

DETERMINANTS OF ENVIRONMENTAL INNOVATION IN THE BRAZILIAN INDUSTRY¹

Determinantes de la innovación ambiental en la industria brasileña

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ABSTRACT

The aim of this paper is to understand the reasons for the adoption of environmental innovation and clean technologies within the Brazilian manufacturing sector. The study is divided in two parts. In the first one, there is a brief survey of the literature on the determinants of environmental innovation in the Brazilian industry. From the main results, a set of hypotheses is defined in order to establish research topics. In the second part, an empirical analysis is carried out using primary data from two independent surveys, the Survey on Innovation and Technology of the Brazilian Industry (PINTEC) and the Brazilian Annual Industrial Survey (PIA), both carried out by the Brazilian Institute of Geography and Statistics (IBGE). The results show that there is statistically significant correlation between the adoption of environmental innovation and certain characteristics of the firm, such as investment in research and development, average level of employees' education and the size of the firm.

KEYWORDS

Environmental innovation, industry, Brazil

RESUMEN

El objetivo de este trabajo es comprender las razones para adopción de innovaciones ambientales y tecnologías limpias en el sector manufacturero brasileño. El trabajo está dividido en dos partes. En la primera, hay una breve reseña de la literatura sobre los determinantes de la innovación ambiental en la industria brasileña. Un conjunto de hipótesis es derivado de los resultados de modo a establecer tópicos de investigación. En la segunda parte, un análisis empírico es conducido usando datos primarios de dos fuentes independientes, la Encuesta de Innovación y Tecnología de la Industria (PINTEC) y la Encuesta Industrial Anual (PIA), ambos bajo la responsabilidad del Instituto Brasileño de Geografía y Estadísticas (IBGE). Los resultados indican una correlación estadísticamente significativa entre la adopción de innovaciones ambientales e ciertas características de la firma, como inversión en investigación y desarrollo, promedio de educación de los empleados y el tamaño de la firma.

PALAVRAS CLAVE

Innovación ambiental, industria, Brasil

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INTRODUCTION

The industrial sector became an increasing target of regulations and restrictions, given the high degree of environmental impacts in the life cycle of its output. Because of the financial costs derived from legal standards (current and capital costs for “cleaning” the process, or levies and penalties, in the case of non-compliance), environmental concerns are seen by many businessmen, policy makers and academic economists as an additional cost for the industry, reducing its competitiveness.

However, it is important to examine the micro roots of this problem. The firms/industrial sectors are responsible for pollution or other externalities because of the adopted technology (not only the production technique but also the organisation of the productive process, the environmental performance of the final product and its disposal, etc.). Hence, the firm/sector capacity to generate and adopt *environmentally friendly technologies* is determinant for a better environmental performance.

The innovative capacity of the firm depends on internal and external factors. The internal factors include specific capacities to solve problems and absorb new elements, and the access to innovations developed by others - to become innovative, the firm may require changes in strategies, routines and expectations. The external factors include the regulatory framework, the existing technological paradigm, the National System of Innovation (NSI) and the macroeconomic context.

In the Brazilian case, there is a growing concern over the environment. The industry has suffered increasing pressure from regulatory agencies, NGOs and the society as a whole in order to improve its environmental performance. Many companies have already incorporated environmental aspects in their management strategies, particularly those who opted for voluntary certification (such as the ISO 14000). The firms with global interests, i.e. the ones which are owned at least in part by foreigners, are also subject of international pressures in terms of their environmental behaviour, some of them facing the threat of green barriers in the international trade.

