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PATTERNS OF TECHNOLOGICAL INNOVATION: A COMPARATIVE ANALYSIS BETWEEN LOW-TECH AND HIGH-TECH INDUSTRIES IN BRAZIL

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ABSTRACT

This paper is intended to contribute to the knowledge about the patterns of innovations in different economic sectors. Hence, the general objective is to assess the differences in rates, directions, sources and efforts of innovations between low-tech and high-tech industries in Brazil. The analysis is based on the database of a survey on innovation (PINTEC) conducted by IBGE. The sample includes 8,578 innovative Brazilian companies surveyed from selected low-tech industries (food and textiles manufactures) and high-tech industries (vehicles and electronics industries). Descriptive and factorial correspondence analysis were used to identify the variables regarding rates, directions, sources and efforts of innovation that discriminate the low-tech industries of high-tech. The results confirm that low-tech industries differ from high tech ones in all pattern of innovations dimensions analyzed. Hence, low tech industries, compared to high-tech ones, are less innovative, innovate more in process, have fewer people dedicated to R&D, present suppliers as the most significant source of information and is a larger user of Government funding for the purchase of machinery and equipment. On the other hand, the high-tech industries are more innovative, innovate more in products, have more people dedicated to R&D, search for information of other groups of companies, customers and competitors, and their larger use of public financing is for investing in R&D.

Keywords: Technological Innovation; Low-tech and High-tech Industries; Innovative Brazilian Companies; Innovation.

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PADRÕES DE INOVAÇÃO TECNOLÓGICA: UMA ANÁLISE COMPARATIVA ENTRE INDÚSTRIAS DE BAIXA E ALTA TECNOLOGIA NO BRASIL

RESUMO

Este artigo destina-se a contribuir para o conhecimento sobre os padrões de inovações em diferentes setores econômicos. Assim, o objetivo geral é avaliar as diferenças nas taxas, orientações, as fontes e os esforços de inovação entre as indústrias de alta e baixa tecnologia no Brasil. A análise baseia-se no banco de dados de uma pesquisa sobre inovação (PINTEC) realizada pelo IBGE. A amostra incluir 8,578 empresas brasileiras inovadoras pesquisadas de indústrias de baixa tecnologia (alimentos e têxteis fabrica) e indústrias de alta tecnologia (veículos e eletrônicos Industries) selecionadas. A análise de correspondência é descritiva e fatorial foram utilizados para identificar as variáveis relativas a taxas, orientações, as fontes e os esforços de inovação que discriminam as indústrias de baixa tecnologia de alta tecnologia. Os resultados confirmam que as indústrias de baixa tecnologia diferem da alta tecnologia em todos padrão de dimensões inovações analisadas. Assim, indústrias de tecnologia de baixa, em comparação com aqueles de alta tecnologia, são as menos inovadoras, inovam mais em processo, ter menos pessoas dedicadas à I & D, os fornecedores apresentam-se como a fonte mais significativa de informações e é um usuário maior de financiamento do governo para a compra de maquinaria e equipamento. Por outro lado, as indústrias de alta tecnologia são mais inovadoras, inovam mais em produtos, tem mais pessoas dedicadas a R & D, busca de informações de outros grupos de empresas, clientes e concorrentes, e sua maior utilização do financiamento público é para investir em R & D.

Palavras-chave: Inovação tecnológica; Baixa Tecnologia e Indústrias de Alta Tecnologia; Empresas Brasileiras Inovadoras; Inovação.

INTRODUCTION

Innovation has a central role in the competitive advantages of nations and firms. For this reason, innovation research has become a cornerstone of strategic management inquiry. However, despite the progress achieved on understanding of technological innovation, there are still several themes in open, among them, innovation in low-tech sectors (which includes the mature industries and traditional). The conventional view about the characteristics of these sectors and on the dynamics of the innovative process puts them in a marginal role in the current knowledge economy, which has been neglected in academic debate and policies for science, technology and innovation.

In part, this happen because we are surrounded by science and technology, therefore it is common to always join innovation with some very modern product as well as with functions that utilize the latest scientific findings, taking as its focus only the technical aspects of innovation. Therefore, the literature of innovation and technological change has overestimated the role of R&D as major determinants of innovation, which leads to a disproportionate importance of high-tech firms as the main innovators (Santamaría et al., 2009).

