TESTING THE SCHUMPETERIAN HYPOTHESES FOR THE BRAZILIAN MANUFACTURING INDUSTRY[1]

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Abstract

The aim of this paper is to provide a test of the two Schumpeterian hypotheses for the Brazilian industry. More specifically, this paper tests whether firm size and market concentration have a positive contribution to the probability to carry out R&D efforts and to R&D intensity. The paper uses micro level data from the Brazilian Innovation Survey to test the Schumpeterian hypotheses. Two different sets models are tested. In the first set, we test through a probit model the probability of a company to execute R&D, that is, to have R&D expenditures different from zero. In the second set of models, we test the role played by size and concentration on R&D intensity, measured by the ratio of R&D to sales. The paper concludes for the confirmation of the Schumpeterian hypotheses for the Brazilian manufacturing industry. The results may shed some light on policy issues. The paper argues that tax incentives and governmental financing agencies focus their policies on large companies and contribute for this result.

Keywords: Schumpeterian hypotheses, R&D efforts, Brazil, firm size, market structure

Resumo

O objetivo deste artigo é realizar um teste para a indústria de transformação brasileira das duas hipóteses schumpeterianas. Mais especificamente, o artigo testa se tamanho da firma e concentração de mercado têm uma contribuição positiva para a probabilidade de realizar esforços de P&D e para a intensidade de P&D. O artigo usa micro dados obtidos da Pesquisa de Inovação Tecnológica do IBGE para 2005. Dois conjuntos de modelos são testados. O primeiro é um modelo probit que mede a influência do tamanho e da concentração sobre a probabilidade a inovar. O segundo consiste em modelos tobit que medem o efeito dessas variáveis estruturais sobre a intensidade de P&D. O trabalho conclui pela confirmação das hipóteses schumpeterianas. Ele também busca conclusões sobre política. Principalmente, ele enfatiza o papel das políticas governamentais na alimentação desse resultado, mediante distorções nos incentivos fiscais e nas formas de financiamento público à inovação.

Palavras-chave: inovação – estrutura de mercado – tamanho da firma – hipótese schumpeteriana
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1 INTRODUCTION

The aim of this paper is to provide a test of the two Schumpeterian hypotheses for the Brazilian industry. More specifically, this paper tests whether firm size and market concentration have a positive contribution to the probability to carry out R&D efforts and to R&D intensity.

Excessive concentration and abuse of market power through unfair competition and monopolistic practices are seen as problematical issues to be faced by competent authorities in many countries. An expressive attention is also given to the discussion concerning small *vis-à-vis* large companies and their role to economic development. Therefore, the relations between market concentration, firm size, and innovation processes are relevant to debates around economic or industrial policies, due to the importance of the role of technical progress in economic development.

The contributions of the Schumpeterian tradition value as plausible arguments that indicate the existence of a positive relationship between innovative activity and concentration and between innovative activity and firm size. On the one hand, bigger firms are more likely to display innovative activity and, on the other hand, more concentrated market structures may provide an adequate environment for the undertaking of innovative activities. These propositions are frequently called Schumpeterian hypotheses. The evolution of the debate has brought about two issues: on the one hand, a double causality between technological activity and structural variables and, on the other hand, the importance of other sectoral characteristics in the determinants of the role of innovation. Therefore, sectoral opportunity, appropriability and demand characteristics have shown to play an important role in the sign of these relationships.

This paper tests the Schumpeterian hypotheses for the Brazilian economy using micro-level data from the Brazilian Innovation Survey, undertaken by IBGE (PINTEC). The survey is based on the Oslo Manual and covers a sample of 12,000 Brazilian companies with 10 or more employees (the sample is expandable to the whole Brazilian industry for companies with 10 or more employees). The paper tests the two hypotheses controlling for differences in the sectoral patterns of innovation. Two different sets models are tested. In the first set, we test through a probit model the probability of a company to execute R&D, that is, to have R&D expenditures different from zero. In the second set of models, we test the role played by size and concentration on R&D intensity, measured by the ratio of R&D to sales. The remaining of the paper is organized in four sections. In section 2, we survey international and Brazilian literature on the Schumpeterian hypothesis. Section 2 also highlights the main characteristics of the Brazilian industrial structure. In section 3, we present the database and expose the main results obtained and section 5 presents the main conclusions of the paper.

2 THEORETICAL PREDICTIONS ON THE RELATIONSHIP BETWEEN FIRM SIZE AND CONCENTRATION AND R&D

Schumpeter (1942) emphasized the idea that atomistic markets could satisfy a static and allocative efficiency, yet they would not guarantee efficient allocation dynamically (Kamien & Schwartz, 1982, p. 9). Large enterprises or concentrated markets could be able to engender technical change and promote an expansion of aggregate output. This perception about the existence of a positive relationship between firm size and market concentration, on one side, and innovation, on the other, is frequently denominated by “Schumpeterian hypotheses” (Cohen & Levin, 1989, p. 1060).

The concept of perfect competition, on the other hand, was refuted by Schumpeter due to its excessive emphasis on price competition. For Schumpeter, price competition should be replaced by creative destruction and innovation competition, which would justify the adoption of a monopolistic behavior. In this case, market structure or firm sizes that displayed better innovative behavior could be preferable to more atomistic structures. Therefore, firms’ attempts to exercise their monopoly power and obtain extraordinary profits by retarding their rival’s imitation could be desirable as long as it provided better innovative performance. Furthermore, this power, according to Schumpeter’s view, would be transitory and vulnerable to innovation competition, in other words, resisted until a new creation (innovation) destroyed it (Kamien & Schwartz, 1982, p. 9-11).

Following these ideas, several studies were developed in order to answer two main questions: (i) if innovation increases more than proportionately with firm size and (ii) if innovation increases with market concentration or monopoly power (Cohen & Levin, 1989, p. 1060)[2].

Scholars have elaborated arguments stating that the relation between innovation and market structure can go either ways. On the one hand, a positive link between firm size and innovative intensity would be reasonable because large firms are more likely to support high expenses necessary to innovation with external or internal financial sources. It is also expected that innovation activities involve large fixed costs, which require sufficiently large sales to be covered. If the firm is large and diversified, it will be more able to exploit not anticipated innovation goals (considering the current technological pattern). It can be also noted that bigger firms have a better capacity of sharing their risks among several innovation projects simultaneously developed and that they would have better financial support (Kamien & Schwartz, 1982, p. 47; Symeonidis, 1996, p. 3; Urraca, 1997, p. 16).

On the other hand, arguments in favor of flexibility and inventiveness of small firms vis-à-vis rigidity and bureaucracy inherent in big companies’ organization can sustain the contrary, i.e. a negative relationship between firm size and innovation efforts. Small firms have a greater marginal incentive to innovate once they can interfere in the market structure in their favor, through creative destruction. The larger firms, in turn, do not have such effect since they already enjoy a monopolistic position and an innovation activity could threat or destabilize their positions. Moreover, smaller firms tend to have tight associations with their consumers, making them more flexible to demand-side requirements. Finally, it is possible to argue that larger corporations are more conservative and the incentives of scientists and executives could be very distinct, causing discordance about innovation benefits (Raider, 1998, p. 3; Urraca, 1997, p. 17).