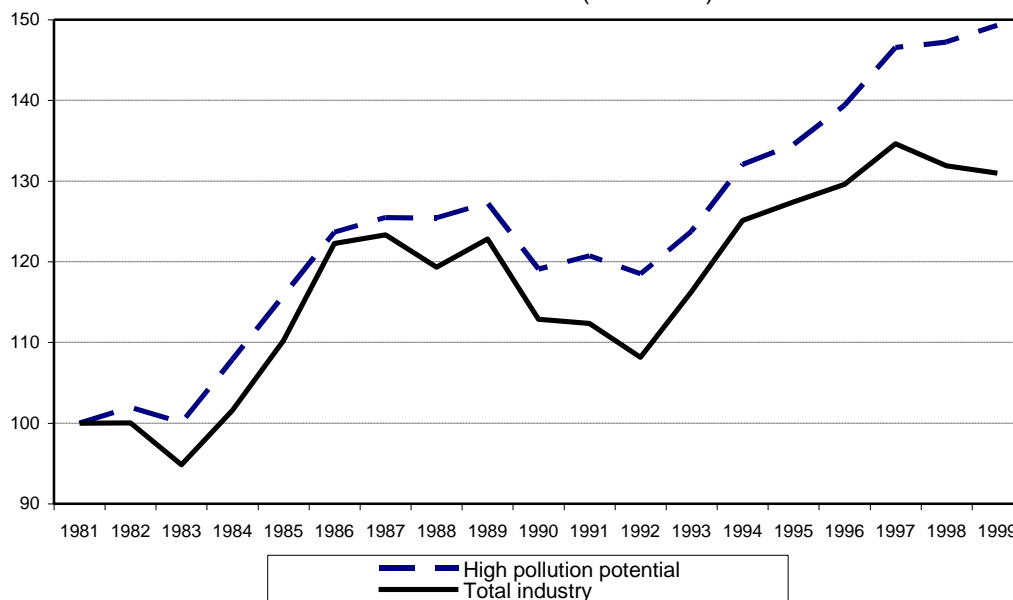
Nevertheless, there is a gap between the pressures and the way companies understand and act in answer to the environmental issues. In order to analyze the innovative behaviour of the Brazilian industrial firm, this paper examines empirical studies dealing with these questions, and presents new results from more recent surveys provided by Brazilian Institute of Geography and Statistics (IBGE). This paper briefly reviews the existing literature on the determinants of environmental innovation in the Brazilian industry. A set of hypotheses is defined in order to guide the empirical analysis of the Brazilian Annual Industrial Survey (PIA/IBGE) and the Survey on Innovation and Technology of the Brazilian Industry (PINTEC/IBGE). The results show that there are statistically significant correlations between the adoption of environmental innovation and certain characteristics of the firm, such as investment in research and development, average level of employees' education and the size of the firm, confirming many of the hypotheses suggested by the previous literature.

ENVIRONMENTAL PERFORMANCE OF THE BRAZILIAN INDUSTRY

Several studies were carried in the late 1990s and early 2000s analyzing the performance

of the Brazilian industry according to its pollution potential (Carvalho 2001; Young 1998; Young and Lustosa 2001). In the absence of actual data, statistics were produced combining industrial output, obtained from the IBGE surveys, and technical emission coefficients, extracted from the literature. Figure 1 shows that the industrial output of sectors classified as of “high pollution potential” grew consistently above the average of the Brazilian industry in the 1980s and 1990s (Carvalho 2001).

Figure 1: Industrial output with high pollution potential and total, 1981/99. Brazil (1981=100)



Source: Carvalho (2001)

One explanation for this trend is the relative specialization of the Brazilian industry as a world supplier of emission intensive goods. Young (1998) used an input-output model, based on constant coefficients for industrial emissions, in order to compare the pollution potential of the Brazilian industrial exports production chain against the domestic oriented production chain.

The main conclusion was that export oriented activities are more emission intensive than the production oriented towards domestic markets. Further empirical studies (Young 1998; Young and Lustosa 2001) confirmed the same result, even though different sets of emission coefficients were used. This result is, thus, compatible with the hypothesis that developing countries tend to concentrate “dirty” industries that become less competitive in developed countries because of tighter environmental controls.

This process was, nevertheless, counterbalanced by the emissions “savings” created by the fast expansion of imports in the 1990s. Because they are produced abroad, there was the avoidance of emissions associated with the expansion of import goods. Note, however, that this counterbalancing effect was much attenuated by the composition of the import goods basket, compared to the exports: the growth in industrial imports was concentrated

in relatively clean activities, particularly those with higher intensity in technology (electronics, for example), while the structure of industrial exports remained associated with more emission intensive sectors. Therefore, the overall reduction in the (potential) emission of pollutants in the Brazilian industry caused by imports growth was smaller than it could have been if these imports were concentrated in “dirtier” activities (intermediate goods, for example).

