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Innovative behavior and economic performance in the Uruguayan Manufacturing Industry 2001-2003.

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Abstract:

Innovation activities are recognized to influence significantly the performance of the firms. The most common interpretation of this relationship would state that a better innovation behavior could always produce a better firm's performance. Nevertheless, in the Latin American economic context, signed by great GDP fluctuations and poor stability of economic policies, the study of this relationship requires a specific methodological effort to characterize different patterns of economic performance, in order to analyze their relationship with the firms' innovative behavior.

For this purpose, we analyzed a set of indicators about firm's economic performance and firm's innovative behavior, in the Uruguayan manufacturing industry.

The relationship between this indicators shows that there is not an univocal association between economic performance and innovative behavior. Conversely, it's possible to distinguish different innovative behavior patterns associated to diverse "styles" of economic performance.

By characterizing the innovative behavior, we are able to develop a more precise approach that may contribute to design a set of policies, with the purpose of achieving a long-term sustainable development of the manufacturing industry.

Introduction

The objective of this study is to characterize the innovative behavior of Uruguayan manufacturing industry based on firms' *cognitive bases*. We present an analysis of the elements that characterize firms' innovative behavior, taken from the results of the latest Innovation Activities Survey (IAS), and try to identify the links between these and the economic performance of Uruguayan industrial enterprises[1].

The main hypothesis behind this research is that the features of the Uruguayan economy, which has problems with dynamism and high growth volatility in the framework of developing socio-economic relationships, determine that the innovative behavior of industrial enterprises has specific characteristics that are different from the theoretical premises derived from experience in developed countries. This framework also influences the fact that capabilities for innovative development is not directly linked to improvements in economic performance and therefore is not integrated into business strategies.

With this objective in mind, this paper is divided into an introduction and four sections. In the first section we briefly present the theoretical framework from which the objective of the study is defined and on which the hypotheses are based. The second section contains the methodology of the research and the results of the procedures that were used. After that, in the third section the results are analyzed in the light of the theoretical hypotheses proposed and in the specific context of the Uruguayan economy. Lastly some conclusions about the results are drawn.

I. Some premises of the theoretical approach

Innovation is defined as a process oriented towards productive problem-solving (Nelson-Winter; 1982), which is characterized by the conjunction between productive needs and technical capabilities. The ambit where this takes place is the enterprise, where knowledge is generated, adapted and applied for the purposes of production. According to this focus the problem-solving search is a specific process in each firm, and it is characterized by a high degree of uncertainty as regards results (Dosi; 1988). During the course of this process the firm generates knowledge and applies it in the creation of new products or processes, going through an accumulative learning sequence.

The fact that the innovation process is specific and accumulative does not mean that there is autarchic learning in the firm. On the contrary, the possibility of maintaining links for the development of innovation processes depends on the enterprises' capabilities to identify its needs and the opportunities and incentives that the environment presents. In this way that the innovative process is understood as a systemic and interactive phenomenon that takes place among the different people in the enterprise and at the same time between the enterprise and its environment. This concept is summed up in the literature by the National

[1] This study has been possible thanks to cooperation from the Direction of the Development Innovation Science and Technology Area (Ministry of Education and Culture) in permitting the authors access to the data processing of the Survey of Innovation Activities in Industry.

Innovation System (NIS) (Lundvall; 1992) which describes *ex-post* the innovation process in developed economies. In the developing countries this concept has been used as a theoretical definition, *ex-ante* the experience, of a normative type in policy orientation (Arocena – Sutz; 2000). This interpretation "from the south" of the NIS entails the methodological question of whether or not innovation in developing economies can be described using systemic relationships as a base, as is done for developed countries.

The characteristics of a firm and of its environment have an impact not only on the possibility of identifying and solving problems in production, but also on the likelihood of being able to implement a competitive strategy based on innovation. The degree of uncertainty associated with the success of innovation is also related to the eventual possibilities of penetration in the market. Markets that are highly intensive in innovative product transactions are characterized by having forms of organization that are regulated by institutional agreements that give an incentive to innovative behavior (Lundvall; 1988). These "organized markets" are part of the systemic dimensions that define the firm's environment in the NIS analysis in the developed countries. In under-developed countries innovation very often comes up against a wide variety of obstacles and there is little incentive in the way markets are organized, as these hinder the commercialization of new products (Yoguel-Boscherini; 2000).

