-operation and Development (OECD), together with the European Union and its statistical agency, EUROSTAT, to develop a special methodology and encourage the performance of national innovation surveys. Such surveys have come to be a systematic practice in developed countries (with the notable exception of the United States of America) as well as in several developing nations.

The availability of the results of innovation surveys presents a unique opportunity for advancing the understanding of this phenomenon, a key to the development and competitiveness of enterprises, regions and countries. Moreover, comparing the results of national surveys can shed light on the features and dynamics of different national innovation systems. To date, however, this line of investigation has been little explored

1. A previous version of this paper was presented at the Globelics Conference India 2006 – Innovation Systems for Competitiveness and Shared Prosperity in Developing Countries, October 04-07, 2006, Trivandrum, Kerala, India <www.globelicsindia2006.org>.

due to the data having become available only recently and to the difficulty of developing international comparisons due to methodological differences in the national surveys.

Thanks to having access to the results of several European surveys and the chance to obtain specifically computed tabulations based on microdata from the Brazilian survey, the authors of this article were able, with the support of Priscila Koeller, to overcome the major difficulties faced in comparing the results of the first Brazilian innovation survey – PINTEC 2000 (IBGE, 2000) – and those of the third round of European surveys – the Third Community Innovation Surveys (CIS3). This work, originally published under the title *Perfil da inovação na indústria brasileira: uma comparação internacional* (VIOTTI *et al.*, 2005), served as the basis for the present article, in which the main original contribution lies in the inclusion of data from the second Argentine innovation survey (INDEC, 2003).

The present article characterizes the processes of technological innovation witnessed in Brazil, Argentina and various European countries[2] during the period 1998-2000.[3] It outlines a comparative profile of the main features of the innovation processes undertaken by the industrial enterprises of each country analyzed, as well as on their innovation efforts and determinants. The characterizations and comparisons presented in this study, which are essentially based on descriptive statistics, will hopefully spur other researchers to perform more in-depth studies of specific aspects, thereby contributing to advancing the understanding of the process of technological innovation in general and, above all, to comprehending this process in developing countries.

2 CHARACTERISTICS AND COMPARABILITY OF THE NATIONAL SURVEYS

The comparison of the results of the Brazilian innovation survey – PINTEC 2000 (IBGE, 2002) – and those of the European survey – CIS3 (EUROSTAT, 2004) – was possible thanks to the cooperation of IBGE and of statisticians from the Institute for Applied Economic Research (IPEA), who computed special tabulations for this purpose and to whom the authors owe special gratitude. Likewise, comparison to the results of the Second National Survey on Innovation and the Technological Behavior of Argentine Enterprises was rendered feasible through the collaboration of the Argentine National Census and Statistics Institute (INDEC, 2005), which conducted the inquiry, and the Argentine branch of ECLAC, which kindly generated special tabulations to this end. The authors also wish to thank these agencies for their invaluable support.

2.The comparisons generally cover the following European countries: Germany, Belgium, The Netherlands, Denmark, Austria, Finland, Portugal, France, Sweden, Italy, Spain and Greece. Unfortunately, however, not all the comparisons could be based on the same fixed panel, whether due to differences in questionnaires across countries, statistically non-representative replies in certain countries or the need for survey microdata to which the authors lacked access.

3. The Argentine survey refers, in fact, to the period 1998-2001.

Comparison of the results of the Brazilian survey and those of CIS3 was greatly facilitated by the fact that the Brazilian questionnaire was based on that recommended by EUROSTAT for the European countries, as well as by the fact that its the sole methodological reference was the so-called *Oslo Manual: proposed guidelines for collecting and interpreting technological innovation data*, organized and published by OECD and EUROSTAT (1997). Comparisons involving the results of the Argentine survey were somewhat more difficult due to certain details of its questionnaire having been inspired by recommendations of the Bogotá Manual (RICYT, 2001) despite its primary reference also being the Oslo Manual. For this reason, the Argentine case could not be included in certain comparisons made between Brazil and the European countries. In other instances, comparisons were made regardless of the queries in the Argentine survey having differed slightly from those on the CIS3 and PINTEC questionnaires. The analyses of such comparisons therefore require special attention.

The first important difference in the Argentine survey concerns the period covered. Whereas the PINTEC and CIS3 refer to the period 1998-2000, the Argentine survey covers the years 1998-2001. This must be borne in mind when analyzing any of the comparisons. It is likely, for example, that the Argentine rate of innovation was positively affected by the fact that the questionnaire asked if the enterprise introduced an innovation between 1998 and 2001 rather than between 1998 and 2000, as in the PINTEC or CIS3.

A second difference refers to the sectors covered by the various surveys. The Brazilian study includes the mining and quarrying and manufacturing industries. The European inquiries embrace not only these sectors, but also electricity, gas and water supply and the service sector. In turn, the Argentine study covers the manufacturing industries plus a "special category" "that includes enterprises with distinct characteristics due to their ties with public entities such as the Ministry of Defense and the National Atomic Energy Commission" (INDEC, 2003, p.95). However, for the purpose of this article, tabulations restricted to the manufacturing industries were computed from the Argentine microdata. In other words, the Argentine manufacturing enterprises referred to throughout this study exclude the aforementioned special category. With regard to the Brazilian and European cases, the study utilizes the sum of the manufacturing industries and mining and arrying.[4] The reader should therefore be attentive to the fact that the sectoral cuts cited and adopted in this study serve to explain some of the differences that may be encountered between the data analyzed herein and those presented in

4. Unfortunately, tabulations for Brazil excluding the mining and quarrying enterprises were not yet available, so the extractive sector was maintained for both Brazil and the European countries. In point of accuracy, however, this should not have affected the outcome of the comparisons since this sector generally has an extremely limited number of enterprises relative to the total of the industry. In Brazil, for example, they account for less than 2% of the total number of industrial enterprises. In the European countries, their share ranges from less than 1% to slightly more than 3% of the domestic total. Furthermore, the overall industrial rates of innovation in the European countries are usually determined by (that is, are identical to) the manufacturing industries.

publications containing the results of the innovation surveys of the countries in question.[5]

It is also important to observe that the quality of the data gathered by the national innovation surveys may vary significantly. In Table 1, information is given as to the characteristics of the samples and methods of collection employed in the innovation surveys analyzed. The share of enterprises that received the questionnaire (sample rate) and the share that replied (response rate), as well as this share in relation to the total number of enterprises (rate of enterprises consulted), are presented. Also indicated is the voluntary or mandatory status of the replies, together with the methods by which they were collected. It should be noted that only 2.5% of the German enterprises actually replied, while the figures for the Brazilian and Argentine industrial enterprises reached 14.1% and 16.0%, respectively. In other words, these countries achieved higher returns than nations such as Germany (2.5%), Portugal (8.7%), Austria (9.5%), Belgium (9.6%), France (9.8%), Denmark (11.7%), Italy (12.4%) and Sweden (13.0%).

TABLE 1
Sample characteristics and collection methods of innovation surveys: selected countries (1998-2000)*

Country	Sample rate (%) (A)	Response rate (%) (B)	Rate of enterprises consulted (%) (A x B/100)	Status	Methods of collection
Argentina	21	76	16.0	Compulsory	Postal
Austria	22	43	9.5	Voluntary	Postal
Belgium	32	30	9.6	Voluntary	Postal
Brazil	15	94	14.1	Compulsory	Telephone, face to face interviews
Denmark	39	30	11.7	Voluntary	Postal
Finland	35	50	17.5	Voluntary	Postal
France	12	82	9.8	Compulsory	Postal
Germany	12	21	2.5	Voluntary	Postal
Greece	30	62	18.6	Voluntary	E-mail, fax, post, followed by face to face interviews
Netherlands	43	55	23.7	Voluntary	Postal
Iceland	Census	93 (pre-survey) 47 (survey)	47.0	Voluntary	Telephone (pre-survey) and then postal
Italy	20	62	12.4	Compulsory	Postal, telephone
Luxembourg	45	72-73	32.6	Voluntary	Face to face interviews
Norway	40	94	37.6	Compulsory	Postal
Portugal	19	46	8.7	Compulsory	Postal
Sweden	27	48	13.0	Voluntary	Postal

Sources: EUROSTAT, 2004, p. 287; IBGE, 2002, p. 16 and 25; IBGE, 2005a; INDEC, 2003, p. 13 (authors' elaboration).
Note: (*) The Argentine survey refers to the period 1998-2001.

5. It should also be mentioned that the more recent CIS3 data used in this study (EUROSTAT, 2006) differ slightly from those obtained from the same source and employed in a previous comparison (VIOTTI *et al.*, 2005). The EUROSTAT CIS3 data base provided on the internet has been undergoing minor changes and improvements. The former analysis also placed electricity, gas and water supply enterprises among the European industrial enterprises. Nonetheless, since this sector tends to be even less important than mining and quarrying, the conclusions reached in the earlier study should not differ from those based on comparisons that exclude this sector.

In only six of the sixteen countries analyzed were the inquiries performed by national statistical institutes that had the legal means, at least the formal means, to oblige the enterprises to respond to the survey questionnaires. This may have led to distortions in the results since innovating enterprises, for example, have a greater interest in replying to questionnaires concerning their innovation activities than do non-innovating enterprises. Both the Brazilian and Argentine enterprises were legally obliged to participate in the survey, a fact that contributed to their being among the countries with the highest response rates. Only the Norwegian response rate matched the Brazilian (94%).

The large majority of countries gathered survey data by posting questionnaires, a method unquestionably inferior to telephone or personal interviewing by duly trained personnel, the procedure followed in Brazil. Nearly all the information on large Brazilian enterprises (500 employees or more) was collected during personal interviews on the premises.[6] The rest of the information on Brazilian enterprises was collected via computer-assisted telephone interviews (IBGE, 2002, p. 16). The characteristics of the sample and the methods of collection, combined with other factors, support the authors' conviction that the Brazilian study is one of the highest in statistical quality of the innovation surveys under consideration.

Another fact that must be remembered is that the innovation performance of domestic economies cannot be simply or directly attributed to the characteristics of the innovation efforts of its enterprises as captured by innovation surveys. After all, a significant part of the differences in the innovation performance of domestic economies may be determined by the shape of their industrial frameworks (sectoral composition or specialization, for instance) or by the overall macroeconomic conditions to which they were subject during the survey reference period. Although such contextualization is not the object of this study, an idea about some of those conditions could be grasped analyzing the selected macro indicators presented in Table 2.

The authors hope that comparative exercises such as the one developed herein will contribute to raising awareness as to the importance of improving innovation surveys, as well as to spotting in what respects they might and ought to be improved. Undoubtedly, enhancing their international comparability is one of the most important respects in which they need to be improved. Another goal should be to redesign the questionnaires so as to better reflect the major phenomena related to the innovation process characteristic of developing countries. As a matter of fact, this concern with the innovation processes typical of developing countries comprises the core of the Bogotá Manual (RICYT, 2001) and was the subject

6. All of the large enterprises in the thirteen states in which such enterprises are common were the object of face-to-face interviews. In the other fourteen units of the Brazilian federation, where the number of large enterprises is limited, they were the object of computer assisted phone interviews.

of a specific annex to the revised edition of the Oslo Manual published in 2005 (OECD/EUROSTAT, 2005, p. 135-148). Nevertheless, much still remains to be done in this direction.

The authors also hope that the international comparisons of innovation surveys undertaken in this study will contribute to identifying key characteristics of national innovation systems, as well as those aspects of public policies and business strategies that best contribute to the success of technological and economic development (or catching-up) processes.

TABLE 2
Macro indicators: selected countries

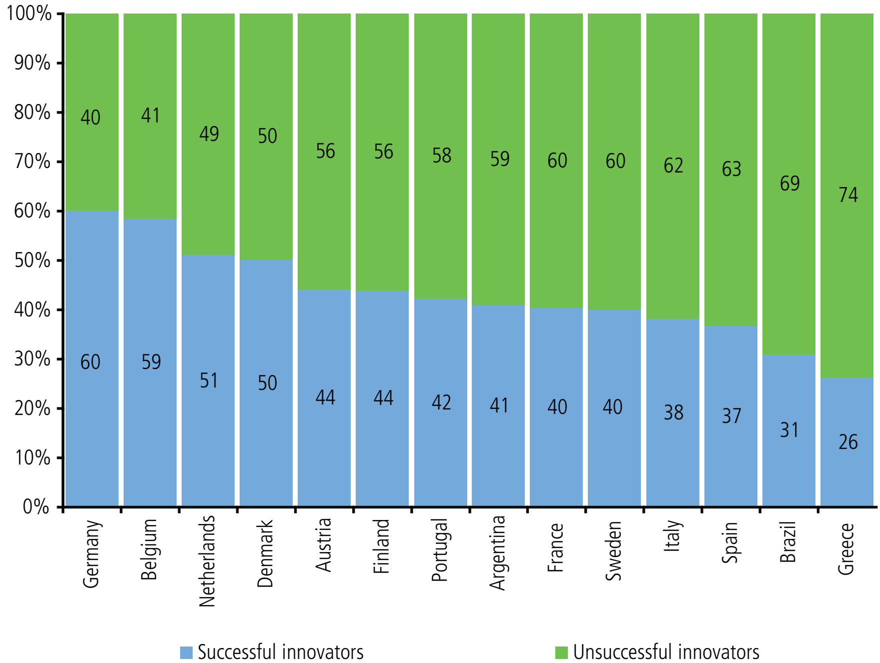
	Argentina	Austria	Belgium	Brazil	Denmark	Finland	France	Germany	Greece	Iceland	Italy	Netherlands	Norway	Portugal	Sweden
Total population (million) (2000)	36.90	8.01	10.25	173.86	5.34	5.18	58.90	82.21	10.92	0.28	57.69	15.93	4.49	10.23	8.87
GDP (constant 2000 US$ bill) (2000)	284.2	193.8	228.4	601.7	158.2	119.9	1328.0	1900.2	112.1	8.4	1074.8	370.6	166.9	106.5	239.6
GDP per capita (const 2000 US$ thou) (2000)	7.70	24.19	22.28	3.46	29.63	23.16	22.55	23.11	10.27	29.92	18.63	23.27	37.16	10.41	27.01
GDP growth (%) (1998)	3.85	3.56	2.03	0.10	2.47	5.00	3.57	2.03	3.36	5.66	1.79	4.35	2.63	4.58	3.65
GDP growth (%) (1999)	-3.39	3.32	3.19	0.80	2.64	3.37	3.35	2.01	3.42	4.41	1.66	4.00	2.13	3.80	4.58
GDP growth (%) (2000)	-0.79	3.36	3.88	4.36	2.83	5.12	4.07	3.21	4.48	5.68	3.03	3.47	2.84	3.38	4.33
Manufacturing value added growth (%) (1998)	1.85	3.84	1.49	-3.30	0.38	7.77	na	2.11	5.31	2.77	1.77	2.96	-0.50	2.28	8.02
Manufacturing value added growth (%) (1999)	-7.93	5.56	0.00	-1.60	1.77	5.41	na	-1.93	1.34	3.97	-0.36	2.37	-0.06	0.66	8.97
Manufacturing value added growth (%) (2000)	-3.82	7.06	4.80	5.46	3.27	12.37	na	5.74	4.59	3.39	2.98	4.37	-0.67	2.37	9.20
Gross fixed capital formation (% of GDP) (2000)	16.19	22.76	21.23	21.81	20.04	19.79	19.47	21.45	23.60	23.89	19.80	22.11	18.57	28.06	17.72
Lending interest rate (%) (1999)	11.04	5.64	6.71	80.44	7.13	4.71	6.36	8.81	15.00	13.30	5.58	3.46	7.61	5.19	5.53
High-tech exports (% of mfg. exports) (2000)	9.04	13.03	9.49	18.61	20.68	27.33	23.75	17.98	13.33	12.26	9.17	35.45	17.13	6.38	22.13
R&D expenditure (% of GDP) (1999)	0.45	1.91	1.96	0.87	2.19	3.23	2.18	2.44	0.67	2.38	1.04	2.02	1.65	0.75	3.65
R&D researchers (per mill inhab) (1999*)	712.4	2313.4	2893.9	344.2	3562.4	6327.9	2716.2	3095.9	1349.5	5665.8	1129.5	2554.2	4088.6	1547.8	4503.3
Tertiary school enrollment (%) (2000)	53.13	56.04	57.10	16.06	57.26	82.81	52.76	48.65	51.29	45.42	48.60	53.06	69.58	47.82	67.39

Source: World Bank, **World Development Indicators 2006**.
Notes: "*" Austria (1998), Brazil (2000). "na" stands for data not available.

3 RATES OF INNOVATION AND SIZE OF ENTERPRISE

There are clear indications in the literature that the competitiveness, growth and development of enterprises, regions and nations are related to the importance, velocity and paths of their innovation processes. The proportion of enterprises in a given country that introduced at least one technological innovation, whether product or process, within a certain period (innovation rate) is a fair indicator of the innovation dynamism of the country. This indicator varies significantly across countries, as illustrated in Figure 1 and Table 3, which show the industrial innovation rates revealed by the innovation surveys in Argentina, Brazil and selected European countries.

FIGURE 1
Proportion of successful innovators and unsuccessful innovators among industrial enterprises: selected countries (1998-2000)*



Sources: EUROSTAT, 2006; IBGE, 2004; INDEC, 2005 (authors' elaboration).
Note: (*) The Argentine survey refers to the period 1998-2001.

In Greece, for example, only 26% of the enterprises introduced new products or processes between 1998 and 2000, while the innovation rate recorded by German enterprises was over 60% in the same period. At 31%, the Brazilian rate is the second lowest, below those of Spain (37%) and Italy (38%). Surprisingly, the

Argentine rate (41)[7] is in the intermediate range (40-44%), together with France, Portugal, Finland and Austria. In the highest range are Denmark, the Netherlands, Belgium and Germany, with innovation rates varying between 50 and 60%.

TABLE 3
Number of industrial enterprises, successful innovators and rates of innovation by size of enterprise: selected countries (1998-2000)*

	Industrial enterprises			Small enterprises			Medium-sized enterprises			Large enterprises		
Country	Total	Successful Innovators	Innovation rate	Total	Successful Innovators	Innovation rate	Total	Successful Innovators	Innovation rate	Total	Successful Innovators	Innovation rate
Germany	50,073	30,137	60	29,093	14,906	51	15,908	10,971	69	5,072	4,260	84
Belgium	6,299	3,689	59	4,472	2,366	53	1,414	987	70	413	336	81
Netherlands	10,884	5,563	51	7,484	3,223	43	2,776	1,833	66	624	507	81
Denmark	4,944	2,474	50	3,588	1,585	44	1,097	687	63	259	202	78
Austria	7,208	3,179	44	5,111	1,611	32	1,511	1,024	68	586	544	93
Finland	3,998	1,756	44	2,783	1,081	39	935	450	48	280	225	80
Portugal	16,551	6,989	42	12,478	4,417	35	3,496	2,157	62	577	415	72
Argentina	10,717	4,392	41	7,053	2,222	31	3,173	1,835	58	491	335	68
France	24,864	10,032	40	13,528	3,868	29	8,886	4,356	49	2,450	1,808	74
Sweden	7,517	2,998	40	5,490	1,867	34	1,609	838	52	418	293	70
Italy	93,429	35,723	38	81,781	28,768	35	10,249	5,909	58	1,399	1,046	75
Spain	45,399	16,644	37	37,323	12,470	33	7,015	3,395	48	1,061	779	73
Brazil	71,273	22,101	31	55,916	14,526	26	12,174	5,511	45	3,182	2,064	65
Greece	7,165	1,882	26	5,427	1,346	25	1,526	440	29	212	96	45

Sources: EUROSTAT, 2006; IBGE, 2004; INDEC, 2005 (authors' elaboration).
Note: (*) The Argentine survey refers to the period 1998-2001.

The innovation rate of Argentine industrial enterprises was significantly higher than the Brazilian. At least a part of this superiority may be explained by the survey for the former having covered a four-year period rather than the three-year period observed in all the other countries. However, since few enterprises are likely to start innovating in the fourth year after having not done so for three, this factor alone cannot entirely account for such a significant difference. Another explanatory factor may be related to the data collection methods adopted in the two surveys. Whereas the

7. Although the Argentine survey includes organizational and trade innovations, this study takes into account only technological product and process innovations (TPP), in accordance with the standard adopted in CIS3 and PINTEC. Therefore, any and all references to the characteristics of the Argentine innovation process refer solely to TPP innovation and are the result of special tabulations obtained by the authors. Likewise, throughout this study, all the figures on Argentina are the result of special computations derived from the application of corresponding expansion factors to the sample data. As originally published, the results of the Argentine survey (INDEC, 2003) display only the unexpanded sample values.

Brazilian inquiry used computer-aided telephone or personal interviews, the Argentine depended on postal questionnaires. The Brazilian interviewers are therefore likely to have been more selective as to which product and process changes were true technological innovations, different from the company employees who completed the Argentine postal form. In spite of these possible methodological explanations for the difference, it is likely that the innovative performance of Argentine industry was effectively and significantly greater than that of Brazilian industry despite the innovative effort of that country having been considerably lower, as will be seen later in this study.

One factor that explains an important part of the variations in innovation rates across countries is the difference in the composition of their industries in terms of the size of their enterprises. It is interesting to note, for example, that the variations across countries diminish significantly in the classes comprised of larger enterprises.

Larger enterprises tend to be more innovative than smaller ones. This fact, designated the Schumpeterian hypothesis in the literature, is once again confirmed by the findings of the national surveys presented herein, as shown in Table 3.[8] For this reason, the domestic industries with a larger share of small enterprises are the ones that register relatively lower innovation rates. The weight of small enterprises is high in Italy (88%), Spain (82%), Brazil (78%) and Greece (76%), precisely the same countries that have the lowest rates of innovation among industrial enterprises of all sizes. Only France (54% small enterprises) and Germany (58%) have industrial structures characterized by relatively lower numbers of small enterprises than Argentina (66%).

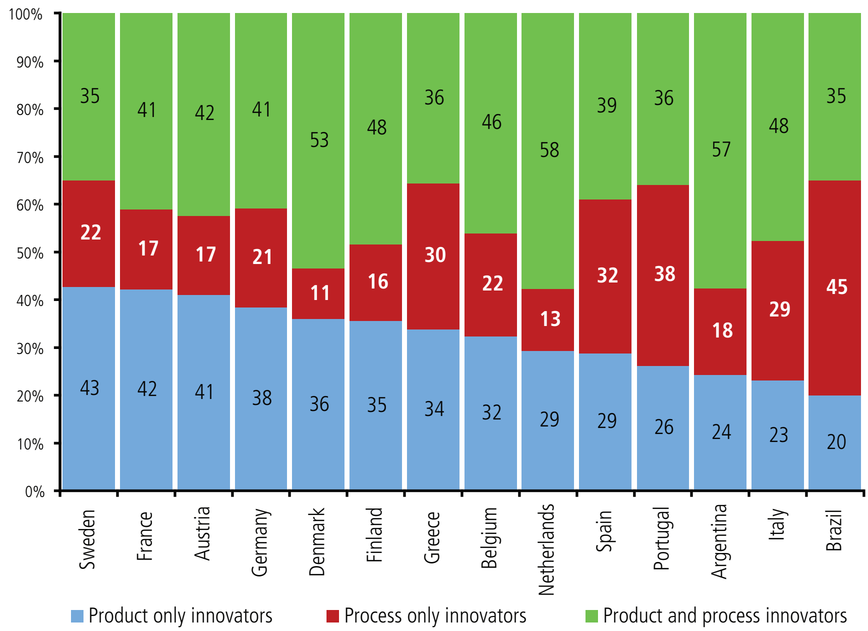
The shares of large enterprises in Italy (1.5%) and Spain (2.3%) are exceptionally low. In Argentina and Brazil, such enterprises represent approximately 4.5% of the total. The weight of large corporations is characteristically high in the German, French and Austrian industries, where their shares account for between 8% and 10% of the total number of enterprises. The innovation rates of the large Brazilian industrial enterprises stand at 65%, more than twice as high as the total for enterprises in all size classes (31%) and superior to the mean for all German undertakings (60%). Nonetheless, only part of the relatively low innovation rate of the Brazilian industrial enterprises can be explained by the relatively high number of small enterprises in the overall industrial structure. It should be noted, for example, that the innovation rate of small Italian enterprises (35%) is much higher than the Brazilian rate (26%) despite both countries having exceptionally high numbers and proportions of small enterprises and the small Italian enterprise having, on average, fewer employees (18) than its Brazilian counterpart (20).

8. In Table 2, enterprises are classified as small if they have 10 to 49 employees, medium-size if they employ 50 to 249 workers and large if they have more than 250 employees. Enterprises with fewer than 10 employees were covered in neither CIS3 nor PINTEC. The original publication of the Argentine survey results defined the size of enterprises in terms of gross revenues rather than number of workers. For this reason, it was necessary to generate special computations to classify Argentine manufacturing enterprises by number of employees, thereby rendering the data compatible with that from the other surveys.

4 PRODUCT AND PROCESS INNOVATORS

Figure 2 depicts the percentage distribution of the enterprises in each country that performed only product, only process or both product and process innovations. In the figure, the countries are arranged in descending order by the product-only innovation rates of their industries. On the one hand, overall analysis of the distribution reveals that there is apparently no correlation between the most innovative industries in general and the most innovative with regard to product alone.

FIGURE 2
Proportion of product only innovators, process only innovators and product and process innovators: selected countries (1998-2000)*



Sources: EUROSTAT, 2006; IBGE, 2004; INDEC, 2005 (authors' elaboration).
Note: (*) The Argentine survey refers to the period 1998-2001.

On the other hand, there does appear to be a certain negative correlation between the national industries that show higher rates of process only innovators and those with higher innovation rates in general. It is easily perceived, for example, that the four countries with the lowest general innovation rates are among the five with the highest shares of enterprises that introduced process only innovations: Brazil (45%), Portugal (38%), Spain (32%), Greece (30%) and Italy (29%).

In the case of Brazil, the elevated concentration of enterprises that innovated with regard to process alone is apparently linked to the predominance of innovations that are merely new for the enterprise and essentially the outcome of the acquisition of machinery and equipment for the productive process, as can be verified in tables 4 and 7 and figures 3 and 7.

5 ENTERPRISES THAT INNOVATE FOR THE MARKET

In the innovation surveys, the minimum requirement for a product or service to be considered an innovation is that it needs to be technologically new or significantly improved for the concerned enterprise; the enterprise does not necessarily have to be the first to have introduced it. Innovations that are pioneering for the enterprise but have already been introduced by other enterprises are much closer to the concept of technological diffusion (or absorption) than to the concept of innovation per se. Fortunately, however, the surveys also include another type of innovation concept: "innovation for the market."

ILLUSTRATION 1
Questions on product innovation for the market from the European, Argentine and Brazilian surveys

Question on product innovation for the market in the European survey
1.4 During the period 1998-2000, did your enterprise introduce new or significantly improved products (goods or services) not only new for your enterprises, but also new for your enterprise's market? Yes ☐ No ☐
Question on product innovation for the market in the Argentine survey
I. Innovaciones logradas 901) Si obtuvo INNOVACIONES como resultado de las atividades de innovación u otras actividades en el período 1998-2001 indique el tipo de resultado y el grado de novedad de la innovación 1 Innovación de Producto Si No Fueron novedosas para… ☐ EMPRESA ☐ Mercado LOCAL ☐ Mercado INTERNACIONAL
Question on product innovation for the market in the Brazilian survey
7. Entre 1998 e 2000, a empresa introduziu produto tecnologicamente novo ou significativamente aprimorado para a empresa, mas já existente no Mercado nacional? ☐ 1 – Sim ☐ 2 – Não 8. Entre 1998 e 2000, a empresa introduziu produto tecnologicamente novo ou significativamente aprimorado para o mercado nacional? ☐ 1 – Sim ☐ 2 – Não

Sources: EUROSTAT, 2004, p. 292; IBGE, 2002, p. 103; INDEC, 2003, p. 13 of the questionnaire.

The introduction of products or processes which, in addition to being new for the enterprise, are new for the market, corresponds more closely to the notion of innovation formulated by Schumpeter, which is associated with new products or processes for the world market. This kind of innovation usually demands greater technological effort than that required to introduce an innovation within the enterprise itself. Consequently, it implies a need for the acquisition of greater technological capacity on the part of the enterprise; at the same time, it offers higher competitive advantages to the enterprise that places the product or process on the market. Likewise, it creates more technological opportunities for the possible generation of associated innovations. "Innovations for the market" should thus be considered superior in quality to those that are new only for the enterprises that introduce them.

Unfortunately, however, the sections on the survey questionnaires dealing with "innovation for the market" present differences that partially compromise the quality and comparability of the findings. Whereas the Argentine and Brazilian surveys include questions on both product and process "innovation for the market," the European inquiry is limited to product innovation for the market. For this reason, with reference to "innovation for the market," the comparisons developed in this study are restricted to product innovation. The definitions of "market" also vary from one survey to another, as seen in Illustration 1. "Innovation for the market" means a product new for the "domestic market" in the case of PINTEC[9] but new for the "local market" in the case of Argentina. This difference in terminology seems to be irrelevant, however, because the instructions on the Argentine questionnaire explain that "local market" means the domestic market. In the case of CIS3, however, the difference is significant because the definition refers to the market in which the enterprise operates. Even so, it is worth reflecting on the outcome of the comparison.[10]

"New product for the market" rates are apparently unrelated to innovation rates as a whole. Greece, for example, the country with the lowest overall innovation rate, has an exceptionally high "new product for the market" rate, beneath only those of Italy, Finland and Argentina. Italy, in turn, which has the highest "new product for the market" rate, is among the four countries with the lowest overall innovation rate. These differences across rates become more even when the general rate is compared to the proportion of enterprises that introduced new products for the market as a share of the total number of enterprises (column D/A in Table 4).

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9. It should be noted that the Brazilian question – "Did the enterprise introduce a technologically new or significantly improved product for the domestic market?" – is potentially ambiguous. Some may have interpreted the question as if it was asking about the intention of the enterprise, i.e., if it introduced a product that had the domestic market as it target, and not if the product was new for the domestic market. As a matter of fact, the question that preceded this one helps in avoiding such an erroneous interpretation when it asked if "the enterprise introduced a product that was new or significantly improved for the enterprise, but already available in the domestic market. Such a possible source of misinterpretation was eliminated from the questionnaire for the most recent Brazilian survey (<http//www.pintec.ibge.gov.br/download/Pintec2005.pdf>) by including a specific question asking if the innovation introduced was "new to the enterprise, but already available on the domestic market," "new to the domestic market, but already available on the world market" or "new to the world market." The questionnaire of the Canadian Survey of Innovation 2005 (<http//www.statcan.ca/english/sdds/instrument/4218_Q1_V5_E.pdf>) includes a similar question. It asks the enterprise whether the product was "a first in your province/territory," "a first in Canada," "a first in North America" or "a world first."

10. With regard to this point, the European questionnaire is extremely imprecise and generates data that are hard to evaluate due to the fact that a given enterprise may operate in various markets, whether subnational, national or international. In this case, to ascertain the proportion of enterprises that innovated for the domestic market, it would be necessary to discover how many actually did so but replied in the negative due to also operating in supranational markets. Simultaneously, it would be necessary to subtract the proportion of enterprises that did not innovate for the domestic market but replied in the affirmative for having introduced products new for the subnational markets in which they operate. One deviation most likely cancels the other, at least partially. Hence, despite the lack of precision, comparing the proportions of enterprises that innovated for the market in Argentina and Brazil with the proportions in European countries is not entirely void of sense.

TABLE 4
Number and proportion of industrial enterprises, successful innovators, product innovators and product innovators for the market: selected countries (1998-2000)*

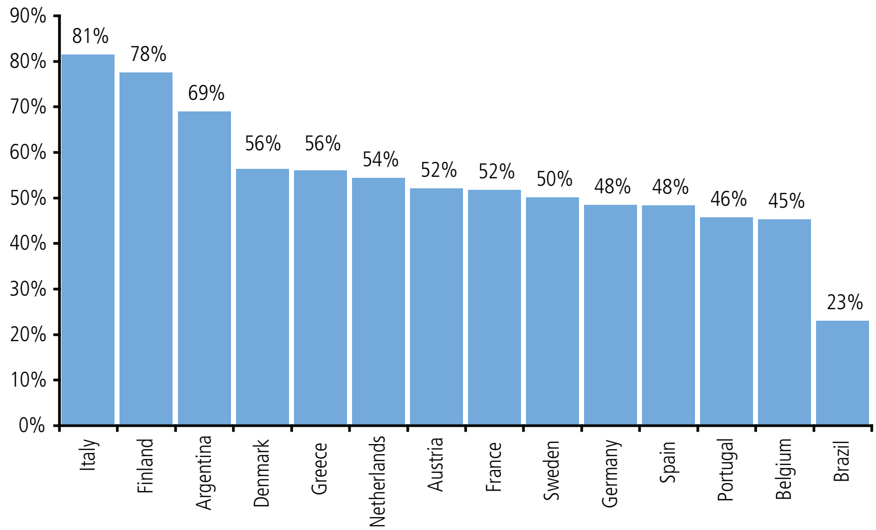
Country	Total (A)	Successful innovators (B)	Product innovators (C)**	Product innovators for the market (D)	D/A (%)	D/B (%)	D/C (%)***
Italy	93,429	35,723	25,237	20,563	22	58	81
Finland	3,998	1,756	1,473	1,142	29	65	78
Argentina	10,717	4,392	3,593	****2,462	23	56	69
Denmark	4,944	2,474	2,211	1,245	25	50	56
Greece	7,165	1,882	1,308	733	10	39	56
Netherlands	10,884	5,563	4,845	2,636	24	47	54
Austria	7,208	3,179	2,650	1,382	19	43	52
France	24,864	10,032	8,353	4,326	17	43	52
Sweden	7,517	2,998	2,328	1,168	16	39	50
Germany	50,073	30,137	23,907	11,584	23	38	48
Spain	45,399	16,644	11,289	5,466	12	33	48
Portugal	16,551	6,989	4,339	1,982	12	28	46
Belgium	6,299	3,689	2,891	1,308	21	35	45
Brazil	71,273	22,101	12,215	2,975	4	13	23

Sources: EUROSTAT, 2006; IBGE, 2004 and INDEC 2005 (authors' elaboration).
Notes: (*) The Argentine survey refers to the period 1998-2001. (**) The total number of product innovators covers enterprises that innovated with respect to product alone, plus those that innovated with regard to product and process. (***) Proportion of total product innovators that innovated for the market. (****) In the Argentine case, innovators for the market comprise the sum of enterprises that innovated for the domestic market plus those that innovated for the world market.

For eleven countries, the "product innovation for the market" rates are between 45 and 56% (See column D/C in Table 4 and Figure 3). Only four countries have rates outside this central distribution range. Italy, Finland and Argentina, at 81%, 78% and 69%, respectively, exhibit rates considerably higher than the others. In contrast, Brazil presents a rate of merely 23%, corresponding to roughly half that of the next lowest country in the ranking. With respect to this type of relatively superior innovation from the standpoint of quality, Brazil is found to be in a relatively less advantageous position than in relation to innovation strictly for the enterprise (Figure 1).

It should be mentioned, however, that the distribution of the European countries by rates of "product innovation for the market" is apparently pointing to a problem in the phrasing of the CIS3 questionnaire. It could be hypothesized, for example, that the exceptionally high Italian rate is owing to the great number of small enterprises within the industrial structure. Since the majority of these small enterprises probably operate in very restricted markets, most of the products they introduce are likely to be new for their specific markets. Adopting a similar line of argument, the opposite probably occurs in the case of Germany, which would explain its limited performance with respect to this particular innovation rate despite the country being the uncontested leader among the overall innovation rates. It is therefore impossible to draw sufficiently safe conclusions by simply comparing rates of innovation for the market. Above all, the preceding analysis patently reveals the need to improve the questionnaire to be applied in future rounds of the Community Innovation Survey. Such improvement is of fundamental importance not only for obtaining more precise indicators regarding the innovation phenomenon as such, but also for distinguishing it from the simple diffusion of products and processes.

FIGURE 3
Proportion of enterprises that innovated for the market as a percentage of product innovators: selected countries (1998-2000)*



Sources: EUROSTAT, 2004, 2006; IBGE, 2004; INDEC, 2005 (authors' elaboration).
Note: (*) The Argentine survey refers to the period 1998-2001.

6 DOMESTIC VERSUS FOREIGN ENTERPRISES IN ARGENTINA AND BRAZIL

Unfortunately, the European survey did not gather data on the origin of capital of industrial enterprises, so this comparison will be limited to the Argentine and Brazilian enterprises. Foreign capital has enormous weight in the industrial structures of both countries.[11] Although not that expressive in terms of the total

11. With respect to origin of capital, the Argentine survey places enterprises in one of two categories: those without and those with foreign participation, the latter being defined as those having a foreign capital share of more than 1% (INDEC, 2003, p. 95). It was therefore necessary to prepare additional tabulations for the sake of comparison with Brazil. In these tabulations, a enterprise is considered foreign if over 50% of the capital is owned by private or corporate foreign interests. Whereas the Brazilian survey presents findings based on net sales revenue, the Argentine study uses gross sales revenue. To render the data comparable, gross revenues or turnover were employed for both countries. The information on gross revenues refers to 2000 in the case of Brazil and to 2001 in the case of Argentina. The innovation rates correspond to the period 1998-2000 for Brazil and 1998-2001 for Argentina. The data for both countries refer only to the manufacturing enterprises.

number of enterprises, it is extremely significant in the higher size classes and accounts for an exceptionally high share of turnover (see Table 5).

TABLE 5
Brazilian and Argentine industrial enterprises by size, origin of capital, proportion of total number of enterprises, share of turnover and rate of innovation*
(%)

Enterprises	Brazil		Argentina	
	Domestic	Foreign	Domestic	Foreign
Total				
Number of enterprises	97	3	92	8
Total turnover	67	33	54	46
Successful innovators				
Number of enterprises	31	61	40	58
Total turnover	62	38	51	49
Small				
Number of enterprises	99	1	96	4
Total turnover	95	5	95	5
Successful innovators				
Number of enterprises	26	37	31	55
Total turnover	91	9	95	5
Medium-sized				
Number of enterprises	94	6	86	14
Total turnover	78	22	69	31
Successful innovators				
Number of enterprises	44	65	59	52
Total turnover	73	27	68	32
Large				
Number of enterprises	81	19	75	25
Total turnover	62	38	36	64
Successful innovators				
Number of enterprises	63	80	62	86
Total turnover	59	41	38	62

Sources: IBGE, 2004; INDEC, 2005 (authors' elaboration).
Note: (*)The data for Brazil refer to the year 2000 and those for Argentina to 2001.

Foreign corporations are responsible for nearly half the turnover of the Argentine manufacturing industries and a third of the Brazilian. The innovation rates of the foreign manufacturing enterprises are far higher than those of the domestic enterprises in both countries and in all size classes, though the differences diminish among the larger enterprises. In Brazil, the innovation rate of foreign enterprises is double the national average and, in Argentina, it is 45% higher. At 58% and 61%, respectively, the innovation rates of the foreign enterprises in Argentina and Brazil roughly match the average for Germany (60%), the European country with the highest innovation rate. Such rates appear to confirm the expectation of many economists and policymakers that these enterprises may constitute a privileged vehicle for driving the technological development and raising the competitiveness of late industrializing countries such as Argentina and Brazil. However, this expectation needs to be more closely qualified.

For the most part, the superiority of the innovation rates of the foreign enterprises in the two countries can be explained by the simple fact that these enterprises are strongly concentrated in the larger size classes. In Argentina and Brazil, as in other countries, the rates of innovation of the manufacturing industries rise significantly with the size of the enterprises (see Table 3). Hence, the rates of innovation of the large enterprises in Argentina (68%) and Brazil (65%) are more than twice those of the small enterprises, which stand at 31% and 26%, respectively. Among the large enterprises, the differences in the innovation rates registered by domestic enterprises and foreign enterprises are considerably narrower. However, since 99% of the small Brazilian enterprises and 96% of the small Argentine enterprises are of domestic ownership, the overall innovation performance of the domestic enterprises in the two countries is profoundly affected by the fact that the domestic enterprises are concentrated in this size class. Moreover, there is evidence that even within the large size class, defined as enterprises with 250 or more employees, the foreign enterprises are considerably larger than the domestic enterprises.

It is also important to analyze the sectoral distribution of domestic and foreign enterprises, as well as their respective rates of innovation, by manufacturing activity.[12] As in other countries, the innovation rates of Brazilian and Argentine enterprises are very unevenly distributed across the various manufacturing industries (Table 6 and Figure 4).

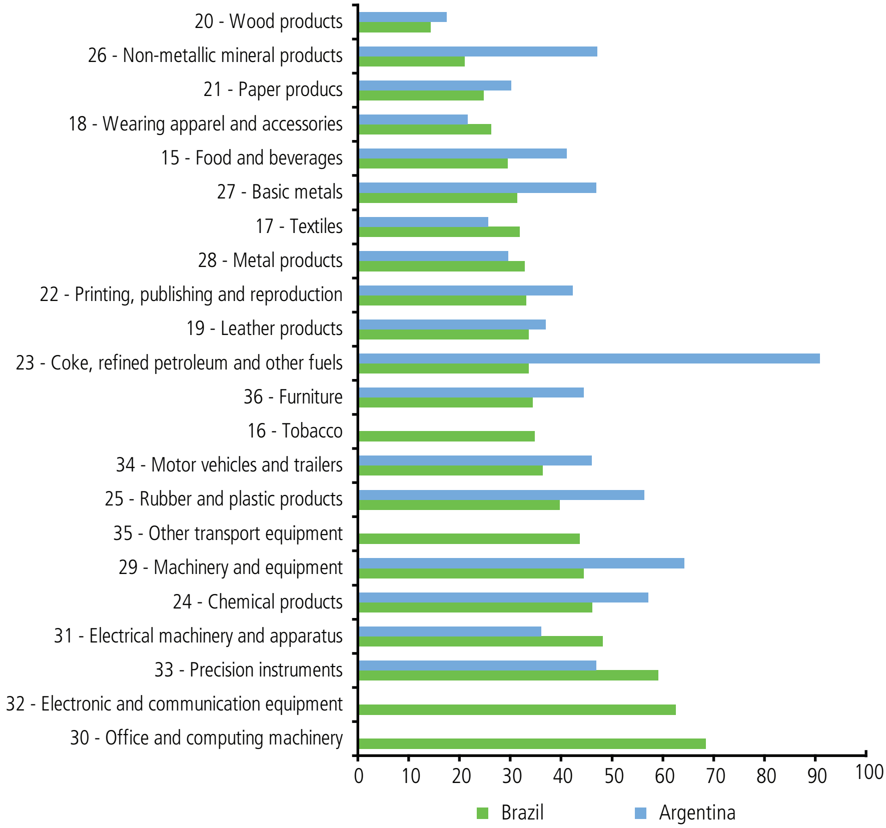
12. Unfortunately, it was impossible to obtain separate data on the innovation performance of each of the manufacturing activities or sectors in the European economies.

TABLE 6
Innovation rates of industrial enterprises by activity and origin of capital: Brazil (1998-2000) and Argentina (1998-2001)

Activity	Brazil						Argentina					
	Total		Domestic		Foreign		Total		Domestic		Foreign	
	Innov. rate	Rank	Innov. rate	Rank	Innov. rate	Rank	Innov. rate	Rank	Innov. rate	Rank	Innov. rate	Rank
10, 11, 13 and 14 – Mining and quarrying*	17.2	22	16.2	22	54.9	16	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
15 – Food products and beverages	29.5	18	29.2	17	41.4	23	41.1	11	41.4	9	38.2	15
16 – Tobacco products	34.8	10	28.8	18	47.3	21	na	na	na	na	na	na
17 – Textiles	31.9	16	31.3	15	54.3	18	25.7	16	24.6	16	54.8	13
18 – Wearing apparel and accessories	26.2	19	26.2	19	71.6	12	21.6	17	22.0	17	na	na
19 – Leather and leather products, luggage and footwear	33.6	13	33.4	11	54.5	17	37.0	12	36.8	12	na	na
20 – Wood and wood products	14.3	23	14.1	23	59.0	15	17.4	18	16.2	18	86.1	5
21 – Pulp, paper and paper products	24.8	20	23.0	20	75.2	9	30.2	14	27.5	15	85.0	6
22 – Publishing, printing and reproduction of recorded media	33.1	14	33.5	10	13.2	24	42.3	10	41.2	10	53.1	14
23 – Coke, refined petroleum products, nuclear fuel and alcohol	33.6	12	31.5	14	52.8	19	90.9	1	100.0	1	83.3	7
24 – Chemicals and chemical products	46.1	5	42.5	6	72.1	11	57.1	3	54.8	4	66.5	11
25 – Rubber and plastic products	39.7	8	39.3	8	50.3	20	56.3	4	56.2	3	58.1	12
26 – Non-metallic mineral products	21.0	21	20.4	21	78.9	6	47.1	5	45.7	6	71.8	10
27 – Basic metals	31.4	17	30.1	16	75.4	8	46.9	7	44.7	7	100.0	2
28 – Fabricated metal products, except machinery and equipment	32.8	15	32.1	13	72.9	10	29.6	15	30.1	14	15.6	16
29 – Machinery and equipment	44.4	6	42.9	5	60.8	14	64.2	2	62.8	2	75.9	8
30 – Office, accounting and computing machinery	68.5	1	66.4	1	82.6	3	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
31 – Electrical machinery and apparatus	48.2	4	48.5	4	45.4	22	36.0	13	33.8	13	94.5	3
32 – Electronic and communications equipment	62.5	2	61.5	2	69.5	13	n.a.	n.a.	n.a.	n.a.	100.0	1
33 – Medical, precision and optical instruments and appliances, automated industrial equipment, watches and clocks	59.1	3	56.1	3	78.5	7	46.9	6	51.9	5	n.a.	n.a.
34 – Motor vehicles, trailers and semi-trailers	36.4	9	32.2	12	81.5	4	46.0	8	39.5	11	73.4	9
35 – Other transport equipment	43.7	7	41.4	7	80.3	5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
36 – Furniture and miscellaneous manufacturing	34.4	11	33.9	9	87.1	2	44.5	9	42.0	8	92.3	4
37 – Recycling	13.1	24	09.3	24	100.0	1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
TOTAL	**31.5**	-	**30.6**	-	**61.8**	-	**41.0**	-	**39.6**	-	**58.2**	-

Sources: IBGE, 2004; INDEC, 2005 (authors' elaboration).
Note: (*) Mining and quarrying and recycling were not covered by the Argentine survey. "na" stands for data not available.