Taking into consideration the linkages between market concentration or market power[3] and innovation intensity, the literature lists some reasons for believing it as being positive. A first argument is associated to an understanding that oligopolies have less uncertainty about the maintenance and appropriability of a post-innovation market power

[2] The literature usually credits the assumption of positive effects derived from both relationships to Schumpeter, even though the first one is attributed to Galbraith as well (Kamien & Schwartz, 1982, p. 22).
[3] Although it is not totally correct, we are going to treat market power and concentration degrees as equivalent concepts.

degree due to a less rivalry present in these market structures. Besides, a firm that already has some extent of market power will easily extend it to a new product, through built advantages as previous distribution channels or marketing expenses in branding. Another point is that firms with market power are better able to finance innovation costs because of the monopoly profits earned previously and the greater capacity of capturing financial support. Finally, firms that detain market power have a greater accessibility of qualified workers and capacity of keep industrial secrets (Cohen & Levin, 1989, p. 1074-75; Kamien & Schwartz, 1982, p. 28; Urraca, 1997, p. 24).

Once again, a negative relationship can be supported. The preexistent monopoly power can be free from competitive pressure necessary for the undertaking of a commitment by the firm towards an innovative behavior. It is also noted that a firm that already detains market power can have less incentives to innovate since its previous profits are sufficiently high to discourage too costly and uncertain innovation investments (Urraca, 1997, p. 24).

Empirical findings were inconclusive about the relationship between firm size/market concentration and innovation intensity. Many authors disagreed about the significance of these relationships. There was also no consensus if such relationships are linear, exponential, more or less proportionally or quadratic ("inverted U" shaped). This inconclusiveness may be a result of some empirical problems, including sample selection biases, omission of relevant variables, collinearity between firm size or market structure and other firm and market characteristics, and the effect of innovation on firm size or concentration degree (mutual causality direction)[4] (Cohen & Levin, 1989; Urraca, 1997, Kamien & Schwartz, 1982).

Other relevant perspective is derived by the fact that the results vary significantly across industries. It implies the importance of taking into account the firm and sector-specific technological determinants of innovation, which might turn the Schumpeterian hypothesis less valuable. Therefore, many studies approached the subject under a sectoral viewpoint or, in other words, adding technological factors that could explain the sectoral patterns of innovation. The inclusion of technological variables, such as proxies of appropriability and opportunity conditions, tended to improve the results and to diminish the explanatory power of firm size and concentration on innovation activities (Cohen & Levin, 1989).

There are three most important variables that might determine the difference of innovation degree across sectors, according to Cohen & Levin (1989) review, which are related to: (i) demand conditions, which express demand-side pressures; (ii) technological opportunities, reflecting the likelihood of innovating for a given investment amount; and (iii) appropriability conditions of innovation's benefits and profits. Additionally, studies incorporated factors related to cumulativeness of technical advances, which besides appropriability and opportunity features, determine a technological regime of a industry, under the neo-Schumpeterian conception of Nelson & Winter (1977, 1982) in special. These characteristics and other particular to each industry, knowledge base, and market structure are essential to define innovation's rhythm and direction.

Following this perspective, it is important to mention the tendency of inclusion of sectoral variables in the studies. The most important contribution is the Pavitt typology (Pavitt, 1984), under the sectoral pattern of innovation. Pavitt's (1984, p. 343) purpose was to "describe and try to explain similarities and differences amongst sectors in the sources, nature

[4] Following the neo-Schumpeterian conception that these variables are endogenous, as in Nelson & Winter (1982).

and impact of innovations, by the size and principal lines of activity of innovating firms, and by the sectors of innovations' production and main use". To fulfill his objective, Pavitt created a classificatory firm division, under an innovation pattern and according to the firm's technological trajectory. The Pavitt's typology attempts to deal with the sectoral elements related to technological regimes and trajectories, making thus possible to analyze the linkage between structure variables and innovation through a much broader framework. This framework in turns is more suitable to an industrial organization approach of innovation, permitting to understand it as a production process and to observe other relevant faces of innovation rather than R&D intensity. This classification generated the following sectoral typification: supply dominated sectors (traditional basically), production intensive (scale intensive and specialized suppliers) and science-based sectors (chemical, electrical, and electronic).

2.1 SCHUMPETERIAN HYPOTHESES AND THE BRAZILIAN MANUFACTURING INDUSTRY

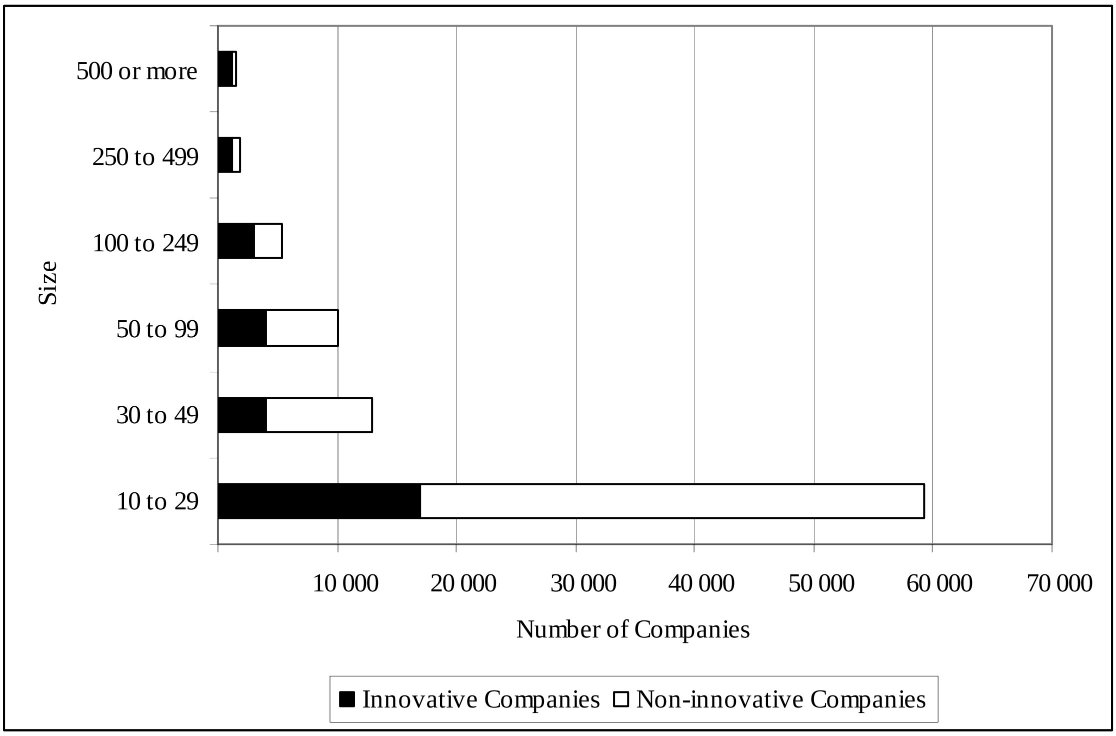
This section attempts to cover two purposes. It will show the main structural characteristics of the Brazilian manufacturing and mining industry and it will survey the literature that has associated structural variables with innovative activity or market performance.