To analyse the innovation processes in a developing economy it is necessary to take into account not only institutional characteristics but also the definition of "novelty" that this process involves. The definition of novelty depends on the way something is perceived by a subject. This is why the idea that innovation is "context specific" (Sutz; 2000) gives it a dimension that is essential when it comes to understanding it in underdeveloped countries. Although there are innovations in the world market that are derived from developing countries and from Latin America in particular, because of the type of market, the productive tradition and the economic limitations that prevail in this region, a high proportion of these innovations are not novel at the international level due to the fact that they consist in developing and applying technical solutions that are already known in other parts of the world.

In line with the above, in order to study the innovation process in Uruguayan industry three dimensions were chosen to give an approximation to a cognitive basis for assessing firms:

a- *The internal capabilities of the firm*, understood as the capabilities of its personnel to identify and solve production problems through generating and applying knowledge, and also their ability to cooperate with other agents for that purpose.

b- Links that the firm maintains with its environment to undertake innovative activities.

c- *The firm's innovation experience*, understood as an approximation to an analysis of the firm's specific learning trajectory.

II. A measure of the innovative behavior of firms in relation to their economic performance

The IAS 2003 is based on the definition of "innovative enterprises" as being those which undertake some innovative activity. [2] Using this definition, the questionnaire is ordered by activities that an enterprise has carried out. The IAS 2003, in contrast to its predecessor the IAS 2001, gathers information from all enterprises regardless of whether or not they were innovative.

In line with the objective of this study, a selection was made from the IAS 2003 of 24 variables that were considered as proxy indicators of the dimensions chosen for analyzing innovative behavior, from the characteristics of firms and their economic performance (see methodological appendix).

In the first stage of the analysis of these dimensions, Principal Components Analysis (PCA) methodology was used .The main objective of PCA is to analyze the relationships among the variables and also to find similarities between the individuals, through the linear correlation index and the distance measures respectively. Using this method eight components were identified, which sum up the information from the original variables as a linear combination of them.

The PCA methodology needs quantitative variables, so variables which capture the amount of investment in different innovation activities were taken into account and not variables that recorded in a dichotomized way whether the enterprise carries out these kinds of activities. Similarly, the number workers of people involved was taken into account according to their professional type and level of training.

This made it necessary for us to choose between two limitations. If we take the absolute quantitative variables as they are expressed in the data base, the representation of large enterprises is overestimated because of their levels of investment and the number of people employed. However, if the investment variables are considered as intensity in relation to the volume of sales and the number of professionals involved as a proportion of the total number of people employed in the firm, a linear relationship is assumed between the level of investment and requirements for qualified personnel, and the size of the enterprise. This linear assumption leads to an underestimation of the relative weight of large enterprises. In this study both procedures were tried, and the second was adopted. This choice means accepting the possibility of underestimating the innovative behavior of some large enterprises, but if the other option had been chosen it would not have been possible to identify the specific behavior of the small and medium size enterprises, which make up 95% of the total sample.

Cluster analysis was carried out on the eight resulting components, and internal variance minimization and external variance maximization criteria were used

[2] Innovation activities considered: internal or external R&D, the acquisition of capital goods, hardware and software for innovation purposes, technology transfer, industrial design, management and training improvements oriented to processes or product development or to organizational or trading innovations.

(Ward method). Through this analysis eight clusters were obtained which allow us to group the firms according to the dimensions expressed by their components (see methodological appendix).

Finally, these procedures were used to identify three innovative behavior patterns in Uruguayan manufacturing industry.

II.a. The PCA results

Through the use of PCA eight components were obtained, and these yielded a total explained variance of 56.56% and an adequate representation of 75.48% of the cases analyzed. It can be seen that it was not possible to typify 24.52% of the enterprises as they are not well represented by the new axis-components. Of the 696 enterprises that were poorly represented, 366 stated that they had engaged in some innovation activity, which means that it has not been possible to typify 34.9% of the innovative enterprises using the components built from the dimensions selected.

Table 1. Components representation levels

Component	Well-represented cases	Accumulated % of well-represented cases
1	1170	41.21
2	1194	42.06
3	1287	45.33
4	1559	54.91
5	1698	59.81
6	1863	65.62
7	2047	72.10
8	2143	75.48

Own elaboration. Source: IAS, 2003.

Next, the eight components extracted and the respective variables which make them up, that is to say the variables that have the greater relative correlation to the axis-component, are listed below.

The figures show the sign and the intensity of the correlation that each variable has with the corresponding component.

Each component is a summarizing indicator of the original variables. Before applying the PCA there were 24 dimensions of analysis, once the PCA was applied the factorial space was reduced up to 8 components.

