The innovative behaviour of Uruguayan firms - stylized facts revisited[¥]

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Abstract

High-relevance knowledge accumulation is one agreed necessary condition to boost development, one that Uruguay is still far from meeting but that has increasingly attracted the attention of policy-makers. The comprehension of the innovative behaviour of private agents is thus critical for the correct design of incentives to promote the activity. The descriptive analysis of Innovation Surveys' data summarised in this paper is a contribution in that direction.

A large share of manufacturing innovators focus just on new processes, particularly when oriented to the local market and facing an economic downturn. The generally low novelty degrees attained are, partially explained by the large market imperfections and the lack of a national system that effectively protects property. A further major barrier stems from the widespread use of sub-optimal innovation technologies, as revealed by the chosen innovative input mixes. Organisational efficiency and highly skilled workers are key pre-requisite to engage in innovation. Therefore, the evidence suggest that policy action should focus on the establishment of systematic linkages between firms and scientific research institutes, the provision of financial-aid to apply for international patents, at least while developing the incipient NIS; and the design of mechanisms that would ease the penetration of outside markets.

JEL codes: C43; D21; O31; O32

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1. Introduction

As of today, effective constraints to economic growth that have been systematically identified by the empirical literature involve poorly qualified labour; insufficient provision of public goods; financial market failures; and shortcomings in the regulatory framework and/or the overall business environment; among others. These features are however unable to fully explain the meagre performance of the Uruguayan economy along the 20th century, closely linked to the sluggish dynamism exhibited by private investment (Bértola *et al*., 2005; Hausmann *et al*., 2005).

It has been argued that the country's sensitivity to its neighbours' economic performance, historically mirrored in highly volatile fiscal and exchange rate public policies, has been until recently one major structural deterrent for investors. Indeed, the diversification of exports registered along the last decade, that reduced the country's dependence on the demand from Argentina and Brazil, was matched to an increased macroeconomic stability and also to significantly enlarged investment rates. Yet, continuous growth would only turn into economic development once production patterns shift towards knowledge-capital intensive activities. A necessary condition for successfully undertaking such path is that most agents systematically devote non-negligible efforts to innovation activities, a behaviour that is still far from being generalised.

The provision of incentives to increase R&D and the promotion of other innovation strategies in order to allow for a better performance in the future has consequently become a growing concern for the government that has been reflected in the creation of institutions devoted to promote the activity. This is the case of the *Ministerial Bureau for Innovation*, in which four ministries (Industry and Energy; Agriculture and Livestock; Economy and Finance; Education and Culture) interact together with the Office of Budget and Planning in order to define general policies that support scientific research in the country. Further, pre-existent institutions, such as the Sectoral Commission of Scientific Research (CSIC) at the *Universidad de la República* (the public university) and the National Agency of Research and Innovation (ANII), became even more active actors seeking to strengthen the links between academic researchers and productive agents. Mixed ventures between the government and private entrepreneurs and/or foreign organisations have also been largely encouraged. [1] In parallel, public support to scientific research on innovation activities, their underlying rationale, expected impacts and eventual spillovers has been increasingly provided through diverse channels.

[1] Some examples worth to be cited include the Programme for the Development of Basic Sciences (PEDECIBA); the Programme for Technological Development (PDT); the Pasteur Institute; the National Institute of Research in Agriculture and Livestock (INIA).

The innovative behaviour of private agents has been analysed using data that stem from the first three waves of the Innovation Survey (IS) carried out along 1998 to 2006 (Arocena and Sutz, 2008; Bértola *et al*., 2005; Bianchi and Gras, 2005; Bianchi *et al*., 2008; Cassoni and Ramada-Sarasola, 2010 and 2012; Crespi and Zuñiga, 2010; Hall and Maffioli, 2008; Hausmann *et al*., 2005; Pittaluga and Vigorito, 2005). The existing literature has led to the identification of some specific barriers that hamper knowledge accumulation activities and has also suggested that distinct innovative profiles characterise firms with particular attributes, such as size; national ownership; sales markets; among others.

Recent work, however, has set a warning on the reliability of some of the reported stylised facts arguing that they do not necessarily reflect the patterns that characterise the vast majority of firms – those small-sized (Cassoni and Ramada-Sarasola, 2010; 2012). The statement is founded on the fact that the weight of medium and large firms within the three samples would be overestimated by construction unless sample design effects are accounted for (Fazio *et al.*, 2008).

Moreover, according to the new evidence some of the obstacles highlighted by the early research may not be as binding as the lack of an in-depth knowledge on innovation production technologies. As a consequence, firms would operate far below the production technology frontier, a fact that would in turn explain the low novelty degree generally attained by innovative firms in all industries, regardless of their specificities and irrespective of the prevailing macroeconomic entourage. Similarly, the rationale is consistent with agents perceiving knowledge accumulation activities as highly risky and with an excessively long investment time-horizon, to an extent that would not serve to counterbalance the non-negligible returns driven by innovations.

Motivated by the above, the analysis summarised in what follows intends to be a twofold contribution to the empirical literature on Uruguay. A first goal sought relates to the robust identification of the regularities that characterise the innovative behaviour of firms along the period 1998-2006. A second aim refers to the characterisation of the existing technologies of innovation in terms of the prevailing input mixes within specific subsets of firms considered of relevance. In doing so, particular emphasis is set on the distinction of innovators according to the type of innovation pursued – processes and/or products – and to their novelty degree - firm, local or world market innovations.

In the next section we briefly review the theoretical literature on the mechanisms underlying knowledge accumulation processes that serves to justify the posterior categorisation of innovative inputs, innovations and innovators. Methodological issues are discussed in Section 3 while the main patterns that stem from the data are depicted in the

following section. The most salient stylised facts and some policy recommendations are summarised in the final section.

2. Theoretical benchmark

The literature on the effects of innovation on economic growth can be traced back to Schumpeter (1942) and Solow (1957) who envisaged knowledge accumulation as the driving force of technical progress. The residual factor obtained from the estimation of aggregated production functions provided with the initial empirical proxy for technical progress within the applied research. Later on, data availability enabled its substitution by a function of knowledge-capital endowments, considered the key source of all technological advances. The accumulated expenditure on R&D activities soon became the most widely used proxy indicator. Indeed, even though R&D is not the sole input nor does it represent the largest share of total innovation investment, as documented for example by Denison (1985), it is undoubtedly the innovation input *par excellence.* The returns to knowledge-capital were therefore quantified as the impact of R&D on productivity by means of estimating econometric models with aggregated data (see the survey in Mairesse and Sassenou, 1991).

Improved empirical results were afterwards obtained by means of the use of firm-level datasets, their generalised availability being also partially responsible for the renewed interest observed on the analysis of knowledge accumulation from a microeconomic perspective. Griliches (1979) proposed its rationalisation as a sequential two-stage process in which a first behavioural relation reflects the extent to which the firm's decision to undertake innovation activities is influenced by diverse factors. Theoretically expected obstacles and triggers include information channels; cooperation mechanisms; funding sources; public policies; institutional settings related to scientific and technological research; among others. Their relative weight on the final decision would be however strengthened or weakened depending on the general and specific benchmark of the firm's economic activity and also on its vulnerability with respect to each particular dimension. At a second stage, the amount of financial resources to be invested in innovation has to be decided upon, the final outcome being assumed to depend, as before, on diverse features related to the firm, the market and the overall business framework. The resulting increase in knowledge-capital is assumed to be afterwards materialised in an improved productivity level driven by its impact on the firm's overall production technology.

The above rationale benchmarked almost all the empirical research on knowledge accumulation processes for at least two decades, when a new significant contribution was brought into light by Crépon, Duguet and Mairesse (1998), hereafter referred to as CDM. The authors convincingly argued that accumulated R&D *per se* need not have a substantial impact on firm performance unless it brought forth a tangible innovation in terms of new products

and/or novel procedures. The up to then inclusion of R&D in the firm's production function would thus be a miss-representation of the actual mechanisms at work. Consequently, the reliability of the results obtained within such scheme were casted into doubt and most frequently proven inaccurate by the posterior empirical evidence (Hall and Mairesse, 2006).

The CDM proposal thus extended Griliches' model postulating a third stage in the innovation decision-process at which accumulated R&D would be transformed into an innovative output. In explicitly stating the technology that gives rise to an innovation - the so-called knowledge production function (KPF) – the CDM model allowed for the comprehension of the innovative behaviour of firms from a completely different and enlightening perspective that soon became the theoretical setting of most of the empirical work on innovation and productivity.

Even in spite of the non-homogeneous empirical implementation of the model, particularly with respect to the KPF, country comparisons have enabled the identification of several stylised facts even though the evidence on the size of the effects up to date is still not enough robust to assess the existence nor the size of significant differentiated effects across countries. Some of the theoretically predicted linkages, in contrast, are yet to be properly understood while the dynamics inherent to innovation and its eventual cyclical behaviour are most unexplored areas.

Stylised facts that are common to most of the existing international literature include:[2]

- Large firms are more prone to innovate than small companies are. The evidence is however mixed regarding the existence of linkages between size and innovation intensity and also on the direction of the effect while it is also inconclusive with respect to its roles within the KPF or in terms of the odds of achieving an innovation.
- Cooperation and information availability from several sources are identified as relevant triggering factors. Depending on the nature of the linkages, they are also found to increase innovation investment rates and to have a positive impact on the generation of a novel output.
- The access to external financial-aid allows firms for devoting an enlarged financial effort to innovation activities, although no regularity can be identified across countries in terms of the relative impact of the diverse funding sources.
- The expected benefits linked to public support and funding are not unambiguously backed up by the international evidence. Neither are those associated to the roles played by foreign entrepreneurs and economic groups at any stage of the innovation process. These

[2] Some of the papers reporting several of the above-listed stylised facts are: Crespi and Zuñiga (2010); Griffith *et al.* (2006); Hall and Maffioli (2008); Hall and Mairesse (2006); Klette and Kortum (2004); and Raffo *et al.* (2008).

findings strongly suggest that actual linkages are more complex in nature and/or that the effects are heterogeneous depending on certain specific firm-characteristics.