One of the most important characteristics of the Brazilian manufacturing industry is the widespread presence of small and medium enterprises. According to the PINTEC 2005[5], companies with 10 to 49 employees represent 79.4% of the 91,055 manufacturing and mining companies captured by the survey; and only 3.7% are firms with 250 or more employees (see figure 1). These figures are similar to those presented by the European Union. According to Eurostat (2007), taking companies with over than 10 employees, 76% have a size between 10 and 49 employees (small companies) and 4.4% are greater than 250 employees (large companies). This structure of the Brazilian manufacturing and mining industry is accompanied by a low propensity to innovate of the small companies. Only 29% of the small companies in the Brazilian productive structure introduced at least one innovation from 2003 to 2005, while over 70% of the large companies have introduced innovations in the period. These numbers contrasts with those presented by the major European Union, where over 40% of the small companies are innovative.

Figure 2 shows the percentage of firms that undertake R&D activities in the Brazilian industry by size group. It shows a more radical picture of the lack of technological activity in the Brazilian industry. Only 6.5% of the firms undertake R&D efforts. In small companies, these figures are reduced to 5%, stressing also an important phenomenon associated with the Brazilian industry: its high level of heterogeneity. In this case, the heterogeneity is related to firm size. Small companies are less likely to undertake R&D activities. Furthermore, medium sized companies also are not likely to carry out R&D efforts. Figure 2 shows that in size cohorts between 50 and 249 employees less than 20% of companies undertake R&D expenditures. Moreover, changes when firms achieve 500 employees are quite radical, that is, the curve on the relation of R&D to number of employees is quite steep. However, as stressed by the literature on Schumpeterian hypotheses, this could be associated with technological imperatives due to sectoral characteristics of the innovative process. This feature illuminates the rest of the paper.

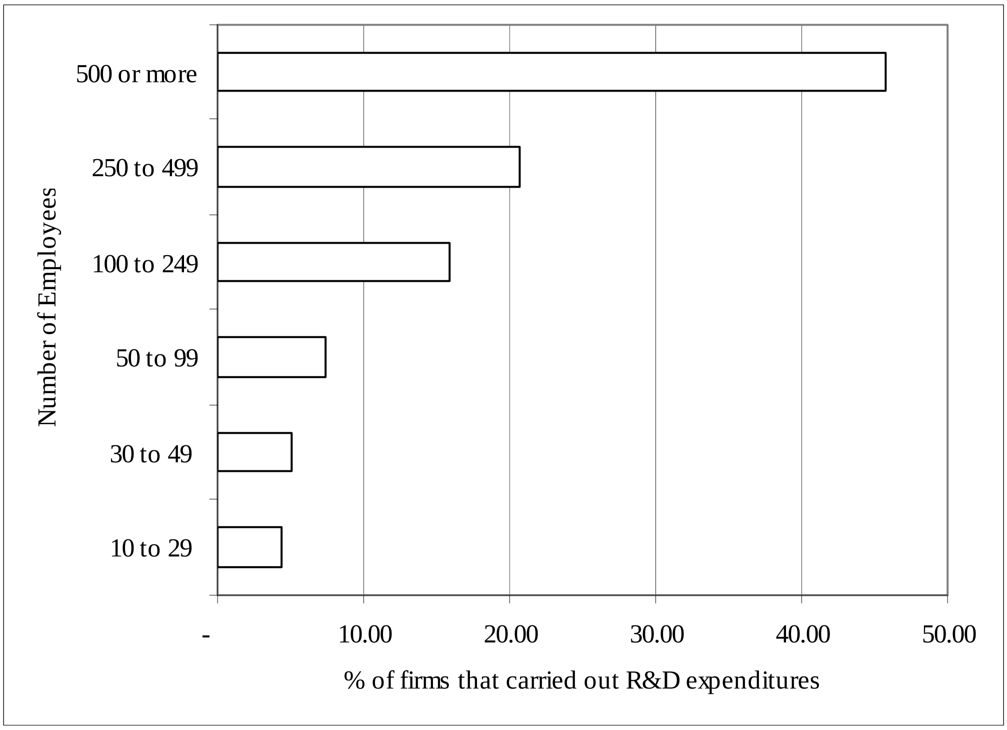
[5] IBGE, Pesquisa de Inovação Tecnológica, 2005, http://www.ibge.gov.br.

Figure 1 Number of Companies by Size Cohort and by Innovative Performance, 2005*



Source: IBGE, Pesquisa Industrial de Inovação Tecnológica, 2005.
* Innovative companies are defined as those companies that have introduced a product or process innovation that represented novelty to themselves, between 2003 and 2005.

Figure 2 Percentage of Firms that Undertake R&D Activities by Size Cohort*, 2005



Source: IBGE, Pesquisa Industrial de Inovação Tecnológica, 2005.
* Firms that undertake R&D expenditures are defined by firms that have positive R&D expenditures.

Due to the importance of small enterprises in the Brazilian economy, the relation between size and performance variables has been widely studied, concluding for very low performance level of small size companies. Using data collected from income tax statistics, Pinheiro and Moreira (2000) find size, measured by a revenue variable, the most important variable to explain exporting performance of Brazilian companies. Kupfer and Rocha (2005) also confirm this hypothesis. They use data from the Brazilian Innovation Survey (PINTEC) for 2000 and show that size, measured by number of employees, is the most important variable to explain the probability to export and the exporting revenue to total revenue ratio. The quadratic variable for size is negative in both equations, showing concavity of the tested functions. Another result found by authors is that the largest probability to innovate is obtained when companies are around 25,000 employees while the largest exporting ratio is obtained when companies' size reaches 20,000 employees. Coutinho et al. (2002) undertake case studies in twenty manufacturing industry sectors and show similar perception about the effect of size on performance. They add that the greater the product homogeneity, the greater the importance of size in determining market performance.

However, the results on innovative performance and innovative effort have not been so straightforward. On the contrary, they are mixed, depending mostly on sectoral characteristics and the origin and size of the sample. Using a sample of 167 firms belonging to 32 different sectors of the Brazilian manufacturing industry, Macedo and Albuquerque (1999) calculate the elasticity of R&D expenditures to sales. These firms were selected from a larger sample containing only companies that had registered R&D values different from zero. They find mixed results. Whenever the elasticity is calculated without a control of a quadratic variable, elasticity is valued under one, whenever, the square variable is included, it presents the quadratic form has a negative and significant value and the size variable is valued near 2, showing that the relation of size to R&D expenditure seems to have an inversed-U shape. Gonçalves (2001) performed the elasticity test for a sample of 68 high technology Brazilian firms. He rejects the Schumpeterian hypothesis that R&D expenditure increases with size for high tech sectors. He finds an elasticity of revenue to R&D expenditure of less than one. These two studies had the shortcoming of the sampling procedures. The sample was not representative taking the size distribution of the Brazilian economies in consideration. Resende (2007) uses a better sample, taken from the State of São Paulo's Innovation Survey (PAEP/SEADE). Though it has a clear regional limitation, it covers more than 7,000 companies. Resende (2007) runs a four simultaneous equations system in which one of them has R&D to sales ratio as dependent variable. He finds size as the most important variable to explain R&D intensity.