FIGURE 4
Innovation rates in Brazilian (1998-2000) and Argentine (1998-2001) industrial enterprises by activity

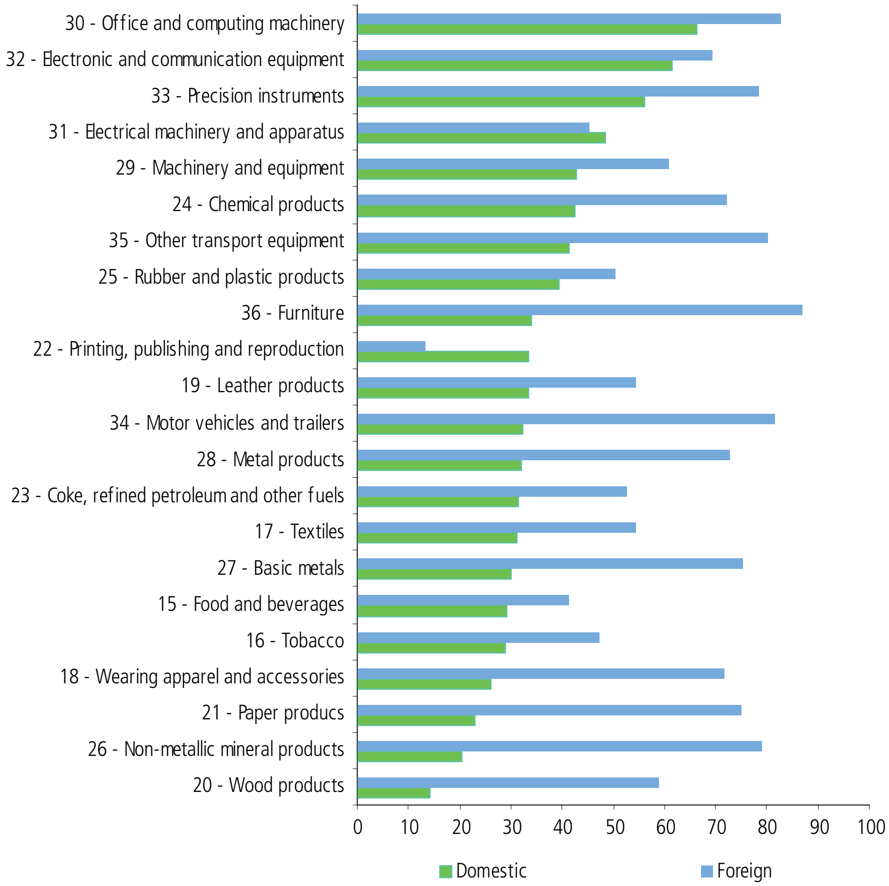


Sources: IBGE, 2004; INDEC, 2005 (authors' elaboration).

Interestingly, the ranking of the most innovative Brazilian sectors roughly corresponds to the classification of activities by technological intensity.[13] For example, activities 30 (office and computing machinery), 32 (electronic and communications equipment) and 33 (precision instruments), all high-tech, are exactly the activities that display the highest innovation rates in Brazil. At the same time, of the seven activities with the lowest innovation rates, only one is not on the low-tech list. In Argentina, the activity with the highest innovation rate (23 – coke, refined petroleum and other fuel) is medium-low-tech.[14] The activities that present the next four highest innovation rates (29, 24, 25 and 26) are divided between typically medium-high-tech activities (the first two) and medium-low-tech activities (the last two).

13. For a classification of activities by technological intensity, see, for example, EUROSTAT 2004b, p.7.
14. The Argentine data on activities 30 and 32 are not available.

FIGURE 5
Innovation rates in Brazilian industrial enterprises by activity and origin of capital (1998-2000)



Source: IBGE, 2004 (authors' elaboration).

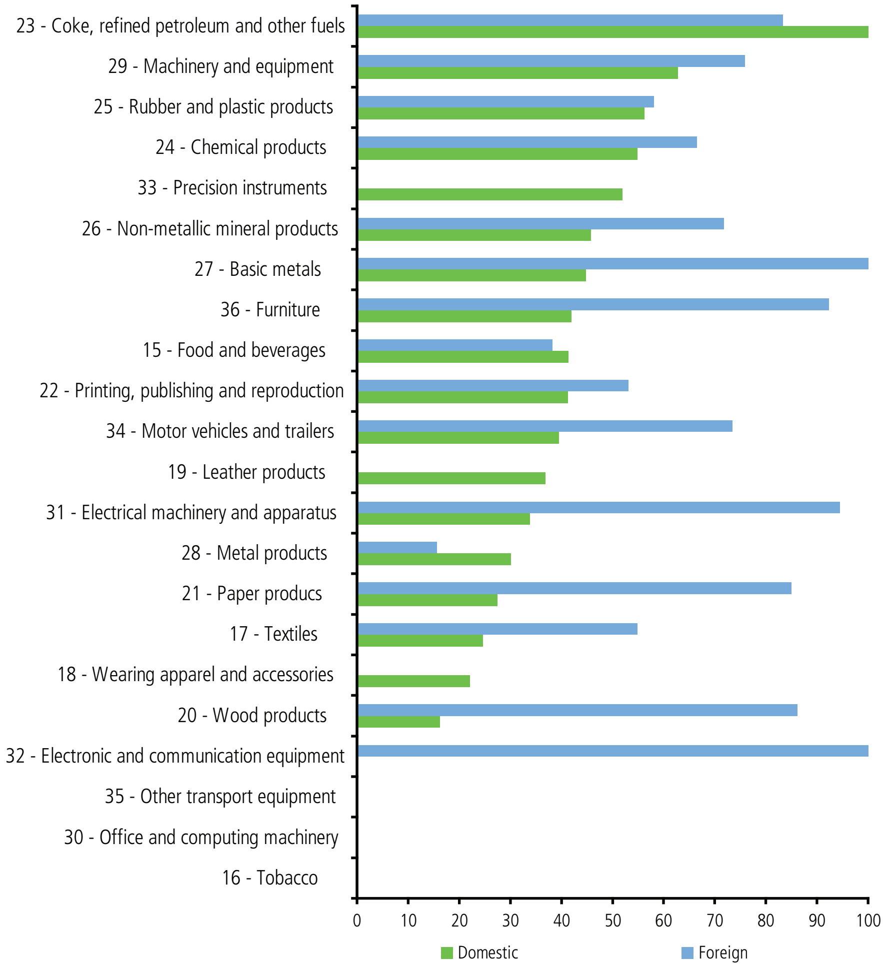
In the case of Brazil (as shown in Table 6 and Figure 5), in those sectors in which the domestic enterprises as a whole have high innovation rates, the differences in the rates of innovation between enterprises with domestic capital and those with foreign capital are less significant. However, the variations are substantial in the more technologically mature and low-tech sectors. This can be explained, at least in part, by the fact that, in these sectors, there are far greater disproportions between the average size of the domestic and foreign enterprises. While those with domestic capital tend to be pulverized into a large number of small enterprises, the same does not occur with the foreign-capital enterprises. Such asymmetry in the scales of domestic and foreign enterprises is considerably less marked in the more modern and higher-tech sectors.

Still with respect to the Brazilian case, it is curious to note that, even disregarding recycling, a sector in which there are only five foreign enterprises, all innovative, there exists a certain inversion in the ranking of foreign enterprises by innovative activity. Certain low-tech activities, such as furniture (36) and non-metallic mineral products (26) are relatively well positioned among the more innovative sectors. Likewise, the innovation rates of foreign enterprises in the natural-resource-based sectors also appear to be quite high. This may be the outcome of the need, imposed either by characteristics of the local natural resources or by requirements of the markets that purchase such products, to make innovative efforts to adapt and improve technologies transferred from abroad. This probably demands greater efforts than those required in certain more advanced sectors, where inputs and outputs are relatively standardized and where innovation perhaps occurs in steps over time or coincides with the transfer to the country of complete production lines. Other more advanced sectors, such as electronic and communications equipment (32), precision instruments (33) and electrical machinery and apparatus (31) are comparatively low in the sectoral innovation ranking of foreign enterprises.

Surprisingly, the foreign enterprises are relatively less innovative precisely in the higher-tech sectors they dominate. This may indicate that these enterprises are likely to contribute less than generally supposed to the technological capability and technological development of Brazil. An econometric exercise performed using data from the Brazilian innovation survey corroborates this hypothesis, revealing that, in comparison to domestic enterprises, foreign enterprises invest a significantly smaller share of their revenues in R&D when factors such as enterprise size and sectoral distribution are controlled for (ARAÚJO, 2005, p. 150, 165).

Analysis of the Argentine case is partially hampered by the nonavailability of data on various activities, concentrated, unfortunately, in the sectors characterized by the highest degrees of technological intensity. Even so, it is once again possible to perceive a certain imbalance between the innovation activities of the domestic and foreign enterprises. In other words, as in the case of Brazil, the sectors in which domestic enterprises are the most innovative do not correspond to the sectors in which foreign enterprises are the most innovative. Furthermore, with regard to the latter, there is apparently no relation between high-tech activities and high rates of innovation. The five activities in which the foreign enterprises in Argentina are most innovative are, in descending order, sectors 32, 27, 31, 36 and 20. Only the first of these activities can be classified as high-tech. The second is medium-low and the third medium-high, while the last two are, in fact, low-tech.

FIGURE 6
Innovation rates in Argentine industrial enterprises by activity and origin of capital (1998-2001)



Source: INDEC, 2005 (authors' elaboration).

One possible explanation for this unexpected divergence between the innovative activity and technological intensity of the foreign enterprises in Argentina and Brazil may rest in a preference for passive learning strategies[15] on the part of foreign enterprises, and especially among those in high-tech sectors. Thus, following the path of least technological effort typical of the passive technological learning strategy, they may be simply transferring to Argentina and Brazil the

15. On passive and active technological learning, see Viotti (1987, 2002, 2004).

technologies for producing goods originally developed for the global market and manufacturing these goods basically using global components or inputs (global outsourcing). However, in the more traditional sectors, such as furniture, these enterprises would be obliged to make greater local innovation efforts so as to adapt their production lines to local raw materials and inputs (generally closer to natural resources within the manufacturing chain), as well as to the preferences and incomes of the local consumers.[16]

The divergence underlined above and the possible dominance of passive technological strategies among the foreign enterprises in Argentina and Brazil may be responsible, at least in part, for the frustrated expectations concerning the role of these enterprises as a vehicle for driving technological development and raising the competitiveness of these economies. Were these expectations properly founded, the performance of the Argentine and Brazilian manufacturing industries should be far superior given the extraordinary levels of participation already achieved by foreign enterprises in these two economies.

7 INNOVATION EFFORTS BY ENTERPRISES

The Argentine manufacturing enterprises that conducted innovation activities in 2001 invested only 0.3% of their turnover in research and development (R&D), as demonstrated in Table 7, which compares the innovation activity expenditures[17] of several countries.[18] The dimension of the R&D effort of the Argentine enterprises is so limited that it corresponds to less than half the efforts made in 2000 by Portuguese and Danish enterprises (0.7%) and to a third of that evidenced among Brazilian enterprises (0.9%). The Spanish and Norwegian enterprises displayed R&D investment levels close to the Brazilian figure (1.0% and 1.1% of revenue, respectively), while the Italian, Belgian, Dutch, Finnish, German and French enterprises recorded significantly higher R&D investments, ranging from 1.6% to 3.8% of revenues. Surprisingly, there does not appear to be a correlation between the dimension of R&D efforts on the part of enterprises of each country and their

16. This analysis was partly inspired by the comments of Roberto Vermulm.

17. Enterprises with innovation activities include both successful innovators and those that attempted but failed to introduce innovations, as well as enterprises that were developing projects that were underway at the time of the survey.

18. Brazilian expenditures in *reais* were converted to euros using the average daily exchange rate for the year 2000, i.e., R$ 1.6898 = 1.00 according to the Brazilian Central Bank (BACEN). Likewise, Argentine expenditures in Argentine *pesos* were converted to euros using the average daily exchange rate for the year 2001, i.e., $ 0.8926 *pesos* = 1.00, also according to BACEN. In the Brazilian and European surveys, the innovation activity categories are identical. The Argentine questionnaire, however, is somewhat different in this respect, so several of the innovation activity categories maintain an approximate rather than an exact correspondence with the other surveys. To render comparison with the Argentine data feasible, it was therefore necessary to make the following adjustments. The sum of Argentine outlays on the acquisition of "capital goods" and "hardware" for innovation purposes was taken to correspond to the "acquisition of machinery and equipment" in the Brazilian and European surveys. Similarly, the sum of Argentine expenditures on "software" and "technological transfers" was considered the equivalent of "acquisition of other external knowledge" in the other surveys. Lastly, the sum of "training," "consulting," "engineering and industrial design" and "management (in-house)," in the case of Argentina, were taken to correspond to the sum of "training," "market insertion of technological innovations," plus "project design and other technical preparation" in the case of the other countries.

innovation performance, whether in terms of innovations new to the enterprise (see Table 3) or new to the market (see Table 4).

The dimensions of the intramural R&D efforts made by enterprises in the various countries are basically in accord with the total R&D ranking. Although the proportion of turnover dedicated to extramural R&D is generally a fraction of that dedicated to intramural R&D, this fraction varies considerably across countries. In Portugal, for example, the investment in extramural R&D is equivalent to 75% of the investment in intramural R&D while in Germany the share is a mere 7%.

TABLE 7
Expenditures on innovation activities (in millions and as a proportion of turnover) for industrial enterprises with innovation activities: selected countries (2000)*

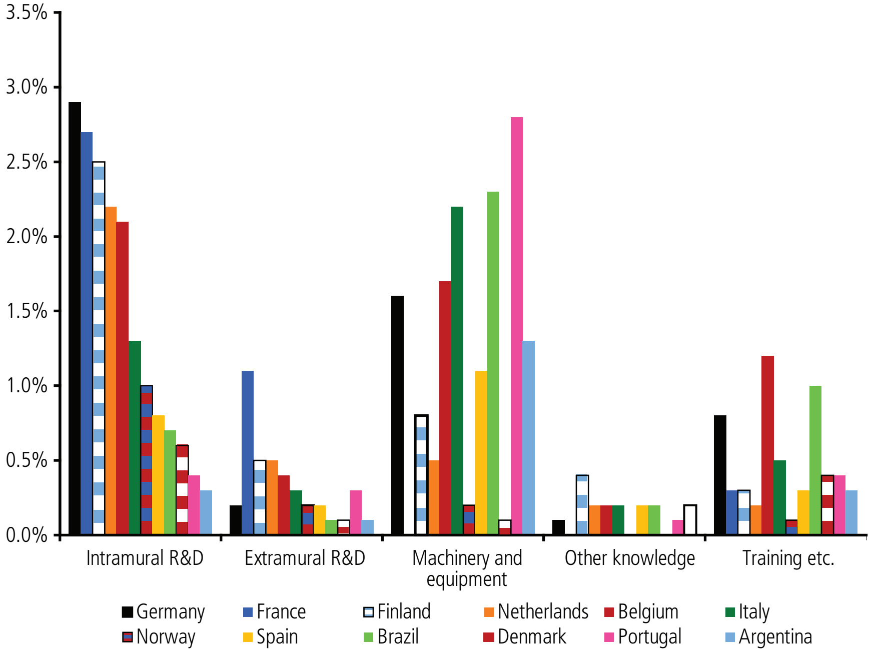
Country	Turnover	Innovation activity expenditures											
		R&D		Intramural R&D		Extramural R&D		Acquisition of machinery and equipment		Acquisition of other external knowledge		Training, other design preparation and market introduction	
	mi	mi	%	mi	%	mi	%	mi	%	mi	%	mi	%
France	602,177	22,738	3.8	16,115	2.7	6,622	1.1	n.a.	n.a.	n.a.	n.a.	1,776	0.3
Germany	1,167,045	36,018	3.1	33,597	2.9	2,421	0.2	18,205	1.6	1,102	0.1	9,821	0.8
Finland	91,613	2,770	3.0	2,311	2.5	459	0.5	717	0.8	331	0.4	235	0.3
Netherlands**	16,749	4,374	2.7	3,553	2.2	821	0.5	805	0.5	370	0.2	329	0.2
Belgium	14,929	3,631	2.5	3,018	2.1	612	0.4	2,452	1.7	304	0.2	1,663	1.2
Italy	44,756	7,215	1.6	5,962	1.3	1,253	0.3	9,966	2.2	775	0.2	2,146	0.5
Norway	9,280	1,029	1.1	858	1.0	170	0.2	201	0.2	28	0.0	108	0.1
Spain**	27,691	2,795	1.0	2,130	0.8	665	0.2	2,866	1.1	432	0.2	844	0.3
Brazil	297,638	2,566	0.9	2,197	0.7	369	0.1	6,831	2.3	689	0.2	3,025	1.0
Portugal	57,774	416	0.7	254	0.4	162	0.3	1,593	2.8	53	0.1	244	0.4
Denmark	43,361	297	0.7	263	0.6	35	0.1	39	0.1	2	0.0	176	0.4
Argentina	78,151	248	0.3	208	0.3	40	0.1	992	1.3	160	0.2	209	0.3
Greece	22,368	n.a.	n.a.	n.a.	n.a.	23	0.1	530	2.4	n.a.	n.a.	85	0.4

Sources: EUROSTAT, 2006; INDEC, 2005; BACEN, 2006; Viotti *et al*., 2006, p. 667 (authors' elaboration).
Notes: (*) The Argentine data refer to 2001. (**) Since it was not possible to obtain information on the Netherlands and Spain in EUROSTAT 2006, the data on these countries include electricity, gas and other energy-supply enterprises in the manufacturing sector and are the same as those used in Viotti *et al.* (2005, p. 667).

For the majority of the countries in Table 7, there appears to be a positive correlation between the proportion of turnover invested in intramural R&D and the percentages invested in extramural R&D, as can be verified in Figure 7. In a less evident, yet relatively consistent form, there is apparently a negative correlation between the percentages for R&D expenditures and those referring to the amounts spent on machinery and equipment specifically purchased for the introduction of new or technologically improved products and processes.

Expenditures on the acquisition of other external knowledge are relatively low and vary only slightly from country to country, but the amounts spent on activities such as training fluctuate considerably and are apparently in no way correlated with R&D expenditures (see Figure 7).

FIGURE 7
Expenditures on innovation activities as a proportion of turnover for industrial enterprises with innovation activities: selected countries (2000)*

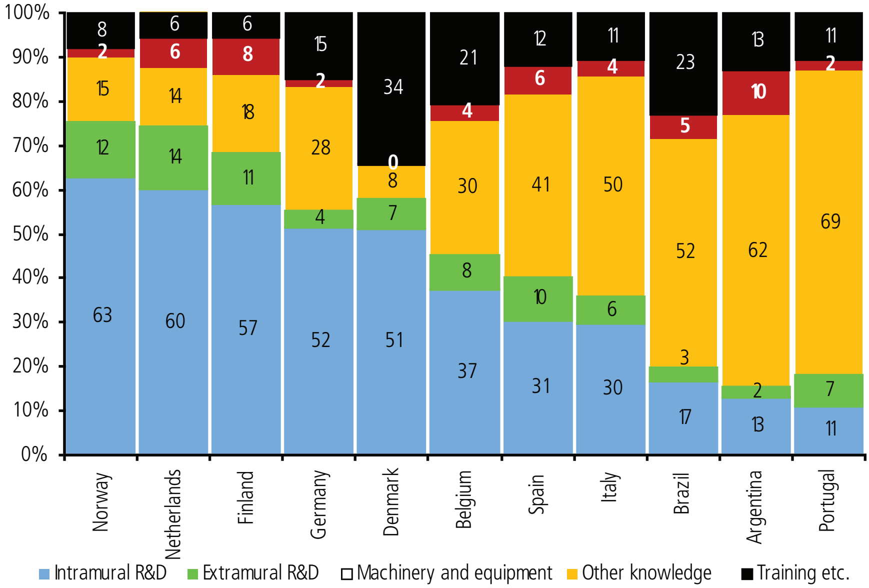


Sources: EUROSTAT, 2006; INDEC, 2005; BACEN, 2006; VIOTTI *et al.*, 2005: p. 667 (authors' elaboration).
Note: (*) The Argentine expenditures correspond to the year 2001.

On analyzing the distribution of the total expenditures on innovation activities by category, intramural R&D and the acquisition of machinery and equipment stand out (see Figure 8). The inverse correlation between the proportion spent on intramural R&D and that referring to the acquisition of machinery and equipment is striking. In general terms, the higher the share spent on intramural R&D among the innovation activities, the lower the share earmarked for the purchase of machinery and equipment. On the one hand, it is notable that Portugal, Argentina, Brazil and Italy directed half of their innovation efforts or more to the acquisition of machinery and equipment. At the same time, these countries allocated to intramural R&D between a ninth and slightly less than a third of their total innovation activity expenditures. On the other hand, countries that directed more than half their innovation activity expenditures to intramural R&D – Norway, The Netherlands, Finland, Germany and Denmark – allocated only 8% to 28% of the total to the acquisition of machinery and equipment.

FIGURE 8

Expenditures on specific innovation activities as a proportion of total expenditures on innovation activities for industrial enterprises with innovation activities: selected countries (2000)*



Sources: EUROSTAT, 2006; INDEC, 2005; BACEN, 2006; Viotti et al., 2005, p. 667 (authors' elaboration).
Note: (*) The Argentine expenditures correspond to the year 2001.

The share of the acquisition of machinery and equipment in the overall innovation activity expenditures of Portuguese, Argentine and Brazilian enterprises (more than 50% of the total), coupled with the relative insignificance of intramural R&D outlays (17% of the total or less), points to a process of technological change strongly dominated by the simple absorption of technologies and innovations generated in other economies. Such a process is characteristic of national systems based on passive technological learning (VIOTTI, 1987, 2002, 2004).

This hypothesis is corroborated by the fact that the innovating enterprises in these three countries, together with those in Italy and Greece,[19] are those with the fewest number of intramural R&D employees (see Table 8 and Figure 9). Whereas the average number of R&D workers is 3 per innovating enterprises in the five countries cited, the average in other countries ranges from 5 to 16.

19. It should be noted that the Italian enterprises that invested in innovation activities spent 50% of the total on machinery and equipment. A similar comparison cannot be made in the case of the Greek enterprises owing to the data on innovation activity expenditures being incomplete. However, these enterprises allocated 2.4% of their total revenues to the acquisition of machinery and equipment, a percentage higher than that of the Italian (2.2%), Brazilian (2.3%) and Argentine (1.3%) enterprises.

TABLE 8
Number of intramural R&D personnel employed by successful industrial innovators: selected countries (2000)*

Country	R&D employees (2000)*	Successful industrial innovators (1998-2000)**	R&D employees per successful industrial innovators
Sweden	48,787	2,998	16.3
France	140,777	10,032	14.0
Finland	16,923	1,756	9.6
Germany	263,301	30,137	8.7
Belgium	29,910	3,689	8.1
Netherlands	34,933	5,563	6.3
Austria	19,888	3,179	6.3
Denmark***	13,280	2,508	5.3
Greece	5,532	1,882	2.9
Argentina	12,324	4,392	2.8
Italy***	95,243	35,814	2.7
Spain	35,068	16,644	2.1
Brazil	41,467	22,698	1.8
Portugal	8,014	6,989	1.1

Sources: EUROSTAT, 2006; IBGE, 2002; INDEC, 2005; Viotti *et al.*, 2005, p. 667 (authors' elaboration).
Notes: (*) The Argentine data refer to the year 2001. (**) The Argentine data correspond to the period 1998-2001.
(***) Since it was impossible to obtain this information for Denmark and Italy in EUROSTAT 2006, the data on these countries include electricity, gas and other energy-supply enterprises in the manufacturing sector and are the same as those used in Viotti *et al*. (2005, p. 670).

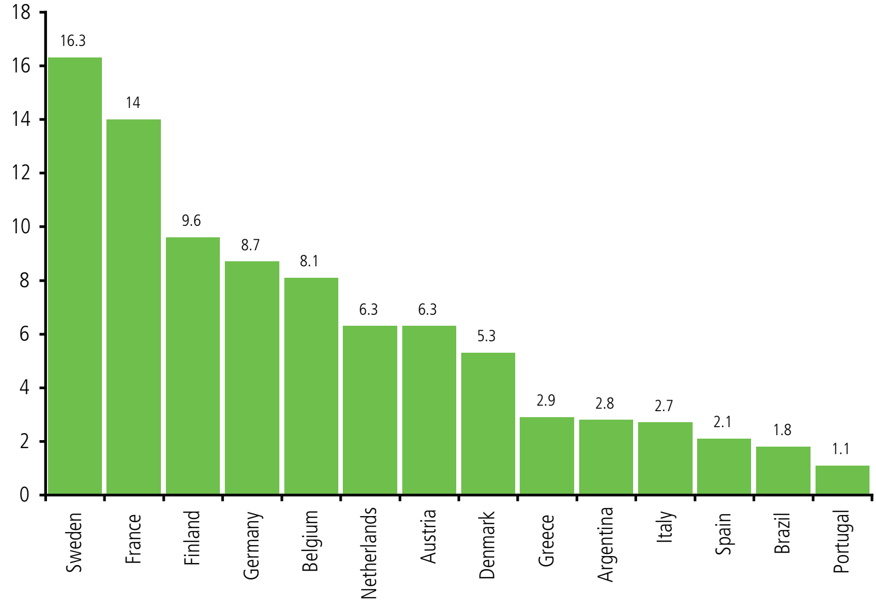
The countries that lead the internal R&D list in terms of proportion of turnover – Germany, France, Finland, The Netherlands and Belgium – also head the roll in number of intramural R&D employees per enterprise, though their relative positions are altered.[20] In these countries, the average number of R&D employees per enterprise is from 3.5 to roughly 8 times higher than in Brazilian enterprises, where the average is only 1.8 workers dedicated to R&D.

Given the fact that the Argentine enterprises were those that invested the smallest share of turnover in intramural R&D (0.3%, or half of the Brazilian 0.6%), the average number of R&D employees seems quite high (2.8). This is most likely explained by the fact that the Argentine manufacturing sector, in contrast to the Brazilian, has relatively few small enterprises.

Nonetheless, it should be taken into account that even Italy, endowed with an industrial structure that has an even higher proportion of small enterprises (87% of the total) than Brazil (78%), and enterprises with an average number of employees (18) even lower than the average in similar enterprises in Brazil (20), presented an average number of R&D workers (2.7) 50% over the Brazilian average (1.8).

20. Since it was not possible to obtain data on the innovation activity expenditures of Sweden and Austria, they were omitted from Table 6 and it cannot be determined whether or not they are among the leaders in intramural R&D.

FIGURE 9
Average number of intramural R&D personnel employed by successful industrial innovators: selected countries (2000)*



Sources: EUROSTAT, 2006; IBGE, 2002; INDEC, 2005 (authors' elaboration).
Note: (*) The Argentine data refer to 2001.

Access to information not only on the number of employees dedicated to R&D, but also to the qualifications of these human resources is of vital importance for better understanding the technological capability of enterprises. Such information therefore merits special emphasis in innovation surveys. Unfortunately, the European surveys did not give due attention to this fact and limited their task to simply verifying the proportion of the total number of employees with higher education and the number of R&D workers (EUROSTAT, 2004, p. 291, 294). This aspect of the innovation surveys clearly represents a frontier to be explored via future methodological improvements. Interestingly, the Argentine questionnaire includes a detailed section on the human resources linked to innovation activities (INDEC, 2003, p. 11) and the Brazilian inquiry contains questions on the formal qualifications of employees dedicated to R&D (IBGE, 2002, Appendix).

An analysis of some of the findings of the Brazilian survey on the qualifications of R&D personnel was presented in a previous article by the authors of this study (VIOTTI *et al.*, 2005, p. 671). An intriguing fact mentioned in that article refers to the existence of a possible imbalance between vital elements of the national learning system and the process of technological innovation in the country. The subsystem responsible for preparing top-level human resources was capable of graduating 18 thousand professionals with Master's degrees and an additional 5 thousand with Ph.D.s in the year 2000 alone. However, according to the Brazilian innovation survey, only 3 thousand individuals with graduate degrees were engaged in R&D activities in manufacturing enterprises in the same year.

By way of summary, it should be stressed that the innovative enterprises in Portugal, Argentina, Brazil, Italy and Spain invested more than 40% of their overall expenditures on innovative activities on the acquisition of machinery and equipment required to introduce new products and processes. The same countries invested proportionally less in intramural R&D, as well as employing the lowest average numbers of R&D workers per enterprises. In view of these features, these countries are among those that should be investigated to ascertain whether or not they fall within the hypothesis regarding systems in which technical change is characterized by the kind of technological learning typical of essentially imitative economies wherein technical change is essentially limited to the absorption and improvement of innovations generated in other countries.

8 PRIMARY RESPONSIBILITY FOR DEVELOPING INNOVATIONS AND INFORMATION SOURCES

An excellent way to figure the wealth of the innovation processes of enterprises and national innovation systems, together with their learning processes, is to analyze the ties among enterprises, as well as between enterprises and institutions, developed for the purpose of generating innovations or obtaining information relevant to the innovation process.

The European, Argentine and Brazilian surveys all collected data on the sources of information underlying the development of innovations. However, in contrast to the European and Brazilian surveys, the Argentine inquiry did not gather data as to the primary responsibility for developing innovations. For this reason, the analysis herein will necessarily be restricted to comparison of the European and Brazilian cases, reproducing that formerly presented in Viotti *et al.* (2005, p. 672-675).[21]

21. Table 8 covers the manufacturing and mining and quarrying and, in the case of the European countries, electricity, gas and energy-supply enterprises, though this hardly alters the results due to the number of such enterprises being quite limited. The total number of product innovators includes those that introduced only products plus those that introduced products and processes simultaneously and the same procedure was adopted with the process innovators. The categories "enterprise itself" and "related enterprise within group," which appear separately in the PINTEC, were merged for the sake of comparing the Brazilian data to those on the countries surveyed in the CIS3, where the information is presented under a single heading. In Brazil, the enterprises themselves were primarily responsible for 71% of the product innovations and 11% of the process innovations. Related enterprises within the same groups accounted for the residuals of 4% and 1%, respectively.

TABLE 9
Number and proportion of product and process innovators that develop innovations with partners: selected countries (1998-2000)

Country	Product innovators						Process innovators					
	Mainly by other enterprises or institutions		Within the enterprise or enterprise group		In co-operation with other enterprises or institutions		Mainly by other enterprises or institutions		Within enterprise or enterprise group		In co-operation with other enterprises or institutions	
	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%
France	285	4	6,355	81	1,248	16	559	10	3,540	62	1,644	29
Italy	1,717	7	19,738	78	3,821	15	2,875	10	19,750	72	4,953	18
Spain	970	9	8,030	76	1,571	15	2,067	18	6,577	59	2,534	23
Sweden	138	6	1,787	75	447	19	236	13	1,025	58	502	28
Brazil	2,151	17	9,519	75	988	8	15,135	83	2,141	12	883	5
Norway	71	5	999	74	289	21	179	15	654	56	327	28
Austria	204	8	1,971	74	506	19	378	20	884	46	665	35
Germany	1,471	6	17,413	73	4,923	21	2,772	15	10,750	58	4,984	27
Finland	52	3	1,079	72	372	25	24	2	818	70	324	28
Belgium	211	8	1,880	72	537	20	514	22	1,025	44	782	34
Portugal	462	11	3,105	71	802	18	940	18	2,980	57	1,273	25
Iceland	11	6	125	69	44	24	23	15	76	51	51	34
Netherlands	390	8	3,324	68	1,156	24	1,023	26	1,750	44	1,185	30

Sources: IBGE, 2004; EUROSTAT, 2004b (authors' elaboration).
Notes: The Argentine survey did not include a question in this respect. This table was originally presented in Viotti *et al.* (2005, p. 673).

With regard to product innovation, in 68% or more of the enterprises in all the countries listed in Table 9, the primary responsibility for developing products rests with the concerned enterprise or with an enterprise in the same group. Least frequently, the primary responsibility for product innovation lies with other enterprises or institutions without cooperation ties, except in Brazil, where the least common instance refers to "in cooperation with other enterprises or institutions."

As to process innovation, the prime responsibility also fell to the concerned enterprise or enterprise of the same group, with the notable exception of Brazil, where the share of this category is a mere 12% and the process is more often generated by other enterprises or institutions. In Brazil, the proportion of enterprises that owe their process innovations to other enterprises or institutions is exceptionally high at 83%, or more than triple that of any other country cited in the table. This disequilibrium is probably explained by the predominance among

Brazilian enterprises of process innovations resulting from the simple purchase of machinery and equipment from outside suppliers, which, as previously mentioned, accounts for more than half the amounts spent on innovation activities in general. That this disequilibrium is not mirrored in the same proportion in the case of enterprises that innovate with respect to product may be linked to their far more accelerated rate of innovation for the domestic market (23%, compared to 11% on the part of those that innovate with regard to process) (IBGE, 2002, p. 32).

The proportion of Brazilian enterprises that innovate, whether product or process, and attribute the primary responsibility to the enterprise "in cooperation with other enterprises or institutions" is disproportionately low in comparison to other countries. This points to exceptionally weak links between the innovating enterprises and either the innovation or learning systems, and specifically with certain of their principal agents such as other enterprises and research institutes.

In nearly all the countries considered, the manufacturing enterprises that conducted innovation activities attributed more importance to information obtained from within the enterprise itself to that received from any other source (see Table 10 and Figure 10). The exceptions to the rule are Germany and Denmark. In these countries, the enterprises placed clients or customers one or two percentage points above "within the enterprise" as prime sources of information.

By means of examining Table 10 and analyzing the average percentage shares (raw or normalized) of enterprises that ascribe high degrees of importance to given sources of information, it is possible to rank the mean perceptions of the enterprises as to the relative significance of each source. In descending order, the most important sources of information for innovation activities are: "within the enterprise"; "clients and customers"; "suppliers"; "fairs and exhibitions"; "competitors"; "other enterprises within the enterprise group"; "professional conferences, meetings and journals"; "universities and other higher education institutes"; and "government or private non-profit research institutes." Interestingly, even if universities and research institutes were united into a single category, they would still rank last in the order of importance attributed to the various sources of information consulted by enterprises for their innovation activities. Ironically, it is precisely the relations between enterprises and these types of institutions that tend to be at the center of the national science, technology and innovation policies; meanwhile, the relations between enterprises and their other sources of innovation information are usually relegated to positions of secondary importance or simply overlooked.

TABLE 10

Proportion and ranking of enterprises with innovation activities that considered given sources of information highly relevant to innovation: selected countries (1998-2000)*

Country	Within the enterprise			Other enterprises within the enterprise group			Suppliers			Clients or customers			Competitors			Universities or other higher education institutes			Government or private non-profit research institutes			Professional conferences, meetings and journals			Fairs and exhibitions		
	%	N	R	%	N	R	%	N	R	%	N	R	%	N	R	%	N	R	%	N	R	%	N	R	%	N	R
Germany	36	22	14	8	5	9	19	12	9	37	23	5	14	9	4	7	4	3	2	2	11	15	9	2	25	15	4
Argentina	45	33	5	18	13	1	16	12	10	19	14	13	14	10	2	na	na	na	na	na	na	na	na	na	na	na	na
Austria	50	38	3	9	7	6	15	12	11	24	18	6	5	4	13	5	4	4	3	2	5	9	7	5	9	7	9
Belgium	53	32	6	13	8	3	29	18	5	26	16	11	10	6	9	5	3	5	3	2	10	8	5	9	16	10	8
Brazil	50	24	12	5	2	12	35	17	6	36	17	8	21	10	3	9	4	2	6	3	3	15	7	4	34	16	3
Denmark	25	23	13	0	0	13	16	15	7	27	25	3	9	8	5	5	4	1	3	3	4	7	6	6	16	15	5
Spain	33	25	10	9	6	7	24	18	4	19	15	12	10	7	7	3	2	12	5	4	2	10	7	3	19	15	6
Finland	45	42	2	8	8	4	11	10	13	25	23	4	4	4	14	3	2	9	5	5	1	2	2	13	4	4	13
France	48	32	7	12	8	2	16	11	12	40	27	2	16	11	1	2	1	13	2	1	12	4	3	11	9	6	10
Greece	58	30	8	0	0	13	36	18	3	25	13	14	12	6	11	6	3	7	4	2	9	20	11	1	34	18	2
Netherlands	53	46	1	8	7	5	11	10	14	18	16	10	8	7	8	3	2	10	2	2	6	5	4	10	6	5	11
Italy	27	29	9	3	3	11	17	18	2	16	17	7	8	8	6	2	2	11	2	2	8	5	6	7	14	14	7
Portugal	34	24	11	6	4	10	26	19	1	24	17	9	9	6	10	4	3	6	3	2	7	7	5	8	28	20	1
Sweden	49	34	4	9	6	8	21	14	8	42	29	1	7	5	12	4	3	8	2	1	13	4	2	12	6	4	12

Sources: EUROSTAT, 2004: 246; EUROSTAT, 2006; INDEC, 2005; Viotti et al., 200, p.: 674 (authors' elaboration).

Notes: (*) The Argentine survey refers to the period 1998-2001. "%" stands for the percentage of enterprises that considered as highly important for innovation a selected source of information. Since each enterprise could give more than one answer to the question, the sum of the percentages for a country could conceivably be over 100%. Using that sum for each country as a basis, new normalized percentages were computed (sum = 100). These new percentages are presented in the "N" columns. From the "N" percentages, it was possible to determine the relative importance the enterprises in each country attribute to each source of information and thereby rank it ("R" on a 1 to 14 scale). In the Argentine survey, "universities" and "research institutes" were cited in only one question. The same occurred with regard to "conferences" and "fairs". Therefore, in the case of Argentina, the sum of the high-relevance replies for these four sources (23%) was used to normalize the other sources.

9 PUBLIC FINANCIAL SUPPORT FOR INNOVATION ACTIVITIES[22]

In almost all the national innovation surveys, the industrial enterprises cite economic factors as comprising the principal hindrance to the innovation process. Among these factors stand out the high costs of innovation and the limited financial resources available for financing innovation activities (EUROSTAT, 2004a, p. 34, 35; VIOTTI *et al.*, 2005, p. 677-680). This is unquestionably one of the reasons that granting public financing for innovation activities on favorable terms constitutes one of the main public policy tools with respect to these activities.

In the majority of the countries studied, the proportion of innovative industrial enterprises that received public financing for developing such activities is high (see Table 11 and Figure 10).[23] In countries such as Finland, Austria, the Netherlands and Italy, approximately half the innovating enterprises benefited from public financial support. Furthermore, EUROSTAT (2004a, p. 25), taking into account the aggregate findings of the European Community surveys (CIS3), estimated that more than a third (35%) of the European industrial enterprises with innovating activities received public funds in support of such activities.

TABLE 11
Proportion of successful industrial innovators that received public financial support for innovation: selected countries (1998-2000)*

Country	Received public financial support (%)	Financial source*		
		Local or regional authorities (%)	Central government (%)	European Union (%)
Finland	51	9	46	8
Austria	50	26	39	15
Netherlands	45	5	40	5
Italy	44	25	20	7
Portugal	36	2	15	26
Greece	34	4	17	16
Spain	31	23	12	5
Belgium	29	24	4	5
France	29	10	24	6
Germany	27	16	14	6
Sweden	20	8	3	10
Brazil	11	-	-	-

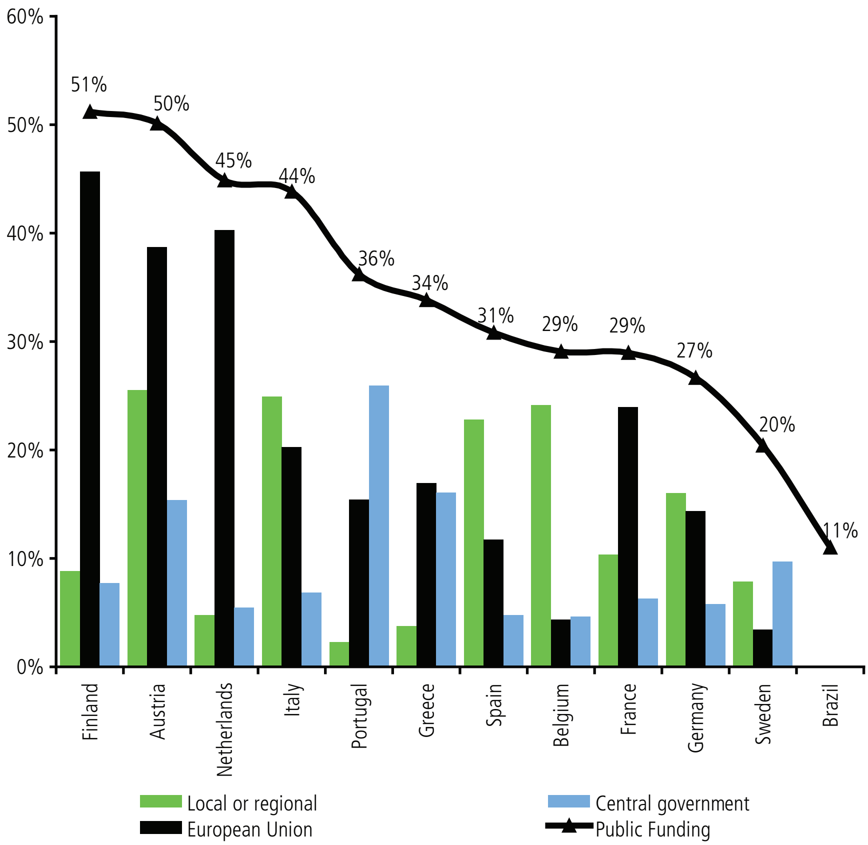
Sources: EUROSTAT 2006; IBGE, 2004; INDEC, 2005 (authors' elaboration).
Note: (*) An enterprise may have received public financial support from more than one source.

22. In a previous article, the authors also analyzed cooperation between enterprises for the purpose of innovation, i.e. joint R&D or other innovation projects undertaken with other organizations, and the barriers to innovation they face (see sections 8 and 9 of Viotti *et al.* 2005, p. 675-680). However, due to certain difficulties in developing these comparisons, the authors chose not to develop such analyses in this study.

23. In Table 10, the data on Brazil refer to the manufacturing and extractive industries, while those on the European countries cover these industries plus electricity, gas and energy-supply enterprises. Unfortunately, various problems made it impossible to include information on the public financing of Argentine enterprises. However, the findings published in the Argentine inquiry indicate that only about 5% of the enterprises surveyed (unexpanded data) used public funds in support of their innovation activities over the period 1998-2001 (INDEC, 2003, p. 55).

The Brazilian case stands in stark contrast, for only 11% of the innovating enterprises received public financing for the development of such activities. This figure corresponds to less than one-third the proportion of European enterprises and roughly half that of Sweden, the European country lowest on the scale. The impact of this disproportion is accentuated when it is recalled that, during the reference period, the Brazilian interest rates were among the highest in the world and the availability of long-term financing was extremely limited. In addition, the relative disadvantage of Brazilian enterprises is further aggravated by their restricted technological capabilities and relatively limited possibilities for self-financing in comparison to enterprises in most European countries.

FIGURE 10
Proportion of successful industrial innovators that received public financial support for innovation: selected countries (1998-2000)



Sources: EUROSTAT, 2006; IBGE, 2004; INDEC, 2005 (authors' elaboration).

Attention should also be called to the fact that, in the European countries, public support of the innovation activities of industrial enterprises is distributed across local or regional authorities, central or national governments and the European Community itself. Although the Brazilian survey did not collect information on the distribution of financing by level of public entity, it is known that this type of financing is essentially granted by the federal government. In the European case, the financial funds of the Community are surprisingly important. Interestingly, the relatively less developed countries that are targets of the regional policy of the Community ("cohesion countries" such as Portugal and Greece) are those with a proportionately higher number of enterprises receiving financial support from the Community. This fact exposes one of the main features of the European regional development policy, which is its emphasis on the promotion of innovation as a tool for the development of the lagging regions or countries.

10 CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE INNOVATION SURVEYS

The analysis of the Argentine, Brazilian and European innovation surveys undertaken in this study has revealed important features of the industrial innovation processes of the selected countries and placed them in perspective by means of comparison. In spite of the contributions that innovation surveys have made to enhance the understanding of innovation processes and national innovation systems, certain limitations related to their methodology are evident.

In order that the surveys might better comprehend the innovation processes of industries, their ability to grasp the different scopes of innovation will have to be improved, together with their ability to gauge the technological and innovative capabilities of enterprises.

In addition, more precise methods are needed for distinguishing innovations that are new for the enterprise from innovations that are new for the market. The concept of innovation for the market is much closer to the original idea of Schumpeter, which is linked to products and processes that are truly pioneering, that is, that have never before been produced or used on the (world) market. The introduction of a product or process that is new only for the enterprise is more a reflection of the notion of diffusion than of innovation per se. Even if the surveys continue to adopt the broader definition of innovation (which includes "new for the enterprise," which would be better classified as "diffusion"), it is important that they more clearly differentiate the scope of each type of innovation.

Innovations that are "new for the market" usually signify impacts on the competitiveness of enterprises, regions or countries which are wholly distinct from the impact of an innovation "new for the enterprise" alone. In the case of innovation for the market, the technological capabilities required, as well as the opportunities available, are also far superior. Consequently, it is of fundamental importance to ascertain if a national innovation system is characterized by the expressive presence of enterprises that innovate for the market or if its rate of innovation essentially reflects the presence of enterprises that introduce products and processes that are new for themselves alone.[24]

The comparisons of the innovation process across the industries of the countries analyzed in this study were partially compromised by the imprecision of the concept "innovation for the market" employed in the various national surveys. As seen in section 5, the "innovation for the market" definition that covers a product that is new to the market in which the enterprise operates, the procedure followed in the European questionnaire (CIS3), is of limited use and should be refined. To improve the quality of the survey findings, as well as to render them comparable at the international level, a clear distinction needs to be drawn between what constitutes a pioneer innovation for the enterprise concerned and what constitutes a pioneer product or process for the world market. A better understanding of the nature and dynamics of the national systems for technical change could also be gained through the explicit adoption of an intermediary concept: "innovation for the domestic market," referring to products and processes introduced to the domestic market for the first time, though not new in other parts of the world.[25]

Another aspect that needs to be further explored in the innovation surveys concerns the technological capabilities of enterprises. On these capabilities depend not only the efficiency and efficacy of innovation policy measures, but also the present and future success of the innovation and learning processes of the enterprises themselves. In truth, it is hard to measure the physically intangible knowledge, capability and skill bases on which the innovation process rests. Nonetheless, certain facets of this base can and should be measured directly or indirectly by innovation surveys. This applies, for example, to the human-resource base on which enterprises depend for their productive activities, and especially to those employees dedicated to R&D activities. Unfortunately, as mentioned earlier, the European survey did not give due attention to this item. Making this improvement would not necessarily involve significantly higher costs to the enterprises when answering the survey questionnaire, for most companies have precise, readily available information on their employees and their qualifications.

24. As suggested in earlier studies (VIOTTI, 1997, 2002, 2004), it would be more accurate to designate the latter as a case of national learning or imitation systems rather than of national innovation systems in the strict sense.