- The greater challenges faced by firms in developed countries that participate in world markets relative to those locally-oriented are mirrored in their increased innovation propensity although not necessarily in a larger investment rate or innovation output value. The opposing results reported for Latin America, in turn, again suggest that the linkages are less clear-cut than expected, the relative share of exports to markets of distinct degree of competitiveness being a likely neglected dimension that may explain the diversity of results.
- Even though empirical studies that include technology-related features in the models are still scarce, their findings suggest that they do play a role in all stages of the innovation process. Dimensions identified as influential relate, among others, to factor-intensity, skill-level of the workforce, previous experience in R&D activities and R&D infrastructure at the firm.
- The odds of attaining an innovation significantly increase with the innovation investment rate.
- The innovation output elasticity with respect to the innovation expenditure in developed countries is generally within the interval (0.2, 0.6). The insufficient evidence for developing economies does not allow identifying any reliable range of values.
- Innovations are found to shift the labour productivity function, playing a role similar to that of a discrete technical change.
- Significant returns to knowledge-capital are found for developed countries, their size being estimated in around 0.1. The scant evidence for non-developed economies prevents from drawing any conclusion on both their existence and magnitude.

The above-listed regularities also generally observed in Uruguay according to the accumulated empirical studies that have also provided with some insights on the dynamics of innovation and on the key role played by certain technology-related features (Cassoni and Ramada-Sarasola, 2010; 2012).

The reported findings suggest that both the innovation propensity and the innovativity level have a counter-cyclical character while the innovation intensity is, as expected, procyclical. Therefore, knowledge accumulation in Uruguay is suggested to be used as a means to cope with a recessive economic entourage. In contrast, it is not considered as equally key to increase the potential gains within a prosperous economic frame. Dynamic-related dimensions of relevance refer to the firm's overall production technology prior to deciding to engage in innovation and the pre-existence of infrastructure to carry out R&D activities at the firm. A

capital-intensive technology is found to foster both the innovation propensity and intensity while a highly productive workforce is a further triggering factor that allows all other things equal, for reducing the amount of resources invested in innovation inputs. Disposing of an R&D formal department at the firm, in turn, acts as an incentive to carry on with the activity and it also results in an enhanced innovation output.

The input composition of the total innovation investment has been identified as a technological dimension linked to the feasibility of attaining distinct types of innovations of heterogeneous novelty degrees. Uruguayan firms that invest in training programmes and in R&D and those with a highly diversified innovation expenditure are suggested to be the most efficient and successful innovators.

The descriptive reports on the results obtained from each IS are a further basic source of information used to characterise the prevailing patterns in the country. However, in erroneously treating all firms as equally likely to be included in the sample they provide with a picture of actual facts that is at times quite misleading.[3] The next section is therefore devoted to the characterisation of the IS samples that would permit to fully understand the outreach of their associated information sets. The indicators to be used to identify actual trends are described afterwards.

3. Characterising innovation surveys' data

3.1. Methodological aspects

The Innovation Survey has been carried out every three years since 2000 and it is aimed at gathering information on innovation activities undertaken by manufacturing firms along the preceding three years. The frequency of the data is hence the three-year span except when expressed in monetary values (sales, innovation expenditure and exports) or in number of employees (total, by occupation, by education) in which case they are referred to the current year. Although four waves have been completed to date, data from the 2007-2009 survey are still unavailable to the public.

The surveys were administered through personal interviews attaining high response rates in all three instances – above 90%. Firms in the samples are those selected by the National Institute of Statistics for the Annual Economic Activity Survey. As such, they constitute a representative sample for the overall manufacturing sector in terms of both the value of production and the level of employment. Contrarily, the inference based on ISs data would only reflect the innovative behaviour of firms in the sample since its representativeness with respect to innovation activities cannot be granted nor can the expansors be assumed to be

[3] See Baptista (2004); DICyT/ INE/MEC/PDT (2006) and ANII (2006).

suitable.[4] Nevertheless, the analyses restricted to these particular subsets have proven to serve for the identification of several key factors that are most likely to be also influential for firms outside the sample.

Whenever the sample is defined by means of a random sampling model, the use of primary data would depict an accurate reflection of actual patterns. Otherwise, sample design effects should be controlled for through the use of observations weighted by the firm's probability of selection. This is the case of the Uruguayan ISs' samples that combine mandatory inclusion units – those with 50 or more workers and those surpassing certain level of sales – and a subset of the remaining firms selected through a stratified sampling model. Since the strata are defined in terms of the number of employees (three categories – 1-to-4; 5-to-19; and 20-to-49 workers) and the economic sector (20 4-digit ISIC categories), the use of unweighted data would give rise to stylised facts biased towards those that characterise large firms within particular industries (Table 1).[5] Indeed, while the share of certainty units in the sample is always over 60%, they are just around 4% of the total population of firms regardless of the year (see the upper part of Table 1).

[4] The drawback has not gone unperceived at the National Institute of Statistics. However, until now budgetary restrictions have prevented to build a specific sample for the IS.

[5] Firms with less than 5 workers discriminated by sector are excluded from the Table due to data non-availability.

Table 1. Population and sample of firms: distribution by size and economic sector

	2000	2003	2006	2000	2003	2006
	(number of firms)			(%)		
Total Firms - Population	15881	12266	12837	100%	100%	100%
1 to 4 workers	10747	9259	9013	68%	75%	70%
5 to 19 workers	4032	2318	2864	25%	19%	22%
20 to 49 workers	571	390	583	4%	3%	5%
50 & more workers	339	299	377	3%	3%	3%
Mandatory inclusion	602	524	575	4%	4%	5%
Stratified sampling	15279	11742	12262	96%	96%	95%
Total Firms - Sample	761	814	839	100%	100%	100%
1 to 4 workers	52	24	29	7%	3%	3%
5 to 19 workers	148	211	185	20%	26%	22%
20 to 49 workers	222	280	248	29%	34%	30%
50 & more workers	339	299	377	44%	37%	45%
Mandatory inclusion	602	524	575	79%	64%	69%
Stratified sampling	159	290	264	21%	36%	31%
*Total Firms: 5 or more workers**/*						
Population	5027	3021	3821	100%	100%	100%
Sample	709	790	810	100%	100%	100%
Food/Beverage/Tobacco						
Population	2036	1217	1383	41%	40%	36%
Sample	217	265	261	31%	34%	32%
Mandatory inclusion	180	183	188	83%	69%	72%
Stratified sampling	37	82	73	17%	31%	28%
Textiles/Leather products						
Population	823	429	556	16%	14%	15%
Sample	142	134	132	20%	17%	16%
Mandatory inclusion	124	97	97	87%	72%	73%
Stratified sampling	18	37	35	13%	28%	27%
Wood/Paper						
Population	731	342	493	15%	11%	13%
Sample	85	91	97	12%	12%	12%
Mandatory inclusion	68	52	64	80%	57%	66%
Stratified sampling	17	39	33	20%	43%	34%
Chemicals/Oil & derivatives						
Population	174	179	219	3%	6%	6%
Sample	117	129	143	17%	16%	18%
Mandatory inclusion	106	101	114	91%	78%	80%
Stratified sampling	11	28	29	9%	22%	20%
Metallic prods & machinery						
Population	695	464	597	14%	15%	16%
Sample	107	123	127	15%	16%	16%
Mandatory inclusion	90	61	77	84%	50%	61%
Stratified sampling	17	62	50	16%	50%	39%
Other manufacturing inds						
Population	568	390	573	11%	13%	15%
Sample	41	48	50	6%	6%	6%
Mandatory inclusion	33	34	35	80%	63%	70%
Stratified sampling	8	18	15	20%	37%	30%

*/ Firms with less than 5 employees were excluded due to data non-availability.
Source: Own calculations based on Innovation Surveys data (1998-00; 2001-03, 2004-06); ANII/DiCyT/INE.

The imbalance is partially rooted on the large proportion of firms with less than 5 workers in the universe that is matched to their meagre contribution to total output and employment (4% and 10%, respectively).

Even if these units were excluded from the population, the share of medium and large firms would still remain far below that observed in the sample (10% *versus* 40% approximately) while population and sample shares also differ across economic sectors (see the lower part of Table 1).

The differences are particularly large in Chemicals and Oil & derivatives and in the residual grouping ('Other manufacturing industries') regardless of the year as well as in Food, Beverages and Tobacco industries until 2006. Given the size of the observed gaps, the largest biases are most likely to stem from the systematic over-representation of firms in the Chemical industry.

The magnitude of the distortions introduced in almost all the empirical research performed for Uruguay using ISs' data cannot be stated *a priori* since it depends on both the methodology and the sample used, as it will become apparent in the following section.

Further still, additional data-related errors disregarded by most of the early studies are also linked to the merits of the dataset itself. Indeed, leaving aside firms with less than 5 employees, the quality of the information provided by most interviewees is quite good whilst numerous and non-negligible distortions arise once transformed into a set of ordinal and cardinal variables.

The errors so introduced would have generally been reversible had them been detected, thus revealing that the datasets have not been subject to the necessary consistency checks. In contrast, the information provided by micro-firms is considered as insufficiently reliable given the excessively large number of errors detected. Given their minor share of the sample, their exclusion is most recommended.

Some of the resulting flaws imply that innovative firms, innovators and output types are incorrectly classified while others generate incoherent innovation expenditure levels, number of patents or innovative sales values, among other miss-measurements.[6]

Additional inconsistencies stem from the registration of monetary values in divergent units (pesos, thousand pesos, etc.); from the non-homogeneous direction of the rankings associated to diverse scaled answers (the best/highest subjective qualification is indistinctively defined as the top or the bottom values of scales); and from the incompatibility across waves of the IS of

[6] These inconsistencies are readily detected by comparing the figures reported for aggregates with the sum of those corresponding to particular categorisations (innovative products of distinct novelty degrees that do not match the reported total number of new products; the total sum of shares do not add to 1; etc.).

the reported data on some attributes of the firm, such as its starting year, juridical nature or economic sector.

The random assignment of zeros and missing value labels to both a genuine nil value and a non-response is one last major drawback worth to highlight given its crucial incidence in the calculus of relative shares.[7]

3.2. The variables of interest: definition and relevance

Within the CDM rationalisation, the analysis of the phenomenon of knowledge accumulation involves at least four dimensions: the extent up to which it is observed; the characterisation of innovation investment patterns; the prevailing typologies of innovations; and the observed profiles of innovators.