Kannebly (2004) uses also the PAEP/SEADE database to find out the main characteristics of the innovative firm. The paper uses a non-parametric methodology based in a tree classification to show the capacity of different independent variables to explain the variance of a binary dependent variable, which was valued one, whenever firms were taken to be innovative and zero, otherwise. The paper finds that the exporting performance of firms is the most important explanatory variable for innovation, followed by size. Kannebly, Porto and Pazello (2005) follows the same methodology, but uses PINTEC 2000 - a national coverage database with a sampling of 10,000 firms expandable to 72,000. They test innovation in two different levels, according to the degree of novelty of the innovation(s) introduced by companies. First, they use a dependent variable that requires innovation as a novelty to the firm, instead of to the Brazilian market, which represents a wider definition of innovation. Then they use a dependent variable that requires the firm to innovate at the market level. Their results are mixed. When a wider definition of innovation is used, firm size is the second most important variable to explain innovation (exporting behavior is the most important variable). However, when a more restrict version of innovation is tested, results show that size does not explain innovative performance.

The evidence concerning the effects of market concentration on innovation in the Brazilian economy have not gone through a comprehensive investigation as size has been. Kannebly (2004) does not find the four-firm concentration index an important variable for the explanation of innovative performance. The paper uses controls for technological characteristics in order to test the Schumpeterian hypotheses. Resende (2007) also does not find support for the Schumpeterian hypothesis on the effects of concentration over R&D intensity.

3 EMPIRICAL TESTS AND RESULTS

3.1 DATA AND METHODS

The paper uses data from the Brazilian Technological Innovative Industrial Survey (PINTEC), undertaken by The Brazilian Institute of Geography and Statistics (IBGE) for 2005. The survey is based on the Oslo Manual and covers a sample of 12,000 manufacturing Brazilian companies. It includes all companies with records on official Brazilian innovative databases and all companies with 500 or more employees. The sample is expandable to the whole Brazilian industry for companies with 10 or more employees. In addition, companies are classified in three-digit sectors according to the National Classification of Economic Activities (CNAE, in Portuguese abbreviation). CNAE has 103 three-digit sectors in the mining and manufacturing industries and our aggregation resulted in 86 manufacturing sectors.

The paper examines the two Schumpeterian hypotheses controlling for differences in the sectoral patterns of innovation and firms and demand characteristics, testing two sets of model. The first set of models, through a probit test, tries to capture the influence of firm size (*SIZE_EMP*) and market concentration (*HHI*) on the probability to undertake R&D expenditures. In this case, it uses an innovation expenditures (*R&D*) variable, which values 1 if the firm spent some amount in R&D activities[6] during the year of 2005 and 0, otherwise. The second set of models uses a tobit estimation to investigate the influence of firm size and market concentration on R&D intensity, measured by the ratio of R&D expenditures to sales (*R&DIN_EX*), which lies between 0 and 1.

For each model set, we test four different models:

(1) *Simple models* – including size and its square variable, concentration and its square value and the multinational dummy (*MNE*) as independent variables;

(2) *Opportunity and appropriability models* – additionally to the simple model variables, they includes the ones that account for

[6] As pointed out in the PINTEC questionnaire, R&D activities include *creative work systematically employed in view of increasing the accumulation of knowledge and its use for new applications developments. The plan, development and test of prototypes and pilots are many times the most important phase of R&D activities. It also includes software developments, since it involves a technological or scientific improvement.*

technological opportunity, appropriability, and the final good sector (*FIN*);

(3) *Pavitt dummies models* – additionally to the simple model variables, these models incorporate dummies that represent Pavitt's (1984) taxonomy, that are suppliers dominated (*SUP_DOM*) and science based (*SCI_BAS*);

(4) *Pavitt sectors models* – the simple model is tested considering the firms separately regarding to their sector's classification on Pavitt's tipology.

The paper uses the number of employees (*SIZE_EMP*) as a proxy for size and the Hirschman-Herfindahl Index (*HHI*), which is the sum of squared market shares for all firms for each three-digit sector, for market concentration. A multinational enterprise dummy (*MNE*) is also included to incorporate firms' attributes and it assumes 0, when the firm's capital controller is national, and 1, if it is foreign or mixed.

The paper analyzes sectoral characteristics through a final good sector (*FIN*) dummy - which controls models to firms that operates in sectors that produce final goods predominately (see list in Annex I), as a measure of demand conditions - and by technological opportunities and appropriability variables.

The importance given to external[7] sources of information and knowledge (or innovation) indicate technological opportunity. These variables are calculated as a average proportion of firms that indicated high importance to the introduction of innovation, for each kind of information source and within each CNAE three digits sector. These averages consider the nature of the information source and represent the following technological opportunity variables:

(i) Entrepreneurial opportunities (*OPORT_ENT*): It represents the sectoral average proportion of firms that found highly important the information acquired from suppliers, consumers, competitors, and consultancy firms or independent consultants;

(ii) Scientific opportunities (*OPORT_SCI*): It uses the same methodology described above, but is related to information derived from universities or research institutes and centers of professional capacity and technical assistance.

The appropriability variables are specified by the methods of protection used:

(i) Intellectual property rights appropriability (*APPROP_APP*): proportion of firms that used written protection (patents, industrial design registration, brands, and copyrights) for each three-digit sector;

(ii) Strategic protection appropriability (*APPROP_STRA*): proportion of firms that used strategic protection (complexity of design, industrial secrets, leading time over competitors, and others) for each three-digit sector.

[7] Internal sources and sources relative to other companies that bellow to the same group are excluded.

Finally, there are dummies representing the Pavitt's Taxonomy (see Annex I). The three-digits sectors are divided into three categories (see Annex I): (i) suppliers dominated (*SUP_DOM*); (ii) science based (*SCI_BAS*); and (iii) production intensive (*PROD_IN*).

Table 1 presents the descriptive statistics and table 2 and 3 show the correlation statistics for respectively Pearson and Spearman correlation indexes.

Table 1 Descriptive Statistics

	Obs	**Mean**	**Std. Dev**	**Smallest**	**Largest**
HHI	11748	0.074329	0.090518	0.013641	0.863839
SIZE_EMP	11748	2942894	1094258	0	45176
R&DIN_EX	11615	7.97E-06	0.000207	0	0.018322
OPORT_ENT	11748	0.297034	0.033384	0.195652	0.604167
OPORT_SCI	11748	0.073482	0.035104	0	0.25
FIN	11748	0.509874	0.499924	0	1
APPROP_STRA	11748	0.02477	0.020701	0	0.166667
APPROP_APP	11748	0.038818	0.029967	0	0.2
MNE	11748	0.08129	0.273292	0	1
SUP_DOM	11748	0.462121	0.498584	0	1
SCI_BAS	11748	0.057712	0.233208	0	1
PROD_IN	11748	0.480167	0.499628	0	1
R&D	11748	0.157984	0.364742	0	1
R&D_EX	11748	507.8542	11626.24	0	934600