25. As indicated before, innovations new for the enterprise, new for the domestic market and new for the world market were clearly distinguished in the second round of the Brazilian innovation survey (IBGE, 2005b) and, to an extent, had already been differentiated in the Argentine survey (INDEC, 2003). CIS4, the fourth round of the European surveys, corresponding to the period 2002 to 2004, adheres to the same characterization of innovation for the market used in CIS3.

More detailed reports on the acquisition of capital goods (once again, information that should be relatively easy for the enterprises to gather and supply) would enrich the data on the technological capabilities of enterprises, as well as on the flow of embodied technologies as revealed by the machinery and equipment purchased.

While a better definition of the scope of innovation and a stronger emphasis on the technological capability of enterprises are of interest to developed economies, they are of even greater strategic importance to developing economies. In the absence of a clear distinction between what is new only for the enterprise and what is new for the world market, it is hard to accurately appraise the features of the process of technical change in developing economies since these economies are usually characterized by the simple absorption of innovations generated in the industrialized economies. Thus, the imprecision of the concept of innovation employed in the surveys clouds the enormous differences that separate national innovation and learning systems of highly distinct natures.

Furthermore, placing relatively strong emphasis on R&D activities or stressing the links between enterprises and other elements within the national innovation system may be suitable options in developed countries having elevated technological and innovation capabilities. In developing countries, however, the existence of technological capabilities cannot be taken for granted. Indeed, the lack or fragility of these capabilities could likely constitute the main reason for the frequent inefficacy and inefficiency of policies aimed at stimulating R&D activities within enterprises, straightening the ties between enterprises and research institutions and strengthening intellectual property in developing economies. For these reasons, in developing countries, it is especially important that the innovation surveys direct more attention to technological capabilities at the enterprise level.

Given the accelerated globalization of corporations throughout the world, identifying whether the majority capital of enterprises is of domestic or foreign origin is important in all economies. It is particularly important, however, in developing economies. The analyses performed for Argentina and Brazil (section 6),[26] economies in which foreign corporations play a very strong role, indicate that the expectations on the part of many economists and policymakers as to the potential contribution of foreign enterprises to the quality and dynamism of the innovation process in these countries may be overly optimistic. In this regard and as indicated before, it should be recalled that an econometric exercise based on the findings of the Brazilian survey detected that foreign enterprises invested a significantly smaller share of their revenues in intramural R&D than did domestic enterprises (ARAÚJO, 2005). For this

26. On the CIS3 questionnaire used in European countries, the first question is whether or not the enterprise is part of a business group and, if so, the name of the country where the group is headquartered. From this information, it would theoretically have been feasible to analyze eventual differences in the innovation processes of foreign and domestic enterprises in European economies, though this possibility was apparently not exploited in the handling of the survey results for these economies.

reason, the innovation surveys should be redesigned to provide more and higher quality data relative to differences that perchance exist between the innovation and learning processes of foreign and domestic enterprises.

The inverse correlation between expenditures on intramural R&D and on the acquisition of machinery and equipment for innovation purposes, discussed when analyzing the distribution of expenditures on innovation activities (Figure 8), seems to be associated to the quality of national innovation or technical change systems. Hence, countries that allocate high proportions of their innovation activity expenditures to R&D and low proportions to the purchase of machinery and equipment (Norway, the Netherlands, Finland, Germany and Denmark) comprise a group characterized by superior innovation processes. In contrast, countries with an inverse distribution relative to these expenditures, that is, a lesser share earmarked for intramural R&D and a greater share for machinery and equipment (Portugal, Argentina, Brazil, Italy and Spain), constitute systems with inferior innovation processes.

The latter countries invested more than 40% of their total amounts spent on innovation activities on the acquisition of machinery and equipment for introducing innovations. The same countries invested proportionally less on intramural R&D and employed, on average, the fewest number of R&D workers per enterprise. These characteristics place these countries among those that should be studied from the standpoint of verifying the hypothesis that they are among those where the process of technological learning is typical of essentially imitative economies in which technical transformation is basically restricted to the absorption and improvement of innovations generated abroad.

Since a strong corroboration of this hypothesis would also require that these countries had the lowest innovation rates for the world market, the comparative exercise performed in this study did not allow for a more complete evaluation. The comparisons in section 5 were restricted to product innovations for the market and the outcomes appear to have been considerably affected by methodological differences in the national surveys consulted. This may have occurred, for instance, because a questionnaire defined the market as being the operating market for the enterprise or because there was a very high proportion of small enterprises in the Italian industrial sector and the majority served limited local markets. Thus, it may be possible to further verify the above hypothesis at a later date but, as suggested above, conditioned on the adoption of a better definition of the concept of innovation for the market by future surveys.

The analysis of the proportion of enterprises indicating that selected sources of information were considered as highly important for innovation (see section 8 and specifically Table 10) revealed a certain order of priorities, which require the attention of those who formulate, execute and analyze science, technology and innovation policies. As mentioned above, the enterprises attribute a clear order of importance to their sources of information, the most outstanding being (in descending order): sources "within the enterprise"; "customers and clients"; "suppliers"; "fairs and exhibitions"; "competitors"; "other enterprises within the enterprise group"; "professional conferences, meetings and journals"; "universities or other higher education institutes"; and "government or private non-profit research institutes." Even considered together, universities and research institutes fall in last place. Curiously, the ties between enterprises and such institutions are usually at the center of national science, technology and innovation policies, while the links between enterprises and their other sources of information tend to be relatively neglected. Public innovation policies, especially in developing countries, therefore stand to benefit from more attention to the other sources of information underlying the innovation efforts of enterprises.

In the view of certain analysts and policymakers, direct support of enterprises for the purpose of conducting innovation activities corresponds to an undesirable form of intervention reminiscent of public policy stances unsuited to modern economies. It is interesting to note, however, that, between 1998 and 2000, a significant proportion of European industrial enterprises received public financing for their innovation activities (see section 9, Table 11 and Figure 10). On average, more than a third of these enterprises received some form of public financial support of innovation and in several countries such financing was granted to 50% or more of the innovative enterprises.

In Brazil, only 11% of the innovating enterprises received such financing. However, public financing for innovative activities should be attributed special importance in developing countries such as Brazil given that the enterprises in these countries usually have less capacity for self-financing, less access to long-term private credit, pay higher interest rates and face greater degrees of uncertainty.

Since financing on suitable terms is apparently of great importance to the success of innovation, future surveys should direct more attention to this issue, including gathering information on private sources of funding. At the same time, it should be remembered that it is public financing and its impact on the success of innovation activities that are easiest to track and apply when formulating and evaluating innovation policies. Enhancing the quality of information innovation surveys provide on this aspect may eventually induce analysts and policymakers to make more extensive use of the findings of innovation surveys, which has been quite limited to date (ARUNDEL, 2005).

In conclusion, despite encountering certain difficulties and limitations on comparing the results of the national innovation surveys, positive results were achieved. The comparative analysis of the surveys has contributed to a better understanding of the characteristics of the national innovation systems of the countries studied. Likewise, specific features of the processes of technical change in developing countries have come to light. Finally, recommendations have been offered for improving the innovation surveys and the use of their findings for policymaking.

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CHAPTER 8

THE EXPORT POTENTIAL OF BRAZILIAN AND ARGENTINE INDUSTRIAL FIRMS AND BILATERAL TRADE

Bruno César Pino Oliveira de Araújo

1 INTRODUCTION

In recent years, Brazil and Argentina have both experienced notable increases in exports, though within distinctly different contexts. Whereas Argentina began to register balance-of-payments surpluses on current account after the 2001 crisis (KOSAKOFF; RAMOS, 2005), Brazil has been recording surpluses since 2003.

However, the high figures do not reveal the true dynamics of the entry/exit of firms into or out of the international market, nor do they reveal if the vigorous growth in the exports of the two countries was due to export coefficient increases or to new insertions.

Studies indicate that, in Brazil, exports have traditionally risen via increases in the export coefficient of firms that already export (PINHEIRO; MOREIRA, 2000; MARKWALD; PUGA, 2002), as recommended by export-promotion policy. However, since export-coefficient increases have a limit, if the rate of export growth is to be maintained, the export base must be broadened.

In this regard, the "failure of the export-promotion agencies" in the early 1990s led to a certain discomfort, for the traditional export-stimulation policies had little impact on total exports and, even when successful, their effect was rarely lasting (GUSSO *et al.*, 2004).

This failure of the agencies occurred in the context of rapid changes in trade arrangements, the growing integration of productive chains and a consequent rise in the importance of intra-industry and intra-firm commerce. In this environment, the few major international market agents (players) have acquired tremendous importance, especially in countries such as Brazil and Argentina. In a way, this has inhibited, at least to an extent, the impact of export-promotion measures such as product diffusion, participation in trade fairs and missions, and so forth. Moreover, it explains why the increase in exports is mainly due to firms that already export since they are more readily inserted into productive chains at the world level.

This scenario presents new challenges to policymakers engaged in export promotion. In the first place, it should be underlined that such policies are indeed necessary, though in a new format given that several of the positive results associated with a broadening of the export base go far beyond the balance of trade. Exporters, for example, gain easier access to imported inputs and equipment and tend to adhere to higher technological standards due to their greater exposure to competition, as well as to the possibility of technological cooperation with other firms in the productive chain (AW; HWANG, 1995; CLERIDES *et al.*, 1998). A growing body of empirical literature is dedicated to evaluating productivity gains subsequent to the entry of firms into the international market and, with reference to the Brazilian case, Araújo (2006) demonstrates that firms that participate in the international market grow and become more productive than comparable firms that do not.

Furthermore, in the near future, volume should come to rest on an amplified export base, for the increase in exports cannot continue to be indefinitely supported by rises in the export coefficients of firms that already export.

In the second place, regardless of the format that export-stimulation policies come to assume, the cost of such policies will demand an increasingly clearer focus. It is with regard to this point that one of the contributions of this study lies. Neither in Brazil nor in Argentina do the non-export firms comprise a homogenous set. As to the non-export firms, the traditional dichotomy exporter *versus* non-exporter conveys the impression that it is very hard for a non-export firm to enter the international market and, indeed, the majority of the firms in the non-exporter set are characterized by low competitivity, such that, on average, it would in fact be difficult to engage them in foreign trade. However, considering there is a subset of firms that do not export but lie on the "export threshold", the short-term impacts of export-promotion policies aimed at broadening the export base could be enhanced if they were to focus on this subset.

Likewise, in neither country do the firms that export comprise a homogeneous set. In both there are world-class exporters, leaders in their markets, smaller scale exporters and even occasional exporters. Hence, another contribution of this study is to provide a classification framework for Brazilian and Argentine export firms.

Using this classification as a reference, the sectoral profile is analyzed from the standpoint of export potential in order to verify if the overall export list of one country complements that of the neighboring country and to ascertain if bilateral trade is a viable alternative for inserting potential export firms.

To summarize, the goals of this study are to: (*i*) classify, for Brazil, as well as for Argentina, industrial firms by export potential and thereby surpass the conventional exporter/non-exporter dichotomy; (*ii*) characterize the groups resulting from this classification and, most importantly, (*iii*) point out the differences and similarities between the two countries, together with the ways they complement one another, within the proposed export-potential classification.

The remainder of the text is organized in the following manner. In the next section, the recent industrial evolution of the two countries is discussed. In the third, the data arising from the two studies are presented. In the fourth section are found details concerning the methodology and matching algorithm and in the fifth, a brief review of the empirical literature underlying the probability model on which the matching is founded. In the sixth section, the results of the probability models, together with the classifications by export potential, are presented for Brazil and Argentina. In the seventh, the groups formed are characterized and the pattern of entry/exit of firms and sectoral mapping of export potential analyzed for each country. The concluding observations are presented in the eighth and final section.

2 THE ECONOMIC CONTEXT AND RECENT INDUSTRIAL EVOLUTION OF ARGENTINA AND BRAZIL

Brazil and Argentina have similar industrial histories. During the post-war period, both countries invested in the industrialization process via import substitution (ISI), which came to an end after the second oil shock; both faced severe macroeconomic restrictions in the 1980s and; both stabilized and opened their economies during the 1990s. Nevertheless, subtle yet important differences arose in response to the opening of the respective economies.

According to Kosacoff and Ramos (2005), the protection offered to Argentine industry during the ISI process led to an idiosyncratic accumulation of technological knowledge that diverged from the international technical frontier. Therefore, the end result of the Argentine ISI process was an industrial park somewhat distant from the levels of technology, productivity and scale of world industry. In addition, entrepreneurs faced difficulties when adapting their administrative models (and their mentality models) to the new reality, one far different from the protectionism of the seventies and the "stagflation" of the eighties.

Without a doubt, during the stabilization process and the opening of the economy, subsidiaries of transnational enterprises were in an advantageous position for facing the growing competition since they had privileged access to technology and to the international credit market. In fact, many Argentine groups eventually sold their interests to foreign firms, such that the participation of transnational in the economy rose in the 1990s. Other Argentine firms chose to circumvent domestic credit restrictions by seeking loans abroad. These latter were the most affected by the volatility of capital flows, as well as by the termination of the convertibility regime in late 2001.

Thus, the most dynamic sectors during ISI, such as the metal/mechanical sector, are only a third of what they were in the 1970s (KOSAKOFF; RAMOS, 2005). Throughout a process that began in the mid-seventies, Argentine industry lost so much dynamism that by 2004, industrial value added per capita was 40% lower than it had been in the 1970s (KOSAKOFF; RAMOS, 2005).

After 2001, the level of income per capita showed a frank recovery, returning in 2005 to the 1998 pre-crisis level. Industrial GDP per capita has also been on the path to recovery after reaching its lowest 40–year level in 2002. However, what most calls attention is the change in the macroeconomic context: end of the convertibility regime, improvements in the fiscal framework and, in the external sector, trade and current-account surpluses.

Benefited by a flexible exchange rate, improved terms of trade and world growth, Argentine exports have been increasing vigorously and guaranteeing a positive balance of trade. Argentine exports are concentrated, except for the automotive industry, in natural resource sectors and the transnational firms are responsible for a large share.

It should be noted, however, that despite exchange-rate depreciation, imports also rose significantly over the period. To give an idea, imports in the first five months of 2005 were equal to total imports in 1997 and at a similar GDP level (KOSAKOFF; RAMOS, 2005). Most striking is the importation of final goods by firms. Among the possible explanations, Kosacoff and Ramos (2005) argue that the rise in the import coefficient of firms reveals exercise of the "wait option"; in other words, since the Argentine economy is one of the most volatile in the world, and because firms still consider the future uncertain and have restricted access to credit, given the growing demand, they prefer to import rather than make the risky, and to an extent irreversible, decision to invest.

In sum, at the time the economy started to open, Argentine industry was verticalized, and though firms were producing a well-diversified mix of products (which is typical of protected industries), they lacked scale. Thus, the response of Argentine industry to growing international competition was a higher degree of specialization, notably in the more traditional, natural resource-based tradable goods sectors. Simultaneously, a rapid integration process was set in motion to attain scale and deverticalize the manufacturing sector, plus encourage organizational and technological innovations aimed at guiding the sector to the international frontier, mainly through the acquisition of capital goods and purchase of technology. During this process of structural transformation and industrial reorientation, the transnational firms played a fundamental role because they did not suffer the same credit restrictions and enjoyed privileged access to technology.

However, it would be a mistake to think of the Argentine industrial structure as homogeneous. A mere 400 firms account for approximately 40% of industrial product. Moreover, various Argentine firms were proactive in the 1990s. Some of these firms, which strove to differentiate their products and invested in brands, internationalized and became major world players in their respective segments, such as Edival y Baso (motor valves), TRANSAX (gearshifts), Arcor (foodstuffs) and INVAP (nuclear reactors) (KOSAKOFF; RAMOS, 2005).[1]

In Brazil, the opening of the economy induced a restructuring of the industry similar to that witnessed in Argentina, the difference being that the sectoral profile did not change (CASTRO; ÁVILA, 2004). Nor did the opening of the economy generate the specialization predicted by traditional comparative advantage models. While it is true that certain sectors lost significantly in the first instance, it is also true that others gained formerly unseen comparative dynamic advantages. Consider, for example, the case of the metal/mechanical complex, most notably the aircraft and automotive segments.

Although the sectoral profile was not altered, in many firms and productive chains, the opening of the economy forced changes in control and denationalization. To adapt to the new competitive environment, the Brazilian firms had to make adjustments, but in most of the firms, these adjustments were incomplete and unbalanced insofar as they privileged technical/operational efficiency, deverticalization and outsourcing (but without modification in the productive chains), changes in product management and organization and, lastly, the introduction of process innovations via the importation of equipment and inputs (CASTRO; ÁVILA, 2004). However, the majority of firms failed to invest in competitive strategy measures such as product differentiation, research and development and the generation of value through the creation of trademarks.

Even so, there is an elite set of Brazilian industrial firms that competes via innovation, product differentiation and trademarks. These firms have strong external presence and receive premium prices for their products. According to De Negri and Castro (2005), approximately 1,200 firms that chose to adopt this strategy retain a fourth of total industrial earnings despite representing no more than 2% of the total number of enterprises.[2]

Since 1994, Brazilian industrial output has grown 40% according to the Brazilian Geographical and Statistical Institute (IBGE). However, aggregate industrial performance is closely linked to the macroeconomic environment and reveals a stop-and-go pattern. Once the economy stabilized, industry almost immediately responded to the recovery of purchasing power, especially at the lower income levels, so that, according to IBGE, industrial output rose 7.6% in 1994; unfortunately, this performance was repeated in neither 1995 (+1.83%) nor

1. For a comparison of Argentine firms according to competitive strategy, see the first chapter of this book.
2. For a comparison of Brazilian firms by competitive strategy, see the first chapter of the study cited.

1996 (+1.73%), mainly due to the crisis in Mexico. A partial recovery occurred in 1997, when industrial output rose 3.88%, but the crisis that culminated in the termination of the foreign-exchange anchor affected industrial growth in the following years, so industrial output dropped 2.03% in 1998 and 0.66% in 1999. Then, in the year 2000 and a new macroeconomic context (fiscal discipline, a floating exchange rate and inflationary goals), industrial output increased 6.64%. This performance was subsequently interrupted in 2001 by both domestic (energy crisis) and international events (terrorist attacks, recession in the United States and Argentina), the result being that output increased a mere 1.57%. In 2002, financial speculation and the restrictive monetary policy of the second semester held output growth at 2.7%, with the gains recorded being mainly thanks to the first semester. The monetary policy restrictions continued throughout the first semester of the following year so industrial output remained practically unaltered (+0.1%). The opposite occurred in 2004, when the monetary policy restrictions were lifted and the international scenario turned quite favorable, thereby permitting the strong recovery of industrial growth (+8.4%). This growth trend, though somewhat weakened and not as sectorally homogeneous as in 2004, was maintained in 2005, when industrial output climbed 3.1%.

Most striking in this period is the notable and continuous growth of exports and imports as of 2002. Exports totaled US$ 46.5 billion in 1995 and closed at US$ 60.3 billion in 2002. By 2005, this value had nearly doubled, reaching US$ 118.3 billion. While part of this increase is explained by a rise in the prices of the commodities Brazil exports, the *quantum* exported has also increased significantly (15.6% in 2003, 19.2% in 2004 and 9.3% in 2005). Moreover, the composition of the export list reflects the heterogeneity of the Brazilian productive sector. In 2005, for example, among the segments that most grew in volume exported, products such as cell phones, aircraft and automobiles are found alongside traditional commodities such as coffee, sugar and iron ore.

In counterpart, imports, which closed 2002 at US$ 47.2 billion (slightly under the US$ 50 billion registered in 1995), reached US$ 73.5 billion in 2005. There were also *quantum* increases, 18.12% in 2004 and 5.41% in 2005. In 2005, capital goods were those that registered the highest growth rate (26.7% in relation to 2004 to attain a total US$ 15.4 billion).

This continuous export growth in the context of an exchange rate that has also continuously appreciated since early 2003 draws attention. While this question alone deserves specific research, let us simply comment that theories relating fixed costs of entering the world market to hysteresis in trade flows furnish part of the explanation. Accordingly, firms that already export, and have therefore already incurred initial entry costs, consider it more advantageous to bank narrower margins than to exit the world market and incur re-entry costs, especially given the sharpening of competition in the international markets in which Brazil is competitive. Whereas the same phenomenon has occurred on the import side, the recent appreciation of the exchange rate still does not appear to have occasioned as immediate a response on the part of firms that export to Brazil.

3 DATA

This study is based on industrial research at the firm level in two countries. In the case of Argentina, the data refer to the Second Survey on Innovation and Technological Behavior of Argentine Firms, based on fieldwork in conjunction with the National Statistics and Census Institute (INDEC), the Secretariat for Science, Technology and Productive Innovation (SECyT) and the Economic Commission for Latin America and the Caribbean (ECLAC). The qualitative data are for the period 1998-2001, whereas the quantitative data refer only to 2001. In the case of Brazil, the data used in this study were derived from several bases: the Annual Industrial Survey (PIA) and the Technological Innovation Survey (PINTEC), both conducted by IBGE; the external trade data base of the Secretariat for Foreign Trade (SECEX) of the Ministry of Development, Industry and Foreign Trade (MDIC); the Annual Report on Social Indicators (RAIS) of the Ministry of Labor and Employment (MTE); and the Foreign Capital Census (CEB) of the Central Bank of Brazil (BACEN). All quantitative information refers to the year 2000, the reference year for the PINTEC quantitative data. The qualitative information covers the period 1998-2000.

In the cases of both Argentina and Brazil, the data are in accord with the United Nations International Standard Industrial Classification (ISIC), sectors 15 to 36, which refer to the manufacturing industries. For Brazil, the information precisely corresponds to the PIA and is therefore comprised of firms that employed over 30 workers in the year preceding the survey. In contrast, the information for Argentina refers to firms with more than 10 employees.

In the Brazilian PINTEC, the sample was biased to allow the researchers to interview innovative undertakings since technological innovation is a rare phenomenon. In contrast, in the Argentine study, the enterprises were randomly selected from the 1997 input-output matrix. However, the research institutes calculated expansion factors for each firm surveyed to avoid prejudicing the statistical inferences.

Integration of the Brazilian data bases produces a final sample of 7,746 industrial firms. Note that a firm may represent a set of plants, in the case of multi-plant firms. Taking the expansion factor into account, these 7,746 firms represent 22,193 production units, or 73% of employment, 88% of industrial value added and total net income and 89% of Brazilian industrial exports. In Argentina, the 1,688 firms interviewed correspond to 11,721 production units or 42% of employment, 65% of revenue and 80% of manufactured exports.

It should be noted that the surveys contain methodological differences as to the concept of certain variables. In addition, one survey may present variables that do not appear in another. When pertinent, comments will be made in the text with regard to these differences. Another point that should be mentioned is that, whereas the Brazilian quantitative data refer to 2000, a year that was good for industry, the Argentine data were gathered in 2001, the year that witnessed the apex of the crisis that culminated in the end of the convertibility regime in the month of December.

3.1 Differences between exporters and non-exporters

Export and non-export firms are compared in Table 1. In Brazil, of a total 22,193 firms, 6,947 or 31.3% are exporters. In Argentina, the percentage is similar at 31.9%, which corresponds to 3,735 firms.

For Brazil, the variable designated industrial value added (IVA) is used. This variable, which represents the value added during the production process, is defined as the revenue of the firm less consumption of raw materials and intermediate goods. Also employed is expenditure on electric energy, which in econometric studies often serves as a proxy for the use-of-capital factor. In addition to these two variables, neither of which appears in the Argentine study, the work elaborated by De Negri (2003), who calculated indicators of efficiency of scale in industry using Data Envelopment Analysis (DEA), can also be applied to the Brazilian case. In compensation, the Argentine survey discriminates expenditures on innovative activities, that is, on the purchase of machinery and equipment, the acquisition of R&D outside the firm and the contracting of technology, industrial design and training aimed at the use of new technologies. These expenditures were aggregated and calculated as a proportion of revenue.

In both countries, exports account for approximately 22% of the revenue of the firms. Comparing firms that export to firms that do not confirms the traditional dichotomy between exporters and non-exporters. On average, export firms are larger, more productive and more efficient, employ better educated workers and innovate more than non-export firms, in accordance with the profile outlined by Tybout (2003). The variables selected for the comparison herein will be more finely detailed on presentation of the probability model.[3]

3. It is suggested that the reader interested in a more detailed description of the characteristics of Brazilian export firms analyze the works of F. De Negri (2004) and Ellery Jr. and Gomes (2005). For a more detailed portrayal of Argentine export firms, consult Chudnovsky, López and Orlicki (2005).

TABLE 1
Statistical description of export firms and non-export firms

	Brazil (2000)		Argentina (2001)	
	Non-export firms	Export firms	Non-export firms	Export firms
Number of firms	15,246	6,947	7,986	3,735
Average IVA (US$ thousand)	1,032.62	2,489.39	-	-
Average revenue (US$ thousand)	-	-	2,893.48	17,431.90
Productivity (IVA/Worker – US$ thousand)	12.01	32.53	-	-
Productivity (Revenue/Worker – US$ thousand)	-	-	64.91	106.58
Electric energy expenditure(US$ thousand/ Worker)	0.52	1.14	-	-
% of employees by educational level:				
complete primary schooling	82	70	75	66
complete secondary schooling	16	24	21	28
university degree or higher	3	7	5	9
% of firms by size class (number of workers employed:				
1 (1 to 30)	12	4	61	26
2 (31 to 50)	35	14	15	23
3 (51 to 100)	32	23	15	23
4 (101 to 250)	15	28	7	20
5 (251 to 500)	4	15	2	5
6 (501 to 1000)	1	8	0	2
7 (1001 or more)	1	7	0	1
% of firms with:				
increasing returns to scale	85	58	-	-
constant returns to scale	5	12	-	-
decreasing returns to scale	10	30	-	-
% of firms by type of innovation:				
product for firm	17	31	15	29
product for market	4	17	14	34
process for firm	29	39	19	42
process for market	3	13	5	15
Internal R&D/IVA (%)	0.82	1.46	-	-
Internal R&D/Revenue (%)	-	-	0.19	0.26
Innovation activity/Revenue (%)	-	-	0.01	0.01
% of transnational firms	1.29	16.75	4.00	14.00

Sources: Brazil: IPEA and original elaboration based on data from PIA, PINTEC, RAIS, SECEX and BACEN. Argentina: IPEA and original elaboration based on data from the Second Innovation and Technological Behavior Survey.
Obs.: The information is in US$ at 2001 prices.

As commented earlier, comparison between the industries of the two countries is rendered difficult by macroeconomic divergences, as well as by the tabulations for Brazil having been made, when possible, in relation to the IVA (productivity, for example), such that the productivity measures are not directly comparable. In any case, it is readily verifiable that the Argentine labor force is more qualified and that the Brazilian firms, especially the export firms, are larger. The Argentine firms only appear larger because of the classification scheme adopted, which set the sample-size cut-off at10 employees.[4]

As to R&D expenditures in relation to revenue, earlier tabulations indicate that Brazilian industrial firms invest roughly 0.7% of their revenues in R&D (SALERNO; DE NEGRI; CASTRO, 2005) and that Argentine firms invest about 0.2%. These percentages are far below European investment levels. In France, for example, the percentage of revenue that firms spend on R&D is 2.5% and in Germany the percentage is 2.7%.

With regard to innovation, the tabulations indicate that Argentine firms innovate more for the market than Brazilian firms both from the standpoint of product and process. Since innovation is procyclical in relation to the macroeconomic environment, this paradox has two possible explanations: (*i*) the question posed in the survey refers to the period 1998-2001 in Argentina, but to the period 1998-2000 in Brazil, or (ii) cognitive differences exist as to the concept of innovation of new product/process for the market on the part of the respondents.

4 METHODOLOGY[5]

Intuitively, potential export firms can be defined as firms that do not export but present a level of competitivity similar to that of firms that do. However, knowing that international competitivity is owing to various factors, how can all these factors be compared simultaneously? By some means, this set of factors has to be ranked on a scale, such that firms in similar positions on the scale have similar levels of competitivity.

Therefore, the technique chosen was propensity score matching (PSM). This technique is widely applied in the so-called quasi-natural experiments used to assess social programs (*e.g.* minimum-wage and labor retraining/repositioning programs).[6]

Our research problem is quite different, however, from that originally solved by PSM. Although PSM could be used to test the causal relationship between exports and productivity, here the technique will be used for a different purpose.[7]

The probabilistic model will serve to condense the competitivity indicators onto a scalar. This having been done, the pairs on the scalar will be matched.

4. In fact, when the first size class (1-30 employees) is disregarded, the distribution by firm size is seen to be more concentrated at the upper end for Brazil than for Argentina.

5. This section is based on Araújo and Pianto (2005).

6. On quasi-natural experiments in the field of economics, see Meyer (1995).

7. Girma *et al.* use PSM in its original form for this purpose, defining the fact that a firm exports or not as the treatment and subsequently accompanying export and non-export firms over time, thereby applying the "difference of the differences" technique (with reference to this technique, see Meyer [1995]).

Hence, the procedure assumes the following form. Let $\hat{p}(X_j)$ stand for the probability that firm *j*, a non-export firm, will export. Let us assume that *j* is a potential exporter if, within close range of $\hat{p}(X_j)$, there is at least one $\hat{p}(X_i)$, with *i* being an export firm. The idea is that, if the model is well specified, potential export firms and matched exporters will have similar characteristics.

In more formal terms, we know that $\hat{p}(X_j) = \Phi(X_j \mathrm{b})$, where ( ) is a function of accumulated distribution, *j* is the line vector of the determinants of export probability for firm *j* and is the column vector of the estimated coefficients of the model. If PSM renders $\hat{p}(X_j) \approx \hat{p}(X_i)$, then $\Phi(X_j \mathrm{b}) \approx \Phi(X_i \mathrm{b})$ and

$$\Phi(X_j \mathrm{b}) \approx \Phi(X_i \mathrm{b}) \Rightarrow X_j \mathrm{b} \approx X_i \mathrm{b} \Rightarrow \sum_{k=1}^{q} \mathrm{b}_k (x_{jk} - x_k) \approx 0$$

The interpretation of the above expression is the following: either (*i*) potential export firms possess characteristics very similar to their matched export firms such that *ji*, or (*ii*) even presenting some distinct variables *jk* and *ik*, these differences, when weighted by the *k*, somehow compensate one another. In practice, as will be demonstrated, the results favor the first interpretation for both Brazil and Argentina.

Using PSM to locate potential export firms offers a methodological advantage over other alternatives, for instance, defining potential export firms as those that do not export despite their $\hat{p}(X)$>0.5. The first advantage is that this cutoff point is necessarily arbitrary: Why 0.5 and not some other value? The second advantage is that PSM allows for identification of hidden export champions (WAGNER, 2002) that would likely remain unidentified if a probability cutoff were employed. This can be illustrated in the following manner. Assume that the sole determinant of export probability is firm size, in linear form, and that the relation is positive. Upon setting a probability cutoff point, a size cutoff is implicitly established as well, leading to conclusions of the type “firms under size have no export potential,” which contradicts the observation that numerous smaller firms enjoy excellent levels of competitivity on the international market.

It should be noted that application of the matching algorithm produces, in addition to firms with export potential and matched export firms, two other types of firms: unmatched export firms and unmatched non-export firms. Interestingly, all these groups, and not only the matched export/non-export firms (“cases” and “controls”) have economic significance.

If the model is well specified, the distribution of $\hat{p}(X)$ will be asymmetric to the left for non-exporters and asymmetric to the right for exporters. Thus, unmatched non-export firms, being firms with a low $\hat{p}(X)$ that have not found export firms with similar characteristics, are firms with lower levels of foreign competitivity and export potential. Analogously, unmatched export firms are firms that tend to present a higher $\hat{p}(X)$ and have not encountered any non-export firms with like characteristics. These firms stand at the highest level of international competitivity.

We therefore have a fourfold classification scheme by export potential:

- Level 1: Non-export firms (unmatched non-export)
- Level 2: Potential export firms (matched non-export)
- Level 3: Paired export firms (matched export)
- Level 4: Outstanding export firms (unmatched export)

It should be stressed, however, that the quality of this classification depends on the probability model. Therefore, in order to provide a basis for the model, the next section contains a brief discussion of the empirical literature on the microdeterminants of international trade. Special attention is given to studies of the theme that deal with Brazil and Argentina.

5 EMPIRICAL DETERMINANTS OF INTERNATIONAL TRADE AT THE FIRM LEVEL

According to prevailing economic theories, the relative productivity of a firm, relative use of factors, size of firm and efficiency of scale, in addition to technological factors, are foreign trade determinants. However, one should be aware of the difficulty of constructing firm-level variables to fit some of these theories (notably the Heckscher-Ohlin theorem, which is essentially macroeconomic). For this reason, caution is necessary when constructing and interpreting these variables because there is more than one way to do so.

Besides these determinants, others often appear in macroeconomic models. In empirical texts, it is common to see, for example, age of firm (as a proxy for past competitivity), degree of competition within the sector (HHI, CR) and transnationality (for which specific literature exists, *e.g.* Dunning (1981) and Dunning (1993)). The fixed costs of entering the international market, which explain the phenomenon of histeresis in foreign trade, also play an important role. Consider, for example, the lagged response of trade flows to changes in the macroeconomic environment such as those associated with changes in the exchange rate.

For the purpose of this study, articles were reviewed on both developing and developed countries, as well as studies that specifically refer to Brazil and Argentina.[8] In these two countries, work with microdata is comparatively recent owing to the difficulty of accessing individual data that are held in strict secrecy. Nonetheless, since Willmore (1992), the literature in this area has been rapidly expanding. The works analyzed for Brazil include, in addition to that by Willmore (1992), articles by Pinheiro and Moreira (2000), Arbache (2002), Carneiro (2002), De Negri (2003), F. De Negri (2004), De Negri and Freitas (2004) and F. De Negri (2005). For Argentina, articles by Chudonovsky, López and Orlicki (2005) and Chudnovsky, López and Pupato (2005) were taken into consideration.

In the case of Argentina, Chudnovsky, Lopez and Orlicki (2005) are concerned with the relationship between innovation and export performance. On the basis of the same data we employ, the authors conclude that introducing a new product on the market raises the probability of exporting by an average 7.4%. However, with regard to the export coefficients, only process innovation for the firm appears to exercise a positive impact on the Argentine industrial aggregate. When the data are disaggregated by technological content (according to the UNCTAD classification), it becomes apparent that whereas process innovation for the firm has a positive impact on export intensity for firms in medium- and high-tech sectors, process innovation for the market positively influences the export coefficients of firms in both the low- and high-tech sectors. As to the control factors, productivity, size, transnationality, importation by firm and quality of labor force generally have the expected signs with respect to the shape of probability and to that of intensity.

In turn, in Chudnovsky, López and Pupato (2005), the focus is on ascertaining the determinants of innovative activities and innovations, together with the impact of innovations on the performance of firms. Amongst the determinants of innovative activities and innovations are exports. For this work, since the authors were able to rely on the first version of the National Survey on Innovation and Technological Behavior, which covers the period 1992-96, the estimates considered fixed effects, time effects and sectoral trends. The conclusion is that the fact a firm exports affects neither the probability nor the intensity of its innovative activities. Moreover, in the multinomial innovation probability model, exports positively affect the probability of a firm being innovative with respect to product and process together, but not with its being innovative with regard to product or process alone.

In conclusion, the articles on Brazil suggest that the export determinants reflect the intermediate stage of industrial development of the country's economy. On the one hand, the foreign trade statistics indicate that Brazil continues to

8. For a more complete review that deals with the econometric issues involved, consult Araújo (2005).

have comparative advantages in commodities, as well as natural-resource and labor-intensive sectors. On the other, the microeconomic models suggest that microeconomic factors such as scale returns, innovation and technology, together with human capital (though agreement is not uniform as to this latter) make the difference for exports. Thus, different firms in the same sector may reveal different levels of international competitivity. The results of the microeconometric studies for Brazil and Argentina are summarized in the table below.

TABLE 2
Empirical evidence on export determinants in Argentina and Brazil

Article	Sample	Research problem	Methodology	Main Results
Chudnovsky, López and Pupato (2005)	1,633 Argentine firms, 1992-96, and 1,688 Argentine firms, 1998-2001	Determinants of innovation, innovative efforts and impacts of innovation on productivity	Logit with fixed conditional effects, multinomial model for types of innovation (product, process or both)	The fact that a firm exports affects neither the probability nor the intensity of innovative activity. In the model, exports positively affect the probability of a firm innovating with respect to product and process.
Chudnovsky, López and Orlicki (2005)	1,688 Argentine firms, 1998-2001	Role of innovation in exports	Probit and OLS, without Heckman correction	Product innovation positively affects export probability, but not export intensity, which is impacted by process innovation for the firm within the cluster. Disaggregation by technological content (UNCTAD) yields mixed results.
Willmore (1992)	3,764 export, 2,826 import and 652 transnational firms, 1980	Role of transnationals in Brazilian foreign trade	Probit and truncated OLS	Although transnationals export and import more, their trade balance is negative. R&D negatively affects volume imported.
Pinheiro and Moreira (2000)	18,400 firms, 1995-97	General test of determinants by destination	Probi*t* and truncated OLS	While the determinants may vary according to destination, the relation between firm size and exports is always positive. Export-promotion policy should focus on firms that already export.
Carneiro (2002)	55 large firms with all information, 1995 and 2000	Verify if transnationals tend to export more to their countries of origin and regional blocks	Probit	Transnationals indeed tend to export more to their countries of origin as they achieve business success. The same occurs in relation to regional blocks (NAFTA, MERCOSUR and ALCA).
Arbache (2002)	50,000 firms, 1998	Verify export determinants and impacts of opening of economy on competitivity, as well as suggest government policies	Probit	There are comparative advantages that do not rest on traditional theory and the opening of the economy exerts a negative impact on income distribution. Strategic industrial and trade policies are suggested.
DeNegri (2003)	50,000 firms, 1996-2000	Illustrate the role of efficiency of scale as an export determinant	DEA methodology for efficiency frontier, then sectoral probit for 2000	Efficiency of scale is, in fact, an important determinant.
DeNegri and Freitas (2004)	50,000 firms, 2000	Illustrate the roles of efficiency of scale and innovation as export determinants	Sectoral probit and Tobit	In both models, the innovation and efficiency-of-scale indicators are positive and significant.

(continued)

(continuation)

F. DeNegri (2004)	50,000 firms, 1996-2000	Measure the impact of transnationals on Brazilian foreign trade	OLS with fixed and random effects	When the effects are fixed, transnational firms do not export more than domestic firms, but they do import more. When the effects are random, transnational firms both export and import more, but the balance remains negative.
F. DeNegri (2005)	50,000 firms, 2000	Measure the impact of transnationals on Brazilian foreign trade by technological content (UNCTAD)	Truncated OLS for imports and exports	The impact of transnationals on exports is stronger in medium-tech sectors, whereas their impact on imports is stronger in high-tech sectors.

Source: Original elaboration, Araújo (2005).

6 PROBABILITY MODEL AND CLASSIFICATION SCHEME IN ACCORDANCE WITH EXPORT POTENTIAL

6.1 The probability model

The probability models in which the matching is performed, with the estimates being calculated using the probit technique, have as the binary dependent variable the fact that a firm exported or not in 2000 (for Brazil) or 2001 (for Argentina). It is important to mention that these models do not "test" the determinants of international commerce at the firm level, but merely provide a basis for the matching algorithm.[9]

The export probability determinants can be divided into five groups as follows:[10]

- Productivity – This determinant relates to the Ricardo theorem. For Brazil, the data are from the PIA and productivity is defined as industrial value added divided by the average number of workers employed in the year 2000. Since the Argentine survey does not contain data on manufacturing value added, the revenue per worker employed serves as the productivity measure, as commented earlier.
- Factor intensity – Based on the Heckscher-Ohlin theorem, to determine the intensity of use of capital, the PIA data on electric energy expenditures per worker were utilized. In turn, the proportion of qualified labor, defined as the proportion of workers with complete primary schooling (according to the RAIS), is used to ascertain the intensity of use of human capital.[11] Unfortunately, expenditures on electric energy are not included in the Argentine study. For the proportion of qualified labor in Argentine firms, the ratio used is the number of workers with higher education to the total number of workers.

9. Such tests would have to take into account at least the effects related to histeresis and to the strong dependency of current on past export performance. This would involve panel analyses and the use of certain techniques that would not permit application of the matching algorithm.

10. The model also employs sectoral controls (2-digit ISIC) and federal, state and territory controls (for Brazil only).

11. These proxies are admittedly imperfect.

- Scale and gains in scale – A larger firm is more capable of running risks and overcoming the fixed costs associated with insertion into the international market (WAGNER, 2002), in addition to having privileged access to the credit market. Moreover, serving the international market requires a production scale that is often incompatible with smaller-size firms. For these reasons, the production scale of a firm is expected to be positively correlated with its export probability. The scale of a firm is represented by its number of employees, so seven employee classes were constructed:

- class 1 - from 1 to 30 employees
- class 2 - from 31 to 50 employees
- class 3 - from 51 to 100 employees
- class 4 - from 101 to 250 employees
- class 5 - from 251 to 500 employees
- class 6 - from 501 to 1000 employees
- class 7 - 1001 or more employees

For Brazil, in addition to scale, it was possible to estimate the likelihood of gains in scale owing to international trade, *i.e.* marginal decreases in unit cost due to marginal increases in the size of the firm. The technique used was Data Envelopment Analysis (DEA), formerly applied by De Negri (2003). Employing DEA, a deterministic production frontier with conceivably different gains in scale can be estimated in such a way that the firm faces three possibilities: increasing, constant or decreasing returns to scale (scale classes 1, 2 and 3, respectively). The possibilities are captured by binary indicators (dummies).

- Technological determinants – For Brazil, the innovation variables are based on the PINTEC and comprise binary indicators as to whether the firm was engaged, during the period 1998-2000, in product innovation for the firm or for the market or in process innovation for the firm or for the market. The same variables are used for Argentina and are based on the Second Survey on Innovation and Technological Behavior, which refers to the period 1998-2001. With regard to innovative activities, both models incorporate a research and development (R&D) ratio in squared form: R&D/industrial value added (IVA) for Brazil and R&D/revenue for Argentina. The Argentine survey also includes detailed information on other innovative activities such as training and acquisition of licenses. All these expenditures (on purchase of machinery and equipment, external acquisition of R&D, technology contracts, industrial design and training) were aggregated and divided by the revenue of the firm to mount the indicator "innovation activities/revenue."

• Transnationality – For both countries, a binary indicator is used to represent a foreign share in capital of more than 50%.

Finally, the results of the model are presented in Table 3.

TABLE 3
Probability models for the determinants of firms' exports (Argentina and Brazil)

Variable	Brazil (2000)		Argentina (2001)	
	Coefficient	Sig.	Coefficient	Sig.
Intercept	-3.130	**	-2.679	**
Productivity	0.002	**	0.320	**
Capital/Labor ratio	0.023	**	-	-
% Qualified workers	0.002	**	-0.058	n.s.
Class 2 employees	0.093	*	0.836	**
Class 3 employees	0.345	**	0.691	**
Class 4 employees	0.930	**	1.206	**
Class 5 employees	1.336	**	1.230	**
Class 6 employees	1.551	**	1.385	**
Class 7 employees	1.479	**	1.767	**
Increasing returns to scale	-0.076	+	-	-
Decreasing returns to scale	0.178	**	-	-
Product innovation for the firm	0.186	**	-0.052	n.s.
Product innovation for the market	0.365	**	0.332	**
Process innovation for the firm	0.019	n.s.	0.146	**
Process innovation for the market	0.227	**	0.257	**
Internal R&D/IVA	3.440	**	-	-
$(\text{Internal R\&D/IVA})^2$	-30.350	**	-	-
Internal R&D/Revenue	-	-	0.098	**
$(\text{Internal R\&D/Revenue})^2$	-	-	-0.014	**
Innovation activity/Revenue	-	-	1.825	**
Foreign share in firm over 50%	0.854	**	0.330	**

Obs.: Log Likelihood = -9,745.50 (Brazil) and -5,152.89 (Argentina). Number of observations = 7,746 (Brazil) and 1,528 (Argentina). Number of export firms (expanded) = 6,947 (Brazil) and 3,532 (Argentina). Number of non-export firms (expanded) = 15,246 (Brazil) and 7,241 (Argentina). Reference group: SIC 1 firm located in Sergipe with class 1 employees and constant returns to scale. Only in Brazil were regional controls used. Controls for the Distrito Federal and sectoral controls were not reported.** Significant at 1%, * Significant at 5%, + Significant at 10%.

Almost all the variables in the model have the expected signs, both for Brazil and for Argentina. Productivity, the capital/labor ratio, firm's size and transnationality are positively related to firm's exports. Size apparently inflects slightly as of class 6 for Brazil (though seemingly this does not occur for Argentina). In other words, the larger the firm, the higher the likelihood that it exports because the larger scale contributes to overcoming the costs of entering the international market, as well as to generating economies of scale within the firm. In addition, larger firms have readier access to financing, which is an important factor in these two countries, both of which have imperfect credit markets. These results are consistent with the microeconomic studies discussed in section 4.

In Brazil, the fact that a firm has increasing returns to scale negatively affects its export probability. This occurs because increasing returns to scale indicate inefficiency of scale, for the firm could enhance its production scale to lower its unit cost. One way to gain scale, for example, is to participate in international trade (HELPMAN, 1984). Analogously, the fact that a firm has decreasing returns to scale suggests that there are no longer advantages to be gained from scale. This said, the signs of the models for these variables are as expected since it is understandable that inefficiency of scale is negatively associated with exports. Similar results are found by Davis and Weinstein (2003) for both the probit and tobit estimates, though the authors interpret the outcome as a puzzle.

As to technology, in both Brazil and Argentina, it is extremely important that the firm be innovative, notably with respect to product and process for the market. For the Brazilian firms, the only variable that is not significant in the model is the innovation dummy representing process for the firm. This may reflect efforts on the part of the firm to keep pace with the technological changes in its sector, but without generating competitive advantages in the international environment. For Argentina, the only innovation variable that is not significant is new product for the firm. The signs for R&D (positive for the term at the first potential and negative for the term squared) suggest that the ratio between this variable and export probability takes the form of an inverted “U” and thus has a peak. While this stands for both Brazil and Argentina, the coefficients are not directly comparable because they refer to different indicators. For Brazil, the peak lies at roughly 5% of R&D to IVA, whereas the peak for Argentina is lower at 3.5% of R&D to revenue, probably due to the crisis.

With specific reference to the impact of innovation on exports, the results of this study are somewhat different from those of Chudnovsky, López and Orlicki (2005), who found that, in Argentina, only the innovation of a new product for the market affected the probability that a firm would export. This difference in results is explained by the fact that these authors did not use expansion factors in their econometric models.