Although the general outreach of these concepts is shared by all the applied work on the topic, their precise definition is largely heterogeneous across studies due to the restrictions posed by country-related specificities. Therefore, the proper understanding of the empirical evidence critically relies on the unambiguous specification of the concepts involved in each facet.

Innovative firms are here defined as those that declare to have invested in an innovation input at least once during the three-year span and regardless of them having or not invested on innovation inputs during the year on which the IS is carried out. Analogously, firms that declare to have generated a novel output during the 3-years lapse are classified as innovators even in cases for which the innovative share of sales is zero during the year when the IS data are collected. Further, no innovative sales should be reported, by definition, whenever innovators are specialised just in novel procedures.

Innovation activities impose highly divergent challenges to firms of distinct characteristics that are linked to both their financial and technological capabilities. Consequently, the share of firms that engage in innovation is expected to differ depending on their economic activity; size; national ownership; market-orientation; organisational type; and/or maturity stage (generally proxied by the 'age' of the firm).[8]

Once the typology of innovative firms is established, a second behavioural dimension of relevance relates to their innovation investment profile in terms of both the total amount of resources devoted but also on its composition by input. Innovative inputs are classified in nine types – internal R&D; external R&D; physical capital; hardware; software; training programmes; consultancy services and technology transfers; engineering design; and industrial

[7] A detailed list of the errors identified is available upon request.
[8] The maturity dimension is excluded from the analysis here performed due to the insufficient reliability of the data.

design. In order to simplify the analysis, the diverse inputs are grouped in four types based on theoretical and statistical arguments. Internal and external to the firm R&D are jointly considered given the negligible number of firms that invest in external but not in internal R&D activities (33 out of 558 cases).

A similar pattern is observed in the case of hardware and software investment and hence they are also aggregated into one innovative input. Noting that only 54 out of 966 firms that invest in novel physical capital do not devote any resources to the acquisition of ICT tools, the three inputs are included in a sole category. At the other end, training programmes are kept as a sole category.

Lastly, engineering and industrial design as well as external technical assistance and technology transfers, that are defined as individual inputs whenever they are not performed as an additional R&D activity, as is generally the case, are aggregated into one innovative input type given their common inherent nature.

The relative weight of the diverse inputs in total innovation investment *per se* can only provide with a partial picture of actual trends since it is uninformative with respect to the input mixes observed. The degree of diversification of expenditure is one facet of utmost relevance to characterise the set of feasible technologies of innovation, even if only the extreme cases are here differentiated – fully concentrated on one input and fully diversified across all four types of input.

The characterisation of innovations is a third key dimension of knowledge accumulation practices, both in terms of the output type achieved and its degree of novelty. The IS classifies innovations in four – products; productive processes; organisational procedures; and commercialisation methods – and it also sets a distinction according to their relevance by postulating three degrees of novelty - new to the firm; new to the local market; and new to the world.

The distribution of innovative firms along the resulting 12 categories allows for evaluating the state of the art given the configuration of the observed knowledge-capital increases. Moreover, the combined analysis of innovation input mixes and output types and relevance would serve to shed light on the production technology of innovations of diverse character, information that is essential for the in-depth comprehension of the phenomenon.

As in the case of inputs, an enriched rationalisation of the innovative behaviour of firms would result if output mixes are also acknowledged for given it would allow for the identification of technological complementarities among output types. This complementary facet would also serve to distinguish among innovators according to the outcome of their activities. One relevant distinction is linked to innovation being focused only in one type of

output – products or processes - or else involving both products and at least one type of procedure.

The innovative behaviour of firms may be hampered or triggered by distinct environmental dimensions that are also explored with the IS. Barriers that discourage firms to engage in innovation; obstacles faced when undertaking the activity; the relative role of the firm's having or not sufficient access to information and financial-aid from diverse sources; the role played by the National Innovation System; and the observed impacts of innovation activities on firm performance are therefore also described. The answers that give rise to the data are generally posed in terms of a 4-strata scale. Given the subjective nature of the responses, the diverse concepts are taken as effectively present only when classified in the top of the ranking provided following the international recommendations on the matter (see, e.g., Fowler, 2009; or Kanouze and Elliot, 2010).[9]

4. Stylised facts

4.1. Overall patterns

The propensity to innovate is quite low in Uruguay compared to developed countries (between 31% and 38% in the 10-year period *vis à vis* around 60% according to the OECD Eurostat 2009 yearbook). Yet, given its counter-cyclical evolution, the non-significant decline observed from 2000 to 2006 cannot be taken as evidence on its exhibiting a decreasing time-trend. The finding is opposed to that reported by most of the existing empirical studies based on the unweighted datasets thus unravelling the perverse effects of ignoring the design of the sample (see column 1 in Table 2).

The comparative distributions of total firms, innovative units and innovators serve to identify differentiated behaviours across subsets with distinct characterisations and in time. The innovation propensity increasingly rises with size, the proportion of innovative firms in each size-stratum being above that associated to the total sample except for the case of the smallest units. However, micro firms are fully responsible for the increase in the overall propensity observed at the bottom of the economic cycle given that the corresponding gap goes down in 5pp (Table 2).

[9] For example, a specific feature is defined as an obstacle only if the interviewee declares that it is a most binding barrier.

Table 2. Distribution of firms by various characteristics 1998-2006

	All	Micro	Small	Medium	Large	Non-corp	Corporate
2000							
All firms	100%	78%	15%	5%	2%	93%	7%
Innovative [1/]	35%	60%	25%	10%	5%	88%	12%
Innovator [2/]	96%	59%	26%	10%	5%	87%	13%
2003							
All firms	100%	69%	20%	8%	3%	94%	6%
Innovative	38%	56%	25%	13%	6%	93%	7%
Innovator	99%	56%	25%	13%	6%	93%	7%
2006							
All firms	100%	46%	39%	11%	4%	94%	6%
Innovative [/]	31%	26%	45%	20%	9%	88%	12%
Innovator	96%	25%	45%	21%	9%	90%	10%

	All	Full National	National & Foreign	Full Foreign	Full-local	Local & Export	Full-export
2000							
All firms	100%	96%	1%	3%	89%	11%	0%
Innovative	35%	96%	2%	2%	81%	19%	0%
Innovator	96%	96%	2%	2%	81%	19%	0%
2003							
All firms	100%	95%	2%	3%	82%	16%	2%
Innovative	38%	94%	2%	4%	73%	25%	2%
Innovator	99%	94%	2%	4%	73%	25%	2%
2006							
All firms	100%	95%	1%	4%	80%	19%	1%
Innovative	31%	89%	2%	9%	67%	32%	1%
Innovator	96%	90%	3%	7%	69%	31%	0%

	All	Food, Bev.& Tobacco	Textiles	Wood & Paper	Chemicals & Oil	Metal Prod.	Other manuf.
2000							
All firms	100%	39%	15%	17%	10%	13%	6%
Innovative	35%	45%	10%	15%	14%	14%	2%
Innovator	96%	44%	10%	15%	15%	15%	1%
2003							
All firms	100%	41%	14%	13%	10%	16%	6%
Innovative	38%	34%	7%	16%	15%	19%	9%
Innovator	99%	34%	7%	16%	15%	19%	9%
2006							
All firms	100%	38%	14%	15%	10%	16%	7%
Innovative	31%	24%	9%	21%	17%	19%	10%
Innovator	96%	23%	8%	22%	17%	19%	11%

Notes: [1/] As a percentage of total firms. [2/] As a percentage of innovative firms. 'Micro' firms are those with 5 to 19 workers; 'Small' units include those with 20 to 49 workers; 'Medium' sized companies are those with 50 to 149 employees; and 'Large' firms refer to those with 150 and more workers. The percentages of size-strata differ from those in Table 1 due to the exclusion of sample units corresponding to firms with less than 5 workers.
Source: Own calculations based on Innovation Surveys data (1998-00; 2001-03, 2004-06); ANII/DiCyT/INE.

Table 3. Distribution of innovators by novelty degree of innovations 1998-2006*/

	All	Micro	Small	Medium	Large	Non-corp	Corporate
2000							
World-level	9%	4%	12%	16%	38%	4%	43%
Local market-level	40%	43%	30%	44%	36%	43%	18%
Firm-level	78%	71%	95%	80%	80%	77%	89%
2003							
World-level	5%	2%	5%	11%	30%	5%	12%
Local market-level	44%	40%	48%	50%	58%	44%	44%
Firm-level	96%	96%	99%	97%	92%	96%	95%
2006							
World-level	13%	1%	14%	17%	33%	11%	33%
Local market-level	48%	50%	45%	54%	49%	47%	61%
Firm-level	96%	78%	98%	92%	91%	96%	96%

	All	Full National	National & Foreign	Full Foreign	Full-local	Local & Export	Full-export
2000							
World-level	9%	8%	36%	21%	0%	46%	50%
Local market-level	40%	39%	48%	51%	41%	28%	0%
Firm-level	78%	79%	76%	69%	79%	85%	75%
2003							
World-level	5%	4%	14%	27%	1%	17%	24%
Local market-level	44%	43%	45%	62%	46%	40%	24%
Firm-level	96%	96%	100%	89%	96%	96%	100%
2006							
World-level	13%	12%	8%	30%	3%	36%	67%
Local market-level	48%	49%	27%	47%	50%	45%	67%
Firm-level	96%	96%	100%	94%	98%	92%	83%

	All	Food, Bev.& Tobacco	Textiles	Wood & Paper	Chemicals & Oil	Metal Prod.	Other manuf.
2000							
World-level	9%	4%	31%	2%	20%	4%	20%
Local market-level	40%	55%	25%	37%	28%	18%	47%
Firm-level	78%	67%	77%	95%	80%	96%	47%
2003							
World-level	5%	5%	17%	1%	5%	8%	2%
Local market-level	44%	32%	38%	38%	59%	63%	41%
Firm-level	96%	99%	96%	89%	93%	99%	98%
2006							
World-level	13%	20%	16%	2%	17%	19%	2%
Local market-level	48%	48%	33%	36%	49%	68%	50%
Firm-level	96%	95%	88%	97%	96%	99%	97%

*/ The percentages do not add to 1 given that some firms attain innovations of diverse novelty degrees.
Source: Own calculations based on Innovation Surveys data (1998-00; 2001-03, 2004-06); ANII/DiCyT/INE.