Another important result of the same set of studies was that the direct costs of introducing environmental control strategies are relatively low, considering the industry as a whole. Young (2004) showed that the estimated loss of exports induced by higher production costs caused by the control of water pollutants (BOD and heavy metals) would remain between 1% and 2% of the total value of Brazilian exports. In other words, the comparative advantage of being “dirty” are not as high as argued by those against more effective environmental controls. But the impacts of introducing pollution abatement measures may be very different in terms of sectors and destination markets. The sectors facing the highest risks of losing markets are footwear, non-ferrous metallurgic and other metallurgic goods. Another important factor is potential losses in specific markets where buyers become more environmentally conscious. In the analysis carried out, the exports destined to the NAFTA region are the ones that would require more expenditure in environmental control.

A different conclusion about the environmental consequences of international trade and globalization comes out when dynamic effects are considered. The static nature of the input-output exercises described above did not allow capturing the so-called technological effect, which is essentially dynamic and very difficult to measure and model. When the role of environmentally-induced innovation is added to the analysis, it becomes clear that companies with global insertion (either because of capital ownership or trade flows) have a different behavior when compared to nationally-owned, domestic oriented ones: export-oriented companies tend to adopt more intensively environmental innovations than the average of the Brazilian industry.

Another set of empirical studies were based on the São Paulo Survey on Economic Activities (PAEP), performed by the SEADE Foundation with technical support from IBGE. The PAEP survey was carried out in 1996 for the state of São Paulo, reaching a total number of 43,900 industrial companies, from all sectors. The answers were voluntary, explaining the difference in the number of answers in each table.

The relevance of the PAEP survey was that it included questions on economic performance (output, employment, exports, investment, etc.) and the determinants of innovation within the firm, including environmental issues. More specifically, the PAEP questionnaire if the firm was concerned with the following environmental issues:

- Business opportunities – if the answering company considered that the development of environmentally friendly products and processes is a source of increasing its business activity. Possible answers: yes/no;
- Environmental implications: market losses – if the answering company considered that its environment performance has resulted in the loss of markets, domestically or internationally. Possible answers: yes/no;
- Environmental implications: higher costs – if the answering company considered

that the activities associated with its environmental performance have resulted in higher costs (investment in control measures, fines and levies, etc.). Possible answers: yes/no.

- Factors motivating the company to innovate (from 1994 to 1996): environmental preservation –indicates the degree of importance given by the answering company to the strategy of environmental preservation as a motivation factor to innovate. Possible answers: indifferent, less important, important, very important, or crucial.
- Investment: changes in the production process for environmental reasons (from 1994 to 1996). Possible answers: yes/ no.

Using this information, Lustosa and Young (2001) and Lustosa (2002) tested empirically some of the hypothesis present in the theoretical debate, mainly the relation between a higher concern with environmental investment and (i) the company innovative behavior, (ii) importance of exports in relation to total sales, and (iii) capital ownership (if national or foreign).

The first hypothesis to be tested was that companies with global interests (at least part of its property is owned by foreigners) tend to adopt environmental innovations and to perceive the environment as business opportunities (thus with potential losses if inadequate environmental procedures are adopted) in a higher degree than the others.²

The analysis from crossing the variables above with the origin of capital ownership showed that, from the 843 companies with global interests (capital owned at least partially by foreigners), 52% believed that the development of products and processes less harmful to the environment may turn out to be a business opportunity. If the companies that were solely owned by foreigners are considered, the percentage of positive answers increases to 55%. Among the companies exclusively owned by nationals, the percentage drops to 29%. Therefore, this result confirms the hypothesis that firms with global interests are more inclined to foresee the environmental questions as business opportunities than the nationally owned ones.

A similar result was obtained when the question was about costs being increased by environmentally related activities: 41% of the companies with global interests answered positively, while this number was reduced to 15% for the nationally owned companies. The conclusion was that nationally owned companies do not perceive the environmental issues in the same way as the companies with global interests, confirming the hypothesis previously presented.