Each enterprise has a new group of coordinates in this new sub-space that would place the enterprise on the new axis. If the new coordinates on the new axis are close to the origin, we would say that these enterprises are baricentric, and as a consequence these enterprises take low or zero values for the variables that make up the axis. In other cases it is possible that the new coordinates place the enterprise at the positive end of the axis-component, with a value that is quite far from the origin. In this case we would say that the enterprise is intensive or has

high values in the variables that determine or build that axis. If the enterprise is placed by the new components at the negative end of the axis, we would say that the enterprise is not intensive or that it has low values for the variables that build the axis.

Enterprises that are relatively far from the origin in the different axes are characterized by the variables that compose the axis under study. This does not involve a limiting classification of these enterprises as they can have lower relative intensity values on other axes that are determined by other variables.

Component 1 accounts for 17.8% of the explained variance. The reason why this first component does not reach higher levels could be the levels of response variability. At the same time this component works as an average of the others because all the other variables have a positive correlation with it, as they influence its building with a positive sign. A total of 93 % of the cases that are well represented in this component are not innovative enterprises.

Component 2 contributes 8.1% of the total inertia, and consequently at the first factorial level 26% of the explicit variance is accumulated.

Figure 1. significant correlations in axis 2

-	0	+
Apparent productivity[3] (-0.5955) Export propensity (-0.4947) % of FDI[4] (-0.4747)		Training investment (0.4388) Personnel involved in innovation in non-formal units. (0.3948)

Component 3 contributes 6.6% of the total inertia, and accounts for 32% of the explained variance.

Figure 2. significant correlations in axis 3

-	0	+
Nº. of people employed (-0.461)		% TTS professionals[5] (0.5844) % TTS professionals in R&D (0.5205)

Component 4 contributes 5.47% of the total explained variance, and total explained variance rises to 38.14%.

Figure 3. Significant correlations in axis 4

-	0	+
R&D linkages (-0.3567), Other innovation activity linkages (-0.3487)		% of NTTS[6] professionals (0.5186) % of technicians (0.4152) Computing investment[7] (0.3408)

[3] Total sales value over the number of employees in the enterprise.

[4] Foreign Direct Investment.

[5] Technologically Trained Scientists (TTS) are considered those with training in physics, chemistry, mathematics, statistics, medicine, engineering, architecture or agricultural sciences.

[6] The professionals non TTS (NTTS) include professional trained in social sciences or humanities.

[7] Includes software and hardware investment.

With the 5 axes 43.5% of total explained variance is accounted for, and the contribution of component 5 to this is 5.13%.

Figure 4. Significant correlation in axis 5

-	0	+
Links for financing (-0.4356)		R&D investment (0.5621) Export propensity (0.4364) N°. of people employed (0.3699)

Component 6 contributes 4.5% and now the accumulated value for total variance is 47.8%.

Figure 5. Significant correlations in axis 6

-	0	+
		% TTS professionals in other innovation activities (0.4337) Design investment (0.4205)

Component 7 contributes 4.47%, and total variance rises to 52.28%.

Figure 6. Significant correlations in axis 7

-	0	+
Personnel involved in innovation in non-formal units (-0.3377)		Capital goods investment (0.5602) Personnel involved in innovation in formal units (0.4697)

Component 8 contributes 4.27% and accumulated total variance reaches 56.56%.

Figure 7. Significant correlations in axis 8

-	0	+
Transfer investment (-0.5616)		Management investment (0.5310)

During the processing 71 cases that behaved as outliers and affected the calculation procedure were excluded. All cases which had a "norm"[8] value higher than three standard deviations with respect to the mean were considered outliers. Considering the criteria for sample expansion, these cases make up 2.4% of the total sample.

The 71 excluded cases show high values for the variables under study. In all cases they are innovative enterprises with more intensive investment in innovative activities than the average and also more have high-qualified personnel. With only one exception they are enterprises without FDI, they are mostly medium and small (97.2%), they have low export propensity, and all went into operation before 1998.

[8] The "norm" is a measure which analyzes the dispersion of cases with respect to the cloud of points, and it is calculated as the sum of the square of all the variables considered.

II.b. The characteristics of clusters by components

We can conceptually define seven of the eight clusters according to the type of firms that make them up and the type of innovative activity that they engage in.

The clusters are characterized according to how the cases are distributed on the different factorial axis. That is to say, the enterprises that are concentrated in a cluster would be characterized by a component if they are more intensive in the activities or attributes that define that component. This does not mean that these enterprises do not carry out other activities or have other attributes.