Firms that are members of an economic group are more prone to innovate than the rest except in 2003, when the reduced propensity of small corporate units more than counter-

balances the behaviour of larger companies.[10]

The pattern is shared by non-national enterprises thus explaining the non-distinct behaviour of firms with different national ownership along the economic downturn, further emphasized by the reduced propensity of large national companies. In 2006, in contrast, non-full-national units of all sizes are found to engage in innovation activities to a larger extent than the rest.

The innovation propensity also differs according to the firm's main sales market, those that are both locally and internationally oriented being more generally engaged in knowledge accumulation processes than their counterparts, particularly during the upswing of the economic cycle.

The increased competitiveness faced in world markets is at the root of the finding and may be also linked to the more frequent innovative behaviour observed among firms in the Chemical products industry where the share of non-full-national firms is half that observed in other sectors. On the opposite, firms in Textiles and in Food, Beverages and Tobacco are found to be the least prone to innovate since 2003.

Regarding the outcome of innovation activities, a first most striking fact is that the degree of success within the 3-year period is invariably high among all categorisations. Significant differences arise however once the relevance of innovations is akcnowledged for: the vast majority of firms innovate at the firm-level while a tiny percentage generate new to the world innovations.

Nevertheless, there is a positive trend towards increasing the overall relevance of innovations that, after a temporary although expected drop at the bottom of the economic cycle, is particularly sharp (around 45%) for the share of firms that innovate at the world-level (see column 1 in Table 3).

The share of international-level innovators increases with size, the differences among size-categories being particularly significant between micro and small-sized units as well as between medium and large firms. The counter-cyclical evolution of local market-level innovators among small and large firms and the increasing trend among medium-sized companies, in turn, explain the rise in the overall share observed in 2003.

The enhanced innovativity of corporate firms in 2000 is matched to their innovations' higher relative novelty but the gaps significantly declined in 2006. Indeed, although they still outperform non-corporate companies, their focus changed towards local market-level innovations at the same time that those novel to the world became a significantly increased share among non-corporate innovators.

[10] The tabulatations that result from combining two or more features are omitted from the paper for the sake of simplicity and only those most relavnt results commented in the text. They are available upon request.

Regarding the national ownership of firms, full national and full foreign companies display a similar behaviour, increasingly generating high level innovations even though the absolute share of those new to the international market among multinationals is still twice the level observed for national companies.

A declining trend is in turn exhibitted by mixed ventures, their emphasis switching from international to local market level innovations to an extent that they are outperformed by national companies in 2006.

As expected, firms fully-oriented to the local market do not attain innovations new to the world but the overall degree of relevance of their innovations increases along the period. The evolution observed for exporters that also sell at the local market is, as expected, procyclical while full-exporters are those that display a most successful performance in terms of novelty degrees all along the period.

The patterns across economic sectors are mostly driven by the share of exporters and multinationals. Indeed, the high novelty degrees attained in the most and the least innovative sectors – Chemicals and Textiles – are linked to their major world market orientation while a similar trend matched to a high penetration rate of multinationals underlies the behaviour of companies in Food, Beverages and Tobacco in 2006.

The type of innovation output obtained serves to better understand the mechanisms at work and in particular the behaviour along the economic cycle. Knowledge accumulation in Uruguay has been largely biased towards creating new processes, that are over 80% of innovations since 2000. The share of new procedures has further increased in time, almost universally in 2003 and for a significant number of firms in 2006.

The largest increments are in turn found among the smallest, non-corporate, non-full foreign, local market-oriented companies. A stable share is observed for multinationals, medium-sized firms and, after a temporary decline, also for small enterprises. The emphasis on innovative processes, in turn, declined after 2003 among exporters and to a lesser extent across large and corporate organisations (Table 4).

The generation of novel products has followed the inverse path, almost universally decreasing along the period (30% on average), the major drop being generally registered after 2003. The most substantial decline in product-innovation is observed among mixed ventures and small firms that became the least frequent innovators in products after that. In contrast, a stable share is exhibitted by multinationals while in 2003 full-exporters turned into the most intensive product-innovators and thereafter remained at the top of the ranking.

Table 4. Innovators by type of innovation and firm characteristic 1998-2006

	All	Micro	Small	Medium	Large	Non-corp	Corporate
2000							
Products	67%	69%	67%	55%	67%	65%	82%
Processes	89%	82%	99%	95%	100%	87%	99%
Prod. & Procs.	56%	52%	66%	50%	67%	52%	81%
2003							
Products	66%	64%	70%	60%	70%	67%	52%
Processes	93%	95%	85%	96%	98%	92%	99%
Prod. & Procs.	58%	59%	56%	56%	68%	59%	50%
2006							
Products	47%	59%	36%	51%	56%	47%	45%
Processes	94%	96%	96%	92%	91%	95%	93%
Prod. & Procs.	41%	55%	32%	42%	47%	42%	38%

	All	Full National	National & Foreign	Full Foreign	Full-local	Loc.al & Export	Full-export
2000							
Products	67%	67%	80%	56%	66%	71%	25%
Processes	89%	89%	88%	95%	89%	97%	100%
Prod. & Procs.	56%	56%	68%	51%	54%	68%	25%
2003							
Products	66%	66%	64%	53%	67%	61%	60%
Processes	93%	93%	95%	96%	91%	97%	100%
Prod. & Procs.	58%	59%	59%	49%	58%	58%	60%
2006							
Products	47%	47%	27%	56%	43%	53%	83%
Processes	94%	94%	100%	94%	97%	89%	83%
Prod. & Procs.	41%	41%	27%	50%	41%	42%	68%

	All	Food, Bev. & Tobacco	Textiles	Wood & Paper	Chemicals & Oil	Metal Prod.	Other manuf.
2000							
Products	67%	66%	78%	76%	63%	59%	60%
Processes	89%	92%	60%	98%	98%	77%	100%
Prod. & Procs.	56%	58%	38%	74%	61%	36%	60%
2003							
Products	66%	54%	71%	67%	82%	77%	47%
Processes	93%	88%	99%	99%	91%	93%	97%
Prod. & Procs.	58%	43%	69%	66%	73%	70%	44%
2006							
Products	47%	42%	38%	45%	53%	53%	45%
Processes	94%	96%	86%	98%	90%	94%	100%
Prod. & Procs.	41%	38%	24%	43%	43%	47%	45%

Source: Own calculations based on Innovation Surveys data (1998-00; 2001-03, 2004-06); ANII/DiCyT/INE.

The divergent speed inherent to the above two opposing time-trends is mirrored in the

steady rise in the weight of innovative processes relative to that of new products. Once again, the stable behaviour of multinationals and the trend towards achieving a balanced share of both types of innovations among full-exporters are the exceptions to the rule.

Given that the mix of innovation types obtained may also be a driver of these trends due to the eventual existence of complementarities among them and also as a reflection of a dynamic path in innovation activities novel procedures being necessary prior to the generation of a new product. These hypothesised mechanisms are partially supported by the data in Table 4, although the comparative statics analysis is unable to provide with conclusive facts.

A high share of product-innovators in a specific categorisation is most generally coincidental with its also exhibitting a large proportion of firms that innovate in both products and processes relative to the remaining categories (as is the case for full-exporters since 2003, e.g.) and *vicecersa* (mixed ventures in 2006, e.g.). Similarly, a high share of innovators in products and processes at a point in time is afterwards matched to an increased share of high relevance innovations at the followiong period (large and full-national firms are two examples).

4.2. Triggers and deterrents of innovation

The IS information allows for measuring the relative impact of some external factors on the decision to engage in innovation activities and also on the amount of resources invested. It also enables the identification of the eventual roles played by diverse agents within the National Innovation System (NIS) and by distinct sources of financial-aid in terms of the degree of success and the type of innovation achieved by firms. The existence of linkages between the type of innovation achieved and the goals sought through innovation activities can be in turn analysed using the data on the actual impact of innovations on firm performance.

4.2.1. Obstacles

Since all firms are inquired upon the obstacles encountered to develop innovation activities, the reported barriers constitute either a binding restriction that prevents the firm to invest in innovation inputs or else a constraint that renders the activity more cumbersome than expected. They stem from three distinct sources - the firm, the market and the overall entourage – and their relevance differs for innovative and non-innovative firms and also in time (Tables 5 to 8).

Firm-level obstacles refer to the lack of a sufficiently skilled workforce; the existence of organisational rigidities; the risks inherent to the activity and to the expected return-horizon of innovation investments not being short enough.

Market-level barriers are associated to small market-size; scarce availability of financial-aid; the ease of imitation from and by other firms; meagre technology-related opportunities;

and lack of cooperation with other agents. The 2006 wave of the IS also collects information on the firm's participation in networks and its having or not cooperation agreements with other companies.

Constraints stemming from the overall frame for business refer to the insufficient availability of market and technology-related information; the lack of public policies on scientific and technological development; the poorly developed institutions devoted to research on science and technology; the inadequacy of the existent infrastructure; and the deficient property-rights systems. Information is also collected although only for by innovative firms, on the number of quality certifications and of patents requested and obtained, differentiated by them being of a national, regional or international outreach.

Firm and market-level barriers are considered a hindrance by a decreasing share of innovative firms while the proportion of enterprises that assign a major weight to the overall frame evolves counter-cyclically, as expected (Table 5). In contrast, all three, except for the case of firm-level obstacles, exhibits a temporary peak immediately after the 2002-crisis.

The evidence thus suggests that the general setting for carrying out knowledge accumulation activities has improved along the 10-year period but also that there still exist strong deterrents for effectively engaging in innovation, at least for a significant number of firms. The steady increase in the percentage of innovators and the stable proportion of non-innovative firms that are not strongly restricted by obstacles of any type gives further support to the hypothesis.

Regardless of the innovative behaviour of firms, the most frequently perceived barriers are always related to the market, as opposed to those stemming from the overall economy that acquire top relevance only at the bottom of the cycle. However, the shares are less heterogeneous among innovators both in 2000 and 2006, the extremely uncertain future economic path in 2003 rendering firm-level constraints comparatively less restrictive. This divergence may be rooted on firms in each subset having a differentiated access to information but it would also be consistent with a relatively more homogeneous characterisation of innovative firms with respect to non-innovators.