Table 2 Pearson Correlation Indexes

	HHI	*SIZE_EMP*	*R&DIN_EX*	*OPORT_ENT*	*OPORT_SCI*	*FIN*	*APPROP_STRA*	*APPROP_APP*	*MNE*	*SUP_DOM*	*SCI_BAS*	*PROD_IN*	*R&D_EX*
SIZE_EMP	0.0389												
R&DIN_EX	0.0073	-0.004											
OPORT_ENT	-0.2323	0.1227	0.0062										
OPORT_SCI	0.0812	0.0614	0.0367	0.2354									
FIN	-0.2005	0.0372	-0.0048	0.1418	-0.0733								
APPROP_STRA	0.1296	0.0386	0.0289	0.1751	0.2892	-0.292							
APPROP_APP	0.2044	0.0194	0.0336	0.2256	0.2093	-0.0247	0.4152						
MNE	0.0713	0.1596	-0.0016	0.0386	0.0914	-0.116	0.1722	0.104					
SUP_DOM	-0.2729	-0.0766	-0.0161	0.0495	-0.3295	0.4184	-0.2729	-0.1985	-0.1392				
SCI_BAS	0.2143	0.0055	0.0505	-0.0379	0.3961	0.0023	0.2916	0.3072	0.0941	-0.2298			
PROD_IN	0.1722	0.0739	-0.0075	-0.0316	0.1436	-0.4187	0.136	0.0545	0.0949	-0.8905	-0.2382		
R&D_EX	0.1057	0.4679	0.0095	0.0292	0.0035	-0.013	0.0672	0.0672	0.0605	-0.0318	0.0341	0.0158	
R&D	0.0979	0.2257	0.0882	0.062	0.1717	-0.0924	0.2006	0.1696	0.2261	-0.1501	0.1463	0.0814	0.0998

Table 3 Spearman Correlation Indexes

	HHI	*SIZE_EMP*	*R&DIN_EX*	*OPORT_ENT*	*OPORT_SCI*	*FIN*	*APPROP_STRA*	*APPROP_APP*	*MNE*	*SUP_DOM*	*SCI_BAS*	*PROD_IN*	*R&D_EX*
SIZE_EMP	0.019												
R&DIN_EX	0.1531	0.29											
OPORT_ENT	-0.1602	0.1676	0.063										
OPORT_SCI	0.3133	0.1471	0.1671	0.2437									
FIN	-0.2024	0.0138	-0.0969	0.1974	-0.1126								
APPROP_STRA	0.052	0.059	0.2021	-0.0099	0.1319	-0.3001							
APPROP_APP	0.1015	-0.0003	0.1547	0.0768	0.0378	-0.0774	0.4461						
MNE	0.095	0.2742	0.2169	0.0209	0.0796	-0.116	0.1665	0.094					
SUP_DOM	-0.4429	-0.1072	-0.1522	0.0636	-0.3387	0.4184	-0.2444	-0.1844	-0.1392				
SCI_BAS	0.1544	-0.0027	0.1572	0.0542	0.2388	0.0023	0.234	0.265	0.0941	-0.2298			
PROD_IN	0.3698	0.1082	0.0784	-0.0888	0.2263	-0.4187	0.1345	0.0601	0.0949	-0.8905	-0.2382		
R&D_EX	0.1529	0.3251	0.993	0.0648	0.1681	-0.0952	0.2029	0.1546	0.2462	-0.1533	0.1519	0.082	
R&D	0.1517	0.3085	0.995	0.0626	0.1657	-0.0924	0.1999	0.1527	0.2261	-0.1501	0.1463	0.0814	0.995

3.2 RESULTS FOR THE BRAZILIAN MANUFACTURING INDUSTRY

Table 4 shows the results for six different probit models. The dependent variable assumes value 1 if the firm has positive R&D expenditures and 0, otherwise. We test an inverted-U relation between size and the probability to undertake R&D and between market concentration and the probability to undertake R&D by the introduction of quadratic variables. In equation (1), the size and concentration variables have the expected sign. As firms increase in size, the probability to carry out R&D activities increases but in a decreasing rate. The highest probability is obtained when companies have around 22,000 employees. Very few companies in Brazil have over 22,000 employees, in practice the probability to perform R&D increases over the whole size range in the Brazilian industry. At the same time, the probability to innovate increases with concentration, though, again, in a decreasing rate. The highest value is obtained when sectors have a HHI index around 0.45. Most sectors in the industry have concentration values below 0.45. The dummy for multinational assumes positive and significant value, showing that multinationals have greater probability to perform R&D than domestic companies. There is no significant modification in the coefficient and significance of other variables.

In equations (2) and (3) we try to capture the effect of introducing sectoral technological variables. In equation (2), variables representing opportunity, appropriability and demand conditions are introduced and in equation (3) we test the value of size and concentration controlled by dummies that group sectors according to Pavitt's taxonomy. In both equations, variables related to size and concentration maintain their signs and significance. Furthermore, the variables for control of sectoral characteristics are in most cases significant and hold the expected signs. In equation (2) with the exception of the variable on entrepreneurial opportunity which is not significant, all other variables are statistically significant and appear with the expected sign, that is, sectors in which firms use the intellectual property system or undertake strategic measures to appropriate the results of their technological efforts are more likely to have firms that undertake R&D efforts; sectors that have universities, independent R&D labs and certification agencies as sources of knowledge are also more likely to have firms that undertake R&D efforts; and intermediary consumption sectors are more likely to have firms that carry out R&D. In equation (3), the science-based dummy shows a positive and significant sign and firms that belong to supply dominated sectors have lower probability to carry out R&D efforts. In all equations, the multinational dummy maintains its sign and significance.

Equations (4) to (6) show tests restricted to firms belonging to three classifications of Pavitt's (1984) taxonomy. The size variables maintain their sign and significance in all equations. However, the concentration variables lose significance in the equation (6) that deals with production intensive sectors.

Table 4 Marginal Values for the Probit Equation

Models/ Variables	**Simple**	**Opportunity and appropriab.**	**Pavitt dummies**	**Supplier Dominated**	**Science Based**	**Production Intensive**
Equations	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
SIZE_EMP	.0000**** (.00001)	.0000**** (.00001)	.0001**** (.00001)	.0001**** (.00001)	.0003538**** (.00007)	.0001**** (.00001)
(SIZE_EMP)2	-1.6e-09**** (.00000)	-1.4e-09**** (.00000)	-1.4e-09**** (.00000)	-3.7e-09**** (.00000)	-2.4e-08**** (.00000)	-1.7e-09**** (.00000)
HHI	.4903**** (.06304)	.2600**** (.05788)	.302**** (.06713)	.6379**** (.1185)	1.081** (.5128)	.2044* (.11733)
(IHH)2	-.5543**** (.11052)	-.3494**** (.08364)	-.3471**** (.10491)	-1.85**** (.37463)	-2.70**** (.851)	-.073 (.14831)
MNE	.1715**** (.02276)	.01**** (.0178)	.1270**** (.01982)	.1118**** (.0261)	.0804 (.09814)	.183**** (.03065)
OPORT_ENT		-.0459 (.07514)				
OPORT_SCI		.4794**** (.06961)				
APPROP_STRA		.7318**** (.13336)				
APPROP_APP		.3926**** (.11457)				
FIN		-.0256**** (.00575)				
SUP_DOM			-.0477**** (.00694)			
SCI_BAS			.0629**** (.01604)			
CHI2	475.99	701.59	612.43	218.01	49.96	210.59
N	11748	11748	11748	5429	678	5641

Dependent variable assumes value 1, when R&D expenditures are positive, 0, otherwise.
Standard errors are in parentheses.
* 10% level of significance, ** 5% level of significance, *** 1% level of significance, **** 0.1 level of significance.