Table 2. Groups identified by the cluster analysis

Identification	Definition	Cases	% of cases
1	Low or null innovative intensity	2135	75.20%
2	Young SMEs oriented to computing investment with a large number of technical personnel.	155	5.45%
3	Innovative enterprises oriented to capital goods purchase, with few TTS professionals	245	8.62%
4	Large and medium-sized enterprises with high propensity to export novel products.	33	1.16%
5	Heterogeneous composition accumulated around the baricenter.	169	5.95%
6	Medium and large enterprises, with more than 20 years in activity, and high innovative experience.	24	0.84%
7	Innovative SMEs with medium endogenous capabilities, with strong representation from the metal-mechanical industry.	18	0.63%
8	Innovative SMEs with medium endogenous capabilities with high representation from chemical industries.	60	2.11%

Own elaboration. Source: IAS; 2003

As could be reasonably expected, **cluster one** conforms markedly to the distribution of the general sample because of its extraordinary weight.

Most of the enterprises that make up this cluster (80.75%) are well represented when the 8 components are accumulated, but in all cases these components are concentrated at the origin, which means that they are baricentric. This means that these firms have little or no innovative experience, they have no or very few links with the NIS, and their endogenous capabilities are very weak.

In the **second cluster**, when the 8 components are accumulated we have 89% of well-represented enterprises in the PCA.

This cluster is mainly characterized by components 3, 4 and 7. Enterprises which belong to this group are identified by low investment intensity as regards sales in the different innovation activities, but computing investment is an exception to this. There are few links with the NIS and low export propensity. Innovation activities are carried out by informally assigned personnel and there is a relatively high number of technicians and NTTS professionals as a proportion of the total number of employees.

The characterization of **cluster three** derived from the components is barely satisfactory as only 39% of the enterprises which make it up are well represented when we accumulate the 8 components, and of these 70% are baricentric. The remaining 30% are mainly concentrated at the positive end of component 7, which means they are enterprises that invest in capital goods and have formal units working on innovation activities (21 enterprises).

Table 3. Characteristics of the firms in the identified clusters

Cluster	% of innovative firms	Size	Age[9]
Low or null innovative intensity	17.05	75% Small 23% Medium 2% Large	45% Old firms 45% Mature firms 10% Young firms
Young SMEs, in computing investment with a large number of technical personnel.	100.00	83% Small 14% Medium 3% Large	32% Old firms 40% Mature firms 28% Young firms
Innovative enterprises in capital goods purchase, with a small number of TTS professionals.	96.19	51% Small 41% Medium 8% Large	65% Old firms 29% Mature firms 6% Young firms
Large and medium enterprises with high novel product export propensity.	96.84	49% Medium 51% Large	79% Old firms 21% Mature firms
Heterogeneous composition accumulated around the baricenter	57.79	30% Small 34% Medium 36% Large	63% Old firms 32% Mature firms 5% Young firms
Medium and large enterprises, with more than 20 years in activity, and high innovative experience.	100.00	92% Medium 8% Large	88% Old firms 8% Mature firms 4% Young firms
Innovative SMEs with medium endogenous capabilities, with strong representation from the metal-mechanical industry.	100.00	77% Small 23% Medium	17% Old firms 83% Mature firms
Innovative SMEs with medium endogenous capabilities with high representation from chemical industries.	89.03	57% Small 38% Medium 5% Large	61% Old firms 39% Mature firms

Own elaboration. Source: IAS, 2003.

Some 90% of the enterprises that make up the **fourth cluster** are well represented when we accumulate the 8 components. Most of the observations are concentrated in the baricenter of the different components. This can be explained to a certain extent by the way of measuring the variables (intensity), which underestimates the weight of large firms, and these firms have the highest representation in this cluster. One third of enterprises are located at the negative end of axes 2 and 3.

This cluster is the only one which has a relatively high proportion (38%) of enterprises that export products which are novel on the market. This high innovative export tendency could be related to the fact that 75% of the firms that

[9] "Old firms": more than 20 years old; "Mature firms": between 20 and 5 years old; "Young firms": less than 5 years old

make up this group receive FDI. Likewise most of these firms (87.5%) have TTS professional and 68.8% engage in R&D.

In the **fifth cluster** 46% of the enterprises are well represented when we accumulate the 8 components. Nevertheless, they are concentrated in the baricenter, which means that the axis variables have low values for these enterprises.

Some 38% of the enterprises that make up the **sixth cluster** are well represented when we accumulate the 8 components. This cluster is characterized mainly by components 6, 7 and 8.