The relationship between the adoption of environmental innovations and the origin of capital presented a similar relationship. The vast majority (86%) of the firms with global interests consider the strategy of environmental preservation as important, very important or crucial as a motivation factor for the company to innovate. This percentage falls to 78% for domestically owned companies. This shows that most of the companies are more inclined to innovate because of environmental questions, and that this behavior is more evident in the companies with global interests.

² Companies with global interests were considered as the ones with capital ownership classified as foreign (100% of the capital is owned by foreigners) and national and foreign (at least one of the controllers is a foreigner).

A similar trend is also true for export-oriented companies, independently of their capital ownership. In other words, the pressure for better environmental performance is clearer perceived in the companies that are more exposed to the global economy. Companies that have declared the environment as a business opportunity (instead of a restriction) tend to present a higher level of exports. The contrast is more accentuated for domestic owned companies, but the higher perception of the potential for “green” business is found among the foreign owned.

Companies which declared that they had costs in activities related to the environment have a higher proportion of exports in their total sales. Considering only the domestic owned companies, the export average of those who answered positively (2.03%) is almost four times the exports average for those who declared not having this kind of expenditure (0.55%). This difference is also significant for foreign owned companies.

Answers were not homogeneous per sector, but in most sectors it was confirmed the referred relation between higher concern with the environment and more importance of exports in total sale. Some aspects that deserve attention: the questions where differences in the answer patterns refer to costs already incurred related to environmental matters in the sectors with higher export profile (footwear; motor vehicles; machinery and equipment, pulp and paper), the difference between the average export proportion among firms is considerable among firms declaring concern with environmental issues and the ones declaring the opposite - the most important exception to this pattern of answer refers to petroleum refineries and alcohol distilleries

An alternative question was made, in terms of the companies which did or did not invest in changes in the production process aiming at the reduction of environmental problems. Again, the companies with global interests showed a different behavior, with 41% answering positively, against only 18% of the domestically owned companies. The conclusion, again, followed the same pattern: companies with global interests tend to be more prone to adopt environmental innovations than the domestically owned ones, even though most of the latter also consider the environment as an inducing factor to innovation.

Another hypothesis that was tested was whether companies spending more resources in R&D are more inclined to adopt innovations, including the environmental ones, or not. The variable chosen to reflect R&D efforts was “Internal sources for innovation activities, 1994 to 1996 – R&D department”, indicating the degree of importance of the internal department of R&D as an induction source of innovation development inside the company. The possible answers were indifferent, less important, important, very important, or crucial.

The result was that the proportion of companies that invested in changes in the production process aiming at the reduction of environmental problems is related to the importance attributed to their internal R&D department for the innovative behavior of the company. Therefore, the higher the importance of the R&D department, the greater was the proportion of companies that invested in changes in the production process to solve environmental problems. Only 28% of the companies that declared indifference to internal R&D department invested in changes in the production process. This proportion rises to 49% for the companies that declared that their own R&D departments were crucial for the innovation process inside the firm. It was also found a relationship between the degree of

relevance attributed to preservation as a motivation factor for innovation, and the degree of importance of the internal R&D department. The results point out that there is an increase in the proportion of companies that consider relevant to invest in internal R&D activities according to the importance attributed to the environment as a motivation factor for innovations.

The conclusion was that companies investing internally in R&D are more able to generate or adopt innovations, including the ones destined to environmental issues. Companies attributing a higher degree of importance to their R&D departments are the ones with higher positive answers in terms of innovation in processes (carried out to reduce environmental damage), and perception of environmental restrictions as a motivation factor in the innovation process.

This is related to the role of innovations, which systematically changes the effective relationship between production and environmental control costs. The static nature of input-output exercises does not allow capturing the so-called technological effect, which is essentially dynamic and very difficult to measure and model. The analysis of the PAEP survey showed that firms with international insertion tend to be more concerned with environmental issues and to invest the most in “cleaning” their production processes. Export-oriented and/or foreign capital companies tend to consider the competitive advantages of environmental innovations more seriously than inwards-oriented and/or domestic capital firms do. This is associated with higher environmental standards and pressures in international markets, thus being compatible with the hypothesis that the trade and capital openness process tend to encourage the adoption of environmentally sound practices and products.