Table 5. Obstacles for innovation (% share of firms)

Obstacles	Innovative firms			Non-innovative firms		
	2000	2003	2006	2000	2003	2006
Firm-level	59%	47%	54%	42%	56%	58%
Market-level	81%	73%	56%	59%	73%	65%
Economy- level	41%	63%	48%	29%	69%	42%
All three levels	27%	30%	21%	12%	45%	32%
None	12%	11%	21%	22%	18%	24%
Only firm-level	27%	25%	32%	1%	9%	22%
Only market-level	58%	62%	27%	33%	26%	31%
Only economy-level	20%	25%	19%	0%	11%	6%

Source: Own calculations based on Innovation Surveys data (1998-00; 2001-03, 2004-06); ANII/DiCyT/INE.

It is interesting to note that innovators are rarely bound by a unique type of obstacle, particularly in 2006. Moreover, the share of firms that simultaneously face highly restrictive barriers of the three types is similar to that of innovators only constrained by firm and economy-level obstacles. Non-innovative firms are even more rarely discouraged by a sole type of obstacles while except in 2000 all three categories act as major deterrents for at least one third of them.

Even though organisational rigidities are always the most cited obstacles among agents that face major firm-related constraints, their weight has systematically diminished along the period. The same can be said for non-innovators, for whom a low skill level of the workforce is a key, yet decreasing in relevance, deterrent (Table 6a).

Table 6a. Firm-level obstacles (% share of firms)

Obstacle	Innovative firms			Non-innovative firms		
	2000	2003	2006	2000	2003	2006
Innovation associated-risks	36%	21%	25%	18%	13%	12%
Long return-horizon	35%	11%	10%	9%	19%	14%
Workforce skill-level	28%	24%	11%	70%	37%	25%
Organisational rigidities	42%	32%	26%	71%	44%	32%

Source: Own calculations based on Innovation Surveys data (1998-00; 2001-03, 2004-06); ANII/DiCyT/INE.

The evidence thus suggests that highly qualified human resources are a pre-requisite for firms to innovate while organisational inefficiencies are not only a surmountable obstacle but also seem to be more easily overcome through innovation activities. The hypothesis is supported by the increased use of professional and strategic human resources management (HRM) practices in 2004-2006 reported by a large share of innovators, always significantly above that of non-innovators (Table 6b).

Table 6b. HRM and quality strategy and innovation practices (% share of firms)

Profile of new workers 2006	Innov.	Non-innov.	Profile of new workers 2006	Innov.	Non-innov.
Actual skills	45%	16%	Multi-tasks abilities	42%	8%
Team-work abilities	36%	9%	Responsib.& quality	54%	13%
Work organisation 2006	**Innov.**	**Non-innov.**	**Organisation pillars 2006**	**Innov.**	**Non-innov.**
Team-work	70%	39%	Autonomous work	29%	8%
Work rotation	45%	25%	Skilled workforce	48%	14%
Multi-tasks & respons.	54%	29%	Specialisation	42%	8%
Quality groups	25%	11%	Communic.related agents	29%	10%
Premia performance	33%	9%	Cooperation empl/empl	41%	13%
Workers in. in mgnt	44%	17%	Cooperation empl/mgnt	39%	14%
			Org. Cult.-Formal.stats.	32%	8%

Strategy on quality	Innovative		Non-innovative	
	2003	2006	2003	2006
Quality control	73%	76%	61%	41%
Quality follow-up	46%	57%	17%	23%

Source: Own calculations based on Innovation Surveys data (1998-00; 2001-03, 2004-06); ANII/DiCyT/INE.

The explored HRM dimensions relate to (i) the profile of new employees – biased towards actual skills, team-work capabilities, adaptability and/or commitment; (ii) the organisational profile and its degree of formalisation – emphasising multi-level communication and cooperation as well as responsibility and quality standards; and (iii) the pillars of work organisation – founded on individual and/or team work, on specialisation and/or multi-tasking, and on commitment to the firm. The organisational-related benefits driven by innovation activities are also in line with the enhanced relevance assigned to quality standards by the majority of innovative firms, a behaviour that is not shared by non-innovators, particularly in 2006.

Barriers linked to the access to financial-aid have lost relevance for a decreasing share of innovators, as opposed to their relative role among non-innovators. Nevertheless, the lack of funding is never among the most frequently cited binding constraints (Table 7a).

A small market-size is a relevant drawback for a most reduced share of firms that further diminishes in time, particularly among innovators. In contrast, barriers linked to the ease of imitation are shared by a similar proportion of innovative and non-innovative firms until 2003. After that date they become a less generalised obstacle among innovators but with a discouraging effect on an increased percentage of non-innovative firms. Nevertheless, in both cases the ease of imitation is the most frequently cited constraint, a fact that suggests that property-rights are insufficiently protected and also that the benefits from being a 'follower' more than compensate the risks associated to playing a leading role in innovation.

Table 7a. Market- level obstacles (% share of firms)

Obstacle	Innovative firms			Non-innovative firms		
	2000	2003	2006	2000	2003	2006
Lack of financial-aid	27%	18%	16%	22%	27%	30%
Market size	8%	6%	5%	22%	14%	18%
Ease of imitation	34%	41%	33%	36%	42%	44%
Lack of cooperation	46%	43%	24%	41%	46%	40%
Lack of technological opportunities	32%	49%	21%	37%	43%	35%

Source: Own calculations based on Innovation Surveys data (1998-00; 2001-03, 2004-06); ANII/DiCyT/INE.

Similarly, the lack of technological opportunities is a hindrance for a stable share of non-innovators but it has significantly become less relevant after 2003. The same patterns are observed in terms of the role played by cooperation with other agents. However, the negligible number of firms that are members of a network and/or that subscribe cooperation agreements is in sharp contrast with such trends (Table 7b).

Table 7b. Cooperation among firms – 2006 (% share of firms)

Cooperation agreements	Innov.	Non-innov.	Network member	Innov.	Non-innov.
Total	8%	2%	Total	9%	3%
Commercialisation	50%	92%	National network	82%	90%
Training	20%	34%	Regional network	6%	10%
Technology-related	30%	31%	International network	11%	0%
Other	45%	44%	Scient./tech. knowledge	68%	42%
			Management strategies	75%	40%

Source: Own calculations based on Innovation Surveys data (1998-00; 2001-03, 2004-06); ANII/DiCyT/INE.

The evidence thus suggests that their theoretically predicted benefits are not accordingly perceived by firms, particularly in the case of those technology-related. Indeed, 50% of agreements among innovators (and 90% of those signed by non-innovators) refer to commercialisation practices while less than one third of them involve training and/or knowledge-sharing and diffusion cooperation. Further, the distribution of firms by national origin of the economic group signals at their restricted access to international networks.

Nevertheless, the fact that vertical and/or horizontal integration among national innovators most generally involve the acquisition of scientific, technological and management-related knowledge indicates that efforts are being devoted to the promotion of this type of cooperation locally.

The share of innovative firms that face major obstacles driven by the overall entourage, regardless of their source, remains stable or decreases (in some cases counter-cyclically) along

the period. The pattern is observed for non-innovative firms only when macro-level obstacles stem from the lack of information or else from deficiencies in the property-rights system. Otherwise, the perception of non-innovative firms is once again much more erratic both across factors and in time (Table 8a).

Table 8a. Economy- level obstacles (% share of firms)

Obstacle	Innovative firms			Non-innovative firms		
	2000	2003	2006	2000	2003	2006
Lack of public policies	17%	36%	18%	3%	45%	26%
Poor science & techn.-related intits.	25%	39%	25%	16%	43%	28%
Lack of infrastructure	27%	28%	25%	10%	22%	10%
Lack of information	45%	39%	28%	55%	50%	21%
Deficient property-rights system	64%	57%	53%	72%	72%	44%

Source: Own calculations based on Innovation Surveys data (1998-00; 2001-03, 2004-06); ANII/DiCyT/INE.

The property-rights system is not only the most frequently cited barrier for innovative firms all along the period but the sole obstacle shared by more than 50% of innovators in 2006 as well. It also constitutes the most generalised deterrent for engaging in innovation activities. The subjective opinion on the relevance of this particular hindrance is further backed up by the tiny yet increasing share of Uruguayan innovators that apply for patents and/or that are granted with quality certifications. Indeed, while the share of innovators awarded with quality certifications never surpasses 20%, patents applications are processed by at most 9% of innovative firms, even though the rate of approval is extremely high regardless of the national origin of the issuer (Table 8b).

The majority of patents are applied for and awarded in Uruguay while quality certifications are issued mostly by national agencies as well. The large costs associated to property rights at the international level are one well-documented underlying reason for the result (Pittaluga and Vigorito, 2005). Budgetary restrictions may also explain the sharp but temporary drop of international applications in 2003 in spite of them being preferred over those of regional outreach. It is also consistent with the observed rise in the share of international quality certifications on products.In contrast, the costs associated to national patents are substantially lower and hence unlikely to explain the scant number of applications. Instead, the poor development of the national system stands as a most reliable cause. An inefficiency suggested by the data on the temporal distribution of applications and approvals across regions relates to the waiting-time for approval in Uruguay being excessively long compared to that in other countries.

Table 8b. Property-rights – patents and quality certifications (% share of innovative firms)

Patents	2000	2003	2006	Quality Certifications	2000	2003	2006
Applications - Total	2%	6%	9%	Product-Total	5%	13%	15%
National	71%	91%	94%	National	87%	77%	81%
Regional	14%	10%	3%	Regional	0%	3%	4%
International	29%	4%	9%	International	13%	20%	15%
Awarded - Total	2%	5%	11%	Processes-Total	5%	8%	20%
National	70%	96%	87%	National	82%	66%	84%
Regional	15%	7%	20%	Regional	1%	5%	2%
International	22%	2%	30%	International	17%	29%	14%

Source: Own calculations based on Innovation Surveys data (1998-00; 2001-03, 2004-06); ANII/DiCyT/INE.

4.2.2. Information

The availability and access to information is theoretically considered to be a most relevant trigger of innovation activities that also acts as a key fostering factor for a successful innovative performance. The IS provides with data on its degree of importance among innovators and since 2003 also among non-innovative firms.

A first facet explored refers to the degree of relevance of the information effectively received from diverse sources that are classified in four types: (i) internal to the firm and/or provided by the parent company; (ii) stemming from related agents (clients; suppliers; competitors etc.); (iii) obtained from research-related agents (universities, consultants, technological centres, etc.); and (iv) through the access to specialised public instances (journals, magazines, websites, databases, conferences, fairs, etc.).