This cluster contains most of the oldest medium-sized enterprises that carried out innovation activities in the period, and are principally oriented to investment in R&D. All the enterprises in this cluster have TTS professionals working on their different innovation activities. However, like in the case of the firms that make up cluster four, the way the variables are calculated could affect the quality of representation on the different axes.

In the **seventh cluster** 100% of the firms are well-represented when the 8 components are accumulated. This cluster is mainly characterized by components 7 and 4.

Most of the enterprises have a relatively high percentage of technicians employed and NTTS professionals as a proportion of total employees, and they also have a relatively high percentage of personnel formally assigned to various innovation activities and are who state they are engaged in R&D.

There is only one firm that is well represented at the positive end of axis 3, so it is worth noting that this is an outstanding enterprise for its high proportion of TTS professionals, who are mainly engaged in R&D.

Therefore this cluster is characterized by a grouping of innovative enterprises that are small and mature (1985-1998), with medium endogenous capabilities.

In **cluster eight** some 83% of the enterprises are well-represented when the 8 components are accumulated. This cluster is mainly characterized by components 3 and 8.

The cluster contains enterprises that have TTS professionals working in R&D, and that are intensive in investment in management and transfer activities. They all engage in R&D, but with low rates of investment. Besides this, in these firms innovative sales have significant weight as these enterprises commercialize novel products in domestic and foreign markets.

This cluster is characterized by mainly grouping innovative SMEs that have experience and strong endogenous capabilities.

IV. Results analysis

The aim of this study was to typify the innovation process in Uruguayan manufacturing industry starting from an estimation of the *cognitive base* that sustains it and its relationship with the economic performance of the firms.

In the light of the results, we can classify Uruguayan manufacturing industry enterprises into three broad innovative behavior patterns, which emerge from the estimation of the *cognitive base* with which the enterprises conducted innovation in the 2001-2003 period.

The first pattern is characterized by low innovative intensity or none at all (cluster 1). This category contains 75% of manufacturing industry enterprises, of which 83% did not engage in any innovation activity. The remaining 17% of the enterprises stated they had carried out some innovation activity. However, these enterprises, which constitute 34.6% of innovative firms, are not clearly distinguished from the ones that do not engage in any innovative activities. These results are an indication of the low level of innovative intensity in these enterprises, which we can characterize by their low level of investment in innovation activity and by the fact that they have few if any highly qualified personnel. The innovation activities that these enterprises are engaged in are likely to be occasional efforts to solve specific problems but not part of their normal work routine.

The second pattern identifies firms whose innovative processes *are based on the incorporation of exogenous knowledge,* which means that the *cognitive base* of the enterprises in this category has a low level of development.

The innovation activities of these enterprises are basically oriented towards hardware, software and capital goods investment, with the specific objective of introducing change, process improvements and/or innovations, and organizational and/or trading techniques.

It can also be seen that these enterprises conduct innovation mainly with technical personnel, and a small number of these firms have TTS professionals.

In this pattern we find clusters 2 and 3, which make up 14% of the total number of enterprises. Some 97% of the enterprises in this pattern stated that they had undertaken some innovation activity in the period, and they amount to 37% of total innovative enterprises.

Lastly, the third innovative behavior pattern consists of firms which build their innovation process on the *cognitive base* they themselves develop. These enterprises base their innovation process on the knowledge they accumulate as a result of the training and dedication of their personnel in innovative activities, on the intensity of the firm's relationships with the environment to carry out the different innovation activities, and on the firm's innovation experience.

This category contains the enterprises which make up clusters 4, 6, 7 and 8, which amount to 4.7% of the total number of enterprises. Some 94% of the

enterprises in this category engaged in some innovation activity in the period. Finally, we can note that enterprises that build their innovation process on the development of their own *cognitive base* amount to 11.9% of innovative firms.

Table 4. Innovative behavior patterns in the Uruguayan manufacturing industry

Identification	Definition	Clusters	% of cases
1	Low or null innovative intensity	1	75.0
2	Innovation process based on exogenous knowledge integration.	2 and 3	14.0
3	Innovation process based on the *cognitive base.*	4, 6, 7 and 8	4.7

Note. In this classification cluster 5 is not present as it was not analyzed based in the PCA.
Own elaboration. Source: IAS, 2003.

In the lines of analysis below we use this characterization to take a more detailed look at each of the dimensions selected and of the relation between the different innovative behavior patterns and economic performance.

IV.a. Innovation as an unusual activity in Uruguayan industry.