Seroa da Motta (2006) also used the PAEP results in an econometric analysis of the determinants of environmental investment. He found similar results, but with a main difference: if the effect of the size of company is statistically controlled, there would be no evidence that export-oriented companies present a different pattern of environmental concern. The reason presented for this is that large companies are easier to control, and the environmental protection agencies (and also environmental groups and NGOs) tend to focus their attention on them. Therefore, the issue of the size of the firm should be considered in the analysis of the diffusion of environmental innovation. Finally, it is important to consider that the PAEP study was restricted to the State of São Paulo. However, regional differences are very important and how they affect the diffusion of environmentally motivated innovations throughout the productive sector was an issue not examined by this literature.

Altogether, the empirical studies referred to as above suggest the following trends for the adoption of environmental innovation by Brazilian industrial firms and respective research agenda:

- I. There is a connection between the level of investment in environmental protection and the innovation behaviour in Brazilian industrial firms. Hypothesis to be tested: innovative firms tend to invest relatively more in environmental protection.
- II. There is a connection between environmental investment and export-oriented behaviour in Brazilian industrial firms. Hypothesis to be tested: export-oriented firms tend to invest relatively more in environmental protection.

- III. There is a connection between the origin of the capital of the firm and the trend to invest in environmental issues. Hypothesis to be tested: foreign firms have different innovative behaviour than national firms.
- IV. There is a connection between the degree of potential pollutants emission in one sector and the level of environmental protection investment in Brazilian industrial firms. Hypothesis to be tested: firms in sectors that have more pollution potential tend to invest more in environmental protection.
- V. There is a connection between employment and the environmental innovation behaviour in Brazilian industrial firms. Hypothesis to be tested: "clean innovative" firms tend to employ more/less than the rest of the industry.
- VI. There is a connection between the size of the firm and the innovation behaviour in Brazilian industrial firms. Hypothesis to be tested: larger firms react differently to environmental issues when compared to smaller firms.
- VII. The results above are differentiated according to the regional distribution of the firms. Hypothesis to be tested: firms in states/regions with tighter environmental control are more likely to adopt environmental innovation/ invest more in environmental protection.

The next sections present results from very recent studies that were carried out using data from industrial surveys carried out by IBGE. Even though they do not cover all the extensive list of questions presented above, they deepen the knowledge about the environmental behavior of the Brazilian industrial firms.

RESULTS FROM THE PIA SURVEY

The Annual Industrial Survey (PIA) aims at the identification the basic structural characteristics of the Brazilian Industry. Activities are also classified according to the National Classification of Economic Activities (CNAE). Information is gathered about occupied personnel, wages, sales revenues, costs, acquisitions, investment, industrial output and input consumption. It is carried out every year, being the most important tool of empirical analysis of the Brazilian industry.

Often, additional questionnaires are introduced referring to specific topics. In 1997 and 2002, the special questionnaires referred to environmental investment. They included a question on the investment realized by any of the production units in the company aiming at the control of pollutant emissions or to follow environmental standards. Instead of a monetary value, the answer was provided as a percentage of the environmental investment in relation to the total investment performed by the company. According to the questionnaire instructions, environmental investment should include the acquisition of machines incorporating the concept of clean technologies and investment in sewage and residuals treatment.

One important methodological feature is that the sector classification is related to the main production activity of the company. Therefore, in cases where the company operates in more than one CNAE division, the investment was classified according to its most important operation, and it is not possible to identify exactly in which activity the investment has been properly done.

A similar problem occurs in the territorial location of the investment. If the company has more than one operational unit, in territorial terms, the investment was classified in the company headquarters.

The sample used is the largest in any survey of this kind in Brazil: the 1997 survey comprised 107,764 companies; in 2002 they were 135,003. This means that the survey comprises of companies responsible for more than 95% of the industrial output.