Information is always perceived as a most significant input to boost innovation by a majority of innovators and to a lesser extent by non-innovative agents, particularly when provided by related agents as opposed to that from institutions and agents focused on knowledge-generation. In turn, internal sources are of major weight only for a majority of innovative firms (Table 9a).

The second dimension of interest refers to the effectiveness of the National Innovation System as a source of information and to the relative performance of actors with a differentiated profile. Several subsets of NIS agents are differentiated in the IS and are here re-grouped in: (i) related agents including the parent company, clients, suppliers and other firms; (ii) research-related agents that includes universities, technical institutes, laboratories, technological centres and consultancy agencies; (iii) public organisations promoting science and technology activities; and (iv) financial agents.

Table 9a. High relevance information by source (% share of firms)

Source	Innovative firms			Non-innovative firms	
	2000	2003	2006	2003	2006
Any	84%	84%	76%	72%	56%
Source: internal	63%	64%	63%	44%	46%
Source: related agents	62%	60%	64%	73%	67%
Source: research-related agents	24%	23%	23%	24%	22%
Source: specialised public instances	46%	50%	48%	52%	42%

Source: Own calculations based on Innovation Surveys data (1998-00; 2001-03, 2004-06); ANII/DiCyT/INE.

The evidence reveals that one fourth of the firms for which information is a most relevant factor do not approach the NIS with that purpose, particularly among non-innovators. As before, the majority of those that establish linkages with the NIS with that aim get access to information from related agents. The negligible proportion of firms that obtain information from research institutes and other private and public related agents strongly points at a meagre performance of the NIS (Table 9b).

Table 9b. Information sought at the National Innovation System by agent (% share of firms)

NIS agent	Innovative firms			Non-innovative firms		
	2000	2003	2006	2000	2003	2006
Any	62%	64%	75%	30%	40%	23%
Related agents	86%	81%	76%	90%	90%	86%
Research-related agents	10%	1%	4%	1%	9%	0%
Public science &techn.-related orgs.	5%	4%	2%	0%	0%	0%
Financial system	6%	9%	4%	0%	2%	3%

Source: Own calculations based on Innovation Surveys data (1998-00; 2001-03, 2004-06); ANII/DiCyT/INE.

4.2.3. Financial-aid

The scarce availability of external to the firm financial-aid is one most reported obstacle for engaging and successfully carrying out innovation activities in Uruguay. However, the previously described data suggests its role is generally non-binding relative to other constraints, thus rendering necessary a more detailed analysis on its diverse facets.

Financial resources for innovation may be obtained from five sources: own resources (undistributed profits, contributions of partners or transfers from the parental company); related agents (clients, suppliers, related firms); public agents; international institutes; and the banking system.

According to the IS data, between 45% and 65% of firms self-finance their innovation activities, at most 30% receive full external funding while around 20% finance innovation investment with both internal and external resources all along the period (Table 10a).

Even though related agents and the banking system are always the most frequent providers, the majority of firms do not receive financial support from a sole source. Moreover, while their

percentage shares evolve in opposite directions – counter-cyclical for the share of related agents' funding and procyclical for the financial system – contributions from international and public agencies are always minor, regardless of the firm receiving full or partial external support.

Table 10a. Financial-aid by source (% share of innovative firms)

	2000	2003	2006
Only own resources	44%	58%	65%
Only external financial-aid:	30%	20%	14%
Related agents	35%	93%	77%
Public sector	24%	1%	3%
International organisations	11%	4%	7%
Financial system	68%	18%	30%
External financial-aid source:			
Own resources	46%	49%	60%
Related agents	49%	82%	64%
Public sector	14%	1%	10%
International organisations	6%	5%	7%
Financial system	63%	30%	38%

Source: Own calculations based on Innovation Surveys data (1998-00; 2001-03, 2004-06); ANII/DiCyT/INE.

When firms receive partial external funding, they contribute, on average, with 20% to 33% of total resources, the major share stemming once again from related agents, especially at the bottom the cycle. Other sources of financial-aid contribute with a negligible average share. Those that receive full funding for innovation activities, however, are able to obtain a larger share of total funds from both international and banking institutions, as opposed to the negligible proportion provided by public agencies (Table 10b).

Table 10b. Innovative firms: financial-aid by source (% share of innovative firms)

	Partial			Full		
Source	2000	2003	2006	2000	2003	2006
Own resources	19%	26%	33%	0%	0%	0%
Related agents	20%	56%	38%	16%	86%	69%
Public sector	10%	1%	4%	17%	1%	1%
International organisations	0%	1%	3%	45%	15%	23%
Financial system	0%	1%	5%	55%	11%	24%

Source: Own calculations based on Innovation Surveys data (1998-00; 2001-03, 2004-06); ANII/DiCyT/INE.

Although the access to financial-aid may be sought through the NIS, only around 30% of innovators and an even lower proportion of non-innovative firms have approached the NIS

agents with this goal. Since 2003, a large proportion of these firms have got funding for both their current and future innovation activities through this mechanism, the relative participation of contributors varying in time and between the two subsets of firms. While agents directly related to the firm were the most frequent funding source for non-innovative companies in 2000, financial system institutions became the leading contributors in 2006. A similar pattern is observed for innovators whilst in 2006 they were also enabled to establish, although to a much lesser extent, successful linkages with private and public research-related agents (Table 10c).

Table 10c. Financial-aid from the National Innovation System by agent (% share of firms)

NIS agent	Innovative firms			Non-innovative firms		
	2000	2003	2006	2000	2003	2006
Any	30%	27%	27%	10%	22%	9%
Related agents	15%	1%	3%	48%	7%	2%
Research-related agents	21%	4%	12%	2%	15%	0%
Science & tech. organs.	9%	13%	22%	0%	0%	0%
Financial system	4%	66%	58%	16%	42%	72%

Source: Own calculations based on Innovation Surveys data (1998-00; 2001-03, 2004-06); ANII/DiCyT/INE.

The above-summarised evidence thus serves to draw a more general picture on the role played by the access to financial-aid. Even though the evidence discussed in the precedent sub-section is not in line with previous studies concluding that the lack of funding is one major barrier faced for undertaking innovation activities, the regularities above-described suggest that its binding role is not at all negligible.

Indeed, the bulk of knowledge accumulation practices have been fully or mainly self-financed while the major contributions have been provided by related agents.

Contrarily, the share of firms that have been able to get access to funds from banks and other financial agents is comparatively smaller and so is the average contribution received. International organisations and public agencies have played a similar role although in the latter case the contributions are substantially smaller.

4.2.4. National Innovation System

The NIS has increasingly gained an active participation in the promotion of knowledge accumulation practices. Its actual role is therefore explored in the ISs classifying the diverse agents involved and also according to the goal sought by firms that approach the NIS.

Agents are here grouped in: (i) those directly linked to the firm (clients, suppliers, other firms, the parental company); (ii) private and public centres linked to science and technology-related activities; and (iii) financial institutions. The goals pursued by approaching the NIS are

in turn classified in five types depending on them involving information; financial-aid, technical assistance, training programmes or R&D activities.

The evidence reveals that the vast majority of innovators have increasingly approached the NIS in order to establish linkages with diverse agents and with distinct objectives. In contrast, the behaviour is observed for a significantly lower percentage of non-innovative firms that is further unchanged in 2006 with respect to 2000.

General information and technical assistance are the goals most frequently sought by firms within both subsets, the respective proportions being similar in the former case but substantially larger for innovators in the latter. At the other end and particularly among non-innovative agents, information on R&D is the least frequent objective pursued although it has steadily increased in the case of innovators.

The access to financial-aid is sought by a similar and stable share of firms within the two subsets, while those that seek for training programmes are a larger share of innovators but a smaller and decreasing percentage of non-innovative firms (Table 11a).

Table 11a. Linkages with NIS by goal pursued (% share of firms)

Goal	Innovative firms			Non-innovative firms		
	2000	2003	2006	2000	2003	2006
Any	82%	83%	88%	34%	52%	31%
Information	76%	77%	85%	87%	76%	72%
Financial-aid	36%	32%	31%	30%	42%	30%
Technical assistance	75%	76%	85%	58%	47%	48%
Training programmes	53%	47%	50%	24%	17%	11%
R&D	11%	12%	22%	4%	3%	2%

Source: Own calculations based on Innovation Surveys data (1998-00; 2001-03, 2004-06); ANII/DiCyT/INE.

The largest and further increasing share of firms that approach the NIS establishes linkages with research-related institutions, mostly seeking for technical assistance and to a lesser extent for information. Linkages with public organisations are mostly pursued with the same objectives but they only involve a negligible number of firms (Table 11b).

In between and to an extent that varies in time and between innovators and non-innovators, financial agents and those directly related to the firm participate in firms innovation activities mostly providing funding and general information, respectively.

Table 11b. Linkages with NIS by agent (% share of firms)

Agent	Innovative firms			Non-innovative firms		
	2000	2003	2006	2000	2003	2006
Any	82%	83%	88%	34%	52%	31%
Related agents[1/]	28%	20%	19%	53%	26%	34%
Main goal: information [2/]	84%	97%	95%	90%	87%	99%
Research-related agents[1/]	53%	62%	73%	37%	43%	53%
Main goal: technical assistance[2/]	89%	91%	87%	76%	75%	70%
Science & technology orgs. [1/]	10%	7%	10%	0%	1%	1%
Main goal: technical assistance [2/]	97%	95%	98%	100%	79%	100%
Financial system[1/]	6%	22%	19%	8%	19%	25%
Main goal: funding [2/]	60%	98%	86%	60%	98%	86%

Notes: [1/]As a percentage of innovative or non-innovative firms. [2/] As a percentage of firms seeking for linkages with a specific subset of agents.
Source: Own calculations based on Innovation Surveys data (1998-00; 2001-03, 2004-06); ANII/DiCyT/INE.

4.2.5. Impacts

The observed improvements driven by innovation activities are explored only in the 2003 and 2006 waves of the IS. They are divided in four types depending on them being related to: (i) products, either in terms of a new output or to the quality standard of those already offered by the firm; (ii) market-share, either allowing to keep or increase the existing share or by penetrating new markets; (iii) overall performance, differentiating between facets linked to the productive capacity of the firm, its operational flexibility and costs (of labour, energy and raw materials); and (iv) miscellaneous features involving environmental and health-related regulations, national and international quality standards and/or the more efficient use of the capabilities of the workforce.