We should not be surprised to find that the vast majority of Uruguayan industrial firms do not build their innovation process on their own cognitive base. Uruguay is a small country that specializes in low added value raw materials and manufactured goods, and it has almost no state of the art industrial sectors. In addition to this, the economic policy that has been in force over the last few years was focused on fiscal account control and the macro-economic balance, and there were no effective policies to promote innovation in the industrial sector.

Besides that, in the period studied by the IAS 2003, the Uruguayan economy underwent a serious crisis that led to a fall in GDP of more than 20% in real terms. Consequently it is reasonable to expect that investment intensity, and the indicators that reflect it, would be severely affected. However, this is not an exceptional problem linked to an adverse short term situation: over the past 20 years the gross capital rate has generally fluctuated around 14% of GDP.

In this context, there is very little incentive to innovate and there is a high degree of uncertainty, not necessarily about technical possibilities but more about fluctuations in the economy.

At the same time, in the last fifteen years Uruguay has opened up more and more to foreign trade has increasingly opened up to foreign trade. This had a big impact on the manufacturing sector, which had grown up under high levels of protection. In this situation of great and increasing openness, with a matrix of incentives that was transformed by import price reduction and with the final result of the crisis, enterprises had little incentive to run the risks involved in innovation. Therefore, it is no surprise that the relationship between innovative behavior and the economic performance of firms should not show a clear pattern.

Nevertheless, the economic performance indicators available, like propensity to export and the apparent productivity of firms, show higher values in the *innovative behavior with a cognitive base* pattern. Except for the enterprises in cluster 7, all the firms conforming this pattern show better performance than that of the total sample. We should note that the economic performance indicators do not show significant differences between the low or null *innovative intensity pattern* and the group of enterprises that base their *innovation processes on the use of exogenous knowledge.*

In order to go deeper into this analysis, we present below a review of pattern characteristics identified according to the size and activity sector of firms.

In the studies based on the IAS 2001, the size of a firm seemed to be the main explained variable in propensity to innovation (Pittaluga, et al; 2005) and innovation capability development (Bianchi; 2005). In contrast to the IAS 2001, the IAS 2003 makes it possible for us to analyze the behavior of the total number of firms and not only the innovative ones, so we can more accurately understand the relation between innovative behavior and the size of a firm. In the IAS 2003 analysis, taking into account the total number of firms, we can see that the positive relationship between size and likelihood to innovation or having endogenous capabilities is maintained, particularly among innovative firms, but there is great heterogeneity in the innovative behavior of different firms that are the same size.

The relationship between size and innovative behavior cannot be described as a linear relationship. At the international level, different studies agree that the characteristics of this relationship depend on a large extent on activity sector, market environment and a firm's productive integration specificities (Cohen-Klepper; 1992. Rothwell-Dodgson; 1994; Erbes, *et al*. 2004). However, in a low innovative intensity context with the socio-economic characteristics described above, big enterprises are likely to have a better chance to get profits from the benefits of scale than small ones would have to maximize their advantages of flexibility and adaptability.

The peculiar elements in the relationship between size and the innovative behavior of the firm can be seen in the definition or identification of the different clusters that make up the enterprise pattern in which innovation is built on a firm's own *cognitive base*. Clusters 4 and 6 cover large and medium-sized firms. In the former these are firms that have managed to penetrate the international market with novel products, mainly in activity sectors that are related to the raw production of the country, which produces goods that are well inserted into markets in the region like beer and leather, and enterprises in the pharmaceutical sector. In cluster 6 there are enterprises with great innovative experience and relatively large staffs of highly qualified personnel, and these operate in traditional sectors like furniture and other areas that are intensive in the use of physical capital (machinery and chemistry). Firms belonging to clusters 7 and 8 are also in this pattern, and these are mostly small and medium sized. The former are firms mainly related whit metal mechanical sector and they have a large number of technicians and NTTS professionals, and they state that they engage

in R&D. Cluster 8 is mainly made up of firms in the chemical and food sectors that carry out R&D with a large number of TTS professionals. A special feature of this cluster is that is also includes three large enterprises that have a particularly high proportion of TTS professionals on their staff.

This enterprise pattern typology, firms that build innovation on their *cognitive base,* shows that innovative behavior with respect to enterprise size and activity sector is very heterogeneous.

Similarly, when it comes to analyzing the other two innovative behavior patterns, we find that it is not possible to identify a clear connection between innovative behavior type and the size or activity sector of the firm.