The results on the probability to carry out R&D expenditures confirm the Schumpeterian hypotheses for the Brazilian economy and contradict the more recent literature on the relationship between technological effort and structural variables. This contradiction is derived from the fact that the introduction of technological characteristics at the sectoral level does not take significance away from market structure variables such as size and concentration in our results. As noted above, the contrary is expected due to the existence of sectoral patterns of innovation associated as well with industrial organization variables. This finding is quite different from previous literature on the Brazilian economy. Two reasons appear to explain the difference. First, there is the sampling procedure. Papers that cover the whole structure are very rare to find. Only after the publication of PINTEC 2000, scholars could have access to a database that would cover adequately the whole industry. Second, the dependent variable used is quite different from the study by Kannebly, Porto and Pazello (2006). That study used PINTEC 2000 and had therefore a good coverage of the whole size distribution of the Brazilian manufacturing industry; nonetheless, the dependent variable used was the introduction of innovation (valued 1, when the firm introduced the innovation, 0 otherwise). As the comparison of figure 2 with figure 1 exposed above highlight, the probability of a firm becoming innovative is much higher than the probability of a firm undertaking R&D efforts. Furthermore, those figures also showed that this difference was greater amongst small companies. Therefore, the high weight of small companies in the Brazilian industrial structure may be explaining this finding. This result may induce one to think about the benefits of conglomeration in such an economy, that is, an increase in average firm size and a greater concentration of its markets may stimulate technical change.

However, one additional question is whether this finding extends to the intensity of R&D expenditures, that is to the R&D to sales ratio. Table 5 tries to cope with this question. It shows a set of tobit models that have as dependent variable the R&D expenditures to sales ratio.

Equation (1) in table 5 shows a probit model that has size, the Herfindhal-Hirschman index, its quadratic form, and a multinational dummy as independent variables. No control for technological characteristics is used. The size variable does not perform as well as in the probit model. Though it has a positive sign, it is significant only at the 10% level.[8] The concentration variables have the expected signs, HHI has a positive and significant coefficient and a negative and significant coefficient for the quadratic form variable. It indicates that the R&D intensity assumes its higher value at HHI equal to 0.36, which is associated with a four-firm equivalent number, that is, a quite concentrated structure. The multinational dummy is positive and significant at the 1% level.

Equations (2) and (3) introduce controls for sectoral technological characteristics. In equation (2), contrary to what was expected, the size variable gains significance when the sectoral controls are introduced. In addition, all variables that account for sectoral technological characteristics are significant and have the expected value. The multinational dummy loses significance. Apparently, the greater performance of R&D by multinationals is explained by their sectoral locations. The performance of the concentration variable (HHI) does not alter. In equation (3), the sectoral technological characteristics are dropped and we introduce two dummies for supplier dominated and science-based sectors. The behavior of the size and multinational variables does not change with respect to equation (1).

In equations (4) to (6), we test the model of equation (1) restricted to each of the Pavitt's (1984) categories. The performance of the model differs across the type of sectors. In supply-dominated sectors, size, and concentration variables remain very important, while the multinational dummy is significant at the 10% level. In the science-based sectors, all variables with exception of the multinational dummy are significant, while in the production intensive sectors the only significant variables are those associated with concentration.

[8] The quadratic form variable did not appear significant and was dropped from the final equations in table 5.

The results obtained from table 5 suggest that structural characteristics still help explaining the behavior of companies in Brazil. Furthermore, it shows that when sectoral technological characteristics are accounted for, the relevance of size increases. From table 5, one learns that production intensive sectors seem to be the exception in the role of size. This may be the result of a set of features that are peculiar to the Brazilian productive sector: (i) the production intensive sectors are the most well developed sector in the Brazilian economy. They are well consolidated in the Brazilian productive sector, present the best exporting performance, and therefore are the most likely to present features that are common to well developed structures; and (ii) part of these sectors contain medium sized enterprises that supply equipment to the scale intensive sectors of the economy. In order to develop these equipments, these companies are likely to undertake R&D efforts.

Table 5 – Tobit Model – Dependent Variable: R&D to Sales Ratio

Models/ Variables	Simple	Opportunity and appropriability	Pavitt dummies	Supplier Dominated	Science Based	Production Intensive
Equations	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Constant	-.00072**** (.00002)	-.00047**** (.0000807)	-.00063**** (.0000215)	-.00123**** (.0000559)	-.0008**** (.0000979)	-.0004**** (.0000187)
SIZE_EMP	1.51e-08* (8.49e-09)	2.49e-08*** (8.55e-09)	1.41e-08* (8.48e-09)	5.63e-08** (2.65e-08)	1.39e-07** (6.80e-08)	3.82e-09 (6.91e-09)
HHI	.0022**** (.000191)	.001545**** (.0002044)	.0018**** (.0002013)	.0084**** (.0009163)	.0035**** (.0009002)	.0005** (.000191)
(IHH)2	-.0031**** (.0003346)	-.0027**** (.0003341)	-.0026**** (.000339)	-.0230**** (.003786)	-.0096**** (.0019483)	-.0005* (.0002839)
MNE	.0001*** (.0000314)	.00003 (.0000316)	.0001** (.0000315)	.0001* (.0000816)	6.11e-06 (.0001188)	.0000 (.0000291)
OPORT_ENT		-.0016**** (.0002823)				
OPORT_SCI		.0017**** (.0002427)				
APPROP_STRA		.0031**** (.0004563)				
APPROP_APP		.0022**** (.0003075)				
FIN		-.0001**** (.0000189)				
SUP_DOM			- .0002**** (.0000189)			
SCI_BAS			.0001** (.0000317)			
CHI2	157.85	474.83	240.01	161.96	41.69	7.83
N	11615	11615	11615	5370	671	5574

Standard errors are in parentheses.
* 10% level of significance, ** 5% level of significance, *** 1% level of significance, **** 0.1 level of significance.