6.2 Classification according to export potential

For the PSM, the greedy algorithm of the SAS software was used.[12] This algorithm matches pairs of firms at specified levels of precision. For example, a two-digit matching signifies that an export firm with $\hat{p}(X) = 0.5674$ will be matched to a non-export firm with $\hat{p}(X) = 0.6\ xpto$. Hence, the difference between the probabilities matched will never be more than 1%. In a three-digit matching, the same firm would be matched to a non-export firm with $\hat{p}(X) = 0.567\,pto$, and so on.

12. The program is available in Parsons (2001).

The main advantage of this algorithm is its computational simplicity, a very important characteristic when working with samples involving thousands of observations. In this study, the algorithm was applied several times, starting at an initial precision of six digits. When firms did not match at six digits, the algorithm was applied at five, and so forth until reaching the two-digit level. At each step, the matched firms were removed from the sample as procedure dictates. If more than one non-export firm was to be matched to an export firm, the pairing was random. The technique naturally had to be applied in the absence of expansion factors, which were subsequently computed after classification of the firms.

In the original sample prior to expansion, 2,449 Brazilian firms are classified at level 1 and 1,643 at levels 2 and 3, respectively, while 2,011 are considered outstanding exporters (level 4). At the same levels, the equivalent Argentine figures are 597, 236 and 614. Once the expansion factors are applied, firms directed to the internal market account for almost half of the manufacturing industry total in both countries: 10,802 Brazilian firms and 6,202 Argentine firms on level 1; 4,443 Brazilian and 1,783 Argentine firms on level 2; 3,891 Brazilian and 1,392 Argentine firms on level 3 and, lastly; 3,055 Brazilian firms and 2,342 Argentine firms on level 4, as shown in Table 4.

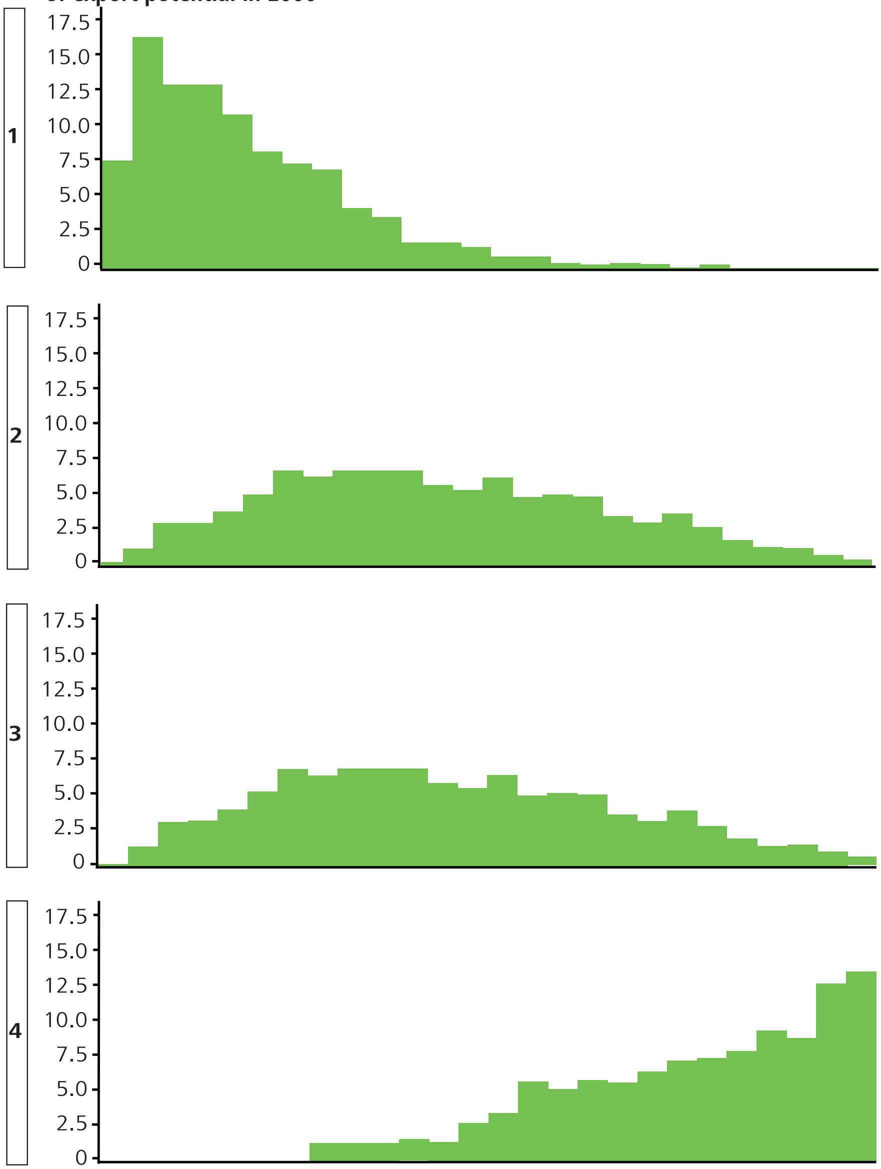
TABLE 4
Analysis of export probability distributions by level of export potential (2000)

	Brazil (2000)				Argentina (2001)			
Statistic	Level 1	Level 2	Level 3	Level 4	Level 1	Level 2	Level 3	Level 4
Number of firms (sample/expanded sample)	2,449/10,802	1,643/,443	1,643/3,891	2,011/3,055	597/6,202	236/1,783	236/1,392	614/2,342
Average *p*(*X*)	0.138	0.373	0.376	0.757	0.189	0.372	0.414	0.581
Median	0.106	0.339	0.346	0.788	0.131	0.349	0.384	0.614
Standard deviation	0.249	0.276	0.326	0.228	0.570	0.574	0.505	0.448
Asymmetry	1.006	0.276	0.22	-0.984	1.027	-0.007	-0.006	-0.653
Kurtosis	0.802	0.737	-0.032	1.844	0.452	-0.798	-0.797	-0.411
Highest Value	0.811	0.995	0.995	1.000	0.963	1.000	1.000	1.000
Lowest Value	0.000	0.018	0.018	0.185	0.008	0.022	0.022	0.084

Source: Original elaboration.

With reference to both countries, Table 4 shows that the distribution of probabilities conforms to that discussed in section 3: firms on level 1 have lower $\hat{p}(X)$ and their distribution is asymmetric to the left, whereas the opposite occurs in the case of those on level 4. Firms on levels 2 and 3 register similar measures of central tendency as well as similar probability distribution indicators. These considerations can be better visualized with the aid of Figure 1, which presents histograms of estimated Brazilian export probabilities, at all four levels of export potential, in the year 2000.

FIGURE 1
Histograms of estimated export probabilities for the four levels of export potential in 2000



Source: Original elaboration.
Obs.: Clockwise from upper left corner: Levels 1 (non-export firms), 3 (paired export firms), 4 (outstanding export firms) and 2 (potential export firms).

7 CHARACTERIZATION OF PRODUCTIVE STRUCTURES ACCORDING TO EXPORT POTENTIAL

7.1 Similarities and differences across categories

As discussed in section 3, in terms of probability, the similarity in firms classified at levels 2 and 3 may be due not to similarities between the firms, but rather to the variables somehow compensating one another.

Fortunately, this is not what happens, as can be demonstrated through mean tests for the quantitative variables and distribution tests for the qualitative variables. The means and distributions of selected variables are presented in Table 5, while the equality of the means is tested for quantitative variables in Table 6.

The equality of the means of the quantitative variables was tested according to ANOVA and Tukey procedures. Despite assuming normal distribution of the variables, both tests hold up well in the event of deviations from the hypothesis when applied to large samples. In addition, there is a null hypothesis rejection bias in the non-parametric tests for large samples. Whereas the ANOVA test gauges the simultaneous equality of the means for all four export potential levels, the Tukey test indicates equality across two or three categories. The ANOVA test rejects the null hypothesis for equality of the means at 1% for all the quantitative variables; the results of the Tukey test at 5% are reported in Table 6. Due to a null hypothesis rejection bias when the test is run with an expansion factor, the mean tests were performed both with and without an expansion factor.[13]

TABLE 5
Statistical description by level of export potential

	Brazil(2000)				Argentina (2001)			
	Level 1	Level 2	Level 3	Level 4	Level 1	Level 2	Level 3	Level 4
Number of firms	10,802	4,443	3,891	3,055	6,202	1,783	1,392	2,342
Average revenue (US$ thousand)	-	-	-	-	2,181.98	5,369.07	7,198.32	23,514.56
Productivity (IVA/Worker - US$ thousand)	9.23	18.76	19.77	48.79	-	-	-	-
Productivity (Revenue/Worker - US$ thousand)	-	-	-	-	54.9	99.0	81.4	122.13
Electric energy expenditure (US$ thousand/Worker)	0.48	0.63	0.71	1.68	-	-	-	-
% of employees by educational level:								
complete primary schooling	82.9	78.53	75.2	62.34	77.0	70.0	69.0	64.0
complete secondary schooling	14.98	17.83	20.18	28.2	20.0	25.0	26.0	29.0
university degree or higher	2.09	3.62	4.61	9.45	4.0	7.0	7.0	10.0

(continued)

13. The following example is illustrative. If a firm has an expansion factor equal to 10, the expanded sample will repeat the observation for this firm 10 times. Although there will be no bias in the calculation of the means, the variance of the expanded sample will be lower than the population it supposedly represents, for the variance within the group of 10 that the firm stands for will be zero.

(continuation)

% of firms by size class (number of workers employed):								
1 (1 to 30)	14.67	5.55	6.64	0.92	69.0	36.0	27.0	25.0
2 (31 to 50)	40.54	22.87	22.27	3.92	11.0	29.0	31.0	18.0
3 (51 to 100)	32.15	31.11	30.15	14.96	12.0	22.0	18.0	26.0
4 (101 to 250)	9.98	26.34	25.9	31.2	6.0	10.0	18.0	20.0
5 (251 to 500)	1.85	8.62	8.8	22.32	2.0	2.0	3.0	6.0
6 (501 to 1000)	0.36	2.95	3.13	14.29	0.0	1.0	1.0	3.0
7 (1001 or more)	0.46	2.57	3.08	12.39	0.0	0.0	0.0	2.0
% of firms with:								
increasing returns to scale	90.55	71.32	70.57	42.44	-	-	-	-
constant returns to scale	3.31	8.79	10.1	14.15	-	-	-	-
decreasing returns to scale	6.14	19.89	19.33	43.41	-	-	-	-
% of firms by type of innovation:								
product for firm	14.7	23.65	25.1	37.58	14.0	16.0	21.0	33.0
product for market	1.72	8.13	8.11	29.28	11.0	24.0	28.0	38.0
process for firm	26.4	35.45	33.67	46.33	17.0	27.0	34.0	47.0
process for market	1.36	6.05	6.43	21.51	3.0	13.0	13.0	16.0
Internal R&D/IVA (%)	0.7	1.1	1,2	1.8	-	-	-	-
Internal R&D/Revenue (%)	-	-	-	-	0.17	0.24	0.22	0.29
External R&D/IVA (%)	0.04	0.13	0.14	0.76	-	-	-	-
Innovation activity/Revenue (%)	-	-	-	-	0.01	0.01	0.01	0.01
% of transnational firms	0.21	3.93	4.43	32.44	3.00	9.00	6.00	19.00

Sources: Brazil: IPEA and original elaboration based on data from PIA, PINTEC, RAIS, SECEX and BACEN. Argentina: IPEA and original elaboration based on data from the Second Innovation and Technological Behavior Survey. The information is in US$ at 2001 pric es.

Once again, it should be remembered that Table 5 is designed not to compare Brazilian and Argentine firms (especially since the majority of the indicators/variables are not directly comparable), but rather to assess the efficacy of the algorithm used to classify the firms of each country by export potential. Thus, as Table 6 shows, groups 2 and 3 present equal means for nearly all the quantitative variables for both countries, though the results differ slightly depending on whether or not the expansion factor is applied.

In turn, level 1 reveals less favorable competitivity indicators, while those for level 4 are the most favorable. An emblematic case is productivity: for Brazil, the productivity of outstanding export firms is 2.5 times higher than that of paired export firms, and non-export firms fail to achieve even half the productivity of potential export firms. Even though the measure of productivity is different for Argentina, the productivity of outstanding export firms is 50% higher than that of paired export firms, and the productivity of level-1 firms is barely over half that of potential export firms. This demonstrates that neither the export group nor the non-export group is characterized by homogeneity.

TABLE 6
Mean tests (Tukey grouping) of quantifiable variables by export potential

	Brazil (2000)		Argentina (2001)	
	Equal levels		Equal levels	
	Parametric tests		Parametric tests	
	Weighted	Unweighted	Weighted	Unweighted
Average revenue (US$ thousand)	-	-	2=3	1=2=3
Productivity (IVA/Worker - US$ thousand)	2=3	2=3	-	-
Productivity (Revenue/Worker - US$ thousand)	-	-	.	2=3=4; 1=2
Electric energy expenditure (US$ thousand/Worker)	2=3	2=3	-	-
% of workers with university degree or higher	.	2=3	2=3	2=3
Work force	-	-	2=3	1=2=3
Internal R&D/IVA (%)	2=3	1=3; 2=3	-	-
Internal R&D/Revenue (%)	-	-	1=2=3; 2=3=4	1=2=3=4
External R&D/IVA (%)	1=2=3	1=2=3	-	-
Innovation activity/Revenue (%)	-	-	1=2; 3=4	1=2=3; 3=4

Sources: Brazil: IPEA and original elaboration based on data from PIA, PINTEC, RAIS, SECEX and BACEN. Argentina: IPEA and original elaboration based on data from the Second Innovation and Technological Behavior Survey.
Obs.: Tukey grouping at 5%. "–"not available, "." no Tukey group found for variable.

The qualitative variables show a like pattern of differences. The distribution of these variables is shown in Table 5. The distributions for levels 2 and 3 export potential are once again very similar for the workers-employed (size class), returns-to-scale (Brazil), innovation and transnationality variables. Level-4 firms tend to be larger and more innovative and, in Brazil, to have constant or decreasing returns to scale. For level-1 firms, the opposite occurs. The high concentration of transnational firms at level 4 should be noted: 32% of the outstanding export firms in Brazil and Argentina, respectively, are transnationals. Technically, the most suitable tests for verifying the difference in these distributions are the Chi-square, Spearman correlation and residual tests.[14] Since the results of these tests will not be reported in the text, let it suffice to say that, with regard to the qualitative variables, the Chi-square tests reject the null hypothesis for equal distribution across firm levels, while the Spearman and residual tests indicate that the extremes of the distributions tend to concentrate at levels 1 and 4.

From what has been said, it is clear that the non-export group is mainly comprised of firms with very low competitivity indicators which, in turn, push the mean indicators of non-export firms down, thereby reflecting on

14. The residuals test goes beyond the Chi-square test in that it makes it possible to identify which level is "pushing" the Chi-square and in what direction. Its statistic follows a normal distribution and is given by the formula: $Z_{obs} = \frac{m_{obs} - m_{esp}}{\sqrt{m_{esp}(1-p_l)(1-p_j)}}$, where m_{ob} and m_{esp} are the observed and expected frequencies, respectively (as in the Chi-square test), and p_l e p_j are the line and column probabilities. For our purposes, module values higher than 1.96 (critical to normal value at 5%) indicate the influence of that cell in the Chi-square test. It should be noted, however, that the information derived from the residuals test is worthless if the Chi-square tests fails to reject the null hypothesis. Concerning this test, see Agreste (1996).

the differences between non-export and export firms presented in Table 1. This knowledge leads to a better understanding of why estimates that rely on the McDonald and Moffitt decomposition (1980) find that the variations in total volume exported are mainly due to increases in the exports of firms that already export and not to increases in export probability, thus explaining why they are not very encouraging in relation to broadening the export base.[15]

TABLE 7
IVA, revenue and exports by level of export potential

	Brazil (2000)				Argentina (2001)			
	Level 1	Level 2	Level 3	Level 4	Level 1	Level 2	Level 3	Level 4
Number of firms	10,802	4,443	3,892	3,055	6,202	1,783	1,392	2,342
Total IVA (US$ thousand)	6,275,568	9,467,723	13,082,729	72,233,968	-	-	-	-
Total revenue (US$ thousand)	-	-	-	-	1,532,640	9,573,052	10,020,061	55,071,100
Average IVA (US$ thousand)	581	2,131	3,361	23,645	-	-	-	-
Average revenue (US$ thousand)	-	-	-	-	2,182	5,369	7,198	23,514
Total exports (US$ thousand)	-	-	6,509,837	37,011,915	-	-	1,609,152	17,321,432
Average exports (US$ thousand)	-	-	1,673	12,115	-	-	1,156	7,396

Sources: Brazil: IPEA and original elaboration based on data from PIA, PINTEC, RAIS, SECEX and BACEN. Argentina: IPEA and original elaboration based on data from the Second Innovation and Technological Behavior Survey.
Obs.: The information is in US$ at 2001 prices.

Ellery, Jr. and Gomes (2005) contend that, in Brazil, export firms sell an average 6.1 times more than non-export firms on the internal market. In Argentina, they retain a market share equal to 73.8% of industrial revenue. This pattern is also repeated in countries such as France and the USA. However, the fact that the export firms are spread across levels 3 and 4 indicates heterogeneity within the set, as illustrated in Table 7.

15. In the tobit model, the decomposition separates the effect of marginal changes in the explanatory variables on the dependent variable, y, in the following manner: $\frac{\partial E(y \mid X)}{\partial x_k} = \frac{\partial P(y > 0 \mid X)}{\partial x_k} \cdot E(y \mid X, y > 0) + P(y > 0 \mid X) \cdot \frac{\partial E(y \mid X, y > 0)}{\partial x_k}$, where the first part of the right-hand term of the equation stands for a broadening of the export base and the second part for an increase in the volume of firms that already export.

7.2 Entry and exit of firms in the international market

All taken into account, if potential export firms present competitivity indicators so close to those of firms that already export, why do level-3 firms export and level-2 firms do not? In Brazil, one of the answers, according to Table 8, is inertia: 73.4% of the firms classed as potential exporters in 2000 continued to be non-exporters in the period 2001/2003, whereas 87.2% of the paired exporters were already exporters by 1998/1999. Although no data are available for Argentina, a like scenario can be projected despite the frank recovery of exports as of 2001. Hence, what basically differentiates paired export firms from potential export firms is the fact that the first have already exported.

TABLE 8
Entry and exit of firms in the international market by level of export potential (Brazil)

	Exported in 1998/99?			
	1	2	3	4
Yes	204	287	1,433	1,902
No	2,245	1,356	210	109
	Exported in 2001/2003?			
	1	2	3	4
Yes	328	437	1,506	1,917
No	2,121	1,206	137	94

Sources: IPEA and original elaboration on the basis of data from SECEX.

The reasons for this inertia are an open question but, according to the international literature (CLERIDES *et al.*, 1997; ROBERTS; TYBOUT, 1995, 1997), it is strongly associated with the high costs of entering the world market, be they costs in the form of market research, product adaptation, distribution channels or logistics, *etc.* Since level-3 firms already export, they have already overcome these costs or, inversely, refrain from withdrawing from the market in the face of negative shocks so as to avoid re-entry costs.

Another possible explanation is the fact that paired exporters are already inserted into the major world production chains and gravitate around the main players, which are usually transnational firms. This alliance with the major enterprises significantly diminishes fixed export costs, in addition to allowing for differentiated access to the credit market (see Section 2).

Furthermore, potential export firms may occupy very specific niches within the sectoral market, niches that would not be detected by analyses at the level of aggregation of this study.

All considered, even when potential export firms present competitivity indicators that are favorable and similar to those of firms that already export, they would face many difficulties upon entering the international market. For the reasons cited above, analysis of the causes of the inertia in question should be the theme of future studies.

7.3 Sectoral mapping of export potential and bilateral trade: complementary export lists?

To finalize, assuming that the difficulties of inserting potential exports were overcome, what would the insertion path be? Would it be the intensification of bilateral trade between Brazil and Argentina in a search for complementary export lists? Would it be the role of Mercosur in stimulating firms that already export to export more?

The Brazilian manufacturing sectors that exported over US$ 900 million in 2000 were food products, beverages and tobacco products (US$ 8.77 billion); textiles (US$ 947 million); leather, luggage and footwear (US$ 2.05 billion); wood and wood products (US$ 993 million); pulp, paper and paper products (US$ 2.35 billion); chemical products (US$ 5.39 billion); machinery and equipment (US$ 2.47 billion); electrical machinery and apparatus (US$ 1.24 billion); radio, television and communication equipment and apparatus ((US$ 1.786 billion); motor vehicles, trailers and semi-trailers (US$ 3.79 billion); and the manufacture of other transport equipment (US$ 2.67 billion). Some of these sectors are amongst those considered potential-bearing sectors because, in the year 2000, they included a large number potential export firms and were capable of generating more than US$ 300 million if all these firms were to export (assuming their exports were equal in value to those of the level-3 firms).

Thus, the sectors that most stand out in Brazil as to export potential are food products, beverages and tobacco products (ISIC 15 and 16, with 19.27% of the firms that do not export being potential export firms); textiles (ISIC 17, with 38.83% being level-2 firms); leather, luggage and footwear (ISIC 19, with 50.45% of those do not export being level-2 firms); wood, furniture and miscellaneous manufactures (ISIC 20 and 36, with 43% and 36.59%, respectively, being level-2 firms); basic metals (ISIC 27, with 41.07% at level 2); and electrical machinery and apparatus (ISIC 31, with 37.63% at level 2). As expected, strong export potential was not identified in sectors that are extremely scale-intensive and/or obey a highly specific international trade dynamic, a dynamic generally dictated by the large transnational manufacturers of transportation equipment and chemical products, for example.

Table 9 presents the ISIC 2-digit sectoral disaggregation by export potential, the volume exported by level-3 and -4 firms, and the percentage of total volume exported to Argentina by each sector.

TABLE 9
Brazilian export potential by sector and share exported to Argentina (2000)

Sector	ISIC	Number of firms				X- potential of Non-X firms (%)	Average X (US$ thousand)		Total X to Argentina (%)
		Level 1	Level 2	Level 3	Level 4		Level 3	Level 4	
Food products, beverages and tobacco products	15 and 16	2,036	486	513	197	19.27	5,724	29,639	2.77
Textiles	17	479	304	267	174	38.83	1,155	3,674	24.74
Wearing apparel	18	1,786	241	224	31	11.89	537	1,746	38.91
Leather, luggage, handbags, saddlery, harness and footwear	19	386	393	295	241	50.45	1,219	7,019	6.40
Wood and wood products	20	420	317	287	178	43.01	1,141	3,741	4.20
Pulp, paper and paper products	21	365	92	95	74	20.13	1,638	29,723	5.29
Publishing, printing and reproduction of recorded media	22	531	90	68	98	14.49	828	334	17.56
Coke, refined petroleum products, nuclear fuel and alcohol production	23	78	39	26	18	33.33	2,299	118,333	46.43
Chemical products	24	478	397	351	442	45.37	1,328	11,161	16.65
Rubber and plastics products	25	682	360	275	187	34.55	369	2,944	31.46
Other non-metallic mineral products	26	1,191	189	203	70	13.70	1,058	6,065	15.01
Basic metals	27	132	92	71	114	41.07	4,157	43,735	7.74
Fabricated metal products, except machinery and equipment	28	832	307	294	169	26.95	355	3,010	25.27
Machinery and equipment	29	297	336	344	458	53.08	914	4,711	17.63
Office, accounting and computing machinery	30	28	16	10	19	36.36	1,796	2,052	34.47
Electrical machinery and apparatus	31	184	111	125	99	37.63	2,971	8,767	15.55
Radio, television and communication equipment and apparatus	32	53	40	41	53	43.01	922	32,996	31.39
Medical, precision and optical instruments, watches and clocks	33	58	93	63	88	61.59	860	3,038	15.35
Motor vehicles, trailers and semi-trailers	34	127	173	130	213	57.67	661	17,424	35.80
Other transport equipment	35	7	14	8	15	66.67	239	177,936	2.17
Furniture and miscellaneous manufacturing	36	728	420	345	242	36.59	699	1,702	15.84

Sources: IPEA and original elaboration on the basis of data from PIA, PINTEC, RAIS, SECEX and BACEN.
Obs.: *X potential of non-X firms.* –Percentage of non-export firms that are potential export firms, *Average X* – average exports of firms on levels 3 and 4. The sums for the total number of firms in each line and column may not exactly correspond to earlier tabulations due to rounding of the expanded number of firms in each sector.

A similar exercise was performed for the Argentine case, the differences being that the cutoff point for sectoral capacity to generate foreign exchange through potential exporters is lower (US$ 75 million); the data refer to 2001; and certain 2-digit ISIC categories had to be aggregated due to confidentiality problems (categories with few firms). Hence, the sectors that stand out with regard to export potential are food, beverages and tobacco products (ISIC 15 and 16, with 31.9% of the firms that do not export being potential exporters); textiles (ISIC 17, with 19.25% being level-2 firms); leather, leather goods and footwear (ISIC 19, with 31.19% at level 2); wood products, pulp, paper and paper products (ISIC 20 and 21, with 22.91% being potential export firms); publishing, printing and reproduction of recorded media (ISIC 22, with 28.03% at level 2); and manufacture and assembly of motor vehicles, trailers and semi-trailers plus other transport equipment (ISIC 34 and 35, with 34.2% of the non-export firms at level 2). With the exception of textiles, these sectors also figure amongst the largest exporters (value of exports over US$ 350 million), together with coke, petroleum refining and alcohol production (US$ 2.6 billion), chemical products (US$ 1.72 billion), non-metallic mineral products (US$ 1.18 billion) and basic metals (US$ 1.26 billion). As in the case of Brazil, Table 10 shows the ISIC 2-digit sectoral breakdown by export potential, the volume exported by level-3 and -4 firms, and the percentage of their total exports destined to Brazil.

TABLE 10
Argentine export potential by sector and share exported to Brazil (2001)

Sector	ISIC	Number of firms				X-potential of Non-X firms (%)	Average X (US$ thousand)		Total X to Brazil (%)
		Level 1	Level 2	Level 3	Level 4		Level 3	Level 4	
Food products, beverages and tobacco products	15 e 16	913	428	395	320	31.93	1,886	17,995	5.23%
Textiles	17	583	139	113	114	19.25	1004	1,218	38.79%
Wearing apparel	18	534	60	37	12	10.15	364	1,028	16.55%
Leather, luggage, handbags, saddlery, harness and footwear	19	237	107	51	212	31.19	704	3,858	0.30%
Wood and wood products; pulp, paper and paper products	20 e 21	407	121	18	135	22.91	1,826	2,469	32.98%
Publishing, printing and reproduction of recorded media	22	318	124	43	55	28.03	651	606	50.26%
Coke, refined petroleum products, nuclear fuel and alcohol production	23	2	0	3	6	0.00	76,688	397,575	6.49%
Chemical products	24	312	180	194	435	36.62	335	3,824	45.58%
Rubber and plastics products	25	302	111	79	212	26.81	321	1,217	35.89%
Other non-metallic mineral products	26	239	45	31	36	15.71	688	32,056	0.59%

(continued)

(continuation)

Basic metals	27	154	28	29	29	15.25	700	43,230	8.39%
Fabricated metal products, except machinery and equipment	28	542	105	95	212	16.26	197	1,105	10.37%
Machinery and equipment	29	160	56	53	100	26.07	853	3,084	80.32%
Office, accounting and computing machinery; electrical machinery and apparatus	30 e 31	221	105	83	107	32.22	645	863	77.65%
Radio, television and communication equipment and apparatus	32	15	3	34	11	18.05	101	3,153	37.18%
Medical, precision and optical instruments, watches and clocks	33	52	23	20	7	30.69	1,300	1,483	90.44%
Motor vehicles, trailers and semi-trailers; other transport equipment	34 e 35	130	67	83	175	34.20	1,337	11,471	69.93%
Furniture and miscellaneous manufacturing	36	423	12	49	46	2.68	313	424	26.51%

Sources: IPEA and original elaboration on the basis of data from the Second Innovation And Technological Behavior Survey.
Obs.:*X potential of non-X firms* – Percentage of non-export firms that are potential export firms, *Average X* – average exports of firms on levels 3 and 4. The sums for the total number of firms in each line and column may not exactly correspond to earlier tabulations due to rounding of the expanded number of firms in each sector. Some of the ISIC 2-digit classifications were aggregated to safeguard confidential information.

From tables 9 and 10, the following can be perceived:

- The Brazilian share of Argentine exports is larger than the Argentine share of Brazilian exports.
- With few exceptions, the principal export firms in the two countries are concentrated in the same sectors. Moreover, in the more “commoditized” export sectors, their share in the exports of the neighboring country is smaller.
- Insertion of potential export firms via bilateral trade therefore presents a major challenge since the potential export firms in each country are concentrated in segments in which the industry of the neighboring country is most competitive at the international level.

These statements can be more clearly visualized with the aid of Table 11. In this table, the ISIC 2-digit sectors which embrace the largest exporters of one country are seen *vis-à-vis* the potential exporters of the other. In fact, the only Argentine sector to present an export potential that does not figure among the major Brazilian exporters is publishing, printing and reproduction of recorded media (ISIC 31), as well as furniture and miscellaneous manufactures (ISIC 36), all sectors that already destined to Argentina more than 15% of their total volume exported in 2000.

TABLE 11
Largest and potential Brazilian and Argentine export firms
(ISIC 2-Digit Classification)

Largest Brazilian export firms	Potential Argentine export firms	Largest Argentine export firms	Potential Brazilian export firms
ISIC 2-digit classification			
15 and 16	15 and 16	15 and 16	15 and 16
17	17	-	**17**
19	19	19	19
20	20	20	20
21	21	21	-
-	**22**	22	-
-	-	23	-
24	-	24	-
	-	26	-
27	-	27	27
29	-	-	-
31	-	-	**31**
32	-	-	-
34	34	34	
35	35	35	
-	-	-	**36**

Source: Original elaboration.
Obs.: The sectors in bold are those that have export potential and do not figure amongst the largest exporters in the neighboring country.

The foregoing considerations help understand why the recovery of the Argentine economy led to heated debates within the sphere of Mercosur. Despite the macroeconomic frameworks having been different in Brazil and Argentina during the period under analysis, the differences appear to have had mainly structural, rather than contextual, underpinnings. Therefore, the commercial insertion of potential export firms, as well as that of firms that already export, via bilateral trade will be more pacific if focused on technology, with a view not only to exploiting advantages of cost and scale, but also to differentiating products as a competitive strategy, notably in the relatively standardized industrial segments in which the export lists of the two countries are concentrated.

8 CONCLUSIONS

In this study, an export-potential classification framework was constructed for Brazilian and Argentine industrial firms on the basis of microdata on firms in the two countries. The Propensity Score Matching algorithm served as the foundation on which the framework was built. The application of the algorithm was supported, in turn, by theoretical and empirical analyses of selected export microdeterminants.

Instead of simply assigning firms to an export or non-export category, the fourfold classification also identifies firms that do not export but have levels of international competitivity similar to that of firms that do. At least in the short run, it is on these firms that policies aimed at broadening the export base should preferably focus.

After all, the key difference between potential export firms and paired export firms is the fact that the latter have already exported. However, to precisely identify the reasons behind this inertia on the part of potential export firms would require a specific study. Although there is extensive literature relating this inertia to the fixed costs of entering the world market, it could well be owing to the new dynamics of international trade and the increasing importance not only of globally integrated production chains, but also of intra-industry and even intra-firm commerce. This is especially true in Brazil and Argentina, for strategic alliances with transnational enterprises confer favored access to the credit market and serve to reduce exposure to economic volatility, whether at the national or international level. Likewise, the opportunity to attract foreign direct investment (FDI) is among these benefits and therefore a point of strategic relevance when delineating export-promotion policies.

In addition to benefiting the industrial park in various ways, broadening the export base may provide a viable alternative from the standpoint of volume exported, especially considering that the outstanding export firms have a dynamic of their own and may not respond to export-promotion policies. Insistence on broadening the export base does not signify, however, that other potential export groups should be passed over.

Firms may decide to stop exporting for various reasons, including sudden changes in the exchange rate or export regulations, lack of credit or distribution problems, coupled with an immature export culture. Thus, export promotion policy should include stimuli to encourage firms that already export, and especially paired firms, to remain in the foreign market.

A comparison of the sectoral maps of the export potential of the two countries reveals a low degree of complementarity, for the industrial export firms, as well as the potential export firms, are mainly concentrated in the same sectors. While there are significant differences in the macroeconomic environments, these differences are far more structural than contextual.

In practice, the Brazilian firms apparently took advantage of the economic recovery in Argentina, given that Brazilian manufactured exports to Argentina quickly recovered as of 2001, climbing from US$4.5 billion in that year to US$ 6.1 billion in 2005 (an historical high) after having dropped to US$ 1.9 billion in 2002. In contrast, Argentine exports to Brazil have been recovering at a much slower pace:

between 2002 and 2005, Brazilian imports from Argentina only rose from US$ 4.7 billion in the former year to US$ 6.2 billion in the latter.

Bearing these facts in mind and considering the importance of technological determinants to exports, the export-promotion policies of the Southern Cone should be linked to industrial policies aimed at raising the technological standards of firms. This would allow Brazilian and Argentine firms to compete in market niches open to differentiated products, less subject to price fluctuations, as well as create more space for trade negotiations both within Mercosur and between Mercosur and other markets.

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CHAPTER 9

INNOVATION AND THE EXPORT PERFORMANCE OF ARGENTINE MANUFACTURING FIRMS

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1 INTRODUCTION

The relations between innovation and exports have been studied from various angles in recent years, with both directions of causality having been explored. On one hand, several papers have analyzed the impact of the fact that a firm is already an exporter on the probability of its undertaking innovation activities and/or launching innovations to the market (as well as on the relative magnitude of these activities).[1] On the other hand, the influence of innovation activities and/or outputs on the probability of a firm exporting (as well as on the intensity of its export activities) has also been studied.

While some authors have found R&D to have a positive impact on export performance,[2] other papers[3] do not support this conclusion. Likewise, some studies have shown product and/or process innovation capabilities to have a positive effect on exports.[4] Recently, for example, De Negri (2005) found that product and process innovations are relevant to the export activities of Brazilian firms.[5] Summing up, it can be said that the available studies point to the possibility of exports and innovations to an extent being linked via a two-way avenue where each of these variables positively influences the other.

In the case of Argentina, though the interactions between innovation and exports have been discussed in several studies (MILESI *et al.*, 2000, for instance), they have rarely been approached using econometric techniques. However, on undertaking such an analysis, we (CHUDNOVSKY *et al.*, forthcoming) found that the fact that a firm was an exporter had a positive impact on the probability

1. Some papers, such as Kemp *et al*. (2003), Kleinknecht and Oostendorp (2002) and Lööf *et al.* (2003) find that exports have a positive impact on innovation activities. Kemp *et al.* also find that export growth has a positive effect on the magnitude of innovative outputs (measured as the share of new products in total sales).
2. HIRSCH; BIJAOUI, 1985; ITO; PUCIK, 1993; BRAUNERHJELM, 1996; WAKELIN, 1998; WIGNARAJA, 1998, ROPER; LOVE, 2001; STERLACCHINI, 1999; GOURLAY; SEATON, 2004.
3. WILLMORE, 1992; LEFEBVRE *et al*., 1998; SCHLEGELMILCH; CROOK, 1988.
4. NASSIMBENI, 2001; BROUWER; KLEINKNECHT, 1993; STERLACCHINI, 2001; LEFEBVRE *et al.*, 1998; LACHENMAIER; WOESSMAN, 2004; ÖZÇELIK; TAYMAZ, 2004. Some studies find that these results are sensitive to the industry to which the firm belongs (KUMAR; SIDDARTHAN, 1994; DIJK, 2002; GOURLAY; SEATON, 2004).
5. Also see De Negri and Freitas (2004).

of its launching product and process innovations for the market (but not on the probability of its engaging in innovation activities or on the magnitude of such activities).

In the current paper, the same authors analyze the opposite direction of causality, that is, the effect of innovation on export performance.[6] On one hand, the two variables should be positively correlated, for the theoretical arguments (especially those based on neo-Schumpeterian trade theories), as well as part of the abovementioned empirical literature, suggest that being innovative may enhance the probability of a local firm exporting and/or strengthening its propensity to export (i.e., export/sales ratio). On the other hand, since most Argentine exports are based on natural resources, while high-tech exports are limited and the high-tech branches are precisely those in which innovative activities are most relevant because they enable firms to compete in the market, other factors may determine whether or not a firm is in a position to export and, should it decide to export, the intensity of its export efforts.

To verify which of these contrasting hypotheses holds true, we undertook an econometric analysis of the determinants of the export performance of Argentine manufacturing firms in the period 1998-2001 on the basis of information from the national innovation survey (INDEC-SECYT-CEPAL, 2003). In particular, our interest was in studying whether or not launching innovations new to the market has a positive impact on export performance.[7] We were also interested in learning if the impact of innovation on exports varies according to differing factor and technological intensities across sectors. In this regard, innovation activities might be expected to have a stronger influence in medium and high-tech sectors vis-à-vis low-tech, labor-intensive or natural-resource-based branches.

In Section 2, a brief account is given of the export pattern of the country, with emphasis on manufacturing exports. The data underlying the study and the descriptive statistics referring to the firm sample are presented in Section 3, while the estimation strategy and econometric techniques employed are outlined in Section 4. The results of the econometric analysis are presented in section 5 and the conclusions of the study in Section 6.

6. In Chudnovsky *et al.* (forthcoming), on exploring the effect of performance indicators (i.e., productivity) on innovation, we found that innovators performed better than non-innovators in terms of labor productivity in 1992-2001.

7. An innovation survey also exists for the period 1992-1996 (INDEC-SECYT, 1998) and we could have employed it to extend our analysis to an entire decade. However, this earlier survey did not include a question aimed at determining which innovations were new only for the firm and which were also new for the domestic or international market. This is an important limitation, for we have reason to believe that the second kind of innovation has a stronger impact on export activity than the first. We therefore decided to work with the second innovation survey only.

2 A BRIEF ACCOUNT OF THE RECENT EVOLUTION OF THE ARGENTINE EXPORT PATTERN

During the 1980s, exports were almost the only indicator that registered a favorable performance in the Argentine economy. The value of total exports rose more than 50% between 1980 and 1990, while that of manufactured exports increased by 70%. Exports of non-agricultural-based manufactures grew at even higher rates – almost 120% – during the same period. Unfortunately, this strong performance was not the result of expanded industrial production. In fact, industrial production fell during the 1980s amidst the stagnation and high volatility of the Argentine economy as a whole. Hence, the export growth observed was largely the result of economic stagnation (within a scenario of relatively high exchange rates) and was led by scale-intensive branches such as steel, petrochemicals, aluminum and vegetable oils, in which major investments had previously been made.

In the 1990s, exports again grew at high rates, especially as of 1995. By 2001, the total value was 115% higher than it had been in 1990, though the surge in exports ceased in 1998, giving way to stagnation during the prolonged recession of the domestic economy that lasted until 2001. The surge in exports, which took place while the economy was growing fast, was due to a combination of factors: the maturation of large investment projects in the abovementioned scale-intensive sectors, integration within Mercosur and the high international prices for commodities exported by Argentina. However, the scenario worsened with the devaluation of the Brazilian *real* and the drop in international prices, factors that help to explain the loss of export dynamism after 1998.

Whereas agricultural-based manufactures exports rose 55% between 1990 and 2001, non-agricultural-based industrial exports increased almost 150%. Chemicals and petrochemicals, together with motor vehicles, accounted for about 60% of the increase in manufactured exports during the period. Paper and pulp, steel and machinery and equipment contributed with another 25%. In contrast, the share of footwear and leather manufactures decreased, while the share of textiles in total non-resource-based industrial exports fell from 6.3 to 3.7% over the same period.

The main destination for these growing industrial exports was Mercosur, which absorbed almost 70% of the increase in non-resource-based manufactured exports between 1990 and 2000. At the same time, the share of Mercosur in these exports climbed from 23 to 49% over the same decade. Although the role of Mercosur was positive for a large part of Argentine industry, the low share of developed markets as destinations for manufactured exports may be revealing weak competitive capabilities in many industrial branches on the one hand and the influence of the trade strategies of transnational corporations (TNCs), which have come to account for a growing proportion of Argentina's foreign trade, on the other.

In Table 1, data on the Argentine foreign trade pattern are presented employing a classification scheme proposed by the United Nations Conference on Trade and Development (UNCTAD) that distributes sectors according to factor and technology intensity. To this end, nearly 237 product categories, as defined in the UNCTAD Standard International Trade Classification (SITC), Revision 2 at the 3-digit level, were placed in one of the five SITC product groups: primary commodities,[8] labor-intensive and resource-based manufactures[9], manufactures with low skill and technology intensity, manufactures with medium skill and technology intensity and manufactures with high skill and technology intensity. Since this classification does not include the fuel merchandise trade,[10] the figures for Argentine exports correspond to roughly 85% of total average exports for the period 1998-2004.

On comparing Argentine exports and imports between 1998 and 2004, primary commodities are seen to have accounted for 62% of total exports but only 10% of total imports. Labor-intensive and resource-based manufactures, together with low skill and technology intensity sectors, accounted for only 13% of exports and 17% of imports, while medium and high skill and technology intensity branches contributed with 25% of exports (automobiles, plastics and pharmaceuticals being the most relevant) and 72% of imports.

TABLE 1
Argentina: foreign trade pattern (1998-2004)
(Yearly averages in US$ million and %)

	Imports		Exports		Balance
Primary commodities	1,914	10	14,143	62	12,229
Labor-intensive and resource-based manufactures	2,031	10	1,748	8	-283
Manufactures with low skill and technology intensity	1,312	7	1,129	5	-184
Manufactures with medium skill and technology intensity	7,058	36	3,115	14	-3,943
Manufactures with high skill and technology intensity	7,114	36	2,398	11	-4,715
Unclassified	437	2	122	1	-315
Total	**19,867**	**100**	**22,655**	**100**	**2,788**

Source: Prepared by the authors on the basis of information from the ECLAC Foreign Trade Database.

8. Annex 1 contains the list of manufacturing sectors belonging to each category. In the case of primary commodities, the sectors included in the tables in Annex 1 are, in fact, agricultural-based manufactures. In Tables 1 and 2, the primary commodities group also includes unprocessed agricultural products.

9. As seen in the Annex I tables, this group mainly refers to labor-intensive manufactures, while most resource-based manufactures are in the primary commodities group.

10. Most SITC section 3 items were excluded (SITC 322-coal, SITC 323-coke and briquettes, SITC 333-crude petroleum, SITC 334 and 335–petroleum products and SITC 341-gas). Other items were excluded because of incomplete data (i.e., SITC 351–electric current, SITC 675-iron and steel hoops and stirrups, SITC 688–uranium and thorium, SITC 971–gold).

As Table 2 shows, there is remarkable heterogeneity in the regional pattern of foreign trade among the five groups under analysis. Mercosur, and the rest of Latin America, receive the bulk of the goods exported by the medium and high skill and technology intensity branches. In turn, the goods exported by the low skill and technology intensity branches are fairly evenly distributed across world regions, with primary commodities being destined mainly towards Asia and the European Union.

With regard to imports, the principal origin of primary commodities, as well as of labor-intensive and low skill and technology intensity products, is Mercosur. Medium and high skill and technology intensity manufactures come mainly from developed countries, though Mercosur is also a relevant source of imports in the former group.

TABLE 2
Argentina: foreign trade pattern by region (2001)
(U$S million and %)

	Mercosur		Rest of LA		European Union		North America		Rest of the world		**Total**	
						Exports						
Primary commodities	1,953	15	1,143	9	3,573	28	829	6	5,255	41	**12,753**	**100**
Labor-intensive and resource-based manufactures	463	26	248	14	198	11	514	29	339	19	**1,763**	**100**
Manufactures with low skill and technology intensity	210	19	233	21	178	16	200	18	308	27	**1,129**	**100**
Manufactures with medium skill and technology intensity	2,135	67	504	16	268	8	171	5	129	4	**3,207**	**100**
Manufactures with high skill and technology intensity	1,164	47	591	24	176	7	364	15	182	7	**2,477**	**100**
Unclassified	52	41	47	37	8	6	13	11	7	6	**128**	**100**
Total	**5,977**	**28**	**2,765**	**13**	**4,403**	**21**	**2,092**	**10**	**6,220**	**29**	**21,457**	**100**
						Imports						
Primary commodities	1,010	39	926	36	230	9	214	8	191	7	**2,572**	**100**
Labor-intensive and resource-based manufactures	942	43	121	6	425	19	176	8	535	24	**2,199**	**100**
Manufactures with low skill and technology intensity	511	39	89	7	255	19	125	10	335	25	**1,315**	**100**
Manufactures with medium skill and technology intensity	1,681	27	362	6	1.910	30	1,051	17	1,332	21	**6,336**	**100**
Manufactures with high skill and technology intensity	1,296	18	690	10	1.526	21	2,028	28	1,635	23	**7,174**	**100**
Unclassified	43	9	46	9	177	36	109	22	118	24	**493**	**100**
Total	**5,482**	**27**	**2,234**	**11**	**4,523**	**23**	**3,702**	**18**	**4,146**	**21**	**20,089**	**100**

Source: Prepared by the authors on the basis of information from the ECLAC Foreign Trade Database.

3 DATA SOURCES AND DESCRIPTIVE STATISTICS

The data used for this project were drawn from an innovation survey covering the period 1998-2001 (INDEC-SECYT-CEPAL, 2003). The survey was designed in accordance with the methodologies suggested by the Oslo and Bogotá manuals[11] and is comparable to the Community Innovation Surveys (CIS) of the European Union. The survey includes 1,688 firms .representing 65%, 42% and 80%, respectively, of sales, employment and exports of the manufacturing sectors in 2001.[12] The sample was randomly drawn from the Input-Output Matrix survey for 1997. Hence, it was intended to be a representative sample of the manufacturing industries at the beginning of the period covered.

In addition to innovation data, the survey provides information on ownership, sales, employment, exports and imports (among other variables)[13] in both 1998 and 2001. The data on product and process innovations refers to the period as a whole: firms were asked if they had introduced new or significantly improved products and/or processes at any time during the period and, if so, whether they were new only for the firm or also for the domestic/international market.

To process the survey data, the following were excluded from the sample:

- firms with no sales
- firms with fewer than 5 employees
- firms that did not declare their nationality and/or exports

This having been done, the final sample was composed of 1,540 firms.

As Table 3 shows, most of the firms in the sample are either small or medium-sized.[14] However, on analyzing the distribution of export firms by size, the presence of small firms is seen to decrease while that of large firms increases. Large firms account for the bulk of exports and their average export volumes are significantly higher than those of smaller firms.

TABLE 3
Firm sample: descriptive statistics (2001)

	Total	Small	Medium	Large
Number of firms (%)	**100**	29.4	45.7	24.9
Number of exporters (%)	**100**	14.3	49.6	36.1
Distribution of exports (%)	**100**	0.6	12.9	86.5
Average exports (US$ thousand)	**9,829**	186	2,778	34,106

Source: Prepared on the basis of data from the National Innovation Survey (1998-2001).