Positive effects driven by knowledge accumulation activities have been experienced in around 40% of innovative firms in all of the above dimensions although a minor percentage registered all four types of impacts. However, once innovators are classified according to the type of output achieved, this homogeneity vanishes while differences in time are also identified (Table 12).

Positive externalities are registered in a large and increasing share of product and process innovators regardless of the dimension considered, product and market-related benefits being slightly more frequently obtained. Further, the percentage of firms that innovate in both products and processes that achieve improvements in all four facets becomes significant in 2006, even though it is still far below those corresponding to each type of impact. It is however well above the figures associated to innovators that are focused on only one type of output.

The majority of firms that innovate only in products are indeed able to diversify and/or increase the quality of their production as well as to enlarge their market in 2003. Improved

organisational performance is also observed in around 40% of cases. In contrast, the proportion that registered market and product-related gains decreases in 2006 to 50% of their previous levels, and the decline is even larger with respect to other environmental-related and other dimensions. The positive impacts of knowledge accumulation when firms innovate just in new processes are much less generalised, involving at most one third of innovators. The share of firms is further quite homogeneous across the four dimensions and has slightly increased in time, except for the category involving miscellaneous impacts.

Table 12. The impact of innovation (% share of innovative firms)

Impact	Innovative firms		Prod.&Proc. innovator		Only Product innovator		Only Process innovator	
	2003	2006	2003	2006	2003	2006	2003	2006
Product	51%	42%	64%	70%	86%	41%	23%	24%
Market	49%	46%	60%	71%	79%	39%	25%	30%
Overall performance	46%	37%	45%	65%	43%	32%	22%	30%
Other	46%	37%	52%	64%	29%	13%	40%	21%
All	13%	14%	18%	30%	23%	6%	3%	4%

Source: Own calculations based on Innovation Surveys data (1998-00; 2001-03, 2004-06); ANII/DiCyT/INE.

The evidence suggests that innovation output types complement each other thus allowing for additional efficiency gains in the overall production. It also signals at a learning-by-doing process that has increasingly allowed these firms for making use of the novel knowledge achieved through the activity. Regarding specialised innovators, it is apparent that the profile of firms is most divergent, the benefits driven by new processes being achieved by a comparatively low but yet increased share of firms suggesting that novel processes are frequently embraced as a survival strategy.

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4.3. The technology of innovation

The mechanisms through which innovation inputs are transformed into a novel output is one additional dimension of paramount relevance for achieving a comprehensive characterisation of innovators and innovations. Depending on the firm's technology, distinct input mixes would be materialised in different types of output and also in innovations of heterogeneous novelty degree. Therefore, the description of the type of inputs acquired by firms that innovate in distinct types of output constitutes a first step in the understanding of the prevailing patterns of the technology of innovation. Inputs are classified in the four types defined in Section 2 - R&D, Engineering and Industrial design, technology transfers and consultancy services (DTC), Training programmes (TP), and Physical capital, hardware and software (KHS). Innovators, in turn, are classified in two - those that innovate in both products and processes

(P&P) and those that only innovate in productive, organisational and/or commercialisation procedures (OP).[11]

The share of firms that invest in each type of input is not stable in time or across innovators except in the case of KHS that is most similar in all cases. In contrast, an increased proportion of firms invest in DTC regardless of the type of output sought while the overall rise in TP is only driven by firms that innovate exclusively in processes. The prevalence of the behavioural pattern of OPs over that of P&Ps results from both their enlarged share in total innovative firms and the magnitude of the increment. Similarly, even though P&P innovators that invest in R&D are a stable share of firms, the steady overall decline is the result of the evolution observed for those focused just in novel procedures (Table 13).

The above-described heterogeneity in the temporal evolution is matched to largely divergent investment intensity across inputs and innovators. Almost 80% of firms invest in KHS regardless of the type of output sought and the year, as opposed to the meagre percentage that invest in DTC - around 10%. The intensity of TP and R&D investment among firms that innovate in products and processes is, on average, around 20pp below that of KHS during the whole period, as opposed to OP innovators that only in 2006 invest in TP with a similar frequency. Further, only a minor and decreasing proportion of them invest in R&D.

The resulting profile of innovators is thus most divergent: most of the firms that innovate only in processes concentrate their innovation investment in KHS and training while the shares among P&P innovators are much close to each other.

Regarding the degree of diversification of investment, the data suggest that there is a trend towards an increased concentration level among P&P innovators. Indeed, although the drop in the share of firms with a fully diversified expenditure observed from 2000 and 2003 (from 25% to 19%) and the substantial rise in those with fully concentrated investment (from 7% to 21%) come at no surprise given the macroeconomic entourage, the trend is not afterwards reversed.

The above-described heterogeneity across innovators may be further understood by distinguishing them according to certain firm-characteristics. The profile of innovators is thus described for 2006 differentiating firms by size – small (less than 50 employees) and large; by corporate character; by national ownership – full national or not; and sales market – full local or not. The comparison in time is performed excluding 2003 for the sake of simplicity but also due to its atypical macroeconomic characteristics.

[11] Firms that only innovate in processes are not analysed separately due to the innsufficient number of observations (21, 22 and 34 in 1998-2000, 2001-2003 and 2004-2006, respectively).

Table 13. Distribution by innovation input and type of innovator (% share of innovators)

Innovation type	Any output			Product & process			Only processes		
	2000	2003	2006	2000	2003	2006	2000	2003	2006
Input type									
Any input	100%	100%	100%	56%	58%	41%	33%	35%	53%
R&D	41%	38%	27%	52%	57%	50%	15%	8%	5%
DTC	7%	12%	11%	10%	16%	14%	4%	8%	10%
TP	46%	45%	51%	63%	59%	56%	21%	28%	51%
KHS	78%	76%	78%	76%	75%	77%	86%	79%	79%
All inputs	18%	12%	9%	25%	19%	18%	3%	2%	2%
Only 1 input	28%	38%	41%	7%	21%	24%	58%	62%	55%

Notes: The percentages corresponding to firms that innovate in 'Products & processes' and 'Only processes' for each type of input do not add to 1 due to the omission of those that innovate only in products. 'DTC' denotes Engineering and Industrial design, technology transfers and consultancy services; 'TP' refers to training programmes and 'KHS' includes physical capital, hardware and software.
Source: Own calculations based on Innovation Surveys data (1998-00; 2001-03, 2004-06); ANII/DiCyT/INE.

A first finding refers to the patterns of KHS investment that is still the input in which most firms invest (between 70% and 94%). However, there are non-negligible differences between the defined subsets of firms, the widest gap being that observed between small and large P&P innovators (14pp). Further, the relative intensity across categories is non-homogeneous by type of innovator, the largest shares of KHS investors among firms that innovate in both types of output being found for large, corporate, exporting and non-full national companies while for OP innovators the inverse relation is observed when firms are classified by size and sales market (Table 14).

In contrast, differences in the relative intensity of investment in training between categories are homogeneous across types of innovators, the largest shares corresponding to large, corporate, exporting and non-full national companies. Training programmes are the second most frequently acquired input (between 45% and 84%) except in the case of P&P innovators partially or fully owned by foreign entrepreneurs and also of those not fully oriented to the local market. The share of firms that invest in R&D within these two particular subsets (76% and 85%, respectively), that are by far the most intense R&D investors, surpasses that of firms that invest in training programmes. Large and corporate P&P innovators also devote more resources but to a lesser extent to R&D than small non-corporate companies.

Table 14. Firms by input, type of innovator and firm-characteristics (% share of innovators)

	Any output		Product & Process		Only processes	
Size	Small	Large	Small	Large	Small	Large
R&D	22%	39%	42%	67%	4%	10%
DTC	9%	17%	9%	24%	9%	12%
TP	45%	67%	46%	75%	46%	64%
KHS	76%	82%	70%	94%	81%	74%
All inputs	4%	18%	10%	36%	1%	4%
Only 1 input	45%	32%	30%	12%	57%	48%
Corporate	No	Yes	No	Yes	No	Yes
R&D	26%	36%	48%	65%	5%	13%
DTC	10%	18%	12%	29%	10%	13%
TP	49%	74%	54%	71%	47%	82%
KHS	77%	85%	76%	90%	78%	86%
All inputs	8%	14%	17%	29%	1%	5%
Only 1 input	43%	19%	26%	5%	59%	22%
Full-national ownership	Yes	No	Yes	No	Yes	No
R&D	25%	40%	47%	76%	5%	10%
DTC	11%	15%	12%	24%	10%	8%
TP	49%	75%	54%	69%	47%	84%
KHS	77%	87%	76%	90%	78%	88%
All inputs	8%	15%	17%	27%	1%	6%
Only 1 input	43%	18%	26%	10%	59%	20%
Full local-oriented	Yes	No	Yes	No	Yes	No
R&D	18%	46%	33%	85%	4%	11%
DTC	8%	18%	5%	31%	10%	9%
TP	45%	65%	43%	82%	48%	60%
KHS	77%	80%	73%	86%	81%	74%
All inputs	6%	13%	14%	87%	1%	4%
Only 1 input	46%	30%	33%	5%	56%	53%

Notes: The percentages corresponding to firms that innovate in 'Products & processes' and 'Only processes' fore ach type of input do not add to 1 due to the omission of those that innovate only in products. 'DTC' denotes Engineering and Industrial design, technology transfers and consultancy services; 'TP' refers to training programmes and 'KHS' includes physical capital, hardware and software.
Source: Own calculations based on Innovation Surveys data (1998-00; 2001-03, 2004-06); ANII/DiCyT/INE.

Regarding firms that only innovate in processes, differences across categories keep the same sign but not only are the gaps relatively wider but also the percentage of R&D investors is negligible compared to those observed among P&P innovators (between 4% and 13%).

DTC also concentrates a low proportion of OP innovators, similar to that corresponding to R&D investors for large, corporate companies, exporters, mixed ventures and multinationals. There are no significant differences across firm categorisations and hence the shares are twice the size of those observed for R&D among small, non-corporate, full national and fully local

market-oriented companies.