3.3 DISCUSSION

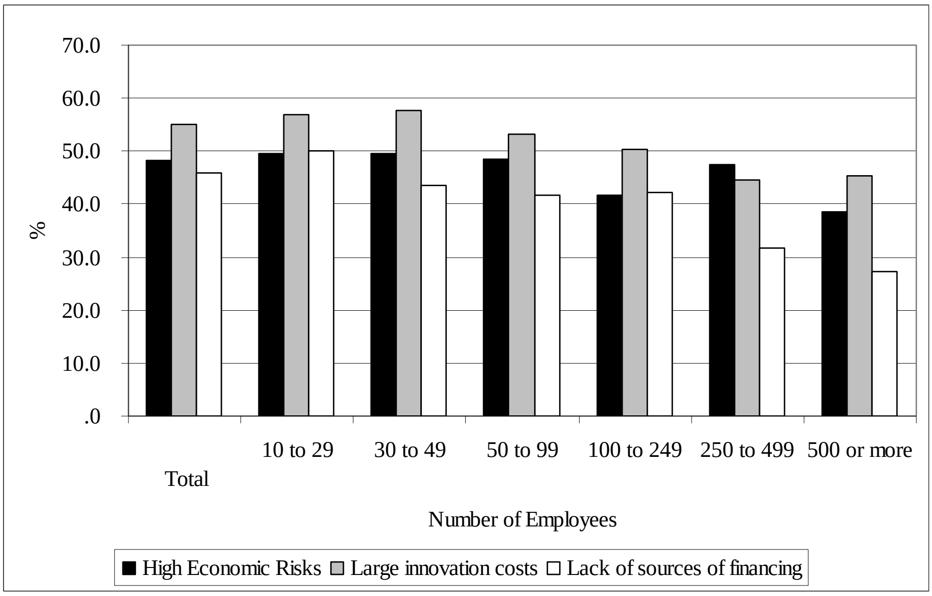
The results obtained in this paper calls for some discussions on the reasons why the Schumpeterian hypotheses are confirmed for the Brazilian manufacturing industries. It may be tempting to state that since small companies and highly concentrated market structures are more likely to carry out R&D the adoption of measures in the direction of conglomeration would be welcomed. Therefore, one would look directly to the antitrust consequences of the Schumpeterian hypotheses. This would even be more relevant if one recognizes the heterogeneity of the Brazilian productive structure, stressed in graphs 1 and 2 above that show that the manufacturing industry in Brazil has an excessive number of small firms and these firms are not likely to undertake R&D or even to perform innovation using other sources of knowledge. This feature could explain the behavior of a certain set of firms that belong to supply dominated sectors, where innovative behavior depends on other sources of knowledge and where the fringe of industries may be composed by firms that are not technologically active. This should even be true due to the dualistic structure of developing economies that may maintain firms in the same sector with very different market orientation and with very diverse technologies at their disposal. Heterogeneity may be an important characteristic of this kind of market and firm size and market concentration may be expressing the level of heterogeneity in each market setting.[9] However, this behavior should not hold in science-based sectors where small firms should be expected to be highly R&D intensive. Nonetheless, in science-based sectors this result is still stronger than in the whole sample. The robustness of this result across sectors tells us that there is more to be explained than heterogeneity in market structures.

This takes us to explain the origins of the advantages of large firms. As stated above, four factors are usually positively associated with the influence of size on innovativeness: scale economies, fixed costs, financial resources and complementary assets. Furthermore, three factors are related to the influence of market concentration on innovativeness: greater protection (appropriability), lower uncertainty from excessive rivalry and greater profits, and therefore greater financial capability. Graph 3 shows that high economic risks, large innovation costs and lack of sources of financing are the most important obstacles to innovation, according to 11,000 innovative firms. All sources of obstacles reduce as firm size increases. However, the reduction of the relevance of the lack of sources of financing is steeper than any other one. This may give us an important clue to explain the difference on R&D expenditures between large and small firms. Small firms seem to find greater obstacles to finance their innovative activities from alternative sources.

It is important to state that Brazil has developed governmental institutions to incentive the undertaking of R&D by companies. This takes place through two main channels. One is tax incentives. However, tax incentives are not available for most small sized enterprises. The Brazilian tax system has a structure to facilitate the declaration by small companies. In this case, taxes are charged as a percentage of sales and no deductions are available. This system has many benefits to small size companies however it does not allow the creation of incentives through taxation dismissals. The Brazilian innovation law nonetheless is plenty of incentives of this type that are used by large companies (see graph 4 on the most important governmental support for innovation). The second method of intervention of Brazilian governmental authorities is through financing of innovation. Once again, the system fails to reach small companies (see graph 4) that have little access to financing from government. However, a significant share of large companies accesses the financial support of governmental agencies. Moreover, large companies are more likely to use both types of incentives than small companies. These policy features shed some light on the results obtained in this paper and calls attentions for different price structures and biased focus of governmental agencies.

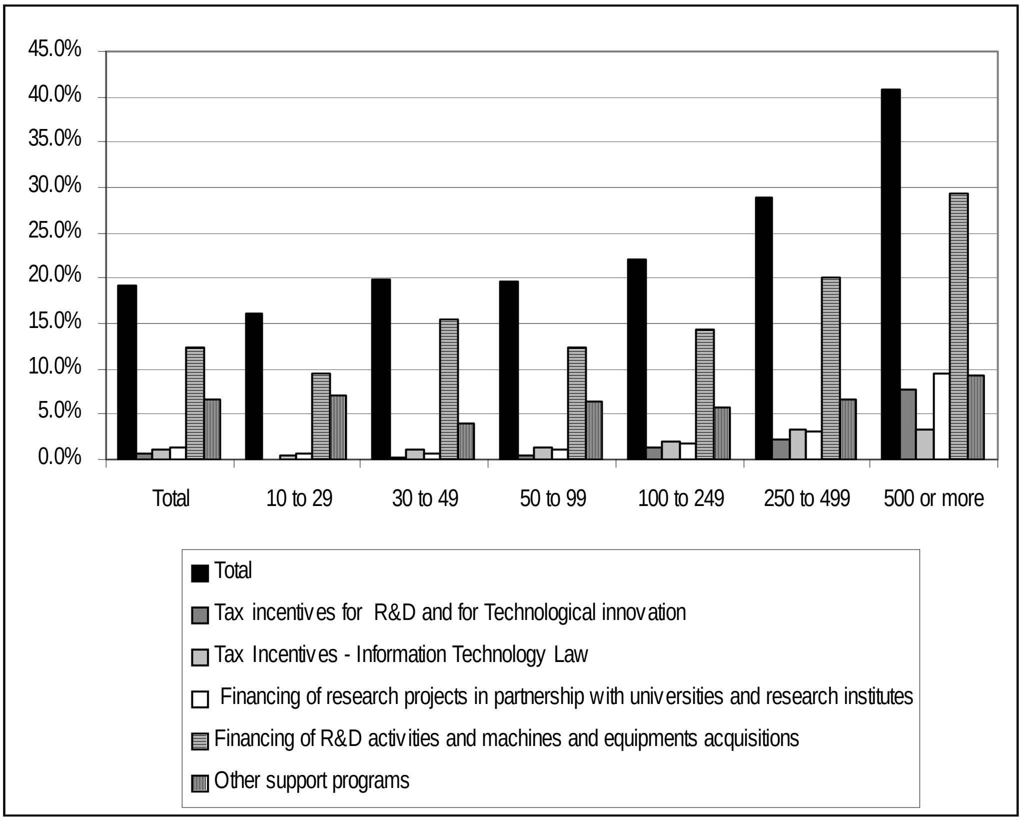
[9] See Cimoli (2005) for recent work on the heterogeneity of productive structures in Latin America and, specifically Brasil (Kupfer and Rocha 2005a).

Graph 3 Most Important Obstacles to Innovate, Innovative Firms, 2005 (%)



Source: IBGE, Pesquisa Industrial de Inovação Tecnológica, 2005.

Graph 4 Governmental Support Programs, Innovative Firms, 2003-2005 (%)



Source: IBGE, Pesquisa Industrial de Inovação Tecnológica, 2005.

4 CONCLUSIONS

The main conclusions driven from this paper show the confirmation of the Schumpeterian hypotheses for the Brazilian manufacturing industry. In the first set of equations tested, we concluded that the probability to innovate is positively correlated to firm size and market concentration. This result was very robust and held in all equations tested. The main explanation for the result was the overall importance of small firms in the Brazilian economy and their lack of R&D efforts.