Barcellos *et ai.* (2006) analyzed the special environmental surveys of the 1997 and 2002 PIAs. Among their findings, the most important were the following:

- Even though the volume of environmental investment remains in absolute terms, there is a significant increase in both the level of the environmental investment and in the number of companies that had invested because of environmental reasons. In the 1997-2002 period, this growth was of 98% of the value of the environmental investment and 71% of the companies involved with them.
- In both years, there is a high concentration of environmental investment in specific sectors that are potentially more pollutant, in particular the intermediate goods sector. In 2002, the intermediate goods sector was responsible for almost 77% of the environmental investment.
- Investment in environmental control is hugely concentrated in intermediate goods sectors. Considering that these are the sectors with the highest emission potential, their conclusion is that they are probably the most controlled by the environmental protection agencies.

Therefore, the PIA surveys of 1997 and 2002 confirm hypothesis IV that there is a connection between the degree of potential pollutants emission in one sector and the level of environmental protection investment in Brazilian industrial firms.

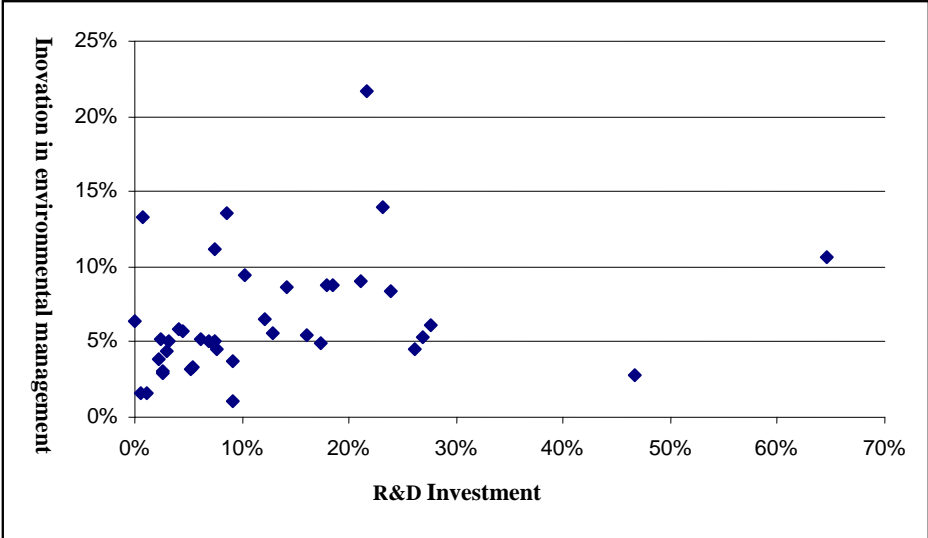
RESULTS FROM THE PINTEC SURVEY

The Industrial Survey on Technological Innovation 2003 (PINTEC - 2003) was carried out by IBGE with the objective of providing primary information on the innovative behavior of Brazilian industrial firms. The National Classification of Economic Activities (CNAE) was adopted. According to the recommendations of the Oslo Handbook, technological innovation is defined by the implementation of products (goods or services) or processes that are technologically new or substantially improved. The implementation of the innovation happens when the product is introduced in the market or when the process becomes to be used by the company.

The literature review suggests that companies that are more prone to adopt innovations are also more likely to present a pro-environment profile. This hypothesis was tested for the most recent data, available from the PINTEC, to check whether this conclusion remains valid for more recent years.

Figure 2 presents the relationship between the level of investment in R&D and the innovative behavior of the company in environmental issues. The correlation coefficient among these two variables was estimated as 0.2782.³

Figure 2. Innovation in environmental management and R&D investment, 2003



Source: own elaboration, using PINTEC 2003

Table 1 confirms this trend, showing that firms which perform R&D continuously tend to adopt more environment innovations than firms which invest occasionally in R&D. According to the PINTEC 2003, 26% of the firms which invest continuously in R&D adopted innovations aiming the reduction of the use of nature resource (water, energy and raw material). This percentage falls to only 17% if consider only the group that invest occasionally in R&D. The percentage of firms that adopted innovations aiming the reduction of Health, Safety and Environmental (HSE) impacts also differ in terms of R&D investment. As the table below shows, 43% of the firms that invests continuously in R&D also adopted innovation aiming the reductions of Health Security and environment impacts. This number falls to 37% when we consider only the firms that invest occasionally in R&D.