IV.b. The endogenous capabilities of firms

The IAS 2003 registered information about the employed personnel characteristics of the whole sample regardless of whether a firm engaged in innovation. This enabled us to analyze the number of highly qualified personnel in all enterprises. An analysis of the number of TTS professionals is probably one of the clearest indicators of a firms' endogenous capabilities. As can be seen in table 5, the simple results of the IAS 2003 show that the rate of TTS professionals in Uruguayan industrial firms is very low.

Table 5. Shortfalls in highly qualified human resources 2001-2003

	Percentage of firms without TTS professionals
Total Sample	77.9
With O.P.[10] < 20	87.4
With O.P. between 20 and 100	63.2
With O.P. >100	21.9
Enterprises without FDI	79.5
Enterprises with FDI	42.6
Innovative enterprises	65.4
Non -innovative Enterprises	84.9
Enterprises that state they engage in R&D	54.5
Source: IAS 2003	

If we follow the theoretical premises outlined above it is clear that the endogenous capabilities of firms are poorly developed. The fact that 54.5% of the firms that claim to carry out R&D do not have TTS professionals on their staffs tells the whole story.

When analyzing this dimension, the firms in the third innovative behavior pattern also stand out. As mentioned above, clusters 4 and 6, which contain big enterprises, have a large number of TTS professionals, and this is also true of cluster 8, which is mainly made up of SMEs. On the other hand, cluster 7 is an example of a grouping of firms that state they engage in R&D but where more than a half do not have TTS professionals.

[10] Occupied Personnel

In the innovative behavior pattern characterized by the incorporation of exogenous knowledge, enterprises that carry out innovation activities but whose endogenous capabilities are poorly developed are clustered. This is in line with the kind of innovation activities that are undertaken, which is mainly the acquisition of assets.

Another indicator used to measure the strengthening of endogenous capabilities was investment in personnel training. This was done in 16% of the total number of firms, which makes it the second most common kind of innovation in Uruguayan industry. Some 74% of the firms that invested in training are concentrated in patterns 2 and 3. When we analyze the scope of the training, understood for our purposes as the number of people in a firm who are trained, we find that again it is the firms in patterns 2 and 3 that make the greatest effort in personnel training. It is understandable that this variable is not discriminative for any specific pattern.

IV.c. Links to carry out innovation activities

As was mentioned in section I, the links that a firm has with its environment to develop innovation activities depend on its endogenous capabilities and on opportunities provided by the institutional network within which the firm operates. All previous data indicate that in Uruguay the institutional network devoted to supporting and developing scientific, technological and innovation activity is very weak, and the system does not operate in an interactive way.

The result of the innovative behavior analysis of the manufacturing industry is coherent with this diagnosis. The intensity of links with the NIS is low, only 49% of the enterprises had any kind of links in the period. An analysis of simple data distribution shows that a large proportion of enterprises do not have links with NIS institutions. Besides this, the intensity of links that firms which are linked to NIS institutions do have (as measured as the number of institutions with which the firms is linked) is markedly low.

All the firms in pattern 3 (with the exception of cluster 8) had some kind of links to undertake innovation. The rate for pattern 2 was only 60%, and for pattern 3 it was 43% of firms. This result confirms the notion that the likelihood of having links for innovation depends to a large extent on an enterprise's ability to identify its needs.

Links to NIS agents is measured by quantifying contacts by objective and by institution, in such a way as to register if a firm had any links during the period, but we do not know the time intensity of the links (whether they were continuous or sporadic) and we do not know the degree of formality or informality of the connection.

Table 6 Intensity of links to NIS[11] by innovative behavior

[11] NIS agents include the universities, technological centers, technical training institutes, laboratories, technological-related units, financial bodies, suppliers, customers, related enterprises, other enterprises, consultants, S&T government agencies and the firm's headquarters.

(% of enterprises)			
		Non- innovative	Innovative
Links for R&D	No links	98.66	89.62
	Links with one institution	1.29	6.00
	Links with more than one institution	0.05	4.38
Links for other innovation activities[12]	No links	75.59	38.29
	Links with one institution	11.08	22.86
	Links with more than one institution	13.33	38.86
Links for training	No links	91.99	62.80
	Links with one institution	4.25	22.55
	Links with more than one institution	3.76	14.65
Links for financing	No links	78.67	74.57
	Links with one institution	15.96	18.29
	Links with more than one institution	5.37	7.14
Source: IAS, 2003.			

If we consider as an estimation that participation in systemic relations means links with more than one institution, it can be seen in table 6 that only a small proportion of enterprises maintained such links. Consequently, it is not possible to classify the innovation process in question on the basis of systemic relations since these are practically non-existent.