The relationship between R&D intensity and size is not as straightforward as between the probability of undertaking R&D and size. However, when we introduce variables to account for sectoral technological imperatives, the significance of the size variable is strengthened, that is, contrary to the literature, the introduction of controls for sectoral technological characteristics increase the significance of the size variable.

Moreover, the results of the effects of concentration on R&D intensity are more robust and stress that firms belonging to more concentrated structures in Brazilian economy are likely to perform more R&D than those active in more atomistic structures.

There are however some important differences in the results when we isolate samples according to types of sectors in Pavitt's taxonomy. In this case, in general, science-based sectors are less likely to display an important relation between size and R&D intensity and production intensive sectors are less likely to have important effects of market concentration.

The discussion over these results shows that the importance given to firm size may be a result of policy incentives to R&D of large firms and the lack of policy focused on small enterprises. Incentives associated with the tax system do not reach small companies and the financing of innovation is directed mainly towards firms of large size.

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ANNEX I

CNAE modified	Description	*FIN*	*SUP_DOM*	*SCI_BAS*	*PROD_IN*
151	Production, processing and preservation of meat and fish	1	0	0	1
152	Processing and preserving of fruit and vegetables	1	0	0	1
153	Manufacture of vegetable and animal oils and fats	1	0	0	1
154	Manufacture of dairy products	1	0	0	1
155	Manufacture of grain mill products, starches and starch products, and prepared animal feeds	1	0	0	1
156	Manufacturing or refining of sugar	1	0	0	1
157	Manufacture of coffee	1	0	0	1
158	Manufacture of other food products	1	1	0	0
159	Manufacture of beverages	1	0	0	1
160	Manufacture of tobacco products	1	0	0	1
173	Spinning, weaving and preparation of textiles fibres	0	1	0	0
174	Manufacturing of textile artefacts	1	1	0	0
175	Finishing of yarn, fabrics and textile artefacts	1	1	0	0
176	Manufacture of textile artefacts by fabrics, except wearing apparel, and of other textile artefacts	1	1	0	0
177	Manufacture of fabrics artefacts	1	1	0	0
181	Manufacture of wearing apparel	1	1	0	0
182	Manufacture of wearing apparel accessories and of professional security	1	1	0	0
191	Tanning and preparing of leather	1	1	0	0
192	Manufacture of luggage, handbags, saddlery, harness	1	1	0	0
193	Manufacture of footwear	1	1	0	0
201	Sawmilling and planning of woods	0	1	0	0

202	Manufacture of wood and of products of wood and cork, except furniture	1	1	0	0
211	Manufacture of cellulose and other pulps for paper production	0	0	0	1
212	Manufacture of pulp, paper, paperboard, and cardboard	1	0	0	1
213	Manufacture of paper or paperboard package	0	0	0	1
214	Manufacture of various paper, paperboard, and cardboard artefacts	1	0	0	1
221	Publishing and printing	1	1	0	0
222	Printing and services activities related to printing	1	1	0	0
231	Manufacture of coke	0	0	0	1
232	Manufacture of refined petroleum products	0	0	0	1
234	Manufacture of alcohol	0	0	0	1
241	Manufacture of Inorganic Chemicals	0	0	0	1
242	Manufacture of Organic Chemicals	0	0	0	1
243	Manufacture of resins, elastomers, fibres, continuous artificial and syntetic filament yarn	0	1	0	0
245	Manufacture of pharmaceuticals, medicinal chemicals and botanical products	1	0	1	0
247	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparation	1	1	0	0
248	Manufacture of paints, varnishes and similar coatings, printing ink and mastics	0	1	0	0
249	Manufacture of other chemical products, pesticides and other agrochemical products	0	0	0	1
251	Manufacture of rubber products	0	0	0	1
252	Manufacture of plastics products	0	1	0	0
261	Manufacture of glass and glass products	0	0	0	1
262	Manufacture of cement	0	0	0	1
263	Manufacture of concrete, ready-mix, cement, and plaster	0	1	0	0
264	Manufacture of ceramic products	0	0	0	1
269	Cutting, shaping and finishing of stone and manufacture of lime and other non-metallic mineral products	0	0	0	1
271	Production of pig-iron and ferro-alloys	0	0	0	1
272	Iron and steel industry	0	0	0	1
273	Manufacture of tubes and pipes	0	0	0	1
274	Casting of non-ferrous metals	0	0	0	1
275	Casting of metals	0	0	0	1
281	Manufacture of structural metal products	0	0	0	1
282	Manufacture of tanks, metal reservoirs and steam generators	0	0	0	1
283	Forging, pressing, stamping and roll-forming of metal; powder metallurgy	0	0	0	1
284	Manufacture of cutlery, hand tools and general hardware	1	0	0	1
289	Manufacture of other fabricated metal products	0	0	0	1
291	Manufacture of engines, pumps, compressors, taps and turbines, except aircraft, vehicle and cycle engines	0	0	0	1
292	Manufacture of other machinery of general purpose	0	0	0	1
293	Manufacture of agricultural and forestry machinery	0	0	0	1
294	Manufacture of machine tools	0	0	0	1
295	Manufacture of machinery for mining, quarrying and construction	0	0	0	1
296	Manufacture of other special-purpose machinery	0	0	0	1
298	Manufacture of domestic appliances	0	0	1	0
299	Maintenance and repairing of machines and equipments	0	0	0	1
302	Manufacture of office, accounting and computing machinery	1	0	1	0
311	Manufacture of electric motors, generators and transformers	0	0	0	1
312	Manufacture of electricity distribution and control apparatus	0	0	0	1
313	Manufacture of wire, cables, and electric insulated conductors	0	0	0	1
315	Manufacture of lamps and lightning equipments	0	1	0	0
316	Manufacture of eletric material for vehicles	0	0	0	1

319	Manufacture of piles, batteries, eletric accumulator, and other electrical equipment	0	0	1	0
321	Manufacture of basic eletronic material	0	0	1	0
322	Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy	0	0	1	0
323	Manufacture of television and radio receivers, sound or video recording or reproducing apparatus, and associated goods	1	0	1	0
331	Manufacture of medical and surgical equipment and orthopaedic appliances	0	0	0	1
332	Manufacturing of mensuration, control and test instruments	0	0	0	1
333	Manufacturing of eletronic systems' machines and equipments dedicated to industrial automation and control of productive process	0	0	0	1
335	Manufacture of optical, photographic, and cinematographic equipments, machines and materials, chronometers and clocks	1	0	0	1
341	Manufacture of automobiles, vans, lorries, buses, coaches, trucks and utilities	1	0	0	1
343	Manufacture of cabins, bodies (coachwork), and tow	0	0	0	1
344	Manufacture of vehicle parts and accessories	0	0	0	1
345	Reconditioning or recuperation of vehicles' motors	1	1	0	0
351	Building and repairing of ships and boats	0	0	0	1
353	Building, mounting and reparation of aircrafts	0	0	1	0
359	Manufacturing of other transportation equipments	1	0	0	1
361	Manufacture of furniture	1	1	0	0
371	Recycling	0	1	0	0