³ In order to test the statistical significance of this value, the Pearson test was adopted. The t-statistic associated with the correlation coefficient was 1.786. For a 90% confidence interval, the minimum value for the t statistic is $t_{40;0,10} = 1.684$. Therefore, the null hypothesis can be rejected.

Table 1. – Environmental innovations and R&D activities

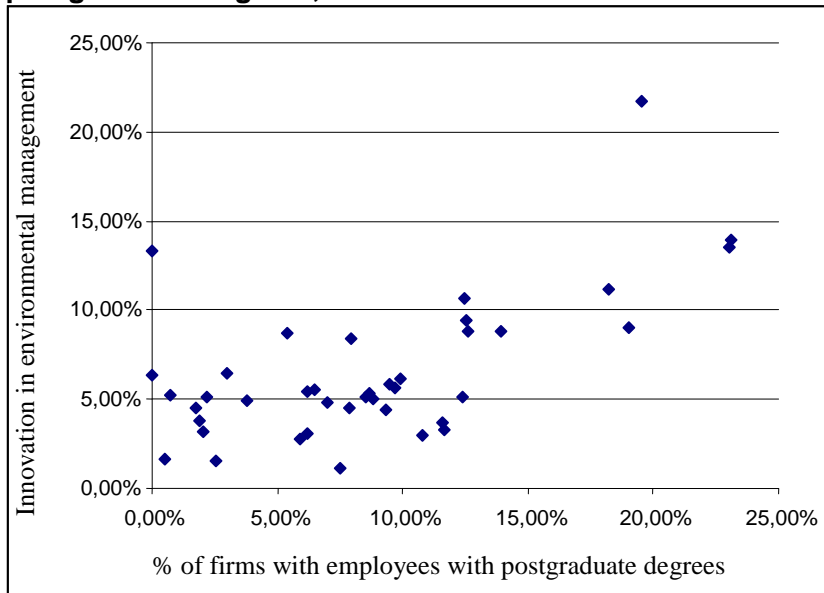
Frequency of R&D activities	Number of firms that innovated	Number of firms that innovated aiming reductions of Natural Resource use (NR)		Innovations aiming reductions of Health Security and environment impacts (HSE)	
		Number of firms	% of firms	Number of firms	% of firms
Occasional	1092	186	17,03 %	412	37,73%
Continuously	726	190	26,17 %	314	43,25%
Total	1818	376	20,68 %	726	39,93%

Source: Podcameni (2007)

Considering that the adoption of environmental innovations require the acquisition of machinery and other forms of investment, this result confirms hypothesis (I) that innovative firms tend to invest relatively more in environmental protection. This result coincides with previous studies, based on the PAEP survey, stating that there is a positive connection between the level of investment in environmental protection and the innovation behaviour in Brazilian industrial firms.

Hypothesis V states that there is a connection between employment and the environmental innovation behaviour in Brazilian industrial firms. At the present level of the research, it was not possible to test whether “clean innovative” firms tend to employ more or less than the rest of the industry in general terms. However, it was possible to establish a correlation between innovation in environmental management and the qualification of employees. Figure 3 shows that there is a positive relationship between the adoption of environmental innovation and the percentage of firms with workers with postgraduate degrees.

Figure 3. Innovation in environmental management and % of firms with workers with postgraduate degrees, 2003



Source: own elaboration, using PINTEC 2003

A similar statistical analysis was carried out to test the statistical significance of this result. The Pearson correlation coefficient (r) was estimated as 0.6017, and the respective t -statistic is 4.6439. This means that the correlation is significant at a 99.9% degree of confidence.