V . Final considerations

The typology of the innovative behavior patterns in Uruguayan industry does not yield to a definite answer to the question of the characteristics and specificities of the innovative process in Uruguay, in fact it indicates that this process ought to be studied in greater depth.

The innovative behavior of Uruguayan manufacturing industry is characterized by its weak endogenous capabilities and by the incorporation of knowledge that is generated exogenously. This raises the questioning of where this knowledge is generated.

In order to be able to answer this question it would be necessary to go deeper into the study of ways in which productive integration takes place at domestic and international levels. In this way we could make progress in establishing a typology of the possible technological spillover in the innovative behavior identified. It is especially important to identify the way that firms that base their innovation processes on the incorporation of assets (some 37% of innovative firms) so as to know what proportion of this effective demand is absorbed by the domestic industrial sector.
In addition to this, the high rate of firms whose cognitive base is barely developed, which includes firms that claim to carry out innovation activities and that have similar characteristics to non-innovative firms, shows that there is a need to create new theoretical categories to understand more precisely the

[12] Other innovation activities include organizational change support, testing, technical support, and design.

innovation processes in developing countries.

The theoretical categories have allowed us to integrally characterize the innovation process of a very small percentage of Uruguayan industrial firms. Nevertheless, it is not possible to accurately characterize the different technological activities that the enterprises claim to carry out because although very often these do not capture the high degree of complexity in innovation patterns, they do represent strategies of technological support for the firm's activity.

These considerations, along with the fact that few enterprises build their innovation processes on their own *cognitive base*, show that innovative behavior in Uruguayan industry has not changed much in the last 20 years (Argenti, et al; 1988). There are still very few technology-based firms, and this is reflected in the ways that knowledge is accumulated.

This indicates that there is a need for active policies to promote innovative activity. For this purpose, one possible mechanism could be a monitoring of the firms that base their innovation process on their *cognitive base.* It can be seen that the development of innovative behavior, particularly among the SMEs in cluster 8, is connected to positive economic performance indicators. Further and more far-reaching study is needed to know if there is any kind of causal relationship between the innovative behavior of these firms and their economic performance and with their consolidation in the wake of the economic crisis. Follow-up on these experiences would open the way to generating input materials for defining policies aimed at the diffusion of learning.

This leads us to the conclusion that it is necessary for policies to be defined on the basis of an integral and systemic conception which acknowledges the strategic importance of links between the manufacturing industry and institutions that engage in research and promote innovation. In this way the NIS could be consolidated and would make a contribution to a development strategy based on innovation.

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Methodological Appendix

Variables selected for the PCA

Table A1. Variables of the firm's internal capabilities	
Name	**Description**
p_per firm	Proportion of personnel receiving training out of total employees.
p_formal	Proportion of firm's personnel working on innovation[13] in formal units out of total employees.
p_no formal	Proportion of firm's personnel working on innovation informally out of total employees.
p_tec	Rate of technicians employed by firm out firm's total employees.
p_prd_	Rate of TTS professionals working on R&D out of firm's total employees.
p_poi_	Rate of TTS professionals working on other innovation activities[14] out of total employed in firm.
p_per firm	Rate of TTS professionals in firm out of firm's total employees.
p_pnpf	Rate of non-TTS professionals employed in firm out of total employed in firm.

Table A2. Variables concerning links with NIS	
Name	**Description**
link-rd	Number of NIS agents firm linked to for R&D activities
link-oinn	Number of NIS agents firm linked to for other innovation activities
link-tr	Number of NIS agents firm linked to for training activity
link-fin	Number of NIS agents firm linked to for financing

Table A3. Variables concerning form's innovative experience	
Name	**Description**
i_cg s	Intensity of investment in capital goods over value of firm's sales.
i_tt s	Intensity of investment in technology transfer over value of firm's sales.
i_d s	Intensity of investment in design over value of firm's sales.
i_mi s	Intensity of investment in management improvements over value of firm's sales.
i_t s	Intensity of investment in training over value of firm's sales.
i_ird s	Intensity of investment in R&D over value of firm's sales.
i_c s	Intensity of investment in computing over value of firm's sales.
P np ts	Proportion of sales of novel products out of total of firm's sales.

Table A4. Variables concerning firm's performance and characteristics	
Name	**Description**
emp.32.1	Percentage of foreign capital in firm
emp.41	Number of personnel employed in firm
emp.53	Percentage of production for export
prodap	Firm´s apparent productivity (sales/employees)

[13] Innovation activities include design, quality control, engineering and R&D.

[14] Other innovation activities include design, quality control and engineering, and exclude people engaged in R&D.