11. OECD (1997) and RICYT (2001), respectively.
12. The response rate reached 76%. This rate is high compared to those of the CIS, which have never exceeded 30%.
13. Unfortunately, no firm-level data are available on stock of capital, value added, wages or hours worked.
14. Small firms have less than 40 employees, medium-sized firms 40 to 200 employees and large firms more than 200 employees.

Table 4 differentiates the performance of the firms in the sample according to their size. It is clear that large firms not only have more employees and higher sales, but are also more productive, employ more skilled personnel and are more oriented to foreign trade. Whereas 77% of the large firms are exporters, the corresponding figures for small and medium-sized firms are 26% and 58%, respectively.

TABLE 4
Performance of firms according to size (2001)
(Ratio between the average for each group and the average for the whole sample)

	Total	Small	Medium	Large
Sales	**100**	5.6	38.5	325.1
Employment	**100**	10.9	49.2	298.1
Sales/Employment	**100**	71.3	107.5	119.9
Share of Skilled Labor	**100**	73.6	94.4	141.3
Exports	**100**	1.9	28.3	347
Exports/Sales	**100**	49.2	105.7	149.4
Imports	**100**	4.0	30.7	340.6

Source: Prepared on the basis of data from the National Innovation Survey (1998-2001).

Table 5 presents information on innovation performance. While 41.2% of the firms in the sample declared they had adopted process innovations new for the firm, 36.2% stated they had launched product innovations new for the market. In all cases, the number of innovators grows as the size of the firms increases.[15]

TABLE 5
Innovation performance of firms according to size (2001)
(%)

	Total	Small	Medium	Large
INNPRODUCT-FIRM	**28.4**	17.3	31.1	36.5
INNPRODUCT-MARKET	**36.2**	20.4	39.8	48.4
INNPROCESS-FIRM	**41.2**	23.9	44.5	55.7
INNPROCESS-MARKET	**18.6**	8.8	18.9	29.7

Source: Prepared on the basis of data from the National Innovation Survey (1998-2001).

Table 6 contains descriptive statistics on the export and non-export firms in the sample. The export firms are larger and more productive than the non-export firms. On average, the former have almost three times as many employees, and labor productivity levels (measured as sales of own products per employee)[16] approximately twice as high as the latter. Likewise, there is a higher share of foreign firms in the

15. According to the survey on which our sample is based, a product innovation is the introduction of a product that is either technologically new (its characteristics or uses differ significantly from the previous products of the firm) or significantly improved (it existed previously but its performance has been improved). In turn, a process innovation consists in the adoption of new or significantly improved methods of production. It may aim at producing or delivering technologically new products that could not be produced or delivered using conventional methods of production, or at enhancing the efficiency of the production or delivery of existing products. In both cases, the innovations may be new only for the firm or also for the domestic and/or international market.
16. Unfortunately, as previously stated, firm-level data on value added and hours worked are not available.

export group, as well as more firms that import,[17] employ higher proportions of skilled personnel and launch product and process innovations.

TABLE 6

Export versus non-export firms: characteristics and performance — mean and standard deviation (2001)

	Whole sample	Export firms	Non-export firms
Number of Firms	1,540	823	717
Exports (US$ thousand)	9,829	18,400	0
	(94,100)	(128,000)	
Export/Sales (%)	12.7	23.7	0
	(30)	(38)	
Sales/Employment (US$ thousand)	114,1	146,7	76,7
	(362)	(483)	(109)
Size (number of employees)	204	294	101
	(425)	(543)	(174)
Share of skilled employees (%)	7.1	9.2	4.7
	(10.2)	(11.2)	(8.3)
Sales (US$ thousand)	36,600	59,358	10,582
	(192,000)	(258,100)	(34,200)
% of variable in group			
FOREIGN	18.4	29.5	5.6
IMPORTER	59.9	80.4	36.4
INPRODUCT-FIRM	28.4	34.7	21.1
INPRODUCT-MARKET	36.2	46.3	24.7
INPROCESS-FIRM	41.2	49.8	31.4
INPROCESS-MARKET	18.6	24.5	11.8
Innovative firms with differentiated products	8.1		
Distribution of firms according to UNCTAD classification			
	Whole sample	%	%
Primary commodities	411	52.1	47.9
Labor–intensive and resource-based manufactures	323	42.7	57.3
Manufactures with low skill and technology intensity	103	52.4	47.6
Manufactures with medium skill and technology intensity	368	60.9	39.1
Manufactures with high skill and technology intensity	206	70.9	29.1

Source: Prepared on the basis of data from the National Innovation Survey (1998-2001).

To classify the firms' exports on the basis of their factor and technological intensity, we used the classification proposed by UNCTAD (2002). Since the sample does not contain data on exports by product, each firm's exports were placed in one

17. Nearly 30% of the exporters are foreign firms and 80% are importers. In contrast, only 6% of the non-export firms are foreign-owned and only 36% are importers.

of the five groups defined by UNCTAD according to the ISIC (Rev. 3) 4-digit sector to which the firm belongs (see Annex 1).[18]

The highest ratio of export to non-export firms is in the group of manufacturing sectors with high skill and technology intensity, followed by the medium skill and technology intensity sectors. The lowest ratio is in the labor-intensive sectors, in which Argentina has weak comparative advantages.

Relevant differences also become apparent on comparing the characteristics of the export firms belonging to the groups of sectors into which we have divided the sample (Table 7). On the one hand, firms in primary commodities sectors generally have higher exports and export intensities than those in other sectors. Their size and productivity levels are also the highest. On the other hand, firms in manufacturing sectors with medium and high skill and technology intensity are more likely to be foreign-owned and to be importers, as well as to have the highest import levels and coefficients.

Confirming our expectations, the proportions of firms that launch product innovations new for the firm or for the market are highest in the medium and high skill and technology intensity sectors. In the case of process innovations, the percentage of firms that conduct such activities is also high in the labor-intensive sectors. Moreover, firms in high skill and technology intensity sectors have the highest R&D/sales and skilled personnel/total employment ratios.

Following De Negri and Salerno (2005), we have included a category termed "innovative firms with differentiated products" in our export sample. De Negri and Salerno further divided their sample into two subgroups: "firms specialized in standardized products" and "firms that do not differentiate products and have low productivity." This classification is based on the idea that innovation allows for higher profits, especially if product innovation increases the probability of a firm obtaining price premiums for its products.

However, since the survey used in this study does not contain information on export prices, we could not define the abovementioned categories in precisely the same way as De Negri and Salerno. Hence, in our work, an innovative firm with differentiated products is an export firm that launched a product innovation that was new for the market during the period 1998-2001 and that registered above average R&D intensity (R&D expenditures/sales ratio) for its respective sector. A group comprising 8.1% of the firms in the sample fell into this category (Table 6).

18. Since UNCTAD (2002) based its fivefold classification on the product categories listed in the Standard International Trade Classification (SITC), Rev. 2, at the 3-digit level, there is not perfect correspondence between the UNCTAD classification and the ISIC 4-digit sectors. See Annex 1 for information as to the sectors in which this problem exists and how we dealt with it.

TABLE 7

Export firms: characteristics and performance by sector – mean and standard deviation (2001)

	Total*	Primary commodities	Labor–intensive and resource-based manufactures	Manufactures with low skill and technology intensity	Manufactures with medium skill and technology intensity	Manufactures with high skill and technology intensity
Number of firms	**823**	214	138	54	224	146
Exports (US$ thousand)	**18,400**	33,873	6,595	9,547	7,979	6,652
	(128,000)	(188,700)	(21,023)	(42,749)	(30,325)	(11,676)
Exports/Sales (%)	**23.7**	37.7	19.7	17.5	20.2	15.9
	(38)	(59)	(29)	(26)	(25)	(20)
Sales/Employment (US$ thousand)	**146.7**	176.2	101.6	97.6	101.5	137.9
	(483)	(343)	(137)	(87)	(126)	(137)
Sales (US$ thousand)	**59,358**	81,128	29,856	34,228	30,497	47,235
	(258,100)	(223,300)	(50,160)	(115,100)	(78,337)	(79,403)
Labor (number of employees)	**294**	400	303	325	196	243
	(543)	(577)	(671)	(831)	(288)	(316)
R&D Intensity (%)	**0.38**	0.19	0.26	0.14	0.34	0.98
	(1.71)	(0.98)	(0.91)	(0.34)	(0.71)	(3.60)
Share of skilled labor (%)	**9.2**	5.2	6.1	8.7	9.8	16.5
	(11.2)	(5.9)	(9.1)	(8.0)	(9.4)	(15.6)
Imports (US$ thousand)	**8,384**	5,158	4,169	6,314	11,393	10,311
	(34,500)	(22,009)	(10,542)	(22,822)	(40,514)	(18,932)
Imports/Sales (%)	**13.1**	6.0	10.9	12.1	17.9	19.5
	(16.9)	(12.2)	(13.3)	(16.4)	(19.8)	(17.1)
			% of variable in group			
FOREIGN	**29.5**	23.4	23.2	18.5	32.1	44.5
IMPORTER	**80.3**	68.2	79.7	68.5	86.6	94.5
INPRODUCT-FIRM	**34.8**	29.0	33.3	24.1	37.1	43.8
INPRODUCT-MARKET	**46.3**	39.3	45.7	35.2	54.5	50.0
INPROCESS-FIRM	**49.8**	43.9	52.2	50.0	52.2	52.1
INPROCESS-MARKET	**24.5**	19.2	27.5	13.0	26.3	29.5
Innovative firms with differentiated products	**15.1**	12.0	13.1	10.2	27.3	23.7

Source: Prepared on the basis of data from the National Innovation Survey (1998-2001).
*Includes firms in unclassified sectors.

As expected, innovative firms with differentiated products are more often found in manufacturing sectors with medium and high skill and technology intensity (Table 7). When the characteristics of these firms are compared to those of other exporters, the two groups are observed to be similar in terms of their propensity to trade. Although the other exporters are larger and have higher productivity levels, the innovative firms with differentiated products use more skilled labor and have remarkably higher R&D intensity levels. The latter finding is predictable considering that one of the variables used to construct the group was R&D expenditures.

TABLE 8

Descriptive statistics for innovative firms with differentiated products – mean and standard deviation (2001)

	Export intensity (%)	Import intensity (%)	Sales/ Employment (US$ thousand)	Share of skilled labor (%)	Employees	Sales (US$)	R&D intensity (%)
Innovative firms with differentiated products	28.3	15.8	97,7	12.2	260	36,346	1.71
	(30.3)	(18.0)	(106,0)	(15,3)	(341)	(67,766)	(4.78)
Other exporters	27.9	15.9	164,4	10,4	336	83,961	0.26
	(44.9)	(19.2)	(289,5)	(11,2)	(589)	(260,000)	(0.69)

Source: Prepared on the basis of data from the National Innovation Survey (1998-2001).

4 ESTIMATION STRATEGY AND ECONOMETRIC TECHNIQUES

We use the binary export/non-export specification typical of the literature on firm-specific effects on export activity. Firms first set their output levels and then they decide whether to sell on domestic or foreign markets, depending in which market they expect to reap higher profits.[19] In this regard, it is important to take into account that entry into foreign markets has specific sunk costs such as market research, product modification and compliance. This means that firms will only enter export markets if their current earnings exceed the fixed entry costs (GIRMA *et al.*, 2004).

Hence, firms' export activity can be analyzed using a double decision model. Firms first decide whether or not to export, which can be econometrically approached through a binomial model (probit or logit). Those that have decided to enter foreign markets then define their export volumes. This leads to a truncated model, since the dependent variable is only observed when it is higher than zero (i.e., exports are positive).

19. BASILE, 2001; BERNARD; WAGNER, 1998; WAKELIN, 1998.

The decision to export can be represented by the following equation:

$$EXPDEC_{ij} = \begin{cases} 1 & f \quad \alpha_0^1 + \varphi^1 X_j + \gamma^1 Z_j^1 + \varepsilon_j^1 > 0 \\ 0 & \qquad \qquad otherwise \end{cases}$$

In turn, the export volume and/or propensity can be modeled as:

$$EXP_{ij} = \alpha_0^2 + \varphi^2 X_j + \gamma^2 Z_j^2 + \varepsilon_j^2 \qquad f \qquad EXP_j > 0$$

where $EXPDEC_{ij}$ is a dummy variable that assumes the value of 1 if firm i in sector j exports and 0 if it does not sell in foreign markets.

EXP_{ij} is the export volume or export propensity of firm i in sector j, defined as the percentage of total sales abroad.

The vector X includes a number of variables aimed at capturing the impact of innovation on export activity – which is the focus of attention of our paper – as well as other control variables generally employed in literature on the subject.

Five variables represent the firm's innovation capabilities:

- INPRODUCT-FIRM is a dummy variable having a value of 1 if the firm introduced a product innovation new for the firm during the period 1998-2001 and zero otherwise.
- INPRODUCT-MARKET assumes a value of 1 if the product innovation was new for the market (domestic or international).
- INPROCESS-FIRM is a dummy variable having a value of 1 if the firm introduced a process innovation new for the firm during the period 1998-2001 and zero otherwise.
- INPROCESS-MARKET assumes a value of 1 if the process innovation was new for the market (domestic or international).
- In a separate specification of the model, another dummy variable is employed: INNOVATIVE FIRMS WITH DIFFERENTIATED PRODUCTS, which assumes a value of 1 for export firms that introduced product innovations new for the market during the period 1998-2001 and had above average R&D/sales ratios (indicative of R%D intensity) for their respective sectors.

The set of control variables includes:

- SIZE is the log of the number of employees. As often pointed out in the empirical literature on industrial organization, larger plants are more likely to export than smaller ones (BERNARD; JENSEN, 1999).[20]

20. WAKELIN, 1998; BASILE, 2001; NASSIMBENI, 2001; WAGNER, 2001; ROPER; LOVE, 2002; CASSIMAN; MARTÍNEZ-ROS, 2003.

- LABOR PRODUCTIVITY is the log of the ratio sales/number of employees. More productive firms may be more likely to compete in foreign markets than less productive ones.[21]
- FOREIGN is a dummy variable that assumes a value of 1 if at least 50% of the equity of firm i in sector j is foreign-owned. Foreign ownership is expected to have a positive impact on export activity.[22]
- IMPORT is a dummy variable having a value of 1 for firms that registered positive import volumes in 2001. Imports can contribute to exports in several ways: capital goods imports enhance technological and productive capabilities; input and components imports may lead to lower costs and/or better quality; and final goods imports allow for specialization strategies (enterprises–especially the affiliates of transnational corporations – may produce and export a small range of products, while complementing their local supply with imported items).[23]
- SKILLS is defined as the share of skilled labor vis-à-vis total labor. Skilled personnel may increase export activity since better qualified employees contribute to firms' technological, productive and marketing capabilities.[24]

Finally, Z accounts for the group of sectoral dummies.

The Heckman two-stage procedure is used for estimating the export equation while correcting for the selection bias. The first step involves estimating a probit regression to determine whether or not firms export. The second step entails estimating an export equation for export firms, correcting for any possible selectivity bias by including the probability lambda of being in the sample for each observation. The latter is estimated via an inverse Mill ratio computed from the probit analysis performed in the first step (HECKMAN, 1979). If the lambda coefficients are not significant, an OLS regression can be used to estimate the determinants of firms' exports and export propensities.

5 DETERMINANTS OF THE BEHAVIOR OF ARGENTINE EXPORT FIRMS: THE ROLE OF INNOVATION

Table 9 reports the results of a probit estimation of the determinants of firms' decisions as to whether or not to become exporters. With respect to the variables of interest, only launching new or significantly improved products for the market appears to have had a positive and significant impact on the probability of a firm becoming an exporter. As shown in column (2), which lists the marginal effects of

21. KNELLER *et al.*, 2005; KUMAR; PRADHAN, 2003.
22. See Aitken *et al.* (1997), Moreira (1999), Kneller and Pisu (2004) and Pinheiro and Moreira (2000).
23. LEFEBVRRE; LEFEBVRE, 2001; DE NEGRI, 2005.
24. See Wagner (2001) and Wakelin (1998).

the variables included in the probit equation, product innovations for the market raise the probability of a firm deciding to export by nearly 7.4%.

TABLE 9
Export decisions of Argentine manufacturing firms

	Coefficient	Marginal Effect	Coefficient	Marginal Effect
	(1)	(2)	(3)	(4)
INPRODUCT-FIRM	0.083	0.033	0.055	0.022
	(0.100)	(0.040)	(0.095)	(0.038)
INPRODUCT-MARKET	0.187**	0.074**	0.190**	0.075**
	(0.091)	(0.036)	(0.089)	(0.035)
INPROCESS-FIRM	-0.109	-0.043	-0.044	-0.017
	(0.095)	(0.038)	(0.089)	(0.035)
INPROCESS-MARKET	0.069	0.027	0.064	0.025
	(0.114)	(0.045)	(0.109)	(0.043)
Productivity	0.075*	0.030*	0.115***	0.046***
	(0.045)	(0.018)	(0.039)	(0.016)
Size	0.310***	0.123***	0.296***	0.117***
	(0.040)	(0.016)	(0.036)	(0.014)
Foreign	0.545***	0.207***	0.503***	0.192***
	(0.124)	(0.045)	(0.117)	(0.042)
Importer	0.816***	0.316***	0.754***	0.293***
	(0.090)	(0.034)	(0.083)	(0.031)
Skills	0.116***	0.046***	0.083**	0.033**
	(0.044)	(0.018)	(0.042)	(0.017)
Primary commodities (D)			0.247**	0.097**
			(0.101)	(0.039)
Low skill and technology intensity(D)			0.514***	0.192***
			(0.145)	(0.049)
Medium skill and technology intensity (D)			0.454***	0.175***
			(0.099)	(0.037)
High skill and technology intensity (D)			0.406***	0.155***
			(0.130)	(0.047)
Constant	-3.451***		-3.490***	
	(0.923)		(0.440)	

Source: Prepared by the authors.
Note: Standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%. All standard errors presented in this study are corrected for random forms of heteroscedasticity.

All the control variables have the expected signs and statistical significance: firm size, labor productivity, share of skilled labor and the fact that a firm imports or that it is foreign-owned all increase the probability of its exporting. As shown in columns (3) and (4), firms in non-labor-intensive sectors are more likely to be exporters.

As mentioned above, we are interested in learning not only why a firm exports or not, but also in what determines how much it exports. The problem with this type of estimate is that a selectivity bias may arise if only firms with positive exports are included. Hence, as previously stated, we chose to employ a Heckman (1979) two-step model in order to account for possible selectivity biases.

The results for the second step of the Heckman (1979) estimation are presented in Annex 2. Since they show that the lambda coefficients are not significant, there is no empirical evidence of sample selection bias in the estimates of the export and export intensity equations.[25] This leads us attribute more weight to the findings resulting from the one-stage OLS estimation (tables 10 and 11).

The second equation is first estimated for the whole sample of exporters. The sample is then divided into five groups according to the UNCTAD classification: primary commodities, labor–intensive and resource-based manufactures, manufactures with low skill and technology intensity, manufactures with medium skill and technology intensity and manufactures with high skill and technology intensity.

On analyzing the sample as a whole, process innovations are seen to have positive impacts on both the magnitude and the relative intensity of firms' exports. Process innovations new to the firm raise exports nearly 33%[26] and increase export intensity, measured in terms of export/sales ratios, by 36%.

With regard to the different groups of sectors, process innovations new for the firm have positive impacts on exports and export intensity in the medium and high skill and technology activities. Such innovations increase exports 69% in the former and 93% in the latter. In turn, process innovations new for the market have positive impacts on exports and export intensity in the low and high skill and technology intensity sectors.

In contrast, product innovations influence neither exports nor export intensity. Moreover, in the case of primary commodities, the correlations between product innovations new for the firm and the level and intensity of exports are negative.

Turning to the control variables, the larger, foreign-owned, higher productivity export firms tend to sell more goods abroad. Employing skilled personnel also has a positive impact on exports. In contrast, being an importer seemingly influences exports negatively, though this finding is not reproduced when the sample is distributed according to the UNCTAD fivefold classification. Productivity and size have positive impacts in all sectors, while the same is true of foreign ownership, except in the case of manufactures with low skill and technology intensity. When analyzing export intensity only, being foreign-owned and employing skilled personnel apparently have positive effects. Being an importer - or, unexpectedly, having high productivity levels[27]- tends to lower the exports/sales ratio.

25. If lambda equals zero, there is no sample selection problem and the parameters can be consistently estimated by OLS using the sample selected (WOOLDRIDGE, 2001).

26. Exp(0.287)-1=0.332.

27. Note must be taken that, due to data limitations, productivity is measured by the sales/employee ratio in this study.

TABLE 10
Innovation and exports by factor and technology intensity OLS estimates (2001)

	Total	Primary commodities	Labor-intensive and resource-based	Low intensity	Medium intensity	High intensity
			Exports			
INPRODUCT-FIRM	**-0.170**	-0.827**	-0.345	-0.230	0.117	-0.387
	(0.148)	(0.353)	(0.418)	(0.530)	(0.251)	(0.304)
INPRODUCT-MARKET	**-0.013**	-0.351	0.268	-0.302	-0.034	0.025
	(0.143)	(0.348)	(0.429)	(0.361)	(0.252)	(0.293)
INPROCESS-FIRM	**0.287****	-0.155	0.569	-0.165	0.528**	0.656**
	(0.146)	(0.319)	(0.457)	(0.419)	(0.257)	(0.297)
INPROCESS-MARKET	**0.138**	0.522	-0.122	2.017**	-0.293	0.594*
	(0.169)	(0.409)	(0.485)	(0.773)	(0.277)	(0.329)
Productivity	**0.713*****	0.879***	0.979***	0.700**	0.418***	0.808***
	(0.084)	(0.167)	(0.227)	(0.302)	(0.154)	(0.133)
Size	**0.906*****	0.721***	0.721***	1.442***	1.029***	0.973***
	(0.065)	(0.111)	(0.205)	(0.207)	(0.123)	(0.130)
Foreign	**0.713*****	0.650*	0.835**	-0.193	0.858***	0.631**
	(0.151)	(0.386)	(0.420)	(0.532)	(0.260)	(0.291)
Importer	**-0.441****	-0.440	-0.517	-0.596	0.262	-0.503
	(0.175)	(0.313)	(0.433)	(0.423)	(0.333)	(0.656)
Skills	**0.228*****	0.134	-0.263	0.609**	0.403**	0.281*
	(0.083)	(0.168)	(0.286)	(0.290)	(0.172)	(0.166)
Constant	**-0.477**	0.985	-0.981	-2.331	2.432	-0.989
	(1.062)	(1.947)	(2.594)	(3.440)	(1.761)	(1.434)
			Export intensity			
INPRODUCT-FIRM	**-0.107**	-0.756**	-0.313	-0.383	0.138	-0.313
	(0.145)	(0.348)	(0.415)	(0.518)	(0.245)	(0.303)
INPRODUCT-MARKET	**0.034**	-0.280	0.243	-0.288	-0.032	0,143
	(0.142)	(0.340)	(0.432)	(0.358)	(0.248)	(0.292)
INPROCESS-FIRM	**0.310****	-0.158	0.607	-0.066	0.521**	0.738**
	(0.143)	(0.315)	(0.456)	(0.405)	(0.253)	(0.291)
INPROCESS-MARKET	**0.176**	0.496	-0.130	2.169***	-0.241	0.700**
	(0.166)	(0.405)	(0.476)	(0.807)	(0.271)	(0.322)
Productivity	**-0.158****	-0.113	0.085	-0.183	-0.449***	0.047
	(0.075)	(0.161)	(0.229)	(0.298)	(0.143)	(0.124)
Size	**-0.097**	-0.276**	-0.267	0.486**	0.037	-0.063
	(0.064)	(0.108)	(0.202)	(0.206)	(0.122)	(0.126)
Foreign	**0.510*****	0.592	0.691	-0.525	0.708***	0.266
	(0.150)	(0.382)	(0.429)	(0.541)	(0.260)	(0.289)
Importer	**-0.506*****	-0.451	-0.657	-0.727*	0.175	-0.470
	(0.172)	(0.304)	(0.438)	(0.415)	(0.325)	(0.605)
Skills	**0.170****	0.103	-0.294	0.608**	0.360**	0.196
	(0.082)	(0.165)	(0.287)	(0.290)	(0.170)	(0.164)
Constant	**2.639*****	5.455***	2.479	0.761	5.543***	0.956
	(0.953)	(1.892)	(2.622)	(3.368)	(1.622)	(1.318)

Source: Prepared by the authors.
Note: Standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%. All standard errors presented in this study are corrected for random forms of heteroscedasticity.

Finally, the results for exports and export intensity using the dummy variable "innovative firms with differentiated products" are presented in Table 11. While belonging to this category does not seem to affect export levels, it enhances export intensity ratios by 43%. This finding, however, is not duplicated when the sample is distributed across the UNCTAD categories.

TABLE 11
Innovation and exports: innovative firms with differentiated products – OLS estimates (2001)

	Total	Primary commodities	Labor-intense and resource-based	Low intensity	Medium intensity	High intensity
Exports						
Innovative firms with differentiated products	**0.250**	-0.097	0.305	0.305	0.281	0.142
	(0.162)	(0.418)	(0.550)	(0.550)	(0.259)	(0.329)
Productivity	**0.722*****	0.834***	1.064***	1.064**	0.393**	0.817***
	(0.082)	(0.161)	(0.223)	(0.223)	(0.159)	(0.132)
Size	**0.926*****	0.703***	0.733***	0.733***	1.060***	1.066***
	(0.061)	(0.113)	(0.187)	(0.187)	(0.120)	(0.120)
Foreign	**0.730*****	0.611	0.739*	0.739	0.826***	0.558*
	(0.152)	(0.379)	(0.392)	(0.392)	(0.259)	(0.315)
Importer	**-0.433****	-0.501	-0.539	-0.539	0.290	-0.576
	(0.173)	(0.323)	(0.415)	(0.415)	(0.342)	(0.593)
Skills	**0.218*****	0.118	-0.236	-0.236**	0.435**	0.332*
	(0.082)	(0.168)	(0.278)	(0.278)	(0.168)	(0.183)
Constant	**-0.360**	1.337	-1.751	-1.751	2.650	-1.238
	(0.999)	(1.862)	(2.486)	(2.486)	(1.815)	(1.402)
Export intensity						
Innovative firms with differentiated products	**0.357****	-0.029	0.267	0.748	0.354	0.367
	(0.159)	(0.415)	(0.524)	(0.554)	(0.255)	(0.334)
Productivity	**-0.140***	-0.154	0.170	-0.262	-0.471***	0.081
	(0.072)	(0.156)	(0.229)	(0.301)	(0.144)	(0.145)
Size	**-0.067**	-0.291***	-0.256	0.428**	0.066	0.058
	(0.060)	(0.110)	(0.186)	(0.178)	(0.119)	(0.116)
Foreign	**0.524*****	0.559	0.601	-0.070	0.687***	0.170
	(0.151)	(0.374)	(0.403)	(0.513)	(0.258)	(0.323)
Importer	**-0.492*****	-0.508	-0.676	-0.608	0.197	-0.543
	(0.169)	(0.312)	(0.419)	(0.478)	(0.335)	(0.530)
Skills	**0.162****	0.091	-0.262	0.600*	0.392**	0.247
	(0.082)	(0.164)	(0.279)	(0.300)	(0.166)	(0.187)
Constant	**2.569*****	5.764***	1.726	1.746	5.741***	0.407
	(0.891)	(1.818)	(2.549)	(3.620)	(1.623)	(1.505)

Source: Prepared by the authors.
Note: Standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%. All standard errors presented in this study are corrected for random forms of heteroscedasticity.

6 CONCLUDING REMARKS

Our analysis has shown that the Argentine manufacturing firms that engaged in innovative activities in the period 1998-2001 strengthened their export activities. Whereas launching product innovations new for the market was found to increase the likelihood of a firm becoming an exporter, adopting process innovations new for the firm was seen to raise export levels and propensities.

These findings may suggest that firms need to have state-of-the-art products to judge themselves capable of competing in foreign markets. However, the levels and relative magnitudes of their export activities are more closely tied to process innovations which, in turn, are presumably related to cost reductions and productivity or quality improvements. Process innovations are apparently more relevant in the medium and high skill and technology sectors, where exports are mainly directed to Mercosur markets.

Lastly, the fact that enterprises are innovative firms with differentiated products does not influence their export levels, but it does enhance their export intensities (export/sales ratios) – though this is observed only at the aggregate level, and not when the various industrial sectors are classified according to their factor and technology intensities.

ANNEX I

Correspondence between UNCTAD (2002) classification and ISIC (Rev. 3) sectors at the 4-digit level

	Primary commodities
1511	Production, processing and preserving of meat and meat products
1512	Processing and preserving of fish and fish products
1513	Processing and preserving of fruit and vegetables
1514	Manufacture of vegetable and animal oils and fats
1520	Manufacture of dairy products*
1531	Manufacture of grain mill products
1532	Manufacture of starches and starch products
1533	Manufacture of prepared animal feeds
1541	Manufacture of bakery products
1542	Manufacture of sugar
1543	Manufacture of cocoa, chocolate and sugar confectionery
1544	Manufacture of macaroni, noodles, couscous and similar farinaceous products
1549	Manufacture of other food products n.e.c.
1552	Manufacture of wines
1553	Manufacture of malt liquors and malt
1554	Manufacture of soft drinks; production of mineral waters
1600	Manufacture of tobacco products
1711	Preparation and spinning of textile fibres; weaving of textiles*
2010	Sawmilling and planing of wood*
2430	Manufacture of man-made fibres
2720	Manufacture of basic precious and non-ferrous metals*
3691	Manufacture of jewellery and related articles

	Labor-intensive and resource-based manufactures
1721	Manufacture of made-up textile articles, except apparel
1722	Manufacture of carpets and rugs
1723	Manufacture of cordage, rope, twine and netting
1729	Manufacture of other textiles n.e.c.
1730	Manufacture of knitted and crocheted fabrics and articles
1810	Manufacture of wearing apparel, except fur apparel
1820	Dressing and dyeing of fur; manufacture of articles of fur
1911	Tanning and dressing of leather
1912	Manufacture of luggage, handbags and the like, saddlery and harness*
1920	Manufacture of footwear
2021	Manufacture of veneer sheets; manufacture of plywood, laminboard, particle board and other panels and boards
2022	Manufacture of builders' carpentry and joinery
2023	Manufacture of wooden containers
2029	Manufacture of other products of wood; manufacture of articles of cork, straw and plaiting materials*
2101	Manufacture of pulp, paper and paperboard*
2102	Manufacture of corrugated paper and paperboard and of containers of paper and paperboard
2109	Manufacture of other articles of paper and paperboard

(continue)

(continuation)

2221	Printing
2519	Manufacture of other rubber products*
2692	Manufacture of refractory ceramic products
2693	Manufacture of structural non-refractory clay and ceramic products
2694	Manufacture of cement, lime and plaster*
2695	Manufacture of articles of concrete, cement and plaster*
2696	Cutting, shaping and finishing of stone
3610	Manufacture of furniture
3693	Manufacture of sports goods
3694	Manufacture of games and toys
	Manufactures with low skill and technology intensity
2710	Manufacture of basic iron and steel
2811	Manufacture of structural metal products
2812	Manufacture of tanks, reservoirs and containers of metal
2893	Manufacture of cutlery, hand tools and general hardware
2899	Manufacture of other fabricated metal products n.e.c.*
3511	Building and repairing of ships
3512	Building and repairing of pleasure and sporting boats
3520	Manufacture of railway and tramway locomotives and rolling stock
3591	Manufacture of motorcycles
3592	Manufacture of bicycles and invalid carriages
3599	Manufacture of other transport equipment n.e.c.
	Manufactures with medium skill and technology intensity
2222	Service activities related to printing
2330	Processing of nuclear fuel
2511	Manufacture of rubber tyres and tubes; retreading and rebuilding of rubber tyres
2520	Manufacture of plastics products*
2610	Manufacture of glass and glass products*
2691	Manufacture of non-structural non-refractory ceramic ware*
2813	Manufacture of steam generators, except central heating hot water boilers
2911	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines
2912	Manufacture of pumps, compressors, taps and valves
2914	Manufacture of ovens, furnaces and furnace burners
2915	Manufacture of lifting and handling equipment
2919	Manufacture of other general purpose machinery
2921	Manufacture of agricultural and forestry machinery*

(continued)

	(continuation)
2922	Manufacture of machine-tools
2923	Manufacture of machinery for metallurgy
2924	Manufacture of machinery for mining, quarrying and construction
2925	Manufacture of machinery for food, beverage and tobacco processing
2926	Manufacture of machinery for textile, apparel and leather production
2929	Manufacture of other special purpose machinery
2930	Manufacture of domestic appliances n.e.c.*
3110	Manufacture of electric motors, generators and transformers
3120	Manufacture of electricity distribution and control apparatus
3130	Manufacture of insulated wire and cable
3140	Manufacture of accumulators, primary cells and primary batteries
3190	Manufacture of other electrical equipment n.e.c.
3311	Manufacture of medical and surgical equipment and orthopaedic appliances*
3410	Manufacture of motor vehicles
3420	Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers*
3430	Manufacture of parts and accessories for motor vehicles and their engines
3530	Manufacture of aircraft and spacecraft*
	Manufactures with high skill and technology intensity
1551	Distilling, rectifying and blending of spirits; ethyl alcohol production from fermented materials*
2411	Manufacture of basic chemicals, except fertilizers and nitrogen compounds*
2412	Manufacture of fertilizers and nitrogen compounds
2413	Manufacture of plastics in primary forms and of synthetic rubber
2421	Manufacture of pesticides and other agro-chemical products
2422	Manufacture of paints, varnishes and similar coatings, printing ink and mastics
2423	Manufacture of pharmaceuticals, medicinal chemicals and botanical products
2424	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations
2429	Manufacture of other chemical products n.e.c.*
2699	Manufacture of other non-metallic mineral products n.e.c.

(continued)

(continuation)

3000	Manufacture of office, accounting and computing machinery*
3150	Manufacture of electric lamps and lighting equipment*
3210	Manufacture of electronic valves and tubes and other electronic components*
3220	Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy
3230	Manufacture of television and radio receivers, sound or video recording or reproducing apparatus, and associated goods
3312	Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment
3313	Manufacture of industrial process control equipment
3320	Manufacture of optical instruments and photographic equipment
3330	Manufacture of watches and clocks
3699	Other manufacturing n.e.c.*

Source: Prepared by the authors.
*In these sectors, there is not perfect correspondence between the 4-digit International Standard Industrial Classification (ISIC) activities and the Standard International Trade Classification (SITC) categories. Hence, we assigned the ISIC activities to the UNCTAD categories, taking into account to which category the bulk of the exports of each sector belonged.

ANNEX 2

Export equation estimates for Argentine manufacturing firms - Heckman two-step procedure (2001)

	Total	Primary commodities	Labor-intensive and resource-based	Low intensity	Medium intensity	High intensity
			Exports			
INPRODUCT-FIRM	**-0.131**	-0.798**	0.042	-0.174	0.153	-0.599
	(0.152)	(0.345)	(0.895)	(0.567)	(0.279)	(0.589)
INPRODUCT-MARKET	**-0.051**	-0.162	0.465	-0.353	0.015	-0.039
	(0.149)	(0.481)	(0.801)	(0.513)	(0.267)	(0.502)
INPROCESS-FIRM	**0.249***	-0.248	0.927	-0.217	0.462*	0.931
	(0.143)	(0.357)	(0.859)	(0.492)	(0.273)	(0.590)
INPROCESS-MARKET	**0.145**	0.291	0.362	1.973***	-0.366	0.198
	(0.159)	(0.588)	(0.958)	(0.736)	(0.298)	(0.693)
Productivity	**0.732*****	0.970***	1.321**	0.671**	0.433**	0.872***
	(0.074)	(0.22)	(0.522)	(0.285)	(0.171)	(0.248)
Size	**1.012*****	0.879***	1.573*	1.405***	1.291***	0.699*
	(0.101)	(0.321)	(0.925)	(0.237)	(0.251)	(0.366)
Foreign	**0.857*****	0.821*	1.841**	-0.150	1.151***	0.287
	(0.19)	(0.489)	(1.32)	(0.609)	(0.378)	(0.631)
Importer	**-0.062*****	-0.055	1.441	-0.706	1.231	-2.494
	(0.327)	(0.779)	(2.110)	(0.629)	(0.826)	(2.198)
Skills	**0.274*****	0.182	-0.697	0.522**	0.488***	0.095
	(0.085)	(0.202)	(0.636)	(0.418)	(0.163)	(0.327)
Constant	**2.88*****	-1.941	-13.552	-1.426	-0.720	3.168
	(2.097)	(5.699)	(13.304)	(4.736)	(3.105)	(5.1089)
Lambda	**0.781**	1.119	4.171	-0.324	1.577	-2.748
	(0.703)	(2.071)	(4.085)	(1.302)	(1.204)	(2.781)
			Export intensity			
INPRODUCT-FIRM	-0.071	-0.734	1.220	-0.304	0.159	-0.441
	(0.149)	(0.334)	(1.006)	(0.565)	(0.258)	(0.375)
INPRODUCT-MARKET	0.091	-0.135	0.464	-0.358	-0.003	0.103
	(0.147)	(0.466)	(0.900)	(0.513)	(0.248)	(0.32)
INPROCESS-FIRM	0.275*	-0.229	1.009	-0.136	0.482*	0.905**
	(0.141)	(0.347)	(0.966)	(0.492)	(0.254)	(0.376)
INPROCESS-MARKET	0.183	0.317	0.414	2.108***	-0.284	0.458
	(0.157)	(0.569)	(1.077)	(0.736)	(0.267)	(0.443)
Productivity	-0.140*	-0.043	0.469	-0.223	-0.439***	0.086
	(0.073)	(0.213)	(0.587)	(0.282)	(0.161)	(0.158)
Size	-0.000	-0.154***	0.69	0.434*	0.189	-0.231
	(0.099)	(0.312)	(1.039)	(0.234)	(0.235)	(0.233)
Foreign	0.639***	0.724	1.821	-0.466	0.879**	0.056
	(0.187)	(0.473)	(1.487)	(0.609)	(0.356)	(0.404)
Importer	-0.164	-0.155	1.543	-0.880	0.744	-1.687
	(0.322)	(0.759)	(2.372)	(0.627)	(0.801)	(1.418)

(continue)

(continuation)

Skills	0.211	0.139	-0.781	0.487	0.41***	0.082
	(0.084)	(0.197)	(0.715)	(0.417)	(0.155)	(0.209)
Constant	6.06***	3.205***	-11.652	2.014	3.692***	3.498
	(2.061)	(5.548)	(14.955)	(4.725)	(2.942)	(3.282)
Lambda	0.703	0.86	4.689	-0.448	0.926	-1.681
	(0.57)	(2.022)	(4.592)	(1.296)	(1.171)	(1.795)

	Total	Primary commodities	Labor-intensive and resource-based	Low intensity	Medium intensity	High intensity
			Exports			
Innovative firms with differentiated products	**0.272**	-0.340	1.804	1.288	0.349	-0.489
	(0.237)	(0.741)	(1.537)	(1.029)	(0.432)	(0.614)
Productivity	**0.724*** **	0.799***	1.238***	0.750**	0.398**	0.825***
	(0.073)	(0.162)	(0.318)	(0.313)	(0.163)	(0.156)
Size	**0.932*** **	0.647***	1.184**	1.519***	1.080***	0.924***
	(0.073)	(0.184)	(0.463)	(0.245)	(0.158)	(0.178)
Foreign	**0.739*** **	0.542	1.209*	0.118	0.853***	0.284
	(0.167)	(0.399)	(0.697)	(0.648)	(0.305)	(0.394)
Importer	**-0.412***	-0.634	0.442	-0.074	0.369	-1.668*
	(0.224)	(0.451)	(1.040)	(0.648)	(0.520)	(1.010)
Skills	**0.220*** **	0.109	-0.466	0.921**	0.443***	0.252
	(0.078)	(0.181)	(0.3789)	(0.424)	(0.146)	(0.184)
Constant	**-0.455**	2.439	-8.015	-4.889	2.339	1.368
	(2.018)	(3.178)	(6.545)	(5.047)	(2.289)	(2.694)
Lambda	**0.047**	-0.442	2.091	1.229	0.151	-1.597
	(0.353)	(1.087)	(1.879)	(1.265)	(0.724)	(1.187)
			Export intensity			
Innovative firms with differentiated products	0.375	-0.278	1.845	1.345	0.312	-0.048
	(0.235)	(0.727)	(1.563)	(1.030)	(0.424)	(0.571)
Productivity	-0.139*	-0.190	0.353	-0.132	-0.473***	0.086
	(0.072)	(0.159)	(0.322)	(0.314)	(0.160)	(0.147)
Size	-0.063	-0.348*	0.218	0.561**	0.054	-0.035
	(0.073)	(0.181)	(0.471)	(0.245)	(0.155)	(0.166)
Foreign	0.531	0.489	1.096	-0.162	0.670**	-0.011
	(0.165)	(0.391)	(0.709)	(0.649)	(0.299)	(0.369)
Importer	-0.475**	-0.644	0.357	-0.209	0.148	-1.262
	(0.222)	(0.442)	(1.055)	(0.649)	(0.510)	(0.957)
Skills	0.164**	0.082	-0.504	0.914**	0.387***	0.194
	(0.078)	(0.178)	(0.384)	(0.425)	(0.143)	(0.177)
Constant	2.492	6.892**	-4.868	-1.743	5.933***	2.123
	(1.996)	(3.118)	(6.659)	(5.057)	(2.246)	(2.517)
Lambda	0.039	-0.452	2.202	1.202	-0.093	-1.052
	(0.349)	(1.067)	(1.908)	(1.267)	(0.710)	(1.115)

Source: Prepared by the authors.

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CHAPTER 10

DOES TECHNOLOGICAL INNOVATION CAUSE EXPORTS IN BRAZIL AND ARGENTINA?

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1 INTRODUCTION

Economic theory maintains that developed countries traditionally concentrate their exports in higher tech, higher value-added goods, while developing nations center their exports on labor-intensive, natural-resource-based commodities. Therefore, in markets where the standards of competition are based on product differentiation and innovation, it is only reasonable that developing countries should wish to export higher value-added goods. This desire is motivated by international experience, which consistently shows that any country that has attained high income and development levels has already migrated in the direction of a knowledge-intensive, higher value-added export list.

The problem is that to export is not simply to wish or desire, but depends on the capacities of the firms. Moreover, does technological innovation lead to exports in Brazil and Argentina? It is to answering this question that this article is directed. On the basis of firm-level data for Brazil and Argentina, export functions are estimated for the two countries using various econometric methods. Causality problems are solved through simultaneous equations.

This study is part of the recent IPEA effort to compare the impact of technological innovation across countries. By way of background to the arguments presented, the theoretical literature is reviewed in Section 2 and the database and econometric procedures are described in Section 3. The results of the estimates are given in Section 4 and the principal findings summarized in Section 5.

2 TECHNOLOGY AND EXPORTS

The literature on international trade is relatively consistent. Generally speaking, the theoretical models contend that factor endowment ratios, production scales and technology underlie international trade. Thus, the idea that technology may be a key to driving trade between countries is not a new concept in the literature.

One of the pioneer contributions to international trade theory was the comparative advantage model developed by Ricardo. The classic Ricardian comparative advantages arise from differences in the productivity of labor across countries. These differences, in turn, are linked to climatic variables, national characteristics and, according to some authors, technological disparities (GROSSMAN; HELPMAN, 1994).

Heckscher (1919) and Ohlin (1933) later formulated an international trade model that holds differences in the endowment of labor, capital and natural resources to be the determinants of trade between countries. According to the Heckscher-Ohlin (H-O) model, a country exports goods intensive in the factor with which it is relatively well endowed. In the factor endowment models, technology is considered a production function and is presumably identical in all countries. These models also assume that competition is perfect and that preferences are identical across countries. Fagerberg (1996) argues that such models fail to give due attention to the impact of technology on foreign trade.

In contrast to the Ricardian model, in which trade is determined by differences in the productivity of labor between countries, the H-O model does not consider such differences to be an incentive to foreign trade. However, even if productivity were identical, there would still be room for comparative advantages because of variations in factor endowment ratios. In the H-O model, differences in the relative prices of countries are explained by differences in factor endowments, which comprise the determinants of foreign trade. Hence, a country with a high capital/labor ratio should export capital-intensive goods, while one with a low capital/labor ratio should export labor-intensive goods.

Complementary models based on the relative factor scarcity cannot, however, explain the growth in foreign trade arising from the simultaneous expansion of imports and exports within a given industry. Since technological innovation grants the innovator monopolistic control of the new product, it undermines the assumption of perfect competition that constitutes one of the pillars of these theories. Moreover, it must be taken into account that while technological progress is cumulative and generates dynamic economies of scale, it also carries acquisition and learning costs. From the foreign trade standpoint, the implications of these factors therefore vary widely.

Even so, contributions have been made with regard to including technological differences between countries in essentially classical models. Among the initial contributions were the inclusion of these differences as a factor in the production function and the concept of human capital as developed by Johnson (1968). Over time, the H-O models also evolved in this direction, seeking to explain why countries were paradoxically exporting goods intensive in factors of production that were relatively scarce and importing goods intensive in factors they possessed in abundance. As part of this attempt, the traditional capital/labor approach of the H-O models was modified when the labor factor was broken into skilled and unskilled labor.[1]

Starting in the 1970s,[2] the growth of intra-industry trade among industrialized countries awakened theoretical interest. To explain this feature of foreign trade, the theory that arose reflected the product-differentiation, economy-of-scale and monopolistic-competition hypotheses posited by Chamberlin.[3] By embodying increasing returns to scale, the new foreign trade models provided a framework that complemented the explanations of international trade based on H-O models.

Chamberlin trade models can be found in works by Krugman (1979; 1981), Lancaster (1980), Helpman (1981) and Helpman and Krugman (1985). These models assume that different countries use the same production technology or production function. However, they also assume that two types of goods are produced, one homogeneous and subject to constant returns to scale and the other differentiated, potentially highly diversified and subject to increasing returns to scale. In the presence of economies of scale arising from specialization linked to diversification, different countries should produce different kinds of the latter, which should subsequently be traded internationally.[4]

Before the new international trade theories were consolidated, Posner (1961) constructed a model with two countries, one of them being in the technological forefront and the other managing to imitate the innovation of the first only after some time. In this model, an innovation grants monopolistic power to the leader during the period of time it takes the follower to copy him. Vernon (1966), in turn, defended the thesis that the competitive advantages of American firms were tied to their capacity to innovate new products and processes. According to the product cycle concept, the tendency of firms to produce in their home countries is stronger in the case of new technologies than in the case of mature technologies or products. These ideas, however, were rarely exploited within the context of conventional foreign trade theory. Then, in a product cycle model, Krugman (1979) adopted this type of approach,

1.The article by Leontief (1956) gave rise to the so-called Leontief paradox. Since the Vanek equation (1968) provided the basis for the Heckscher-Holin-Vanek theorem, it could be argued that the H-O paradox is attributable to measurement errors in the quantification of the relative abundance of production factors.