Taken together, the above-described composition of total innovation expenditure reveals that the share of P&P innovators that invest in R&D, training and KHS is quite homogeneous within the categorisations defined, with a distinct – weaker – emphasis on DTC. On the opposite, firms that specialise in processes are significantly more biased towards investing in training and in physical capital and ICT tools. As a consequence, a fully concentrated investment is more frequently observed among OP relative to P&P innovators while the opposite holds with respect to firms with fully diversified innovation expenditure. Moreover, except for corporate companies and those not fully owned by national entrepreneurs, around 50% of OP innovators in all the remaining categories invest in only one input, as opposed to the at most 33% of P&P innovators that do so.

Similarly, a fully diversified investment is rarely observed among firms that innovate only in processes (at most in 6% of cases) while the lowest shares observed among P&P innovators (that correspond to small, non-corporate, full national and full local-oriented firms) are at least twice that level. Moreover, the percentages associated to large, corporate, non-full national companies are quite above - around 30% - while the majority of exporters (87%) invest in all four types of inputs.

4.4. Stylised facts

The behavioural patterns that characterise manufacturing firms in Uruguay along 1998 to 2006 allow for the identification of several stylised facts related to the general entourage for undertaking innovation activities; the characterisation of innovative firms and the technology of innovation in 2006; and the lessons that stem from the evolution of knowledge accumulation practices along the economic cycle.

4.4.1. The overall framework

- The barriers faced rarely stem from a unique source
- Market-related factors are generally the most binding obstacles faced
- The obstacles encountered are less numerous and relevant in 2006 with respect to 1998
- A skilled workforce is a major pre-requisite to innovate
- Organisational performance eases up and is also improved by innovation activities
- Cooperation, particularly in terms of technology-related aspects, is key for a successful innovative performance of firms
- The access to financial-aid is not a most binding obstacle but its relevance in 2006 has increased with respect to 2000
- The cost of international patents is a major hindrance for innovators

- The property-rights national system is inefficient and poorly developed
- Public funding is scarce
- The NIS is still not enough efficient and/or publicised among firms
- Firms approach the NIS seeking for general information and technical assistance
- Information is a most relevant fostering factor for both innovative and non-innovative firms
- More than 50% of innovative firms registered positive impacts of innovation on at least one dimension of firms performance in 2006
- Around 30% of firms that innovate in both products and processes registered positive externalities linked to numerous dimensions of firm performance in 2006

4.4.2. Characteristics of innovative firms and the innovation technology in 2006

- Size
    - The propensity to innovate increases with size
    - The highest novelty degrees are observed for medium and large firms
    - Micro firms and the largest companies are more prone to innovate in products
    - Micro firms and small companies are more prone to innovate in processes
    - Micro firms are more prone to innovate in both products and processes

- Corporate character
    - The propensity to innovate is larger for corporate companies
    - The highest novelty degrees are observed for corporate companies
    - Non-corporate companies are more prone to innovate in both products and processes

- National ownership
    - The propensity to innovate is larger for non-full national firms
    - The highest novelty degrees are observed for multinationals
    - Multinationals are more prone to innovate in products
    - Mixed ventures are more prone to innovate in processes
    - Multinationals are more prone to innovate in both products and processes

- Main sales market
    - The propensity to innovate is larger for firms that operate in both local and international markets
    - The highest novelty degrees are observed for full-exporters
    - Full-exporters are more prone to innovate in products

- Fully local-oriented firms are more prone to innovate in processes
- Full-exporters are more prone to innovate in both products and processes

- Economic sector
  - The propensity to innovate is larger for firms in Wood, Paper, Oil & derivatives and Chemical products industries
  - The highest novelty degrees are observed for firms in Food, Beverages & Tobacco, Metal products, Oil & derivatives and Chemical products industries
  - Firms in Metal products, Chemical products and Oil & derivatives are more prone to innovate in products
  - Firms that do not belong to Textiles nor to Chemical products and Oil & derivatives are more prone to innovate in processes
  - Firms that do not belong to Textiles nor to Food, Beverages & Tobacco are more prone to innovate in both products and processes

- The composition of innovation investment
  - The vast majority of firms invest in physical capital and ICT tools and to a lesser extent in training programmes
  - P&P innovators invest in R&D as frequently as in training programmes
  - A significantly lower share of P&P innovators invest in Engineering and industrial design, technology transfers and consultancy services
  - OP innovators rarely invest in R&D and DTC
  - More than 50% of OP innovators invest in a sole input
  - Around 30% of P&P innovators fully diversify their innovation expenditure
  - The categories within which the share of innovators that invest in R&D and that achieve the highest novelty degrees are coincidental: medium and large, exporting, non-full national and corporate companies

4.4.3. Innovation activities along the cycle

- Firms least prone to innovate at the bottom of the economic cycle (2003) are:
  - Non-micro firms
  - Small corporate companies
  - Small non-national companies
  - Large national firms
  - Fully local-oriented companies
  - Firms in Food, Beverages & Tobacco and in Textiles

- Novelty degrees decrease at the bottom of the cycle
- The share of innovators attaining new-to-the-world innovation decreases the most in 2003 for:
    - Small firms
    - Corporate companies
    - Mixed ventures
    - Firms oriented both to the local and international markets
    - Firms in Chemical products, Oil & derivatives industries
- Innovation in processes generally increases at the bottom of the cycle
- Innovation in products does not follow a homogeneous pattern along the cycle
- Innovation in products and processes does not follow a homogeneous pattern along the cycle
- Innovators in products that decreased the most in 2003 are:
    - Micro firms
    - Corporate companies
    - Mixed ventures
    - Firms oriented both to the local and international markets, as opposed to the increased shares observed among full-exporters
    - Firms in Food, Beverages & Tobacco and in Other manufacturing industries, as opposed to the increased shares found among those in Metal products, Chemical products and Oil & derivatives
- Innovators in process that increased the most in 2003 are:
    - Micro firms, as opposed to the decline observed among small units
    - Non-corporate companies
    - Mixed ventures
    - Firms in Textiles and in Metal products, as opposed to the decrease observed among those in Food, Beverages & Tobacco
- The share of innovators in both products and process that decreased the most in 2003:
    - Small-sized firms
    - Corporate, as opposed to the increase found for non-corporate companies
    - Mixed ventures
    - Firms oriented to both local and foreign markets, as opposed to the rise registered among full-exporters

  - Firms in Food, Beverages & Tobacco, as opposed to the significant increases found within those in Textiles and in Metal products

- The composition of innovation investment
  - A stable share of firms invest in KHS while an increasing proportion invest in DTC
  - The share of OP innovators that invest in TP increases in time as opposed to the declining trend observed for P&P
  - A stable share of P&P innovators invest in R&D while the proportion of OP innovators decreases in time
  - The degree of concentration of total innovation expenditure evolves procyclically and is high among OP innovators all along the period
  - The degree of diversification of total innovation expenditure among P&P innovators goes down substantially in 2003 and remained unchanged thereafter

Taken together the evidence suggests that exporters have evolved towards achieving high relevance innovations involving both products and processes with a larger emphasis on new products if fully focused on world markets. In contrast, subsets of local market-oriented firms have gradually switched from product to process-innovation thus explaining the lower novelty degrees generally attained in parallel to their improved yet scarce ability to generate new to the world innovations. Multinationals and large companies have a similar profile in 2006, generating substantially more international market-level innovations relative to other firms even though the share of new procedures is twice that of products. However, while this innovative behaviour is observed all along the period in the case of full-foreign companies, the temporal path followed by large firms resembles that described for locally-oriented units. As before, the corporate character of firms does not appear to be a relevant facet *per se* but when combined with size it does allow for a differentiated dynamic characterisation.

The increased relevance of innovations observed among firms in Textiles, Chemicals and Metal products at specific points in time are always coincidental with the share of new products exceeding that of novel procedures. This systematic link strongly signals at process-innovation posing challenges of most enhanced difficulty to Uruguayan firms that largely exceeds those encountered when innovating in products. As before, these behavioural features are matched to firms in these sectors being more intense innovators in both products and processes at these points in time.

5. Conclusions

The description of the IS data along 1998 to 2006 provides with a characterisation of the behavioural patterns that are shared by most manufacturing firms in Uruguay and it allows for capturing numerous regularities associated only to specific groupings. It also serves to identify the obstacles faced by innovators, the impacts that are driven by the activity and the roles played by information channels, funding sources and the National Innovation System. It further reveals that the technology of innovation activities and its temporal evolution are largely heterogeneous across innovators and therefore their joint analysis is likely to result in a misleading diagnosis. The biases introduced in the inference by the use of unweighted sample data are at times most significant and thus put into jeopardy the robustness of the results so obtained.

What story do the identified stylised facts tell about innovation activities in Uruguay? Is the resulting characterisation of the knowledge capital accumulated stock consistent with its performing as the foundation of future development?

The evidence points at the prevailing scenario being one in which the structure of local markets is the major deterrent for firms to engage in innovation and/or to devote efforts to attaining high relevance innovations. It therefore comes at no surprise that the most successful innovators are those characterised by a high technology level and a largely efficient organisational performance, particularly in terms of the qualification of their workforce, without financial restrictions, that have access to cooperation and operate in competitive and diversified markets.

The hindering role of local markets imperfections is further magnified by the ease of imitation that is not counter-balanced by a national system that effectively protects property-rights. Non-innovative firms as well as a subset of innovators that are focused on low-relevance innovations, especially involving only new procedures, and that are most generally oriented to the local market, are suggested to use sub-optimal innovation technologies that nonetheless enable them to attain the necessary benefits to survive. Unless this pattern is reversed, the prevailing profile of the bulk of innovators would not serve to boost development in the near future.

Under the hypothesised setting, policy action should be aimed at easing the access of firms to outside markets and to provide them with financial-aid for the acquisition of international patents. Equally crucial are the promotion of cooperation and the provision of instances that facilitate the establishment of systematic linkages between productive agents and institutions devoted to scientific and technological research as a means to improve their access to the necessary technical knowledge. The role played by the NIS on this arena is quite promising

although still below its potential. In particular, the evidence unravels that the NIS has yet been unable to transform public organisations in proactive actors facilitating and promoting high-relevance knowledge accumulation activities as a generalised practice among private agents.

Even though other hindrances are comparatively more important, the scarce availability of external funds from agents that are not directly related to the firm stands as a likely insurmountable obstacle for firms unable to self-finance their innovation activities. Thus, public support, both direct and aimed at promoting international cooperation, are two suggested tasks most necessary to address.

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