Hypothesis VI refers to the issue of the size of the company. The result shows that larger companies tend to present higher degree of environmentally related innovative behaviour than small companies. It was found that the higher is the number of employees, the higher is the proportion of firm's adoption environmentally-related innovations. So, the hypothesis that there is a connection between the size of the firm and the innovation behaviour in Brazilian industrial firms is confirmed by the 2003 PINTEC data.

Hypothesis III affirms that the origin of the capital of the firms affects the environmental policy of the firm and the decision to invest in environmental innovation. The next two tables will analyze this issue.

Considering only the group of foreign capital firms, 31% of the innovation had a significant impact on the reduction of natural resource use (water, energy and raw material) and almost half of the innovations were characterized by reduction of Health, Security and Environmental impacts. If consider the national firms only, this percentage falls to 20% and 36%, respectively. Only 6,26% of national firms adopted environmental management advanced techniques while this number rises to almost 30% when only foreign firms are analyzed. The results pointed out that foreign firms tend to invest more in environmental innovations and tend to adopt more environmental management advanced techniques than national firms.

A possible hypothesis is that foreign firms import its environment policy from its

headquarter. So, in this case, the decision to invest in environmental issues is correlated to the environmental law of the there original country. Other possible hypothesis would be related to the bigger tendency of foreign companies to export. So, in order to participate of the international market, the firm is required to invest in environmental issues demanded by the policy of the country which is importing its product.

Brazil, as the other BRICS, is characterized by strong regional differences. State governments are responsible for enforcing environmental policies that are also decided in local terms. Therefore, it is important whether these differences affect the firm behaviour. Hypothesis VII states that the environmental innovations are differentiated according to the regional distribution of the firms.

Table 2 presents the results at state level. They show important regional differences, and most of the innovative firms are in the richest states of the country. But in relative terms, “late comers” in the Brazilian industrialization, such as Amazonas, Pernambuco, Bahia and Espírito Santo, present higher degree of environmental innovative behavior according to different parameters.

Table 2 - Diffusion of environmental innovations by state, 2003

	Implementation of Environmental Management Techniques	Reduction of HSE (Health, Safety and Environmental) impacts		
		Advanced	High	Mean
	(Yes)			
Brazil	1,96%	8%	4,63%	21,08%
Amazonas	0,18%	11%	7,55%	19,39%
Pará	1,43%	8%	1,79%	24,42%
Ceará	0,30%	4%	6,24%	23,06%
Pernambuco	3,51%	7%	3,59%	17,92%
Bahia	1,44%	8%	6,46%	18,39%
Minas Gerais	3,25%	9%	4,28%	21,99%
Espírito Santo	2,76%	6%	5,12%	25,35%
Rio de Janeiro	2,58%	4%	4,25%	16,45%
São Paulo	1,46%	7%	3,71%	20,68%
Paraná	2,87%	11%	5,68%	20,02%
Santa Catarina	1,57%	6%	6,00%	24,05%
Rio Grande do Sul	2,05%	11%	5,08%	23,79%
Goiás	2,08%	5%	4,83%	23,62%

Source: own elaboration, using PINTEC 2003

One possible interpretation of these results is that they reflect the fact that the new industries that are being established outside the more traditional present a more pro-environment behavior. If true, this hypothesis would mean that the ongoing industrial decentralization process is creating the basis of “clean” local productive arrangements or even local “green” innovation systems. On the other hand, environmental agencies certainly affect the firms’ decisions, but it is not clear whether this is a question of differences in terms of policy design or its enforcement. Further research is necessary in order to understand the importance of regional factors in the diffusion of clean technologies.

CONCLUSION

The analysis carried out in this paper has identified some of the reasons related to the diffusion of environmental innovation among Brazilian industrial firms. It was shown that environmental innovation is positively related to the general innovative character of the firm, size, sector, origin of the capital and state location. Results from previous studies were confirmed and new insights, such as the relevance of regional factors, suggest that studies must be carried out to deepen the analysis.

The hypotheses there were identified for the Brazilian case may also constitute the basis for similar studies in the BRICS context. Many of the problems and characteristics of the Brazilian industry are shared with these countries, but there are also very important differences. Therefore, comparative studies can be very helpful in the design of policies aiming at the higher diffusion of clean technologies.

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