2. Grubel and Lloyd (1971) created an index for measuring intra-industry trade.

3. The Chamberlin (1933) imperfect, monopolistic competition model sought to demonstrate that competitive equilibrium and increasing returns could be compatible in the absence of Marshallian external economies. This model served as the framework for introducing increasing returns to scale into models in the late 1970s. Especially relevant is the work of Dixit and Stiglitz (1977), who, adopting the monopolistic competition perspective, formalized a model used by economists concerned with the foreign-trade theme, including Krugman (1979) and Ethier (1982).

4. The discussion as to the nature of increasing returns to scale and their impact on foreign trade was initiated by Knight (1925) and Graham (1923; 1925). The debate between these authors centered on the question as to whether increasing returns to scale could be either internal or external to the firm, but had to be internal to the industry to which it belonged. One or both of them would be capable of increasing foreign trade. The reciprocal dumping model of Brander and Krugman (1983) also shows that oligopolistic behavior on the part of firms is among the determinants of foreign trade.

postulating that a low rate of technological diffusion across countries serves as a determinant of foreign trade.

In a technological gap model, Krugman (1986) subsequently endeavored to explain why more developed countries produce and export higher tech goods. He also held technical progress to be an endogenous factor in a model in which the monopoly enjoyed by the innovator may benefit society because it encourages innovation (KRUGMAN, 1990). The conclusion derived from this model is that an integrated economy will always be more productive and register higher growth rates than an isolated economy. This, for the author, is the explanation for trade gains. However, the answer as to which country innovates is not stipulated in this model.

Other models in which technical progress is held to be endogenous to the economic system are presented by Grossman and Helpman (1994). The models are divided into two groups according to the type of learning. In the first, or learning-by-doing group, the firm learns from its own production tasks or from activities destined to other ends. The classic example is that of the firm that discovers a better way of doing something while in the course of production. In the second group of models, learning is the outcome of deliberate efforts to create knowledge, that is, of the innovation activities conducted by the firm.

As a rule, in the learning-by-doing models, technology is a function of the experience each country has in producing different goods. There are various specific cases, however, in which the spillovers are limited, whether due to the sector or to the country in which the firm is located. The findings of the innovation and learning-by-doing models are summarized by Grossman and Helpman (1994) as follows:

a) When the learning process is unrestricted and technology rapidly disseminated across countries – that is, when technology is freely available – trade is determined by natural comparative advantages. Thus, we once again have a traditional factor endowment model.

b) When spillovers are limited, whether by distance or by the nationality of the source of knowledge, factors such as country size and existing conditions at the time trade is initiated may play an important role. Examples of this occur when the technological development of small countries is retarded by foreign trade or when countries enter the foreign market at a technological disadvantage. Under these circumstances, competitive forces push these countries to specialize in lower tech, lower growth goods, thereby aggravating the initial discrepancies. This is the case in the Lucas (1988) model, for example. According to Lucas, countries that specialize in technologically advanced industries tend to grow more rapidly than those that do not. Moreover, in virtue of the cumulative nature of technological progress, this standard of specialization tends to be reinforced over time.

c) When the learning process is characterized by dynamic economies of scale, the range of benefits derived from integration and trade may be broader than suggested by static trade models. The Neo-Schumpeterian economists have devoted special attention to foreign trade issues. The theoretical proposition of this school is summarized by Dosi et. al. in the following manner: (*i*) the microeconomic foundations for analyzing foreign trade lie in extending an interpretation of the innovation process to the international plane; (*ii*) the innovation process leads, *ex post*, to a comparative advantage tied to the learning process since innovation, imitation and organizational change are characterized by features specifically related to the sectors and countries in which they are performed rather than to relative factor endowment advantages; (*iii*) the innovation process, by allowing for various kinds of increasing returns (static and dynamic), tends to occasion forms of market interplay that diverge from perfect competition; (*iv*) because certain characteristics of technological change imply that the process may be irreversible, a possibility arises of virtuous or vicious circles with regard to innovation, competitivity and growth; (*v*) lastly, international competitivity is determined by constant technological learning and limited short-term substitution in relation to production and consumption.

In essence, the theories on the determinants of foreign trade are complementary, for any of the aspects stressed in any of the models may be more or less influential, depending on the country, the sector or even the type of good exported.

When the focus of analysis is shifted from factor endowment to technology, firms assume a more important role in shaping the specialization patterns across countries. This occurs because the learning and technological innovation processes are developed at the firm level. In addition, the response to external stimuli may vary widely across firms or groups of firms due to the capabilities and skills previously acquired by each.

Various models show that productivity and the rate of innovation are higher in countries specialized in higher tech goods. Likewise, the growth rates and income levels of these countries tend to be superior to those of countries specialized in standardized goods. Furthermore, in the majority of the models, the initial specialization pattern tends to be reinforced over time, widening the already existing gap between countries in the forefront and those that lag behind. In this context, it is clear that some form of domestic stimulus, such as innovation incentives or technological policies, should be designed to close or substantially narrow this gap.

The pattern of specialization that emerges from these models is one in which the development of new goods falls to the developed countries. In turn, the trade flows between these nations and the developing countries is via continuous innovation by nations in the lead and technological diffusion to those in the rear. Empirically, however, it would be interesting to know if there are circumstances under which this pattern of specialization does not prevail. It would be revealing to ascertain, for example, if countries such as Brazil and Argentina could become competitive in high-tech goods and if product innovation could significantly contribute to their ability to compete in world markets.

3 DATABASE AND ECONOMETRIC STRATEGY

The findings presented in this article are based on data from the National Innovation Survey (PINTEC, 1998-2000) for Brazil and the Second Innovation and Technological Behavior Survey (EICT, 1998-2001) for Argentina.

The PINTEC was designed and conducted by the Brazilian Geographic and Statistical Institute (IBGE). Of the 11,000 firms covered by the sample, 10,328 responded to the questionnaire. When the sample is weighted, the number of firms rises to 72,000. According to IBGE (2004), the general concept and methodology for the PINTEC were derived from the Oslo Manual (1997). In specific terms, the undertaking was guided by the model proposed by EUROSTAT for the third Community Innovation Survey (CIS3), in which fifteen countries belonging to the European Community participated.

The EICT was formulated by the Argentine National Statistics and Census Institute (INDEC). The sample contained 2,225 firms, of which 1,688 responded to the questionnaire. This sample represents the 11,000 manufacturing firms with more than ten employees. According to the survey, the theoretical reference is also the Oslo Manual. However, with the aim of covering the peculiarities of the process of technological innovation in Latin America, certain aspects of the process are considered from the standpoint of the Bogotá Manual, which provides a specific methodology for innovation research in Latin America.

It should be mentioned that the innovation concept used in the EICT is broader than that employed in the PINTEC, for the EICT also stresses the importance of organizational, administrative and trade innovations[5] aimed at obtaining productivity

5. According to the Methodological Report of the Second Innovation and Technological Behavior Survey (EICT, 1998-2001) for Argentina, "organizational innovation embraces the adoption of new ways of organizing and managing an establishment or locale; changes in the organization and management of the production process; the implantation of a significantly modified organizational structure; and the adoption of new or significantly modified strategic guidelines. Trade innovation involves the introduction of means for commercializing new products; new methods for delivering existing products; or changes in packaging and/or wrapping. Having determined if any such innovations have been performed, when in the affirmative, indicate if each of the innovations implemented was new only for the firm (already known on the market); only for the local or domestic market (though not known in the country, the process already used, product sold or organizational/ trade technique in question already employed abroad); or for the world market (a product, process or technique formerly unknown in the sector or manufacturing branch).

and competitivity gains. For the sake of this article, however, including these concepts does not prejudice the comparability of the Brazilian and Argentine surveys because the study focuses on innovation expenditures related to research and development (R&D) investments. As pointed out in the Bogotá Manual, "…as a rule, but even more so with respect to R&D, organizational modernization …is a prerequisite to technological change" (JARAMILLO; LUGONES; SALAZAR, 2001, p.58). In other words, R&D investments are intimately tied to technological process and product innovation.

To answer the question as to whether or not technological innovation leads to exports in Brazil and Argentina, the econometric strategy adopted in this article consists in estimating an export equation specified in accordance with the international trade theories:

$$X_j = \beta_0 + \beta_1 I_j + \beta_2 E_j + \beta_3 C_j + \beta_4 S_j + \xi \qquad (1)$$

where X is the export coefficient, I is R&D expenditure as a share of revenue and E is the production scale of the firm as measured by number of employees. C is a dummy variable for foreign firms and S are dummies for the manufacturing sectors. The index j stands for the firm. Foreign firms are defined as those having 50% or more foreign capital. The sectoral controls are set in accordance with the two-digit National Classification of Economic Activities (CNAE) for Brazil and the Uniform International Industrial Classification (CUCI) for Argentina.[6]

Equation (1) will be estimated using ordinary least squares (OLS) and Tobit procedures. The estimate based on Tobit models is necessary because, as Wooldridge (2000) contends, OLS estimates are biased in the presence of censured data.

Even correcting the coefficients of the OLS model using Tobit estimates, the coefficient of the innovation variable may be biased, for there are reasons to believe that the fact that a firm both exports and innovates may result in simultaneity. In this case, the variable that measures innovation, R&D expenditures/revenue, may be correlated with the term ξ in the export equation. Thus, to determine and measure if the fact that a firm innovates implies that it has a propensity to export, it is necessary to estimate equation (1) using instrumental variable methods. To this end, a variable must be found that is simultaneously exogenous to exports and strongly correlated with innovation. For the OLS, two-stage least squares (2SLS) will be employed. For correcting the Tobit model, an estimate will be made using the Amemiyas general least squares (AGLS) procedure.

To correct the models, suitable instruments must be found. According to Wooldridge (2000), an instrument Z candidate has to meet two conditions: (i) it cannot be correlated with ξ, that is, $Cov(Z_h, \xi) = 0 \quad h = 1,2,3\cdots$ and

6. Since, as Lachmaier and Wöbmann (2004) point out, the "propensity to export and propensity to innovate have strong sector-specific components, the sectoral fixed effects are vital to evade bias from unobserved heterogeneity between sectors."

(ii) it should be strongly correlated with the variable I in equation (1). An instrument can violate neither of these conditions, for the plim of the instrumental variable estimator is given by $\beta_{estimated} = \beta + Cov(Z, \varepsilon) / Cov(Z, I)$.

Lachenmaier and Wöbmann studied the innovations and exports of German manufacturing firms. As instruments, they chose variables that measure impulses and obstacles to innovation at the firm level. They showed that the push and pull variables were strongly correlated with the propensity of the firm to innovate, even after taking into account the size of the firm and the sector to which it belonged. In the German case, these variables met all the requirements for instrumenting an innovation variable.

To instrument equation (1) for Argentina, lagged variables will be used for innovation activity expenditures. In the EICT, data on such expenditures were gathered for the years 1998-2001 and cover the entire period. Lagged variables are generally good candidates as efficient instruments. For Argentina, therefore, in addition to the innovation push and pull variables, the innovation expenditures of manufacturing firms in 1998 were tested as instruments.

For Brazil, the past innovation expenditures of firms cannot be used to instrument equation (1) because although the PINTEC was conducted in 2000 and covers the period 1998-2000, data on innovation activity expenditures were collected for the final year only. As an alternative, the number of products patented by firms and recorded at the National Institute for Intellectual Property (INPI) in 1996, 1997, 1998 and 1999 will be used, together with the instruments suggested by Lachenmaier and Wöbmann (2004).

To validate the instruments, the Wu-Hausman and Sargan tests will be employed. The Wu-Hausman test will serve to verify the exogeneity of the innovation variable and the Sargan test to verify the orthogonality of the instruments to the random term in the export equation. Lastly, the Shea partial R2[7] will be used to verify the relevance of the instruments in explaining the endogenous variable I in equation (1).

4 DOES INNOVATION LEAD TO EXPORTS IN BRAZIL AND ARGENTINA?

Table 1 shows that there are approximately 10,000 manufacturing firms with more than 10 employees in Argentina and 72,000 such firms in Brazil. While there are also numerically more export firms in Brazil, the export coefficient for the Argentine firms is higher at 23.20% compared to 15.77% for the Brazilian firms. On average, the R&D expenditures of Brazilian firms stand at roughly 0.7% of revenues and those of Argentine firms at 0.2%.

7. According to Shea (1996), the correlation between the instrument and the endogenous variable is among the determinants that assure the good performance of the instrumental variable estimates.

TABLE 1
Characteristics of Brazilian and Argentine manufacturing firms

Variable	Argentina (2001)	Brazil (2000)
Total number of manufacturing firms	10,000	72,000
Total number of export firms	3,340	7,299
R&D expenditures/Revenue (%)	0.22	0.75
Export coefficient for export firms (%)	23.20	15.77

Sources: IBGE/PINTEC and INEGI/EICT.

TABLE 2
Export determinants in Brazil (2000) and Argentina (2001). Dependent variable: export coefficient of firm

Country	Argentina	Brazil	Argentina	Brazil	Argentina	Brazil
Procedure	OLS		Tobit			
Equation	1	2	3	4	5	6
R&D/Revenue	-0.28 (0.38)	0.02 (0.04)	-0.42 (0.41) [-0.17]	0.22** (0.11) [0.04]	1.54* (0.83) [0.61]	2.07*** (0.26) [0.41]
(R&D/Revenue)^2	-	-	-	-	-0.22** (0.08) [-0.09]	-0.12*** (0.01) [-0.02]
Foreign dummy	3.44*** (1.60)	6.46*** (0.59)	5.75*** (1.42) [2.30]	16.53*** (0.91) [3.34]	5.94*** (1.43) [2.38]	16.77*** (0.91) [3.38]
Ln of number of employees	3.66*** (0.41)	2.13*** (0.08)	14.33*** (0.44) [5.75]	18.76*** (0.23) [3.79]	14.27*** (0.44) [5.71]	18.63*** (0.23) [3.75]
Constant	-7.13*** (1.77)	-5.96*** (0.34)	-75.42*** (2.15)	-121*** (1.50)	-75.20*** (2.15)	-120.83*** (1.50)
Number of observations	10,571	70,063	10,571	70,063	10,571	70,063
F-statistic	8.40***	54.01***	-	-	-	-
R-square	0.11	0.11	-	-	-	-
Log likelihood	-	-	-19.432	-44.260	-19.428	-44.228

Sources: IBGE/PINTEC and INEGI/EICT.
Obs.: (*) Standard deviation in parentheses –Marginal effect in brackets – Level of statistical significance (***)1% (**)5% (*)10%. Fixed effect control for 2-digit CNAE and CUCI not reported. Cutoff point: export coefficient of firm below 100% and, in the case of Brazil, values over the 99.5 percentile due to their being outliers.

The results of the estimates for equation (1) are presented in three tables. Those obtained using OLS and Tobit procedures are shown in Table 2, while those derived from 2SLS and AGLS are shown in Table 3. On the basis of these findings, the coefficients for Argentina and Brazil cannot be directly compared, nor can it be confirmed that technological innovation is more important to the exports of one country than to those of the other. Only the hypothesis that innovation leads to exports in the two countries can be verified. In Table 4, however, findings are presented that do provide a basis for comparing the countries. These results were obtained by stacking the databases. This procedure allowed for the introduction of a dummy variable having a value of 1 for firms located in Brazil and of 0 for firms located in Argentina. In addition, crossed dummies were constructed between the country variable and three other variables: R&D expenditures in relation to revenues, production scale as measured by number of employees and nationality of firm.

The results for equations (1) to (6) presented in Table 2 indicate that the scale of production is important in both Brazil and Argentina. They also show that the export coefficients of foreign firms are higher than those of domestic firms in both countries. In addition, the R&D expenditure/revenue ratios of firms tend to be positively correlated with their export coefficients.

The results of equations (5) and (6) reveal that the R&D expenditure/revenue ratio is positively linked to increases in the firm export coefficient once the scale, ownership and sectoral controls have been taken into account. A one-percent increase in the R&D expenditure/revenue ratio would therefore raise the export coefficient of Argentine firms by 0.61 percentage points and that of Brazilian firms by 0.44 percentage points. This indicates that technological innovation makes an important contribution to increasing both Argentine and Brazilian exports. It can also be seen that the returns to scale for R&D are decreasing in both countries, as suggested by the negative sign for the squared R&D/revenue variable.[8]

Another hypothesis tested refers to the possibility of increased R&D expenditures exerting a differentiated impact on the export coefficients of foreign firms vis-à-vis domestic firms. To verify this hypothesis, the P&D variable was crossed with the foreign dummy and introduced into the model. The result was significant for neither Brazil nor Argentina. In other words, a one-unit increase in R&D expenditure raises the export coefficient to a similar degree regardless of the firm being domestic or foreign. Consequently, these findings are not reported.

The positive and significant estimates for the firm size and firm nationality variables conform to the economic theory that associates these variables and export performance. Production scale is indeed a relevant factor in explaining the exports of Brazilian and Argentine firms. At the same time, the fact that foreign firms have access to trade channels that are not available to domestic firms gives them competitive advantages in the world market. The estimates for production scale and firm nationality are 2.38 and 5.71, respectively, for Argentina and 3.38 and 3.75 for Brazil. These results were obtained by calculating the marginal effects[9] of the coefficients estimated.

Another procedure for calculating the marginal effect is that suggested by MacDonald and Moffitt (1980). The breakdown proposed by these authors splits

8. To determine if the variable (R&D/revenue)2 is significant in the export model, one can simply apply a likelihood test given by Ω=-2*(L0-L1), where L0 stands for the log likelihood of the restricted model and L1 for that of the complete model. Ω follows an approximate chi-square distribution with one degree of freedom. Thus, Ω=-2*(-19432-(-19428)) = 8, which is higher than the table value Ω of 3.84. For Argentina, the variable therefore contributes to explaining the export model. However, at Ω=.64, it is not significant for Brazil.

9. The marginal effect of a variation in Xik on the expected value of Yi is given by $\frac{\partial E[y_i \mid X_i]}{\partial x_k} = b_k f\left(X_i' b / s\right)$

the effect of the coefficient into two parts, both of which are of interest: (i) the change in Yi caused by values over the limit weighted by the probability of being over the limit and (ii) the change in the probability of being over the limit weighted by the expected value of y when over the limit:

$$\frac{\partial E[y_i \mid X_i]}{\partial x_k} = F(z)\mathrm{b}i\left[1 - \frac{\not{f}\,(z)}{F(z)} - \frac{f(z)^2}{F(z)^2}\right] + \frac{f(z)\mathrm{b}i}{\mathrm{s}}\left(z + \frac{f(z)}{F(z)}\right)$$

TABLE 3
Export determinants in Brazil (2000) and Argentina (2001). Dependent variable: export coefficient

Country	Argentina	Brazil	Argentina	Brazil
Procedure	2SLS		AGLS	
Equation	7	8	9	10
R&D/Revenue	0.70	-0.24	5.80***	3.62***
	(0.49)	(0.15)	(1.24)	(0.95)
			[1.42]	[0.50]
Number of employees	3.61***	2.13***	13.99***	18.82***
	(0.15)	(0.03)	(0.45)	(0.24)
			[3.44]	[2.59]
Foreign dummy	3.50***	6.41***	6.94***	17.16***
	(0.61)	(0.22)	(1.46)	(0.95)
			[1.80]	[2.74]
Constant	-7.07***	-10.23***	-74.97***	-131.75***
	(0.67)	(1.64)	(2.17)	(9.92)
F-statistic/ LR chi2	58.32***	348***	1721***	7557***
R2 / Log likelihood	0.21	0.13	-34628	-193918
Sargan test	0.199	0.191	-	-
Sargan P-value	0.65	0.66	-	-
Hausman Test	7.10	4.85	28.36***	12.97***
Hausman P-value	0.007	0.02	0.001	0.001
Shea partial R2	0.09	0.0092	-	-
R2 F-statistic	521***	325***	-	-
First stage: Dependent variable: R&D Expenditure/ Revenue				
Number of employees	-0.0005	-0.04***	-0.0005	-0.04***
	(0.03)	(0.007)	(0.03)	(0.007)
Foreign dummy	-0.12***	-0.21***	-0.12***	-0.21***
	(0.03)	(0.05)	(0.03)	(0.05)
Innovation expenditures (1998)	0.92***		0.92***	
	(0.02)		(0.02)	
Patents registered (1996-1999)		0.58***		0.58***
		(0.05)		(0.05)
Machinery expenditures (1998)	-0.15***	-	-0.15***	-
	(0.02)	-	(0.02)	-
Innovation risk	-	-0.69***	-	-0.69***
	-	(0.08)	-	(0.08)
R2	0.14	0.06	0.14	0.06
Instrument F-test	52.03***	95***	52.03***	95***

Sources: IBGE/PINTEC and INEGI/EICT.
Obs.: (*)Standard deviation in parentheses –Marginal effect in brackets – Level of statistical significance (***)1% (**)5% (*)10%. Fixed effect control for 2-digit CNAE and CUCI not reported. Cutoff point: export coefficient of firm below 100% and, in the case of Brazil, values over the 99.5 percentile due to their being outliers.

Using the MacDonald and Moffitt breakdown, in the case of Argentine firms, an estimated 69% of the overall change in export coefficients resulting from a shock to the R&D/revenue variable would be generated by changes in the propensity to export. In the case of Brazilian firms, the corresponding figure would be 78%. For Brazil and Argentina alike, these findings indicate that a policy aimed at increasing R&D investments would exert its strongest impact on previously non-export firms that came to export. While this finding is highly relevant for both countries, it is especially important for Brazil, which has eight times more manufacturing firms than Argentina.

The estimates obtained using instrumental variables as a means of correcting eventual biases in the parameters are presented in Table 3.

While the estimates using instrumental variables do not generally modify the interpretations already presented, they do serve to correct the estimated betas in the equations for both Brazil and Argentina. In the AGLS model, the parameter estimates for the variable R&D/revenue are higher than those in the Tobit model. This indicates that the Tobit estimates were too low. The results of the model equations (9) and (10) show that, for Brazil, a one-percent increase in the R&D/revenue ratio would raise the export coefficient an average 0.50 percentage points. For Argentina, a one-percent increase in the ratio would raise the coefficient an average 1.42 percentage points.

The Sargan test does not reject the null hypothesis, which means that the instruments satisfy the orthogonality hypothesis, as required. In turn, since the Hausman test does reject the null hypothesis, it can be affirmed that, as anticipated, the R&D variable is endogenous. This means that estimates of the R&D investment/export ratio may be biased if the instrumental variables are not previously corrected. Once again, in relation to the quality of the instruments used, the partial R2 shows that the instruments significantly contribute to explaining the endogenous variable. From these tests, it can be concluded that the instruments used to estimate the equation for Argentina are generally superior to those used to obtain the estimates for Brazil.

For the Argentine equation, the best instruments were R&D expenditures of firms in 1998 and machinery expenditures of firms in 1998. For the Brazilian estimates, the most adequate instrumental variables were number of patents obtained by firms in the period 1996-1999 and the variable associated with innovation risk.[10]

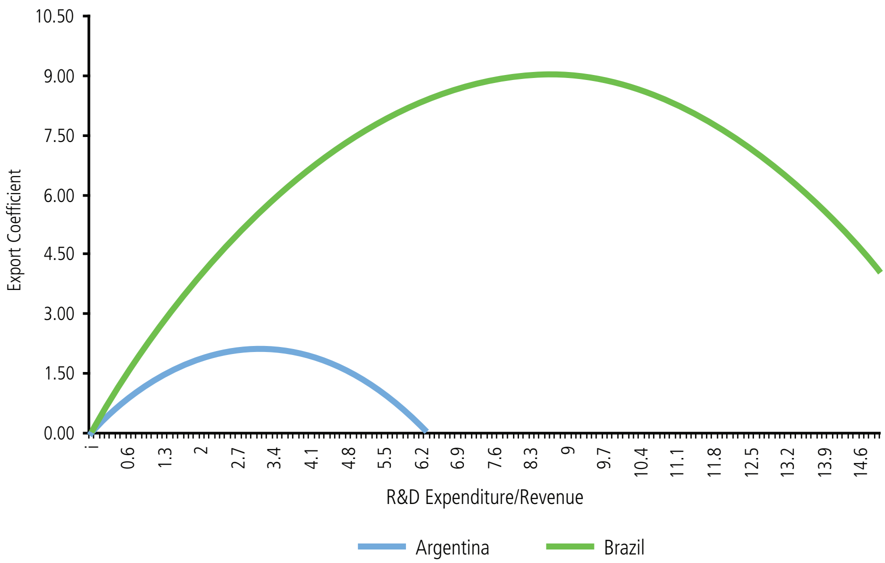
For Brazil, the results of the instrumental variable models suggest that although the instruments meet the requirements, they may be less than ideal for

10. This is a binary variable having a value of 1 when a firm declares that the greatest obstacle to technological innovation is linked to the high risk of innovative processes. We have therefore followed the suggestion of Lachenmaier and Wöbmann (2004) and used obstacles to innovation as instruments in the export equation.

the export equation. An indication of this is the low partial R2, which may be signaling that the variables chosen have limited explanatory power in relation to R&D expenditures.

At any rate, the results of all the models employed – OLS, Tobit, 2SLS and AGLS – confirm the hypothesis that technological innovation leads to exports in both Brazil and Argentina. This having been determined, the question that naturally arises is whether or not stronger innovation efforts (R&D/revenue) would have greater impacts on Brazilian and Argentine exports. In an attempt to answer this question, two procedures were followed. In the first, equations (5) and (6) were used to mount a graph depicting the relations between the export coefficients of firms and the R&D/revenue ratios of the two countries. This graph is displayed in Figure 1.

FIGURE 1
Export coefficient and R&D expenditure/revenue curve for Brazilian (2000) and Argentine (2001) firms



The graph shows that, for Brazil, the inflection point on the curve linking innovation efforts and exports corresponds to R&D expenditures equal to 8.62% of firm revenues. In other words, on average, if the innovation efforts of Brazilian firms were increased, the increase would have a positive impact on their export coefficients up to 8.62% of their revenues. Beyond this point, the impact on exports would become negative, revealing that, from there on, R&D investments would have decreasing returns with respect to their impact on exports. For Argentina, the inflection point is lower at 3.5% of the R&D expenditure/revenue ratio. The graph therefore indicates that Brazilian exports are more closely tied to R&D investments than are Argentine exports. This suggests that, given the characteristics of the manufacturing frameworks of the two countries, the potential for raising the export coefficients of firms via increased R&D expenditures is greater in Brazil than in Argentina.

The second procedure used for answering the question as to whether or not higher R&D expenditures would have greater impacts on export coefficients in Brazil and Argentina was to stack the databases. This having been done, a single equation was estimated for the two countries using a dummy for Brazil, in addition to crossed dummies between the variable for Brazil and the R&D expenditure/revenue, production scale and firm nationality variables. The results of these estimates are reported in Table 4.

TABLE 4
Export determinants in Brazil (2000) and Argentina (2001). Tobit model. Dependent variable: export coefficient

	Coefficient	Standard Deviation	Marginal Effect
R&D/Revenue	0.87**	(0.44)	[0.19]
(R&D/Revenue)2	-0.13***	(0.01)	[-0.02]
Number of employees	14.38***	(0.40)	[3.23]
Foreign dummy	7.43***	(1.34)	[1.67]
Brazil dummy	-44.04***	(1.79)	[-9.91]
Brazil dummy*R&D/Revenue	1.27***	(0.45)	[0.28]
Brazil dummy*Foreign dummy	9.36***	(1.62)	[2.10]
Dummy Brazil*Number of employees	4.57***	(0.44)	[1.02]
Constant	-77.71***	(1.75)	-
Number of observations	81,009		
Number of observations (Brazil)	70,292		
Number of observations (Argentina)	10,717		
Partial R-2	0.15		
Log likelihood	-63.909		
LR chi2(8)	21.238***		

Sources: IBGE/PINTEC and INEGI/EICT.
Obs.: Level of statistical significance (***)1% (**)5% (*)10%. Fixed effect control for 2-digit CNAE and CUCI not reported. Cutoff point: export coefficient of firm below 100% and, in the case of Brazil, values over the 99.5 percentile due to their being outliers.

These results indicate that a one-percent increase in R&D expenditures in relation to revenues would have a stronger impact on the exports of Brazilian firms than on those of Argentine firms. The scale variable (number of employees) remains significant and is also more important for Brazil than for Argentina. Likewise, the foreign firms located in Brazil have a stronger propensity to export than those located in Argentina. However, the negative dummy for Brazil suggests a higher export coefficient for Argentine firms than for Brazilian firms, as already verified in the descriptive statistics, possibly due to the larger size of the Brazilian market.

5 SUMMARY AND CONCLUSIONS

This study tested the hypothesis that technological innovation leads to exports among Brazilian and Argentine manufacturing firms. An export function was estimated for the two countries using various econometric methods, thereby allowing for an original comparison of microdata from the national innovation surveys conducted in the two countries. Employing information on the major obstacles to innovation, lagged expenditures on innovation activities and lagged exports by firms as instruments for R&D expenditures, a vector exogenous to exports was found, thus making it possible to estimate the causal effect of innovation on exports. Since the results of these tests suggest that the OLS and Tobit estimates are biased by the presence of endogeneity, the 2SLS and AGLS estimates are better adjusted.

The findings show that raising R&D expenditures also raises the export coefficients for both Brazil and Argentina. However, the inflection point between exports and the R&D expenditure/revenue ratio is higher for Brazil than for Argentina, indicating that Brazilian exports are more closely linked to R&D than are Argentinean exports. Therefore, given the characteristics of the manufacturing frameworks of the two countries, the possibility of increasing export coefficients by increasing R&D investments is greater for Brazilian than for Argentine firms.

As a means of comparing Brazilian and Argentine exports simultaneously, microdata from the technological innovation surveys were stacked. By using this procedure, the heterogeneity of the data was minimized and the difference in the effects of R&D spending in the two countries was isolated. The results of the crossed dummies employing the country variable and the production scale, firm nationality and R&D expenditure/revenue variables demonstrate that: *i*) Argentine firms have higher export coefficients than Brazilian firms; *ii*) firm size is more important to exports in Brazil than in Argentina; *iii*) in comparison to the foreign firms located in Argentina, those in Brazil are more oriented to the external market; and *iv*) the R&D expenditure/revenue ratio has a greater impact on the exports of Brazilian firms than on those of Argentine firms.

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CHAPTER 11

INNOVATION, BUSINESS STRATEGIES AND PRODUCTION OPPORTUNITIES: FOREIGN FIRMS IN BRAZIL AND ARGENTINA

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1 INTRODUCTION

In the last few decades, the economic performance of the two largest economies in South America, Argentina and Brazil, has been poor and marked by extreme economic turbulence. Identifying long-term moderate and sustained growth paths has therefore become a pressing need in these countries so as to leave behind the recurrent volatility and related economic deterioration.

Even so, since time has stood still in neither country, the years in question have witnessed remarkable structural transformations. Among these should be emphasized the increasing transnationalization of the production systems of the two countries, which have now reached levels rarely observed in other nations of the world. As a result, the investment decisions of the leading firms in these countries lie with corporations that probably consider the weight of the region secondary. Although the implications for the economic structure of the characteristics of the dominant agent are yet to be studied in depth, there is no question that the subsidiaries of transnational corporations (TCs) conmant the local scenario and will in great measure decide its future performance. Hence, the crucial role of the TCs must be taken into account when unfolding any proposed development strategy.

Simultaneously, the link between economic growth and innovation has been reinforced throughout the world, such that today it is hard to analyze one while disregarding the other. A growing body of empirical evidence and sound theoretical arguments support this association: OECD (1996; 1997a), Solow (1979), Romer (1992; 1993; 1994), Lucas (1988), Nelson and Winter (1974; 1982), Silverberg (1988), Silverberg *et al.* (1988), Silverberg and Lehnert (1994). However, returning to the initial concern of establishing a sustainable growth path, how does the strengthening of innovation activities interact with the increasing globalization of the economy?

In answer to this question, this study explores the strategies of the transnational corporations in the region, particularly with respect to innovation, within the broader framework of the "dialogue between Brazilian and Argentine economists on technology, innovation and industry."

The study is organized in three parts. The first surveys the relationship between innovation and research and development (R&D), as well as underlining the leading role that transnational corporations play in these activities throughout the world.

The second part provides a synthetic analysis of the strategies of the transnational corporations in Brazil and Argentina over the last 15 years, first analyzing the strong flow of foreign direct investment (FDI) during the 1990s and then reviewing FDI behavior in the initial years of this century.

The third interfaces the strategies of the transnational corporations in the region and data from the innovation surveys regarding the conduct of the TCs relative to this matter. Lastly, some final considerations are offered.

2 INNOVATION AND RESEARCH AND DEVELOPMENT IN TRANSNATIONAL CORPORATIONS

According to the Oslo Manual, a standard reference with regard to the subject, innovation is the successful introduction, in commercial terms, of a technologically new or significantly improved product or process. The relevance of the innovation is gauged by whether it is new to the world, new to the local market, or simply to the firm that develops it. According to the manual criteria, this kind of innovation is designated "Technological Innovation of Product and/or Process" (TPP) (OECD, 1997a). Adopting a slightly broader definition, innovation can also be taken to include changes (either significant improvements or new procedures) in the sphere of commercialization of products or management of firms, understood, respectively, as innovations in trade or organization (RICYT, 2000).

Although the meaning of innovation can be grasped intuitively, the definition is so broad, vague and diffuse that determining what is or is not an innovation is left to very subjective criteria. While certain activities may or may not be linked to innovation, others leave no room for doubt: these are, by definition, activities within the firm which have innovation itself as their final goal. Such is the case of those Research and Development (R&D) activities which, when performed in a systematic and differentiated manner, offer the advantage of being readily quantifiable. For this reason, R&D expenditure is often used as an innovation indicator by firms as well as by countries.

2.1 R&D: few countries, few sectors and few corporations, the majority transnationals

World expenditure on R&D in 2002 was estimated by UNCTAD at 677 billion dollars. An outstanding characteristic of these activities is their high concentration in geographical, sectoral, and property terms. In 2002, for example, the first ten countries by amount of R&D investment (United States, Japan, Germany, France, Great Britain, China, the Korean Republic, Canada, Italy and Sweden), accounted for almost 87% of the total spent on R&D. Of this select group, only China and Korea do not belong to the club of developed countries.

Roughly two-thirds of world investment in R&D is private. Viewed from this perspective, the expenditures are even more concentrated, with the same ten economies answering for approximately 90% of private business investment in R&D in 2002.

In the developing countries taken as a group, this pattern of concentration is repeated: only ten economies account for more than 97% of R&D investments. Moreover, the nations of South, East and Southeast Asia assembled more than two-thirds of this investment. The only two Latin American economies found among the first ten are Brazil and Mexico.

From the standpoint of corporate investment, 700 firms answer for half the world expenditure and two-thirds of the private investment in R&D. Furthermore, 80% of these enterprises are headquartered in just five industrialized countries (Japan, United States, Germany, United Kingdom and France), while a mere 1% are based in developing countries (mainly Korea and Taiwan).

Finally, of the 700 firms that invest most in R&D, 98% are transnational corporations.[1] In fact, the investments of some of these corporations exceed the R&D expenditures of many nations.[2] These firms are strongly concentrated in certain sectors and more than 50% of the investments are in three industries alone: IT hardware; motor vehicles, parts and accessories; and pharmaceuticals and biotechnology [3](UNCTAD, 2005).

2.2 Globalization of R&D

There are several reasons why innovation activities (specifically R&D activities) tend to be anchored to the home countries of the corporations that develop them and to be the last in the production chain to be transferred to other countries (Lall, 1979). The complex and tacit nature of the generation of knowledge makes it hard and costly to fragment the process and locate different phases in different places. At the same time, researchers generally need to interact "face to face" to exchange and generate new ideas (as vouched for by the long life of R&D centers of excellence). R&D often generates

1. The five firms that invest most in R&D (in absolute values) are among the top 25 corporations classified by assets held abroad.

2. In 2003, for example, Brazil invested US$ 4,824 million and Argentina US$ 522 million in R&D, whereas Daimler Chrysler, the number-one firm in absolute values, invested US$ 7,691 million. The Brazilian values are similar to those invested by Sony, Intel or Samsung Electronics, while the Argentine investment is similar to the efforts made by Shell, Rolls-Royce and Monsanto.

3. According to the 2005 R&D Scoreboard – Volume 2 (2005), seven production branches are more R&D-intensive than the industrial average (3.8%) with regard to expenditure: Pharmaceuticals and Biotechnology (15%); IT Software and Services (10.7%); IT Hardware (8.6%); Healthcare (6.6%); Electronics Equipment (5.5%); Aerospace and Defense (4.9%); and the Automotive and Parts (4.3%) branch. In absolute values, the seven sectors that invest the most are, with a single exception (Chemicals), the same: Automotive and Parts; IT Hardware; Pharmaceuticals and Biotechnology; Electronics Equipment; IT Software and Services; Chemicals; and Aerospace and Defense, in that order.

externalities and creates synergies of location which, in turn, lead to the formation of clusters and agglomeration economies. In principle, this suggests a direct relationship between the localization of R&D activities and the stage of development of the host country. (ALVAREZ; MOLERO, 2004).

When these characteristics inherent to the generation of knowledge, particularly technological knowledge, are added to the commercially strategic value (more relevant each day) of its creation and control, it can be readily understood why technological innovation tends to be geographically centered, usually in the home countries of the respective corporations. This is especially true of innovations that are the fruit of systematic research.

As mentioned above, R&D is one of the least globalized segments in the corporate chain. However, limited R&D has been conducted in the subsidiaries of TCs for some time, for as soon as the first foreign direct investments (FDI) were made, certain technologies had to be adapted, which led to the installation of given R&D activities in the countries receiving the FDI.

Hence, most of the studies concerning what leads a TC to globalize its R&D mention the need to adapt technologies to the local market as one of the main factors. As other motivational factors, they cite access to qualified research personnel and the opportunity to learn from the leading foreign markets and consumers (UNCTAD, 2005).

While there is nothing new in the internationalization of certain R&D activities, there is something novel in the intensity and type of globalization of R&D observed over the last ten years. Between 1993 and 2002, UNCTAD estimates that world expenditures on R&D on the part of overseas subsidiaries of TCs rose from 30 to 67 billion dollars. In this process, verified in all the countries where TCs are headquartered (albeit with different behavior patterns), the developed economies are the final destination of the greater part of the investments (UNCTAD, 2005).

However, the overall share of industrialized countries in the world R&D budget dropped from 97% to 91% between 1991 and 2002, while among the developing countries, that of Asia rose from 2% to 6%. At the same time, TCs based in developing countries increased their share in R&D activities conducted abroad from 2% in 1996 to 18% in 2002. As an additional example of this process, the recent trend among the US transnationals can be cited: between 1994 and 2002, 8% of the investments in R&D performed outside the USA moved from developed countries (with some rearranging within the group to the benefit of Israel and Canada) to developing countries, mainly in Asia.[4]

4. In 2002, 70% of the total invested in R&D by the USA in developing countries was concentrated in China, Singapore, Brazil, Mexico and Korea (in that order). However, on surveying the evolution of these investments since 1994, the share of Brazil is seen to have shrunk from 2% to 1.4% of the total, while that of China has expanded from 0.1% to 3.1%). In fact, the relative importance of Latin America in the overseas R&D investments of US firms has fallen. Between 1994 and 1999, US overseas R&D investment per employee rose two digits in all regions except Latin America.

Likewise, the kind of R&D activities being conducted in these countries is also undergoing a change, no longer consisting in the mere adaptation of products and processes to local conditions, but becoming key points within the global research frameworks of the firms. If the R&D activities developed by the subsidiaries of TCs are rated by technological complexity, as proposed in the UNCTAD World Investment Report 2005 (WIR 05), four major categories can be identified: i) *local adaptation*: market-seeking R&D units primarily directed to adapting technologies developed abroad to local conditions (support units); ii) *integrated local laboratories*: more advanced units capable of autonomously generating innovations directed mainly to the local market (and perhaps to the regional market); iii) *international technology creators*: advanced R&D units positioned at the same level as the firm's principal laboratories in its home country. These units are capable of doing both research and development, and their products can be used at the world level by the firm's head office; iv) *monitoring units*: These "business intelligence" units are dedicated to the search for assets. Category i) tends to be the most common, as well as the oldest, type of R&D unit installed in developing countries. What is now becoming noticeable, however, is that R&D activities are being set up not only to adapt technologies to local markets, but also to develop new technologies for regional and global markets.

Meanwhile, a parallel phenomenon is occurring, in which developing country TCs are investing in R&D abroad, in principle to gain access to advanced technologies and the research capabilities of the developed countries. These investments are not only south-north, but also south-south operations. In general, they are concentrated in Asia since in great part the investing TCs are Asian and the destinations are in the same region.[5]

Certain organizational and technical advances are reducing the obstacles faced by TCs when locating R&D activities outside their home countries. Some of the factors that have often hindered the transfer of R&D activities to overseas subsidiaries, such as the high cost of transferring knowledge, have tended to wane with the arrival of new information and communication technologies (ICTs), while others have become less relevant because firms have been confronted with other necessities: *i*) Increased competition has pushed firms to diminish costs by seeking more economical ways to obtain innovations; ii) Advances in ICTs have improved long-distance communication and transfer of information; iii) New science-based industries have allowed countries with scarce industrial experience, but important scientific and engineering experience, to become attractive sites for the location of R&D activities; iv) Finer differentiation of the R&D process has made it possible to split the stages of research into more modules, so firms are managing to conduct some phases abroad for the purposes of reducing costs and

5. This new trend may signal a new opportunity for Latin American countries.

gaining efficiency (UNCTAD, 2005). Nonetheless, other factors, such as control of the innovation process and the resulting products, plus firm size and industrial structure, continue to play determining roles when deciding where to locate innovation activities.

In the World Investment Report, UNCTAD underlines the following as explanations for the recent increase in R&D investments on the part of developing country TCs (mainly Asian): i) *pull factors,* such as large and growing domestic markets, and/or the availability of large groups of qualified labor at lower costs; ii) *push factors*, including cost increases in home markets and the growing complexity of the R&D process, coupled with stronger competition and the globalization of production, all of which pressure the TCs to innovate increasingly more but at lower costs; iii) *political factors*, such as the measures taken by many countries that receive investments to improve their national innovation systems (including the training of qualified labor); iv) *facilitation factors,* namely advances in ICT, together with the liberalization of trade and investment.

Finally, the recent expansion of R&D beyond the Triad suggests that there is a new set of motivations behind the relocation of part of the activities linked to R&D. Although most of the R&D investments made by the TCs are to adapt products or processes, there are new forces driving the internationalization of other R&D activities, especially in the production sectors associated with new technologies. Joined to the pressure to reduce costs in general and to place new products on the market, the growing expense of R&D activities has led TCs to search for ways to accelerate the process of internationalization, not only by setting aside nonessential activities, but also via locating R&D in countries with lower costs and a ready availability of qualified manpower. This becomes even more imperative in the case of economies that lack the human resources required to perform research tasks within their own countries[6] (OCDE, 2003). In this regard, developing economies offer low costs, access to skills that are not available in sufficient quantity in the home country and velocity in the elaboration of new products and services.

3 FOREIGN DIRECT INVESTMENT AND PRODUCTION STRATEGIES IN ARGENTINA AND BRAZIL

During the nineties, the flow of foreign direct investment (FDI) to Argentina and Brazil increased remarkably, passing from an annual average of approximately 2.1 billion dollars in the period 1985-1989 to almost 30 billion a year between 1995 and 1999. The annual amounts of FDI rose continuously throughout

6. In fact, in its plan for reaching an investment target that would allocate 3% of GDP to R&D, the European Community considers lack of human resources one of the major obstacles, for they reckon it would be necessary to increase the current number of scientists and engineers by 700,000.

the 1990s, allowing these South American countries to triple their share in the total FDI flow at the international level (moving from 1.6% in 1985-89 to 4.8% in the period 1995-99). Even more revealing is the fact that their share in the international flow grew during a boom in total world FDI (one aspect of the phenomenon known as "globalization") that was strongly concentrated in the industrialized countries and a few developing countries.[7] Over these years, total world FDI climbed from an annual average of slightly under 130 billion dollars in 1985-89 to over 600 billion in the last five years of the 1990s.

TABLE 1
Foreign direct investment: world totals (1970-2004)
(US$ million)

	1970-74	1975-79	1980-84	1985-89	1990-94	1995-99	2000-04
World	18,037	30,788	58,724	128,541	205,098	603,012	843,867
Developing economies	4,258	8,488	19,144	23,515	64,024	176,038	205,223
Argentina	81	180	439	730	3,027	10,599	4,175
Brazil	738	1,802	2,075	1,368	1,519	18,325	20,027
Chile	-2	120	319	556	1,207	5,286	4,720
Mexico	413	790	2,160	2,615	5,430	11,422	17,504
China			617	2,620	16,028	42,057	50,894
India	41	33	54	156	414	2,619	3,755
Mercosur	828	2,097	2,603	2,137	4,706	29,273	24,570
Argentina+Brazil	819	1,982	2,514	2,098	4,545	28,924	24,202

Source: UNCTAD – Foreign Direct Investment Database/On-Line.

In the context of the major economic turbulence witnessed in the latter years, the foreign investment flows to both countries diminished, particularly those directed to Argentina. The average FDI destined to Brazil and Argentina fell to just over 24 billion dollars a year in the period 2000-04 (2.9% of the world total), while the total amount of world FDI continued to rise, reaching 843 billion per year between 2000 and 2004. Although it is hard to differentiate transitory from permanent changes, at least in the short run, it seems unlikely that the share of Argentina and Brazil in world FDI will repeat the boom it enjoyed in the nineties. However, in terms of domestic product, the flow of FDI revenue continues to be important for these economies.[8]

7. Among the developing countries, ten (China, China/Hong Kong, Brazil, Mexico, Singapore, Argentina, Bermuda, Malaysia, Chile and Korea) received almost 70% of the accumulated FDI flows directed to the group in the period 1990-2004. Brazil is third in the ranking with an accumulated 200 billion dollars and Argentina sixth with almost 90 billion dollars.

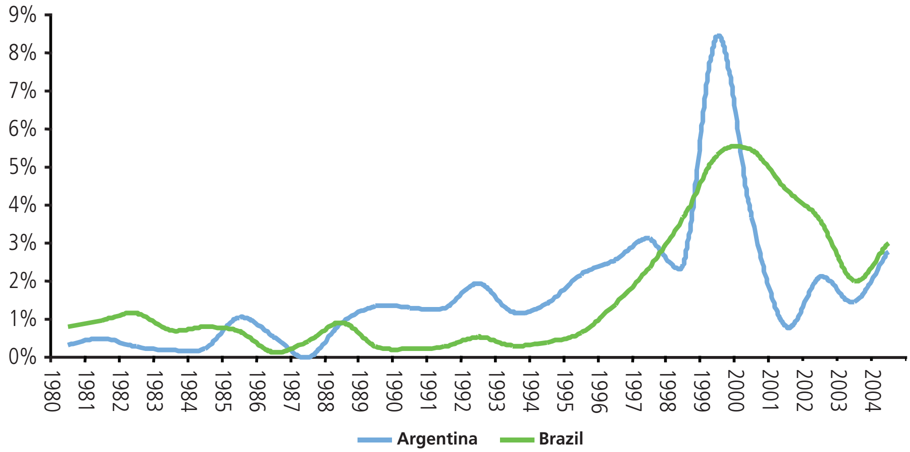
8. According to data supplied by ECLAC, FDI flows to Argentina and Brazil reached 4,662 and 15,193 million dollars, respectively, in 2005.

TABLE 2
Foreign direct investment: world totals (2000-2004)
(US$ million)

	2000	2001	2002	2003	2004
World	1,396,539	825,925	716,128	632,599	648,146
Developing economies	253,179	217,845	155,528	166,337	233,227
Argentina	10,418	2,166	2,149	1,887	4,254
Brazil	32,779	22,457	16,590	10,144	18,166
Argentina+Brazil	43,198	24,623	18,739	12,031	22,419

Source: UNCTAD – Foreign Direct Investment Database/On-Line.

FIGURE 1
FDI flows as percentage of GDP: Argentina and Brazil



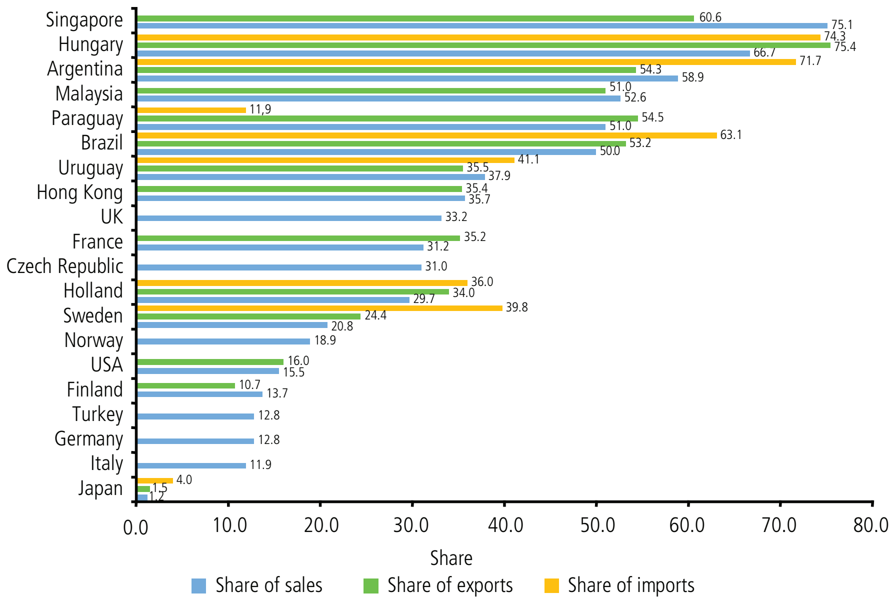
Source: UNCTAD – International Financial Statistics (IMF).

In Argentina and Brazil, the presence of foreign investment in the economy is hardly new, though it has increased substantially in the last fifteen years. During the so-called process of import substitution industrialization, subsidiaries of transnational corporations entered the production sector and assumed leading roles in the manufacturing industries and throughout the domestic scenario. The behavior of these corporations, whose principal strategies are associated with the foreign direct investment that enters a region, affected the structure of markets, altered organizational and production systems and encouraged the development of new and more technologically complex activities for which there was a local demand.

The beginning of a new wave of foreign investment in the nineties coincided with a phase of radical political and economic changes at the national level, as well as in the regional and international contexts. The dynamism of FDI in

Argentina and Brazil forged significant structural changes in the way transnational corporations and other enterprises with foreign capital participate in the economy.[9] The marked rise in the degree of transnationalization of these economies was reflected not only in the share of business sales accounted for by these firms, but also in the contribution they made to the foreign trade of the host countries. The TCs unquestionably dominated the import flow and their contribution to exports was also substantial. On making an international comparison, the large share of TCs in the economies of Argentina and Brazil becomes evident.

FIGURE 2
International comparison of share of TCs in sales, imports and exports (1997 – most recent year available)
(%)



Sources: UNCTAD, OECD, Chudnovsky and López (2000) Bittencourt and Domingo (2000a), Masi (2000) and Laplane *et all.* (2000).

In this context, foreign investment drove the process of industrial transformation that was unfolding in the region in the nineties. During this process, the manufacturing industries were supplanted by the natural-resource, service and infrastructure sectors as the prime destinations for investment. The privatization and deregulation of activities previously restricted to private capital, and especially to foreign capital, drew FDI flows to the region. Among these activities were oil & gas and mining

9. In previous stages in the economic development of Argentina and Brazil, almost all the foreign investments were made by subsidiaries of TCs, generally firms under the complete control of their headquarters. In contrast, since the nineties, the types of investment have multiplied. Among these should be emphasized joint-ventures and investment funds that operate in conjunction with overseas institutional investors.

in the natural-resource segment, plus the telecommunications, electric-energy and financial sectors in the public-service segment. Within the manufacturing sectors, the following stood out as destinations for FDI: the automotive industry,[10] chemical products and food and beverages. In the case of Brazil, investments in machinery and equipment were also relevant, including those in information technology and telecommunications. In recent years, the position of the manufacturing industries as a destination for the FDI flow has again been considerably strengthened, to the detriment of the service sector.

In contrast to earlier periods in which large amounts of FDI entered the region, in this case, the greater part of the capital brought by foreign investors was spent not on the installation or expansion of production units and services, but on the purchase of existing facilities already in operation. Although merger and acquisition operations (M&A) on the part of transnational corporations in Argentina and Brazil had been constantly increasing since the early 1990s, this type of FDI rapidly accelerated in the second half of the decade (when M&A in the two countries stood at an annual average of almost 20 billion dollars, or nearly 40% of the total amount spent on such operations in developing countries). In the current decade, parallel to the decline in the foreign investments in Argentina and Brazil, cross-border mergers and acquisitions have diminished. The overall amount accumulated through M&A in the two countries over the last fifteen years totals 175 billion dollars.

TABLE 3
Mergers and acquisitions: world totals (1990-2004)
(US$ million)

	1990-94	1995-99	2000-04
World	104,149	403,231	557,030
Developing economies	11,864	53,932	59,107
Argentina	2,171	7,983	2,933
Brazil	308	11,819	9,565
Chile	491	3,029	2,272
Mexico	1,415	2,787	7,135
India	130	681	1,333
China	326	1,471	3,447
Mercosur	2,488	19,821	12,562
Argentina+Brazil	2,479	19,802	12,497

Source: UNCTAD – Foreign Direct Investment Database/On-Line.

10. For the automotive sector, a special regime was implemented, whereby a trade compensation agreement encouraged the major firms to maintain plants in both countries.

TABLE 4
Mergers and acquisitions: world totals (2000-2004)
(US$ million)

	2000	2001	2002	2003	2004
World	1,143,826	593,960	369,789	296,988	380,598
Developing economies	70,503	85,755	44,410	40,166	54,700
Argentina	5,273	5,431	1,207	2,467	285
Brazil	23,013	7,003	5,897	5,271	6,639
Argentina+Brazil	28,286	12,434	7,104	7,739	6,924

Source: UNCTAD – Foreign Direct Investment Database/On-Line.

As to the home country of FDI, although the USA is still the major investor, the evolution of flows originating in Spain is notable, for as the country has grown, it has generally used Latin America as a base for the expansion of its firms overseas. While more extensive trade integration has not given rise to an FDI boom of Latin American origin, an FDI internationalization process between Argentina and Brazil has been detected at the local firm level. This process is still open and will almost certainly generate important impacts on microeconomic integration.[11]

During the nineties, the policies aimed at attracting FDI were horizontal in nature, such that in the search for foreign investment, Argentina and Brazil generally adhered to "rule-based" competition. However, there was also competition based on incentives (sectoral and regional). This generated disputes between the countries owing to allegations that investments were being diverted, especially as of the mid-1990s. Likewise, the use of tax benefits to attract investments led to incentives wars within the countries, mainly in Brazil and to a lesser extent in Argentina.

In terms of production strategies, the available evidence on Argentina and Brazil reveals a strong relative predominance of investments directed to the exploitation of raw materials and the search for market access (domestic or regional). Smaller weight is attributed to so-called "search-for-efficiency" strategies such as those developed in Mexico, Central America and the Caribbean (mainly in the so-called *maquila* industries). Still within the framework of market-seeking strategies -addressed to taking advantage of regional market potentials-, the transnational corporations operating in Argentina and Brazil adopted specialization strategies with regard to certain product lines, or actions aimed at complementing other units within the

11. In the first instance, Argentine firms entered the Brazilian market. Subsequently, a group of firms endowed with Brazilian capital were installed in Argentina, mainly through the acquisition of other firms. The purchase of the energy enterprises of the Argentine group Perez Companc by the Brazilian Petrobras, of the cement factory Loma Negra by Camargo Corrêa and the beverage manufacturer Quilmes by AmBev apparently indicate a passage to a different dimension with respect to the globalization of Brazilian firms. This change, which also occurred in the steel and textile industries amongst others, accelerated with the Argentine devaluation and suggests a certain capability on the part of regional firms to seize the opportunities that arise under highly unstable conditions, opportunities to which the transnational corporations based in developed countries are either unable to respond or prefer to ignore in the short run.

global corporate framework. In turn, some local subsidiaries became far more selective when making investment decisions that tended to take on more important roles in the international activities of the corporations to which they belonged, especially in Brazil.

TABLE 5
Latin America and the Caribbean: strategies of transnational corporations in the 1990s

Corporate Strategy	Efficiency seeking	Resource seeking	Market seeking (domestic or regional)
Primary sector		**Petroleum/natural gas:** Argentina, Brazil, Venezuela, Colombia and Bolivia **Mining:** Chile, Peru and Argentina	
Manufacturing sector	**Automotive:** México **Electronics:** Mexico and Caribbean Basin **Clothing:** Caribbean Basin and Mexico		**Automotive:** Brazil and Argentina **Food:** Argentina, Brazil and Mexico **Beverages:** Brazil, Chile, Venezuela and Argentina **Tobacco:** Mexico, Brazil, Argentina and Chile **Chemicals:** Brazil **Cement:** Colombia, Dominican Republic and Venezuela
Service sector			**Finances:** Brazil, Mexico, Chile, Argentina, Venezuela, Colombia and Peru **Telecommunications:** Brazil, Argentina, Chile and Peru **Electric energy:** Colombia, Brazil, Argentina and Central America **Natural gas distribution:** Argentina, Brazil, Chile and Colombia **Tourism:** Mexico, Central America and the Caribbean

Source: ECLAC (2000).

Most of the largest corporations in the world have subsidiaries in both commercial partners, Argentina and Brazil. During the years under study, these affiliates of transnational corporations had high import coefficients for inputs, parts and components and final goods, especially for the production of tradable goods.[12] Even so, their export coefficients, except for occasional sectors based on natural resources and special cases such as the automotive sector, were of slight significance.[13] However, once higher real exchange rates went into effect after

12. In addition, a large part of the external purchases and sales of the subsidiaries of TCs are intra-firm operations and therefore subject to transference prices.
13. It should also be mentioned that, in the manufacturing industries, subsidiaries of transnational corporations play a relatively more active role than domestic firms in intra-Mercosur foreign trade.

the 1990s, there was a gradual increase in the export ratios of the subsidiaries of transnational corporations, and in the last few years foreign subsidiaries have contributed to the remarkable performance of Brazilian manufactured exports.

From whatever standpoint, the prime challenge for Argentina and Brazil continues to be the elaboration of "global products." In other words, the subsidiaries of the transnational corporations installed in their economies should develop internationally competitive product lines basically destined for export to other subsidiaries throughout the world or to new markets. They should also do more than update their operational activities (manufacturing and support tasks, logistics and distribution) and advance to other corporate activities (such as design, research and development, new brands.) capable of generating increases in added value and in the technological content in above average proportions (BARROS DE CASTRO, 2001).

4 INNOVATION STRATEGIES OF THE TRANSNATIONAL CORPORATIONS IN ARGENTINA AND BRAZIL

4.1 R&D efforts in Argentina and Brazil

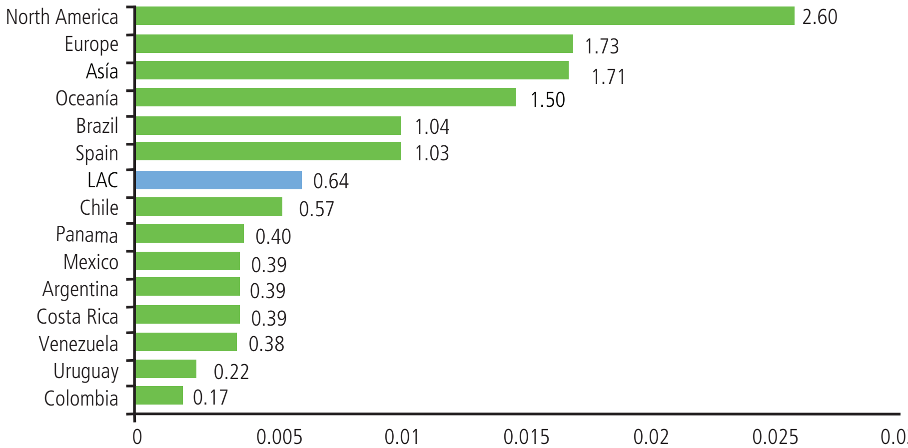
Up to now, transnational corporations have located few R&D activities in Latin America. Exceptions aside, the actions undertaken in the region are in great measure linked to the adaptation of technologies or products for the local markets. Thus, according to WIR 2005, whereas 20% of the total employment in subsidiaries of North American TCs worldwide is in their Latin American affiliates, the R&D employment rate in these same firms is only 7% (essentially in Brazil and Mexico). This obviously reinforces the widespread notion that the FDI in the region has not been characterized by R&D intensity.

However, this is a question that involves not only firms with foreign capital, but R&D expenditures regardless of their source. The indicator that accounts for the percentage of GDP directed to financing R&D clearly shows the regional situation. While the average in the North American countries was equivalent to 2.6% of GDP in 2002 and that of the European and Asian countries was about 1.7%, the Latin American average reached only 0.64% of GDP.[14] In fact, the figures for Latin America are considerably below those for the OECD countries, whether in absolute values or relative to GDP[15] (SECYT, 2005).

14. It must be taken into account that the Latin American countries have been making sustained efforts in science and technology since the 1960s. Since then there has been general awareness of the need to reach the goal recommended by UNESCO as early as the 1970s, that is, to invest at least 1% of GDP in R&D. However, the outcome has been meager, for after years of ups and downs, only one Latin American country – Brazil – has reached this threshold in recent years.

15. In 2002, the R&D investments made by the Latin American and Caribbean countries accounted for 2% of the world total. However, it is necessary to stress the fact that the R&D investments accumulated over the period 1990-2002 exceeded 112 billion dollars, which represents a significant social effort.

FIGURE 3
R&D investment as share of GDP (2002)
(%)



Source: RICYT (2004).

In this regard, only Brazil exceeded the level of 1% of GDP (an average similar to that of Spain). Countries beneath the Latin American average (raised by the relative weight of Brazil) include Chile at 0.57%, followed by Panama, Mexico and Argentina, each with averages of about 0.40%.

While in comparison to developed countries both Argentina and Brazil are far from international standards, the situations of the two are different. Brazil not only invests almost ten times more in R&D than Argentina in absolute values (4,825 and 522 million dollars, respectively), but also doubles the Argentine effort in relative terms, whether measured by intensity (the ratio between R&D expenditures and GDP), R&D expenditure per capita or R&D expenditure per full-time researcher (or equivalent).

TABLE 6
Science and technology indicators for Brazil and Argentina (2003)

Countries	R&D expenditure (US$ million)	R&D expenditure /GDP	R&D expenditure per capita (US$)	R&D expenditure per full-time researcher (2000)	Patent applications (2002)	Patent applications by nonresidents (2002)	SCI publications per US$ million spent on R&D
Argentina	522	0.41	14	47	4,861	4,143	10.8
Brazil	4,825	0.95	27	99	23,995	13,993	3.4
OECD	642,773	2.24	589	179,377			

Sources: RICYT and OECD.

Moreover, on surveying the composition of R&D expenditures by source of financing, the share contributed by corporations is seen to be close to 26% in Argentina. At the same time, government efforts account for 70%, considering that the expenditures on university R&D are concentrated almost exclusively in public universities. In Brazil, on the other hand, if the university system is disregarded, at 40% the private contribution is well above the government contribution, though taken together, the combined contribution of the government and the university system responds for almost 60% of the total spent on R&D. At any rate, both countries are far from the OECD figures, where the average private effort answers for 70% of the total investment in R&D. A similar distribution is observed in relation to the institutional affiliations of researchers (full-time or equivalent), with the role played by the universities standing out in both countries. Once again, the relative position of researchers in Brazilian corporations doubles that of their counterparts in Argentina.

TABLE 7
Composition of R&D expenditures by source of financing and sectoral distribution of researchers (full-time equivalent)
(%)

	R&D expenditure (2003)		Distribution of researchers (2000)	
	Argentina	Brazil	Argentina	Brazil
Government	44.2	30.4	36.1	7.9
Corporations	26.1	41.0	12.2	26.7
Universities	25.9	28.6	50.0	64.7
Nonprofit organizations	2.3		1.7	0.7
International cooperation	1.4			

Source: RICYT.

The results of research efforts are usually measured by two variables: patents and publications, the first being a biased proxy for technological results and the second for scientific results. On analyzing the patent applications made in Brazil, there were found to be almost five times more than in Argentina. More striking yet is that whereas only slightly more than 50% of the applications were made by non-residents in Brazil, in Argentina almost 100% were placed by non-residents. The indicators are therefore signaling more assertive conduct with respect to R&D linked to the productive sector in Brazil than in Argentina.

At the same time, it is interesting to observe that the other indicator, publications, reveals that the Argentine scientific system is considerably efficient. According to the Science Citation Index (SCI), there are nearly 11 publications per million dollars invested in R&D, while in Brazil the rate is only 3.4 publications per million invested.[16]

16. This indicator might also be pointing to a certain deficiency in the investment level. As a reference, it should be mentioned that the rate in Canada is 2.6%, in the USA 1.2%, in Honduras 8.9% and in Ecuador 10.4%. In other words, countries that invest more in R&D have lower rates, indicating that it is the importance of the research that determines publication.

4.2 R&D investments by industrial firms

The results of the innovation surveys for the manufacturing sector in the two countries show that, in 2001, there were almost 72,000 industrial firms with more than ten employees in Brazil and approximately 10,000 in Argentina. As a group, the Brazilian firms invested about 2 billion dollars a year in R&D, while the Argentine firms invested roughly 185 million dollars per year.[17] Whereas the Brazilian firms invested an average 0.7% of their revenue in R&D, the average dropped to 0.2% in Argentina. This percentage is well under the levels of developed countries (*e.g.*, 2.5% in France and 2.7% in Germany).

The surveys also show that industrial sales in Argentina and Brazil are strongly concentrated in sectoral terms. In both countries, the same five production branches, as listed in the two-digit ISIC Rev.3 classification, account for approximately 60% of Brazilian and 70% of Argentine industrial output (manufacture of food products and beverages, manufacture of chemicals and chemical products, manufacture of motor vehicles, petroleum refining and basic metals). In comparison to that of Brazil, Argentine manufacturing is even more concentrated, basically due to the production of food and beverages, a branch that accounts for slightly less than 20% of total industrial sales in Brazil but for almost one-third in Argentina.

In Brazil, three of the above mentioned branches are also among those that invest most in R&D in absolute values (with chemicals and chemical products and motor vehicles being in the first two positions). The two new industrial branches that now appear among the first five in terms of R&D investment are the manufacture of radio, television and communication equipment and apparatus and the manufacture of machinery and equipment (replacing the food and basic metal sectors). In the case of Argentina, there is only one new industrial sector on the list: the manufacture of plastic products (replacing petroleum refining).

Taking R&D expenditure as a proxy for innovation attitude, this is found to be less concentrated in the Brazilian industrial sector. In Brazil, the five leading branches concentrate sales (slightly more than 57% of the total revenue) and R&D expenditure (almost 59% of the total outlay) in similar measure. In the case of Argentina, something different happens, for R&D expenditure is more concentrated than revenue, with the principal manufacturing branches accounting for just over 69% of sales but roughly 80% of R&D expenditure.

At the same time, it is suggestive that the share of R&D expenditure in relation to the total revenue of the branch, is also more uniform in the case of Brazilian industry, as the leading five branches invest about 1% of their revenue (except for the manufacture of radio, television and communication equipment, which by duplicating that percentage, has become third in the ranking).

17. In both countries, nearly 90% of the R&D investment made by firms is with their own resources.

TABLE 8
Sectoral ranking by percentage share of total industrial R&D expenditure – Brazil (2000)
(%)

Sector	Share/Total R&D expenditure	Accumulated share	R&D expenditure/ Turnover
Chemicals and chemical products	15	15	0.76
Motor vehicles, trailers and semi-trailers	13	28	0.97
Radio, television and communication equipment apparatus	12	40	2.08
Coke, refined petroleum products and nuclear fuel	11	52	0.91
Machinery and equipment n.e.c.	7	59	1.03

Source: IPEA.

TABLE 9
Sectoral ranking by percentage share of total industrial R&D expenditure – Argentina (2001)
(%)

Sector	Share/Total R&D expenditure	Accumulated share	R&D expenditures/ Turnover
Chemicals and chemical products	54	54	0.89
Food products and beverages	9	63	0.07
Plastics products	7	70	0.50
Motor vehicles, trailers and semi-trailers	6	76	0.20
Basic metals	4	80	0.20

Source: INDEC.

TABLE 10
R&D expenditure as a percentage share of revenue by industrial sector in the UK, the World, Argentina and Brazil
(%)

Sector	UK	World	Argentina	Brazil
Food products and beverages	1.4	1.8	0.07	0.23
Plastics products	1.3	2.2	0.50	0.62
Coke, refined petroleum products and nuclear fuel	0.2	0.3	0.01	0.91
Chemicals and chemical products*	2.3 to 15.9	3.7 to 15.0	1.19	0.76
Basic metals	0.6	0.9	0.23	0.38
Machinery and equipment n.e.c.	1.6	2.5	0.19	1.03
Radio, television and communication equipment and apparatus	2.7	5.5	0.13	2.08
Motor vehicles, trailers and semi-trailers	4.9	4.3	0.22	0.97

Sources: INDEC, IPEA, and DTI.
Obs.: (*) Whereas the data on the chemical industry are separate from those on the pharmaceutical and biotechnology sector for the UK and the world, they appear under the same heading for Argentina and Brazil.

Surveying the R&D efforts in relation to the revenue of each production branch, most of the above mentioned cases are of little significance compared to the world averages. For example, though the Brazilian manufacture of TV and communication equipment approaches that of the British, it is still less than half the world average. With regard to Brazil, what stands out is the intense effort in the petroleum refining sector. Nonetheless, despite the high coefficients for the manufacture of chemicals and chemical products in Argentina and Brazil, the values observed in these two countries are still far below the world average for the chemical industries (without taking into consideration the R&D-intensive pharmaceutical and biotechnology sectors).

4.3 Competitive strategy of industrial firms and R&D

With a view to better understanding the performance of manufacturing firms according to their competitive strategies in Argentina and Brazil, the "Dialogue between Brazilian and Argentine Economists on Technology, Innovation and Industry" grouped the enterprises in three categories:

Firms that innovate and differentiate products: firms that innovate, creating new products for their markets, export and have above average R&D expenditure/turnover ratios for their industrial sectors

Firms specialized in standard products: firms that export but are not included in the previous bracket, nor in the group of non-export firms that have above average work productivity within their industrial sectors

Firms that do not differentiate products and have lower productivity: firms included in neither of the above brackets

TABLE 11
Number and production scale of industrial firms in Brazil (2000) and Argentina (2001)

Category	Brazil			Argentina		
	Number of firms	Average turnover (US$ million per year)	Workers employed (average number per year)	Number of firms	Average turnover (US$ million per year)	Workers employed (average number per year)
Firms that innovate and differentiate products	971	80.61	679	413	26.78	181
Firms specialized in standard products	13,322	16.39	165	4,644	13.85	95
Firms that do not differentiate products and have lower productivity	55,998	0.72	36	5,661	1.35	40

Sources: INDEC, IPEA.

As illustrated in the above table, the distribution of firms by category forms a pyramid that has a far broader base in the Argentine than in the Brazilian case. Whereas 80% of the Brazilian firms are concentrated in the non-differentiating, lower productivity category, only 53% of the Argentine firms are in this group and 43% of the total are firms specialized in standard products.

It should also be noted that of all the categories for the two countries, the Brazilian non-differentiating, lower productivity firms have the lowest average revenue, while the Brazilian firms that innovate and differentiate products are those with the highest average sales and number of workers per enterprise. The production scale of firms is a prime factor because there are strong correlations between the size and productivity of a firm and its capacity to invest in technological innovation and product differentiation.

The total revenue of Brazilian industry is almost four times higher than that of Argentine industry. As to the share in total revenue by type of firm, those that innovate and differentiate products are responsible for 23.2% of total industrial revenue in Brazil, but for only 12.9% of the industrial revenue in Argentina.

TABLE 12
Indicators of technological innovation in industrial firms in Brazil and Argentina
Brazil: reference year 2000; Argentina: reference year 2001

Category	Brazil			Argentina		
	Average number of workers employed in R&D	Average R&D expenditure (US$ thousand)	R&D expenditure / turnover (%)	Average number of workers employed in R&D	Average R&D expenditure (US$ thousand)	R&D expenditure / Turnover (%)
Firms that innovate and differentiate products	23.8	1,174.1	3.99	6.03	274.8	1.54
Firms specialized in standard products	1.92	56.2	0.54	1.62	11.1	0.14
Firms that do not differentiate products and have lower productivity	0.30	2.7	0.53	0.53	2.1	0.17

Source: INDEC, IPEA.

The average technological innovation effort, measured as R&D expenditures as a percentage of revenue, is relatively low in Brazilian and Argentine industries. However, in the category of firms that innovate and differentiate their products, this percentage is almost 4% in Brazil and 1.5% in Argentina. Although these numbers are still low compared to world levels (particularly in the case of Argentina), in some production sectors they approach the international averages.

With regard to research personnel, in Brazil nearly 67,000 R&D professionals are connected to industrial firms. In Argentina, approximately 14,000 workers are engaged in R&D (in absolute values, one-fifth of the number employed in Brazil). When viewed from the standpoint of competitive strategies, the averages for R&D personnel balance out between the two countries for firms specialized in standard products and the non-differentiating, lower productivity firms. However, the averages reveal a marked difference for the class of firms that innovate and differentiate products (the average six workers employed in R&D in an Argentine firm corresponds to one-fourth the number dedicated to R&D in a representative Brazilian firm). This means that the difference between the two countries is minor for the non-differentiating, low productivity firms but marked for the more dynamic firms.

Strengthening this image, the average annual investments in R&D are seen to amplify these biases. The Brazilian firms that innovate and differentiate products exhibit higher values than their Argentine counterparts (an average 1.2 million dollars compared to an average 275,000 per year, respectively). A difference is also observable in the strategies of firms specializing in standard products, for which the average annual R&D investment is 56,000 dollars in Brazil compared to 11,000 dollars in Argentina.

4.4 TCs, innovation and competitive strategies in Argentine and Brazilian industry

From the Argentine innovation survey, information can be drawn on the behavior of firms with foreign capital. For the purpose of correctly interpreting the results and subsequently comparing them to the outcome of the inquiry on Brazilian innovation, the methodology must be explained. In the case of the Argentine survey, the source released information concerning the percentage share of foreign funds in the firm. On examining the data, this allowed for the establishment of a criterion for the limit as of which an enterprise was considered foreign funded. Thus, if any share whatsoever were declared (no lower limit having been set), the enterprise was categorized as a foreign-capital firm. The logic behind the criterion followed was that a foreign investor would be prepared to take part in a local enterprise only if he actually controlled it, or if the mere fact that he held a share in the firm would affect access to modern technologies (a characteristic that should be emphasized at the time of analysis).

According to the above mentioned criterion, the group of Argentine enterprises with a share of foreign capital (CX) had a larger proportion of firms that generated innovations (77%) in the period 1998-2001. As a matter of fact, 59% of the CX firms achieved product innovations during this period, while 66% obtained process innovations. On the other hand, the firms with no share of foreign funds (SX) presented innovation rates relative to product and process of 42% and 41%, respectively. A similar pattern is observed in connection with organizational innovations: while 51% of the CX firms made significant changes in their organizational schemes, only 31% of the SX firms did so. With regard to the commercialization systems, the ratio also favored the CX firms, which at 40% surpassed the 24% of the SX firms.

Even so, the SX firms destined a larger share of their revenue than the CX firms to innovation activities[18] (IA) and R&D investments.[19] This occurred despite a higher percentage of CX firms having conducted activities that led to innovation. Precisely, though the total IA expenditures of CX firms more than doubled those of SX firms, the relative effort of the latter was stronger; for whereas the CX firms spent 900 million *pesos* (Argentine), equal to 2.05% of their revenue in 1998, on IA, the SX firms directed 444 million *pesos*, or 2.28% of their total sales, to innovation activities.

Adopting a criterion different from that used in the Argentine study, the Brazilian innovation survey stipulated that for a firm to be considered foreign, 50% of the share capital had to be of foreign origin. Since no information was requested on the exact percentage of capital in foreign hands in Brazil, to compare the results of the two surveys, it was necessary to reconcile the data from the Argentine inquiry to the far stricter Brazilian criterion.

On analyzing the data according to this procedure, the average sales of the CX firms turned out to be ten times higher than those of the domestic firms in Argentina, and roughly twenty times higher in the case of Brazil. Likewise, the number of workers employed was three times higher in one country and almost seven times higher in the other. As a result, in both countries the foreign firms were more productive than the domestic firms. Moreover, CX firms registered a notably higher commercial openness than the local firms. Lastly, the R&D expenditures of foreign enterprises were significantly superior (to a much higher degree in Brazil than in Argentina).

18. According to the Bogotá Manual, innovation activities cover all the scientific, technological, organizational, financial and commercial decisions and developments undertaken by firms, including investments in new knowledge aimed at creating innovations. Although not all innovation activities effectively lead to concrete innovations, all true innovations must be seen as the result of the innovation activities of a firm. In turn, innovation activities can be classified as R&D activities (internal or external for the firm); acquisition of incorporated technology (that is, the purchase of machinery and/or equipment for the sole purpose of introducing an innovation); and the acquisition of unincorporated technology (basically, consulting contracts, training, licenses, engineering and industrial design services, also directed to achieving an innovation).

19. Except in 2001, when the increment in the investments of a single international firm led the CX firms to slightly surpass the SX firms.

TABLE 13
Descriptive indicators for average firms by source of capital: Brazil (in *reais* at 2000 prices) – Argentina (in *pesos* at 2001 prices)

Country	Capital	Workers employed	Turnover	Exports	Imports	R&D expenditure
Argentina	Domestic	59	4,385,095	569,805	402,248	10,948
	Foreign	182	47,390,966	14,887,105	7,975,566	119,332
Brazil	Domestic	61	6,016,035	381,790	362,341	183,804
	Foreign	404	111,304,152	9,518,777	10,909,246	5,659,987

Sources: INDEC, IPEA.

At any rate, the change of criterion regarding the definition of a CX firm does not essentially modify the conclusions previously drawn for the Argentine case. Among the firms that invest in R&D, the results show that the CX firms located in Argentina make less innovation efforts than the local firms since, on average, they invest a smaller share of their revenues in R&D than do the local firms.

As to Brazil, De Negri *et.al.* (2005) pose a relevant question: "Who, then, make the stronger innovation efforts, the domestic firms or the foreign firms?" In absolute values, the domestic firms as a group invest slightly more than the foreign firms. However, taken individually, the average Brazilian firm invests significantly less than an average foreign firm (161,000 *reais* for the former compared to 4.9 million *reais* for the latter). This behavior holds when the analysis focuses on the universe of firms that declare to have performed some kind of innovation. When firms of similar size (more than 500 employees) are compared, the difference in innovation efforts drops by half (the indicator of R&D intensity goes to 0.69% for domestic firms and 0.87% for foreign firms).

In a more in-depth analysis, Araújo (2005) demonstrates (through econometric estimates based on a set of variables such as number of workers employed, production sector and insertion in foreign trade) that R&D expenditures as a share of revenue were 80% higher for domestic than for foreign firms. He also points out that the foreign firms that innovate and differentiate conduct R&D activities abroad in larger proportion than the domestic firms, adding that the subsidiaries of transnational corporations are more inclined to promote activities associated with the adaptation of products and processes developed at more advanced facilities than to stimulate local generation of the knowledge required.

According to the Brazilian innovation survey, foreign firms are responsible for 32.7% of total industrial revenue. A similar percentage (32.8%) is observed for the set of manufacturing firms that innovate and differentiate products. Moreover, the innovation rate for foreign firms in Brazil reaches 62%, which is double that for domestic firms. This difference has several explanations. Foreign firms, for example, represent only 1% of the small and medium enterprises, a fact which strongly affects the average innovation performance of domestic industry since SMEs tend to be less innovative.

With regard to the competition strategy of firms as gauged by the above mentioned criterion, it is possible to verify differences in the distribution of the CX firms in relation to the domestic average. In the case of foreign firms, the previously mentioned pyramids assume an urn shape: the base of the pyramid, formed by the non-differentiating, lower productivity firms, is compressed, thereby ceding its majority position to firms specializing in standard products (first minority). Hence, in both countries, the firms that innovate and differentiate products or specialize in standard products concentrate more than three-fourths[20] (75% in Argentina and 80% in Brazil). This shows that the productivity of the CX firms is suited to international competition.

The innovation behavior of firms can also be analyzed according to this classification. Thus, even among the non-differentiating, lower productivity firms, a higher percentage of the CX enterprises performed innovations: in fact, more than 50% of the Argentine CX enterprises and 40% of the Brazilian CX enterprises, in comparison to only 30% of the domestic firms in the same bracket in the two countries. Whereas these differences are explained by product innovation in the case of Brazil, they are explained by process innovation in the Argentine example.

Of the foreign firms identified in the Brazilian industrial sector, 75% failed to be classified as firms that innovate or differentiate products, which in principle contradicts the assumption that exists as to the greater technological dynamism of these firms. According to Negri *et. al.* (2005), this may be owing to the production sectors in which these firms operate. As mentioned earlier, in Brazil, the main FDI pull factors are the relative abundance of natural resources (as in Argentina) and relatively cheap labor. The sectors intensive in these resources are not characterized by intensity in the use of technology. Besides, as already discussed in the first part of this study, the technological innovation strategies of the transnational corporations are dictated by headquarters, which tend to concentrate innovation efforts in their home countries.

20. It must not be forgotten that the criterion for defining a foreign firm is quite strict.

TABLE 14
Technological innovation indicators for Brazilian and Argentine industrial firms by category

Country	Capital	Type of firm	Number of Firms	Distribution (%)	Innovative Firms (%)	New Product (%)	New Process (%)	Both (%)
Argentina	Domestic	Firms that innovate and differentiate products	362	3.7	100.0	100.0	80.7	80.7
		Firms specialized in standard products	4,082	41.2	50.6	39.3	40.8	29.5
		Firms that do not differentiate products and have lower productivity	5,452	55.1	30.2	25.3	22.1	17.1
	Foreign	Firms that innovate and differentiate products	51	6.2	100.0	100.0	82.3	82.3
		Firms specialized in standard products	562	68.4	57.5	43.8	49.6	35.9
		Firms that do not differentiate products and have lower productivity	209	25.4	53.2	23.2	48.9	18.9
Brazil	Domestic	Firms that innovate and differentiate products	716	1.0	100.0	100.0	70.2	70.2
		Firms specialized in standard products	12,081	17.6	43.6	24.6	34.7	15.7
		Firms that do not differentiate products and have lower productivity	55,655	81.3	27.5	14.3	22.1	9.0
	Foreign	Firms that innovate and differentiate products	256	13.9	100.0	100.0	78.1	78.1
		Firms specialized in standard products	1,241	67.4	59.7	44.5	45.7	30.5
		Firms that do not differentiate and have lower productivity	343	18.6	37.2	30.2	27.7	20.7

Source: IPEA.

Although the share of R&D in total IA expenditures is at similar levels for domestic and foreign firms in Brazil and Argentina, the CX firms tend to invest a larger proportion of IA expenditures in unincorporated technology than do domestic firms. However, the opposite occurs with respect to incorporated technology. On considering the competition strategies of the more innovative firms, it is seen that the Brazilian CX firms tend to direct a larger proportion of their IA investments to the acquisition of incorporated technology, while the domestic firms are inclined to spend proportionally more on R&D. This pattern is repeated, though in a considerably more moderate form, in Argentine industry. In both countries, but particularly in Argentina, CX firms that adopt non-differentiating, lower productivity strategies allocate an insignificant proportion of their IA expenditures to R&D, even in comparison to their domestic counterparts. Finally, whereas domestic firms specializing in standard products tend to invest proportionally more on the acquisition of incorporated technologies, CX firms in this category tend to spend more on unincorporated technologies and R&D.

TABLE 15
Argentina: innovation activity expenditures of domestic and foreign firms, total and by category
(*pesos* at 2001 prices)

Innovation Activity	Domestic firms (%)				Foreign firms (%)			
	Total expenditure	Firms that innovate and differentiate products	Firms specialized in standard products	Firms that do not differentiate products and have lower productivity	**Total expenditure**	Firms that innovate and differentiate products	Firms specialized in standard products	Firms that do not differentiate products and have lower productivity
R&D	**118,953,172.02**	35.18	7.76	13.22	**102,170,151.63**	33.61	9.89	0.29
Internal	**99,187,312.48**	30.96	6.15	10.51	**86,070,974.83**	33.38	5.31	0.29
External	**19,765,859.54**	4.22	1.61	2.71	**16,099,176.80**	0.23	4.58	0.00
Incorporated technology	**604,039,649.18**	40.03	76.97	61.66	**281,084,483.07**	34.55	61.02	55.27
Capital goods	**573,526,830.00**	36.17	73.67	58.05	**256,904,181.00**	28.59	57.58	47.72
Hardware	**30,512,819.18**	3.86	3.30	3.61	**24,180,302.07**	5.96	3.43	7.55
Unincorporated technology	**162,921,204.99**	24.79	15.28	25.12	**166,119,104.86**	31.84	29.10	44.43
Software	**25,249,705.20**	3.35	2.80	2.47	**25,138,537.32**	2.99	5.51	5.91
Technology Transfer	**37,617,874.25**	1.44	3.38	11.78	**54,552,011.83**	13.57	7.89	0.17
Engineering & Industrial Design	**39,247,788.57**	9.14	3.55	2.73	**32,944,196.70**	3.81	7.21	12.88
Management	**20,250,206.68**	4.22	1.61	3.07	**19,953,600.81**	6.37	1.97	5.38
Training	**17,375,318.44**	2.83	1.75	1.90	**17,569,291.16**	2.29	3.68	8.01
Consulting	**23,180,311.85**	3.81	2.19	3.16	**15,961,467.04**	2.81	2.84	12.09
Total	**885,914,026.19**	**100.00**	**100.00**	**100.00**	**549,373,739.56**	**100.00**	**100.00**	**100.00**

Source: IPEA.

TABLE 16
Brazil: innovation activity expenditures of domestic and foreign firms, total and by category
(thousand *reais* at 2000 prices)

Innovation Activity	Domestic firms (%)				Foreign firms (%)			
	Total expenditure	Firms that innovate and differentiate products	Firms specialized in standard products	Firms that do not differentiate products and have lower productivity	**Total expenditure**	Firms that innovate and differentiate products	Firms specialized in standard products	Firms that do not differentiate products and have lower productivity
R&D	**2,421,479.56**	28.61	17.49	11.76	**1,948,097.91**	18.70	29.47	9.27
Internal	**2,157,126.09**	26.54	15.05	10.50	**1,577,672.62**	15.15	24.29	7.08
External	**264,353.47**	2.07	2.44	1.26	**370,425.29**	3.56	5.18	2.19
Incorporated Technology	**7,045,934.25**	42.99	57.38	69.14	**5,196,865.69**	49.89	32.53	65.36
Unincorporated Technology	**3,114,362.71**	28.40	25.13	19.10	**3,271,905.91**	31.41	38.00	25.37
Technology Transfer	**464,164.12**	3.59	3.95	3.14	**725,112.78**	6.96	8.74	5.60
Training	**268,637.59**	2.60	1.98	1.94	**161,214.55**	1.55	1.56	1.48
Marketing	**601,134.26**	7.86	3.30	4.65	**824,252.55**	7.91	8.12	7.91
Engineering & Industrial Design	**1,780,426.74**	14.35	15.90	9.37	**1,561,326.03**	14.99	19.58	10.37
Total	**12,581,776.52**	**100.00**	**100.00**	**100.00**	**10,416,869.49**	**100.00**	**100.00**	**100.00**

Source: IPEA.

5 FINAL CONSIDERATIONS

Just as the FDI process implemented by a TC can be separated into stages identifiable by their degree of compromise with the project, the FDI stages in R&D also reveal a complexity that can be classified according to the incremental set of strategies followed by a TC. In fact, recent literature on foreign investment attempts to systematically relate the net direct investment position of a country to its economic development by analyzing its "Investment Development Path" (IDP) (DUNNING, 1988; DUNNING; NARULA, 1994, 1996; NARULA, 1996).

IDP establishes five stages (see the following table), among which stages 3 and 4 are those that essentially determine the localization of innovation activities. In the fifth and final stage, the choice of location depends less on the natural resources of the country and more on the opportunity to acquire new assets, as well as on the capacity of the corporation to organize the advantages and exploit the returns gained through supranational control. In addition, it should be affirmed that access to the final stages, particularly the fifth, is closely linked to more advanced economic development; as a result, the corporations of only a few countries are able to adopt overall globalization strategies, including those aimed at creating new technological assets (ALVAREZ; MOLERO, 2004).

All that has been said reinforces the idea that there is an economic rationale underlying the concentration of R&D in the most developed countries, a rationale that may hinder change in the near future. However, signs have begun to appear indicating a move towards the transnationalization of R&D. Although many TCs still concentrate their principal innovation activities in a single locale, many of the larger firms, especially those with several plants and various products, are opening new R&D units around the world.

What is happening in Argentina and Brazil?

- Although the evidence cited in section 2 points to a growing trend towards the transnationalization of R&D activities and the localization of certain of these activities in developing countries, the region, whether due to structural characteristics (a relative lack of qualified human resources, noncompetitive wages, weak NIS promotion policies, etc.) or to the sectors in which this dynamic is gaining strength (ICTs), remains alien to the phenomenon.
- The evidence presented in section 3 confirms a lack of significant investment in R&D on the part of TCs. Moreover, though it indicates that the region was one of the main destinations for FDI flows during the 1990s (the resurgence of which is again being witnessed, but not in the same intensity), the business strategies of the TCs were primarily directed either to exploiting competitive advantages linked to natural resources, or to positioning the firm with a view to serving the domestic market, whether that of a particular country or of the region as a whole. In this regard, the activities of the TCs focus on adapting products and processes to the local characteristics of the markets.
- Finally, while a superficial comparison of Brazil and Argentina to the rest of the world might indicate that the two share similar fates, in-depth analysis reveals marked differences. Whereas investment and R&D have been stagnating in Argentina for over a decade, Brazil shows evidence of following the path of far more pro-active policies in relation to its production sector. This, joined to the influence of other factors such as the size of the domestic market, has allowed Brazil to enjoy a number of successful cases. There is evidence appearing, for example, of a change in the R&D strategies regarding subsidiaries, which are taking on new responsibilities, mainly in the automotive industry (with signs pointing to the electronics industry as well). In these sectors, the TCs have halted their tendency to limit R&D activities in Brazil, contrary to what continues to occur in the pharmaceutical industry (despite the available capacities and the existence of government laboratories).

- R&D intensity and economic growth tend to be correlated with the proportion of research financed by firms. It is therefore important to know what is happening in the business sector with regard to investment in research and development. Given the correlation between the investment of the business sector in R&D and growth performance, incentives to private investment become a political priority.
- A challenge that faces the region is to broaden its industrial structure, from the simplest to the most complex products, from the most basic to the most advanced innovation activities. Increased specialization in the high-tech production sectors (such as biotechnology) would lead to increased R&D investments. As these sectors have an innate need to invest more in R&D to be able to produce and to compete, a growth in their revenue would augment their relative share in product, thereby raising the R&D investments of the entire private sector. Unfortunately, such sectors arise and mature over long periods of time, so there is little expectation that they alone could sustain the growing participation of the private sector. Neither country has high-tech sectors with a strong share in product. Although there are specific examples at the firm level (INVAP in Argentina, EMBRAER in Brazil), these enterprises do not explain a significant part of the production structure of either country.
- Furthermore, the mere presence of a production sector denominated high-tech is no guarantee that a country will increase its technological capital and stock of knowledge. This will depend on the shape of the value chain. After all, access to knowledge partly depends on the position of the actors in the chain of hierarchy and on the type of specialization assigned to each by the top of the hierarchy. Being attributed a dominant role within the hierarchy guarantees control of the decodification and transfer-of-knowledge mechanisms. This, in turn, allows for the generation of learning dynamics and accumulation of knowledge. On the contrary, exclusion from the network or a marginal position in the hierarchy constitutes a barrier that makes it impossible to exploit the dynamic advantages associated with the creation and diffusion of knowledge (YOGUEL, 2003). The difficulty that local production structures have in accessing and generating knowledge is explained, in part, by the position of local firms within the global production networks. Moreover, in some cases, insertion in global trade circuits has actually been negative with respect to R&D since it has implied transference abroad of engineering and R&D activities formerly performed by local firms.

TABLE 17
FDI development path: underlying factors

	STAGE 1	STAGE 2	STAGE 3	STAGE 4	STAGE 5
FDI level	Limited localization advantages. Little or no FDI from abroad. Few local firms with ownership advantages. No FDI overseas.	General localization advantages. Increasing FDI from abroad. Growth of local industry. Scarce FDI overseas.	Existing facilities. Growing localization advantages. Increasing FDI from abroad. Strong local industry. Rise in FDI overseas.	Strong localization advantages due to existing facilities and benefits of ownership in local firms. More FDI overseas than FDI from abroad.	Similar to Stage 4 except for fluctuations in the FDI balance, which is sometimes heavier on the "overseas" side and sometimes heavier on the "from abroad" side.
Economic structure	PRIMARY SECTOR – On the decline				
	• On the rise MANUFACTURING SECTOR – On the decline				
			SERVICE SECTOR – On the rise		
Industrial advances and evolution of comparative advantages	HECKSHER-OHLIN				
	SECTORS WITH NONDIFFERENTIATED COMPARATIVE ADVANTAGES				
				SECTORS WITH DIFFERENTIATED COMPARATIVE ADVANTAGES	
					INNOVATION-INTENSIVE SECTORS
FDI objectives	Search for advantages derived from the existence of natural resources.	Search for resources, including human resources to lower costs in labor-intensive sectors. Growing investments in search of markets.	Search for markets. Manufacturing investments in search of efficiency, with localization advantages being measured on the basis of existing facilities.	Investments in search of efficiency. Investments in search of markets. Investments to increase the assets of all types of firms.	

Source: Prepared by Alvarez and Molero (2004) on the basis of Dunning and Narula (2000).

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CHAPTER 12

EVIDENCE ON THE INNOVATIVE ACTIVITY PERFORMANCE OF MULTINATIONAL AND DOMESTIC FIRMS: A COMPARISON BETWEEN BRAZIL AND ARGENTINA[1]

Rogério Dias de Araújo

1 INTRODUCTION

It is well known that the decision to internationalize a firm is strongly correlated with the potential returns this decision brings. A firm that decides to exploit any of its intangible assets[2] for foreign production can do so in three ways: *i*) production through subsidiaries; *ii*) joint ventures; and *iii*) licensing contracts. The first two entail different levels of participation, while the third involves transactions between subsidiaries or affiliates that are conducted as if there were no connection between them in order to avoid any conflict of interest.

The three organizational types or knowledge transfer methods cited represent different advantages and disadvantages for a firm. Firms can gain greater profits from their intangible assets if their production is internalized in a subsidiary. In this case, there are normally cost differences associated with the alternatives.[3]

According to Teece (1982 *apud* BLOMSTROM, M; KOKKO, A; ZEJAN, M., 2000), making a choice between the alternatives depends mostly on transaction costs and the public policies of the host country. The main determinants of these costs are: the degree of technological know-how involved, the frequency with which it is transferred, its complexity and its strategic use by competitors.

Multinational firms with vast experience in international operations tend to opt for establishing subsidiaries. However, certain factors can lead such firms to opt for joint venture contracts. A clear example of this is when the economic environment is unknown to the multinational firm, in which case associating with a local firm more advantageous. Another reason is simply risk aversion. If the project is risky, the multinational firm can opt to share it with local firms or other foreign enterprises. Therefore, large projects tend to be configured according to partnership methods. Finally, the government policies of the host country can play an important role, especially in the case of developing countries.

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2. These assets are: knowledge, technology and organization, in addition to marketing and management ability.

3. Implementation costs are a good example because they are present in subsidiary production but not in licensing activities.

It is commonly argued that the increased presence of multinational enterprises in a specific country is beneficial due to the expectation that they will transfer knowledge that is essential for investment in innovation, especially in R&D.

However, in the economic literature that addresses developing countries, some authors defend the position that multinational enterprises adhere to a logic that favors increasing the scale and reducing the cost of R&D, which results in research and development activities – especially basic R&D – being concentrated in a few laboratories located in developed countries.[4] However, developing products for local markets, or even regional markets such as Mercosur, forces multinational enterprises to spend on R&D aimed at adapting products and processes originated in the developed country.

Within this context, the main objectives of this chapter are: 1) to outline the major differences between the innovative activities of domestic and multinational firms in Brazil and Argentina; and 2) to analyze the R&D performance of domestic and multinational firms in Brazil and Argentina.

Besides this introduction and the final comments, this chapter is divided in two parts. Section 2 provides a theoretical reference regarding the technological globalization of multinational enterprises and traces the differences between domestic and multinational firms in their innovative activities in Brazil and Argentina. Section 3 contains an econometric analysis of the performance of domestic and multinational firms in their R&D efforts.

2 TECHNOLOGICAL GLOBALIZATION OF MULTINATIONAL ENTERPRISES: THEORETICAL REFERENCE AND EVIDENCE ON BRAZIL AND ARGENTINA

In this section, the theoretical markers referring to the globalization of research and development (R&D) efforts will be surveyed and evidence on the innovative activities of multinational enterprise affiliates established in Brazil and Argentina will be examined.

2.1 Technological globalization of multinational enterprises

In recent years, economic literature has addressed the factors that lead multinational enterprises to invest outside their countries of origin. The globalization of R&D has been used mainly to enter new markets and to monitor technological developments in other countries.

In 1999, Patel and Vega (p. 146) outlined some of the theories regarding the technological globalization of multinational enterprises. Among the authors they cite are:

4. See, for example, Quadros *et al.* (2000).

a) Vernon, who argued in 1996 that multinational enterprises, having implemented new products and new processes in their markets of origin, move on to new foreign markets. The first stage in this process would be to export developed products to countries where the company did not operate. The second stage would be to produce these goods locally, which inevitably involves the transfer of certain R&D activities, mainly those related to adapting products and production processes.

b) Cantweel (1992) and Chesnais (1992) suggested that the technological globalization of multinational enterprises was related to monitoring the capacities and development of new technologies in foreign countries, given increased R&D costs and complexity.

However, the internationalization of R&D efforts by multinational enterprises has not followed the same trend in recent years. Reddy (1997) identified four historical testing periods for the globalization of R&D by multinational enterprises.

The first period was during the 1960s, when multinational R&D efforts in other countries were aimed mainly at adapting products and processes. Technical services were also provided in order to consolidate multinational access to local markets, though many of these efforts proved insignificant.

The second period occurred in the 1970s and was characterized by R&D efforts abroad aimed at creating essentially new products for local markets and no longer at merely adapting products from the country of origin.

In the third period, during the 1980s, efforts were directed toward generating products and processes destined not only for local markets but also for global markets. This was made possible by a) improvements in communication technologies, which allowed for the more rapid transfer of information regarding the development of products and processes designed for the global market; and b) the convergence of preferences among consumers in various countries, as well as the need to be more competitive on the global market. This period was also characterized by the first R&D performed by home companies and subsidiaries in host countries on a cooperative and complementary basis in order to best utilize the advantages offered by each.

The fourth and final period, in the 1990s, embraced the developments of the previous periods, which now came to be complemented by cooperation between the subsidiaries of multinational enterprises and university research centers in the countries where they were located.[5]

The chart below, from Patel and Vega (1999, p. 147), outlines the historical background of R&D globalization and describes the characteristics and factors leading to the recent globalization of technology by multinational firms.

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5. Currently, the aim of R&D globalization efforts by multinationals is to reduce the cost of determining the advantages offered by each national innovation system.

CHART 1
Technological globalization of multinational enterprises

Objective	Scale	Characteristics of home and host country	Main determining factor for investment in technology
Adaptation of products, processes and inputs to support multinational firms	Small	Considerable advantage of multinational firm in its country of origin	Scale of host market
Monitoring of scientific and technological developments n foreign countries	Small	Considerable advantage of multinational firm in country of origin Advantage used in host country	Quality and scale of science and technology of both home and host countries
Generation of new products. Establishment of large technological centers in foreign countries	Large	Weak presence of multinational firms in country of origin Considerable advantage of multinational firm in host country	Quality and scale of science and technology in both home and host countries, as well as cost opportunities involved.

Source: Patel and Veiga (1999, p. 147).

Thus, even with the division and globalization of R&D efforts, Patel and Vega (1999, p. 154) argue that, in recent years, multinational operations in foreign countries have been characterized as follows:

"(…) adapting products and processes and materials to suit foreign markets and providing technical support to off-shore manufacturing plants remains a major factor. They are also consistent with the notion that firms are increasingly engaging in small scale activities to monitor and scan new technological developments in centers of excellence in foreign countries within the areas of existing strength. However, we find very little evidence to suggest that firms routinely go abroad to compensate for their weakness at home."

In a different tone, Gomes (2003, p. 181) made the following remark concerning Brazil:

"The technological activities that are being transferred to the country do not only address the traditional adaptation activities. Currently off-shore activities have a high technological content, and are also highly creative and integrated with the global program of the MNE (multinational enterprise)."

However, developing countries have recently been adapting products and processes because multinational R&D laboratories in developed countries, or in countries in which National Innovation Systems are highly developed, have been more involved in developing new products and processes that are able to meet the demands of local, regional and international markets, as well as benefit from relative scientific and technological advantages. Thus, R&D efforts are currently being conducted at affiliated companies in cooperation with or using information produced by universities and research centers located in host countries and aimed at adapting products and processes. Furthermore, R&D efforts targeted at developing new products and processes have also been conducted at affiliated companies located in developing countries; however, these efforts continue to be minor in comparison to adaptation activities.

2.2 Key differences between the innovative activities of domestic and multinational enterprises in Brazil and Argentina

Before analyzing innovative activities, it should be observed that, according to the classification scheme used in this research,[6] domestic firms in Brazil and Argentina are concentrated in the "firms specialized in standardized products" category and "firms that do not differentiate products and have lower productivity" category, as shown in Table 1.

It is important to note that 79.19% of the Brazilian sample represents domestic firms that do not differentiate products and have lower productivity. In Argentina, 48.22% of the sample for 1998 and 50.87% of that for 2001 represent domestic firms that do not differentiate products and have lower productivity. It should also be noted that among the multinational affiliates, there are more firms in the firms specialized in standardized products category and in the firms that innovate and differentiate products category in both Brazil and Argentina.

As expected, the net sales per employee statistic is higher for firms that innovate and differentiate products and lower for firms that do not differentiate products and have lower productivity among both domestic and multinational firms in Brazil and Argentina.

Another important point is that, although there are fewer multinational firms than domestic firms in both countries, their share of sales is proportionally greater. Multinational firms are also larger than domestic firms in terms of employees. It should be noted that the number of multinational firms established in Brazil is greater than in Argentina. For example, whereas the multinational firms specialized in standardized products in Brazil had an average of 348 employees in 2000, those in Argentina had an average of 226 and 201 employees in 1998 and 2001, respectively.

6. See the introduction to this book.

TABLE 1
Principal characteristics of firms by category for Brazil (2000) and Argentina (1998 and 2001)
(%)

Category		Share of total number of firms			Share of sales			Number of employees (average)			Sales/ employees (average)		
		Brazil 2000	Argentina 1998	Argentina 2001	Brazil 2000	Argentina 1998	Argentina 2001	Brazil 2000	Argentina 1998	Argentina 2001	Brazil 2000 (Thousand *reais*)	Argentina 1998 (Thousand *pesos*)	Argentina 2001 (Thousand *pesos*)
Domestic firms	Firms that innovate and differentiate products	1.02	3.78	3.38	1.12	3.76	5.52	527	117	135	140.41	90.45	75.75
	Firms specialized in standardized products	17.17	40.35	38.09	49.53	57.23	39.27	147	85	81	126.16	125.73	121.44
	Firms that do not differentiate products and have lower productivity	79.19	48.22	50.87	12.80	24.06	9.21	36	44	39	27.01	39.64	34.24
Multi-national firms	Firms that innovate and differentiate products	0.36	0.31	0.48	14.39	0.62	6.27	1.105	515	490	255.43	219.81	191.97
	Firms specialized in standardized products	1.77	4.97	5.24	21.75	13.64	39.11	348	226	201	279.13	221.71	193.11
	Firms that do not differentiate products and have lower productivity	0.49	2.38	1.94	0.41	0.69	0.62	83	80	63	49.03	79.38	42.36

Sources: Developed by the author, based on Pesquisa Industrial sobre Inovação Tecnológica (PINTEC), Censo de Capitais Estrangeiros do Banco Central (BACEN), Pesquisa Industrial Anual (PIA), Secretaria de Comércio Exterior (SECEX) and Relação Anual de Informações Sociais (RAIS) and Encuesta Nacional de Innovacíon y Conducta Tecnológica de las Empresas Argentinas (1998 and 2001).

In terms of average expenditures on innovative activities, Table 2 shows that domestic enterprises made greater internal R&D efforts than multinational enterprises in both Brazil and Argentina.[7] In Brazil, domestic firms specialized in standardized products spent an average 0.56% on research and development (R&D) in relation to sales, while the multinational firms spent an average 0.38% in 2000. In Argentina, domestic firms specialized in standardized products spent an average 0.15% on R&D in relation to sales, while the multinational firms expended an average 0.08% in 2001.

The fact that multinational firms make weaker R&D efforts in relation to sales than domestic firms may be linked to the hypothesis that the R&D expenditures of multinational enterprises are concentrated on adapting products and processes that

7. With the exception of firms that did not differentiate products and had lower productivity in Argentina in 1998.

come from company headquarters. However, as shown later, this does not necessarily mean that multinational enterprises are less innovative than domestic enterprises.[8]

TABLE 2
Average expenditures on innovation activities in relation to sales by category for Brazil (2000) and Argentina (1998 and 2001)
(average %)

Category		Internal R&D			External R&D			Purchase of technology			Purchase of machinery and equipment		
		Brazil 2000	Argentina 1998	Argentina 2001	Brazil 2000	Argentina 1998	Argentina 2001	Brazil 2000	Argentina 1998	Argentina 2001	Brazil 2000	Argentina 1998	Argentina 2001
Domestic firms	Firms that innovate and differentiate products	4.83	2.55	1.56	0.27	1.16	0.11	3.82	0.09	0.06	3.55	3.42	1.84
	Firms specialized in standardized products	0.56	0.12	0.15	0.10	0.02	0.02	0.14	0.01	0.01	4.77	1.41	0.89
	Firms that do not differentiate products and have lower productivity	0.53	0.13	0.18	0.10	0.05	0.05	0.13	0.00	0.01	8.57	0.95	0.80
Multi-national firms	Firms that innovate and differentiate products	1.63	0.81	1.46	0.22	0.02	0.46	0.29	0.30	0.24	17.25	3.72	1.30
	Firms specialized in standardized products	0.38	0.06	0.08	0.05	0.02	0.04	0.25	0.07	0.07	56.05	1.39	0.90
	Firms that do not differentiate products and have lower productivity	0.36	0.21	0.00	0.09	0.00	0.00	5.45	0.01	0.00	5.00	1.22	0.28

Sources: Developed by the author, based on PINTEC, BACEN, PIA, SECEX , RAIS and Encuesta Nacional de Innovacíon y Conducta Tecnológica de las Empresas Argentinas (1998 and 2001).
Obs.: Variation of the coefficient in parentheses.

It should also be emphasized that the multinational enterprises established in Argentina made less efforts in general than those established in Brazil. Not only were internal R&D efforts weaker in the former than in the latter, but also efforts to purchase machinery and equipment, acquire technology and acquire external R&D. These lower levels may be associated with the types of innovation

8. For Brazil, the ANPEI (2004) study showed that multinational firms made greater internal R&D efforts than domestic firms. However, the difference narrows when the larger firms (500 employees or more) are analyzed. Thus, all indicates that ANPEI (2004) used the PINTEC scheme for defining domestic and multinational firms rather than the Banco Central method of separating firms by origin of capital.

performed in Argentina, as well as with the higher cost of doing the same research and development in Argentina vis-à-vis Brazil.

It was not surprising to discover that the innovation effort that incurred the highest expenses was the acquisition of machinery and equipment. This type of effort naturally demands higher spending and most of the companies that innovated declared they had acquired some type of machinery or equipment specifically geared towards innovation. In Brazil, the multinational firms specialized in standardized products spent an average 56.05% of their net sales on such purchases, while in Argentina the same category of firms spent averages of only 1.39% and 0.90% in 1998 and 2001, respectively. Once again, these data may be mirroring the different characteristics of innovation in Brazil and Argentina, as well as the different economic conditions of the two countries at the time of the surveys.

It is necessary to call attention to the fact that average-based analysis can sometimes be inaccurate due to considerable variations in sample values. Therefore, later in this chapter, regressions will be presented that take these variations into account, together with controlled variables for sector characteristics, educational level of work force and size of firm, among others.

Data on the percentage of firms that innovate processes, products or both in Brazil and Argentina are presented in Table 3. This table shows that, with the exception of firms that innovate and differentiate products, a higher percentage of multinational than domestic firms innovate in both countries.

In Brazil, 37.28% of the multinational enterprises in the firms specialized in standardized products category innovated products or processes, opposed to 26.40% of the domestic undertakings in the same category between 1998 and 2000. In Argentina, 68.05% and 56.71% of the multinational enterprises innovated, opposed to 46.84% and 47.94% of the domestic undertakings in the same category in 1998 and 2001, respectively.

Although the percentage of innovative firms is slightly higher in Argentina than in Brazil, the data are not directly comparable because the number of multinational firms in Argentina (820 in 1998 and 821 in 2001) is considerably lower than the number in Brazil (1,840 between 1998 and 2000). Moreover, in the surveys, the innovator column for Argentina also includes organizational and trade innovations.

TABLE 3
Share of innovative firms by origin of capital
(%)

Category		Process innovators: Brazil 1998-2000	Process innovators: Argentina 1998	Process innovators: Argentina 2001	Product innovators: Brazil 1998-2000	Product innovators: Argentina 1998	Product innovators: Argentina 2001	Innovators: Brazil 1998-2000	Innovators: Argentina 1998	Innovators: Argentina 2001
Domestic firms	Firms that innovate and differentiate products	70.24	84.98	80.61	100.00	100.00	100.00	100.00	100.00	100.00
	Firms specialized in standardized products	34.68	37.66	40.63	24.63	37.59	38.98	43.59	46.84	47.94
	Firms that do not differentiate products and have lower productivity	22.14	22.97	22.22	14.29	25.47	25.55	27.41	28.72	29.29
Multinational firms	Firms that innovate and differentiate products	78.07	87.88	82.00	100.00	100.00	100.00	100.00	100.00	100.00
	Firms specialized in standardized products	45.74	60.15	50.09	44.46	44.74	44.19	59.73	68.05	56.71
	Firms that do not differentiate products and have lower productivity	27.74	28.24	48.11	30.23	28.63	22.64	37.28	32.16	52.36

Sources: Developed by the author, based on PINTEC, BACEN, PIA, SECEX, RAIS and Encuesta Nacional de Innovacíon y Conducta Tecnológica de las Empresas Argentinas (1998 and 2001).

Among the multinational firms specialized in standardized products, the major differences between Brazil and Argentina refer to process innovations. This is curious because among the domestic firms in the same category, the main differences refer to product innovation. Thus, despite the fact that the multinational firms in Argentina spend less than those in Brazil on acquiring machinery and equipment, the data nonetheless indicate that the competitive strategies of the multinational firms differ from those of the domestic firms in Argentina.[9]

Finally, whereas higher percentages of multinational firm affiliates innovate, all indications are that domestic firms make more internal R&D efforts. This leads to the conclusion that the R&D spending of multinational firms is mainly geared towards adapting products and processes, as stated earlier.

9. In the chapter by Ramos and Anlló, further evidence is offered regarding the innovative strategies of domestic and multinational firms in Brazil and Argentina.

3 ECONOMETRIC EVIDENCE ON R&D EFFORTS IN BRAZIL AND ARGENTINA

For researching the performance of foreign and domestic capital enterprises in their R&D efforts in Brazil and Argentina, two industry models were estimated. The methodology and results are presented below.

3.1 Methodology

Two statistical techniques were used to estimate the regressions for Brazil and Argentina: Ordinary Least Squares (OLS) and Probit. The first technique is widely accepted in economic literature and was used to estimate elasticities in this research. The second technique was employed to estimate the marginal probabilities of the occurrence of given events.

One of the main problems in estimating cross-section regressions with OLS is the heteroscedasticity of the samples. Although the estimated coefficients are not biased, they lack minimum variance. Consequently, the estimated coefficients are rejected despite their accurately representing the population. To solve this problem, White's matrix was used to obtain the least possible standard deviation of the coefficients.[10]

Another possible problem in estimating cross-section regressions with OLS is multicollinearity among the variables. In this case, while the estimated coefficients are not biased, they do not present minimum variance. As a result, the estimates are imprecise. One indication of multicollinearity is the presence of several insignificant variables, but an elevated R^2. The multicollinearity problem in the econometric models presented in this paper is not overly serious because the sample is relatively large, so the problem tends to dissipate.[11] Finally, since the problem of autocorrelation in models based on cross-section samples is not relevant, it will not be further commented upon.

The Probit regressions were estimated using the Maximum Likelihood method.[12] What are of interest here are not the coefficients themselves, but the marginal probabilities obtained from these coefficients. Marginal probability is the variation in the probability of an event occurring when the variable Y_i assumes 1 given a variation in the value of the explanatory variable. Under these conditions, marginal probabilities would exist for each explanatory variable.

To obtain marginal probabilities, the value of the probability density function is calculated at estimated Y_i point and multiplied by the estimated value of the coefficient. In this case, there would be marginal probabilities for each estimated

10. For more details on White's matrix, see Gujarati (1995) or Greene (2000).

11. Another way to detect multicollinearity is to analyze the partial correlations among the variables of the estimated models. Correlations above 0.8 indicate a possible multicollinearity problem (see, for example, Gujarati [1995, p. 335]). Notwithstanding, there was no correlation above 0.8 observed in the pertinent variables in the models estimated in this project, whether by OLS or Probit.

12. The Probit function has a normal reduced form:

$\text{prob}(Y_i=1)= \int_{-\infty}^{X b} \frac{1}{\sqrt{2p}} \exp\left(\frac{-z^2}{2}\right) d$ For more information about the Probit estimation technique, see Hoffman (2002) or Greene (2000).

$Y_{i,}$ which would complicate this study due to the reasonably large amount of data used for estimating the models. Notwithstanding, there are two possible alternatives mentioned in the literature, namely: 1) to estimate marginal probabilities based on a mean point, that is, based on a firm with average characteristics for the manufacturing industries; or 2) to estimate a marginal probability for all firms and subsequently calculate an average marginal probability. For the purpose of this research, the first alternative was chosen.

As OLS and cross-section samples, the Probit presents heteroscedasticity and multicollinearity problems. Here, however, heteroscedasticity is a more serious problem than in OLS. Besides being inefficient (i.e. not presenting minimum variance), the estimators are also inconsistent. In other words, they do not approximate the true value of the population as the sample increases. Nevertheless, when calculating marginal probabilities, this problem is not as serious as it appears. According to Greene (2000, p. 830), the marginal probabilities obtained through homoscedastic and heteroscedastic models are similar. Moreover, it is relatively hard to determine precisely which is the heteroscedastic variable and which form of variance it assumes in the estimated models in order to implement corrective techniques.

As to the multicollinearity problem, it is not necessary to be overly concerned because the problem dissolves as the number of observations in the sample increases. In addition, as in the case of the OLS,[13] the partial correlations did not exceed 0.8.

Two models were estimated for each country, one using the Probit technique and the other the OLS technique. In the first model, regressions were estimated for all the firms in the technological research samples for Brazil and Argentina. A dummy variable was used to measure whether or not domestic firms were making stronger internal R&D efforts than the affiliates of multinational firms. In the second model, regressions were estimated only for the affiliates of multinational firms in order to verify whether or not the fact that they acquired more external R&D – which probably came from their headquarters or from affiliates located in countries with well-developed National Innovation Systems – discouraged them from investing in internal R&D.[14]

In all the models, the focus was on estimating theory-based performance regressions, not predictive regressions, especially since there was only one year of data available for the overall sample. Furthermore, all the models were directed

13. See footnote 7 in this chapter.

14. The models estimated did not consider the categories defined in this research, and in the case of Argentina, the coefficients of the categories tended to be insignificant due to the size of the sample. Because one of the goals of this research was to obtain comparable regressions, the coefficients of the categories were removed from the estimated regressions.

to verifying if a substitution or complementary relationships existed between the R&D efforts and other innovative efforts of firms in a given year.

The Probit dependent variable assumed a value of 0 when the firm did not spend on R&D within a specific year and a value of 1 when it did. The OLS dependent variable is the Neperian logarithm for R&D efforts in relation to sales by multinational firms in the Brazilian and Argentine manufacturing industries in a given year.

The first independent variable is the number of employees in a firm.[15] The sign of the coefficient is expected to be positive since most of the economic literature contends that larger firms have a stronger propensity to make R&D efforts than smaller ones.

The second independent variable is the proportion of employees with higher education in relation to the total work force. The sign of the coefficient is expected to be positive.

The third independent variable represents the expenditures on training (specifically directed to developing technologically new or improved products or processes), in relation to sales, of Brazilian and Argentine firms. A positive sign is expected.

The fourth independent variable represents the expenditures of a firm, in relation to sales, on acquiring R&D from another firm or technological institution. Since this variable can stand either for the substitution of internal R&D through external R&D or for positive spillover effects, the results are initially unknown.

The fifth independent variable represents expenditures, in relation to sales, on acquiring external knowledge (technology acquisition), which encompasses technology transfer agreements originating from purchasing licenses for using patents and trademarks and acquiring know-how, software and other types of technical-scientific knowledge from other agents so the firm can develop or implement innovations.

The sixth independent variable represents expenditures, in relation to sales, on acquiring machinery, equipment and hardware specifically geared towards implementing new or improved products or processes. Because many R&D expenses are aimed at adapting productive processes or products to new machinery and equipment, a positive sign is expected for the estimated coefficient.[16]

15. In most of the literature, such as in Matesco (1993), number of employees is used as a proxy for firm size of the firm, the number of employees being less sensitive to economic fluctuations than sales (revenue).

16. Of course there are cases in which firms first do R&D and later buy machinery and equipment. However, in Brazil and Argentina, the R&D efforts of both domestic and multinational firms are currently directed more to adaptation than to the generation of strictly new products and processes. Consequently, multinational affiliates try to adapt the machinery or equipment recommended by headquarters to the products or processes they offer on the Brazilian or Argentine market. Furthermore, many domestic firms first acquire machinery and equipment to raise the productivity of the firm and only later perform R&D to take avail of all the advantages this machinery or equipment offers in terms of future innovations.

The seventh independent variable represents the total exports of Brazilian or Argentine firms in relation to their sales. Firms that trade on the foreign market are expected to innovate more and consequently make greater R&D efforts. Therefore, a positive sign is expected for the estimated coefficient.

The eighth independent variable represents the total imports of firms in relation to their sales. Firms that acquire machinery, equipment or inputs are expected to have to make R&D efforts in order to adapt their products or processes.[17] Therefore, a positive sign is expected for the estimated coefficient.

A dummy for origin of capital was used in the first model to determine whether or not multinational firms tended to make more R&D efforts than domestic firms.

A sector dummy was included in the first and second models to control the specific features of each industrial sector in terms of R&D efforts.

To finalize the overview of the methodology used in this study, certain points should be underlined. First, because all the explanatory variables are in Neperian logarithms, it was necessary to make some changes in order to be able to estimate the models. Since the logarithm 0 tends to negative infinitive and most statistical packages do not recognize this number – and, more importantly, to avoid a considerable decrease in the sample size – 1 *real* or *peso* (local currency unit) was attributed to each firm that did not export in a given year or had no export data. This 1 *real* or *peso* for exports was divided by the net sales revenue of the firm, thus rendering it a value of negligible importance in the final estimation, but necessary for performing the calculations.[18]

Lastly, some readers might argue that the estimated econometric models are subject to contemporaneity problems because the data used in the regressions refer to only one given year. Thus, it is necessary to point out that while the dependent variable essentially represents research and development expenditures, the independent variables related to innovation expenditures refer to the acquisition of relatively complete innovations that are the outcome of past innovation efforts on the part of other firms. As to the import and export variables, they were held to be independent in the models because the focus was on investigating whether or not the fact that firms exported or imported more led them to spend more on R&D in a given year. Therefore, any econometric problems that may have arisen due to contemporaneity of the data are of slight importance.

17. Note that this variable includes only imports, thereby differing from the machinery and equipment acquisition variable, which covers both imports and domestic purchases. In addition, the latter refers only to machinery and equipment specifically acquired for the purpose of innovation.

18. This same procedure was followed for the dependent variable and for the independent variables related to innovative efforts or to export and import coefficients.

3.2 Results

Having concluded a description of the methodology, it is now necessary to explain the results of the two estimated models. This subsection is consequently divided in two parts, one for each model.

3.2.1 First Model

Table 4-A shows that the probability of a firm's spending on R&D was positively correlated with the percentage of its employees with higher education in both Brazil and Argentina. In the case of Brazil, for example, a 1% increase in the proportion of employees with higher education resulted in a 2.4% increase in the probability of R&D efforts. These results are in step with the theory that the more qualified the labor, the greater the propensity of the firm to make innovative efforts.

On analyzing the results, the size of the firm – defined by number of employees – stands out in terms of the significance of the marginal probability of R&D efforts in Brazil and Argentina. According to the results presented in Table 4-A, the probability of a firm making R&D efforts increased 9.0% given a 1% increase in the number of employees in Argentina in 2001. The results for both Brazil and Argentina indicate that larger firms have a stronger tendency to make R&D efforts. This is possibly due to their having readier access to financing for innovation expenses or to their having more own resources for performing innovative efforts than smaller firms.

Spending on training and on acquiring machinery and equipment also showed positive marginal probabilities in both Brazil and Argentina. For example, in the case of Argentina in 1998, a 1% increase in training expenditures in relation to sales corresponded to a 1.8% increase in a firm's propensity to spend on R&D. Similarly, a 1% increase in expenditures on acquiring machinery and equipment in relation to sales corresponded to a 1.1% increase in marginal probability. The findings on Brazil and Argentina demonstrate that: 1) firms that made efforts to train employees or contract technical services were more inclined to spend on R&D than firms that did not; and 2) firms that acquired machinery and equipment geared towards innovation were more inclined to make R&D efforts. This indicates a complementary rather than a substitution relationship in this type of spending.

Notwithstanding, the most significant features in the results shown in Table 4-A are the estimated marginal probabilities for acquiring external R&D, for acquiring external knowledge and for origin of capital.

In terms of acquiring external R&D, it should be noted that the estimated marginal probability for Brazil was 0.4%. For Argentina, the estimated marginal probabilities were 2.6% and 1.8% for 1998 and 2001, respectively. These probabilities indicate a complementary relationship between internal R&D and the acquisition of external R&D in both countries. This relationship is seen again when the estimated marginal probability for acquiring technology is analyzed. Therefore, firms that acquired some sort of R&D, know-how, licenses for exploring patents, etc., tended to make more internal R&D efforts than firms that did not take advantage of the information to be derived from these types of acquisitions. These results show, moreover, that positive externalities arise from the acquisition of R&D, and not the negative externalities foreseen on the basis of initial assumptions regarding public goods.

In terms of the origin of capital, significant differences were found between domestic and multinational firms in the estimated marginal probabilities for Brazil and Argentina. The results presented in Table 4-A show that the multinational firms in both countries were less inclined to make R&D efforts than were the domestic firms. For Brazil, the probability of a multinational firm performing R&D was 8.10% lower than that of a domestic firm. In Argentina, the probability of a multinational firm conducting such activities was 5.8% and 8.2% lower in 1998 and 2001 respectively, than that of a domestic firm. However, these results do not mean that multinational enterprises are less innovative than domestic ones (see Table 3). As mentioned previously, many of the innovations used by multinational firms come from their headquarters or from other affiliates around the world.

Analysis of the estimates calculated using the OLS technique also leads to interesting results. What first stands out is that if the firm was already spending on R&D, a 1% increase on acquiring external R&D in relation to sales corresponded to a 0.32% increase in internal R&D efforts in relation to sales for Brazilian firms. For Argentine firms, the elasticities were 0.33% and 0.36% for 1998 and 2001, respectively. These elasticities once again indicate that R&D acquisitions complemented, not substituted, internal R&D efforts in Brazilian and Argentine firms. It can therefore be argued that it is necessary to efficiently implement some type of public policy aimed at stimulating both domestic and multinational firms to take advantage of the information to be gained from acquiring external R&D in order to improve the quality of their internal R&D. This argument is reinforced by the fact that as spending on acquiring technology rose, internal R&D efforts also rose in both Brazilian and Argentine firms, as indicated by the OLS elasticity estimates shown in Table 4-B.

The level of R&D expenditures in relation to sales and company size are positively correlated for Brazilian and Argentine firms. For example, the estimated elasticity of R&D efforts in relation to sales was 0.34% for Argentina in 2001, given a 1% increase in the number of employees.

As to the percentage of employees with higher education and expenditure on training variables, the estimated elasticities for the two countries were also positive. This reveals that firms that spend more on training employees, contracting technical services or hiring better qualified workers make greater internal R&D efforts, thus underlining the importance of human capital.

TABLE 4-A
Probability of R&D efforts by Brazilian (2000) and Argentine (1998 and 2001) industrial firms [1]

Explanatory variables in Neperian log, except for variable dummies	Brazil regression (2000)		Argentina regression (1998)		Argentina regression (2001)	
	Coefficient	Marginal probability	Coefficient	Marginal probability	Coefficient	Marginal probability
Number of employees	0.364***	0.089	0.325***	0.086	0.315***	0.090
Percentage of employees with higher education in relation to total number of employees	0.100***	0.024	0.416***	0.110	0.411***	0.117
Training expenses in relation to sales	0.081***	0.020	0.067***	0.018	0.070***	0.020
Acquisition of external R&D in relation to sales	0.018***	0.004	0.099***	0.026	0.063***	0.018
Acquisition of technology in relation to sales	0.019***	0.005	0.025***	0.006	0.013**	0.003
Acquisition of machinery and equipment in relation to sales	0.059***	0.014	0.042***	0.011	0.026***	0.007
Export coefficient	0.016***	0.004	-0.007***	-0.002	-0.005^{ns}	-0.001
Import coefficient	0.017***	0.004	0.020***	0.005	0.028***	0.008
Origin of capital	-0.333***	-0.081	-0.221***	-0.058	-0.289***	-0.082
Model statistics	Inter.: 1.7*** Num. of obs.: 8,112 Log Likelihood: -17,915 R^2 : 0.30		Inter.: 2.07*** Num. of obs.: 1,693 Log Likelihood: -2,892 R^2 : 0.41		Inter.: 0.75*** Num. of obs.: 1,810 Log Likelihood: -3,339 R^2 : 0.34	

Sources: Developed by the author, based on PINTEC, BACEN, PIA, SECEX, RAIS and Encuesta Nacional de Innovacíon y Conducta Tecnológica de las Empresas Argentinas (1998 and 2001).
Notes: 1. Dummy for unreported sectors.
Obs.: (*) Significant at 10% (**) Significant at 5% (***) Significant at 1% (NS = not significant).

TABLE 4-B
Elasticity of R&D efforts by Brazilian (2000) and Argentine (1998 and 2001) industrial firms [1, 2]

Explanatory variables in Neperian logarithm, except variable dummies	Brazil regression (2000)	Argentina regression (1998)	Argentina regression (2001)
Number of employees	0.07***	0.47***	0.34***
Percentage of employees with higher education in relation to total number of employees	0.08^{NS}	1.55^{NS}	-0.24^{NS}
Training expenses in relation to sales	0.32***	0.33***	0.36***
Acquisition of external R&D in relation to sales	0.22***	0.49***	0.32***
Acquisition of technology in relation to sales	0.14***	0.11*	0.10^{NS}
Acquisition of machinery and equipment in relation to sales	0.09***	0.14***	0.08***
Export coefficient	0.05***	-0.01^{NS}	-0.004^{NS}
Import coefficient	0.05***	0.03^{NS}	0.08***
Origin of capital [3]	-62.47***	-57.68^{NS}	-61.71^{NS}
Model statistics	Inter.: 1.62* Num. of obs.: 8,112 R^2 : 0.30 F-value: 143.00***	Inter.: 2.31^{NS} Num. of obs.: 1,693 R^2 : 0.37 F-value: 28.40***	Inter.: -3.44^{NS} Num. of obs.: 1,810 R^2 : 0.28 F-value: 20.92***

Sources: Developed by the author, based on PINTEC, BACEN, PIA, SECEX, RAIS and Encuesta Nacional de Innovacíon y Conducta Tecnológica de las Empresas Argentinas (1998 and 2001).

Notes: 1,2. Dummies for unreported sectors. 3 To calculate the value of the origin of capital variable, the following formula was used $(e^{b}-1)*100$, where is the exponential symbol and b is the estimated coefficient symbol. In the strict sense, this value represents not elasticity, but how much or how little multinational enterprises, compared to domestic firms, spend on R&D in relation to sales.

Obs.: (*) Significant at 10% (**) Significant at 5% (***) Significant at 1% (NS = not significant).

In Brazil, the fact that domestic firms tended to make stronger R&D efforts than multinational firms is complemented by the significant differences in the magnitude of these expenditures in relation to sales as shown in Table 4-B. The table indicates, for example, that the multinational firms established in Brazil spent an average 62.47% less than domestic firms in 2000.

In contrast, the results for Argentina are not statistically significant, which reveals there was no difference between the R&D expenditures in relation to the sales of multinational and domestic firms. In any case, since the descriptive analysis (Table 2) shows that the efforts of multinational firms are minimal and the probability of their doing research and development is low, it can be argued that the R&D efforts on the part of multinationals located in Argentina are mainly targeted at adapting products and processes.

Finally, to conclude the analysis of Tables 4-A and 4-B, it is clear from both the Probit and OLS estimates, that the export and import coefficients are positively correlated with the probability of a firm making R&D efforts, as well as with its level of expenditures on R&D in relation to sales.

3.2.2 Second Model

Having analyzed the first model, which encompasses both domestic and multinational firms, the next step is to separately analyze the performance of multinational firms in their research and development efforts.

With respect to the findings of the second model, the estimated marginal probabilities indicate that the larger multinational firms – that is, those with a greater number of employees – were more inclined to make internal R&D efforts in both Brazil and Argentina. This shows that the decision to invest or not in R&D does not depend solely on headquarters, but also on the size of the affiliate. However, size was more important for the multinational enterprises located in Brazil that for those located in Argentina.

The estimated marginal probabilities for the proportion of employees with higher education in relation to the total number of employees indicate that this variable does not affect the probability of multinational affiliates in either Brazil and Argentina making R&D efforts (Table 5-A). On one hand, this reinforces the hypothesis that the efforts of multinational affiliates are basically aimed at adapting products and processes, which does not require highly skilled workers.[19] On the other hand, the estimated marginal probabilities for training expenses – similar

19. On average, of course, those who work for multinational firms are more qualified than those who work for domestic firms. What is being argued here is that an increase in the percentage of employees with higher education was not important in explaining the decision as to whether or not to invest in internal R&D.

in the Brazilian and Argentine cases – reveal that the more a multinational affiliate trains its workers or contracts technical services, the greater its propensity to invest in R&D. Once again, these training expenses may have been essentially directed to equipping labor or the productive process for research and development focused on product adaptation.

The most important results in Table 5-A refer to the marginal probabilities obtained for the acquisition of external R&D variable. Given an increase in spending on acquiring external R&D in relation to sales, the probability of a multinational affiliate making internal R&D efforts increased in both Brazil and Argentina. For example, in Brazil a 1% increase in acquiring external R&D resulted in a 3% increase in the probability of the affiliate investing in internal R&D. In the Argentine model, in 2001 a 1% increase in acquiring external R&D in relation to sales resulted in a 4% increase in the probability of the multinational investing in internal R&D.

The estimated marginal probabilities for the variable referring to the acquisition of external R&D in Brazil and Argentina may be suggesting that – despite the marginal probabilities being low, and despite the R&D efforts of these enterprises being distributed among affiliates around the world – the technological developments acquired through R&D performed at headquarters or at affiliates in other countries may have stimulated, in other words, complemented, the internal R&D efforts of the multinational affiliates located in Brazil and Argentina.

Finally, the estimated marginal probabilities for the export and import coefficients for Brazil and Argentina suggest that the more the multinational affiliates exported, the stronger their propensity to invest in R&D. This confirms the theory that the R&D efforts of these firms focus on creating and adapting products and processes not only for local markets, but also for regional markets such as Mercosur.

As to the OLS results presented in Table 5-B, the elasticities confirm the above observations. In this table, size is seen to be the explanatory variable that most influences internal R&D expenditures in relation to sales in Brazil. However, in Argentina, however, the variable that most affects such spending is the acquisition of external R&D, thus proving that the R&D performed abroad and that performed in the country are complementary.

In terms of the elasticities of the proportion of employees with higher education in relation to the total number of employees, the estimated coefficients are statistically insignificant. This means that the proxy variable for the level of education of the work force did not contribute to increasing R&D efforts in relation to sales when the multinational affiliate was already investing in Brazil or Argentina.

The estimated elasticities for training expenditures in relation to sales were also low at 0.20 for Brazil and 0.52 and 0.35 for Argentina in 1998 and 2001, respectively. Even so, these elasticities support the argument that multinational affiliates engage in R&D mainly to adapt products and processes rather than to create essentially new products and processes.

For both Brazil and Argentina, the estimated elasticities for the acquisition of external R&D show that, within the current context of globalization of R&D investments on the part of multinational enterprises, complementarity was a factor not only when firms were deciding whether or not to invest in internal R&D, but also when they were determining the magnitude of such efforts in relation to sales. It should be pointed out, however, that acquiring external R&D was more important in Argentina than in Brazil. This confirms that, though the absolute level of internal R&D efforts in Argentina is lower than in Brazil, the degree of complementarity between foreign and domestic R&D is more relevant in Argentina.

Finally, the estimated elasticities for both the export and import coefficients indicate that among the multinational affiliates in Brazil and Argentina, those that export more have a stronger propensity to invest (and to invest larger amounts) in R&D than those that import.[20] Again, these findings corroborate the fact that the multinational affiliates in Brazil and Argentina gear their investments not only to local markets but also to the regional market.

TABLE 5-A
Probability of R&D efforts by Brazilian (2000) and Argentine (1998 and 2001) industrial firms[1]
(Only multinational firms in the dependent variable)

Explanatory variables in Neperian logarithm, except variable dummies	Brazil regression (2000)		Argentina regression (1998)		Argentina regression (2001)	
	Coefficient	Marginal probability	Coefficient	Marginal probability	Coefficient	Marginal probability
Number of employees	0.51***	0.20	0.35***	0.11	0.30***	0.08
Percentage of employees with higher education in relation to total number of employees	-0.11^{ns}	-0.04	-0.10^{NS}	-0.03	-0.09^{NS}	-0.02
Training expenses in relation to sales	0.04***	0.02	0.09***	0.03	0.08***	0.02
Acquisition of external R&D in relation to sales	0.09***	0.03	0.07***	0.02	0.13***	0.04
Acquisition of technology in relation to sales	0.01^{ns}	0.005	0.01^{NS}	0.005	0.05***	0.01
Acquisition of machinery and equipment in relation to sales	0.03***	0.01	0.01^{NS}	0.004	0.003^{NS}	0.0007
Export voefficient	0.05***	0.02	0.05***	0.02	0.08***	0.02
Import coefficient	0.03***	0.01	0.03**	0.01	0.05**	0.01
Model statistics	Inter.: 1.16*** Num. of obs.: 645 Log likelihood: -17.913 R^2 : 0.33		Inter.: 1.29*** Num. of obs.: 187 Log likelihood: -222 R^2 : 0.51		Inter.: 3.49*** Num. of obs.: 192 Log likelihood: -205 R^2 : 0.52	

Sources: Developed by the author, based on PINTEC, BACEN, PIA, SECEX, RAIS and Encuesta Nacional de Innovacíon y Conducta Tecnológica de las Empresas Argentinas (1998 and 2001).
Note: 1. Dummy for unreported sectors.
Obs.: * Significant at 10% ** Significant at 5% *** Significant at 1% (NS = not significant).

20. It should be pointed out that the estimated export coefficient for Argentina in 1998 was insignificant, as opposed to the positive and significant result for 2001.

TABLE 5-B
Elasticity of R&D efforts by Brazilian (2000) and Argentine (1998 and 2001) industrial firms[1]
(Only multinational firms in the dependent variable)

Explanatory variables in Neperian logarithm, except variable dummies	Brazil regression (2000)	Argentina regression (1998)	Argentina regression (2001)
Number of employees	0.86***	0.35^{NS}	0.16^{NS}
Percentage of employees with higher education in relation to total number of employees	-0.10^{NS}	-1.21^{NS}	-0.84^{NS}
Training expenses in relation to sales	0.20***	0.52***	0.35***
Acquisition of external R&D in relation to sales	0.31***	0.36***	0.44***
Acquisition of technology in relation to sales	0.07*	0.17**	0.20**
Acquisition of machinery and equipment in relation to sales	0.12***	0.01^{NS}	0.02^{NS}
Export coefficient	0.16***	-0.02^{NS}	0.18***
Import coefficient	-0.06^{NS}	0.003^{NS}	0.01***
Model statistics	Inter.: 0.50^{NS} Num. of obs.: 645 R^2 : 0.24 F-value: 10.56***	Inter.: 0.01^{NS} Num. of obs.: 536 R^2 : 0.45 F-value: 8.61***	Inter.: -1.77^{NS} Num. of obs.: 637 R^2 : 0.42 F-value: 8.20***

Source: Developed by the author, based on PINTEC, BACEN, PIA, SECEX, RAIS and Encuesta Nacional de Innovaciíon y Conducta Tecnológica de las Empresas Argentinas (1998 and 2001).
Obs.: (*) Significant at 10% (**) Significant at 5% (***) Significant at 1% (NS = not significant)
Note: 1. Dummy for unreported sectors.

4 FINAL COMMENTS

We have seen that there are differences between the innovative activities of domestic and multinational firms in Brazil and Argentina. However, whereas in Brazil the differences lie in both the probability and the level of R&D expenditures, in Argentina the differences refer only to the probability of investing or not in research and development. The fact that there are no differences in R&D efforts in relation to sales may be the outcome of the low expenditures on such activities on the part of both domestic and multinational firms in Argentina. Attention should therefore be called to the fact that, in comparison to domestic firms, the percentage of multinational firms that innovate is higher in Brazil as well as Argentina.

Thus, all indications are that the R&D expenditures of the multinational enterprises in Brazil and Argentina are focused more on adapting products and processes than on creating new technological solutions. Even so, some of the efforts made by these enterprises target not only the local markets, but also regional markets such as Mercosur.

Attention should also be drawn to the fact that many countries have been adopting policies that offer incentives to multinational enterprises in the expectation of benefiting from the positive effects of Foreign Direct Investment (FDI). However, these countries sometimes forget that FDI can occur without the host country having to implement incentive policies that fiscally burden the country; or that FDI will not arrive – even if local governments offer extremely favorable incentives – if the institutions are untrustworthy or the growth prospects of the country are limited. Issues related to the macroeconomic environment must therefore be taken into account, as well as the global strategies of multinational enterprises, when evaluating the capacity of a country to attract FDI.

In conclusion, within the current globalized context, technological innovation necessarily underlies sustained growth and development and, more importantly, enables a country to become less dependent and more competitive not only in the regional, but also in the international scenario. For these reasons, it is essential that both Brazil and Argentina actively stimulate technological innovation on the part of domestic and multinational firms, as well as encouraging them to make more effective use of the National Innovation Systems of the countries in which they operate.

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