However, innovations are not only science-based and may be associated, besides products and processes, also to organizational and market innovations (IBGE, 2011; OECD, 2011). Assuming that the low-tech sector comprises relevant part of the economy not only in developing countries but also in developed countries, some authors (De Negri, 2005;Kannebley et al., 2005; Prochnik & Araújo, 2005) indicate the need for a new look on innovation, less restricted to high-tech sectors, because it is not possible to ignore the important inter-relationships that exist between the different industrial sectors, high-tech and low-tech, in the context of innovation and its sources and types.

In addition, there is not sufficient theoretical reasoning and empirical results to say that low-tech companies cannot highlight in innovation as other high-tech companies that make more intensive use of science and technology (Santamaría et al., 2009). Actually, we have many low-tech companies that innovate, even

whether great part of the innovations are process innovations or conducted by third parties (Tunzelman & Acha, 2005). Due this, Pavitt's (1984) typology classifies these firms in the supplier dominated cluster. This group is characterized by the external suppliers as main knowledge sources for the innovation activities and by process innovations.

Therefore, the mainstream literature on innovation proposes the existence of a typical low-tech way to innovate, characterized by a "least noble" form to innovate, usually associated with dependence on third parties, predominance of incremental innovation, discontinuous process and low representativeness for the competitive strategies of these companies.

In this way, this research proposes to assess the rates, directions, sources and efforts of innovation in low-tech and high-tech firms in Brazil. By means of an empirical study, it seeks to make a contribution to answer the following question: are the pattern of innovation, regarding rates, directions, sources and efforts, different for low-tech and high-tech industries in Brazil?

Underlying the research question, the general objective is to assess the differences in patterns of innovations, regarding rates, directions, sources and efforts between low-tech and high-tech industries in Brazil.

To accomplish the general objective, the specific objectives are:

Describe the differences in rate of innovations between low-tech and high-tech industries;

1. Analyze if there are differences in direction of innovative activity between low-tech and high-tech industries;
2. Analyze and analyze if there are differences in sources of innovations between low-tech and high-tech industries;
3. Identify if there are differences in efforts to innovate between low-tech and high-tech industries.

Besides this introduction (chapter one), the paper is structured into more three chapters: the second chapter comprises the theoretical approaches, divided by the literature review of patterns of innovations in low and high-tech industries and presentation of hypotheses; the chapter three presents the methodology adopted in this research, followed by the fourth chapter about the analysis of results. We finish with the final considerations, which includes the theoretical and practical implications, limitations and suggestions for future research.

Low and High-Tech Industries: Patterns of Innovations

In this section, we present a review of the literature about patterns of innovations in low and high-tech industries, which will be useful to respond the research question. We start by defining innovation and presenting the theoretical proposals an empirical results about patterns of innovation in low-tech and high-tech industries. This is followed by an explanation of the hypotheses tested in the empirical section. Innovation refers to the economic application of a new idea (Costa & Porto, 2014; Oliveira, Laranja, Lahorgue, & Born, 2016; Santos, Zawislak, Franzoni, & Vieira, 2015).This driving force behind technological change, differs innovation form invention (the sketch or idea) and diffusion (the spread of innovation by the economy). For Freeman (1982), innovation is “first commercial transaction of one idea involving a new or improved product or process” (p. 7). Success is defined as the economic return that follows the launch of an innovation. Verhees and Meulemberg (2004) claim that the various interpretations of “innovation” over the years can be summarized as “the process of developing a new item, the new item itself, and the process of adopting the new item”.

However, an even broad definition is provided by the OECD (2005) “innovation is the implementation of a new or significantly improved solution for the company, a new product, process, organizational method or marketing, in order to strengthen its competitive position, increase performance or knowledge". This definition expands the meaning of innovation to include two new types: marketing and organizational innovations. This is closer with the Schumpeterian definition, who considers product, process, material, market and organization as types of innovation.

Innovation has been researched on the sectoral, regional, firm, and project levels (Verhees & Meulemberg, 2004). In the present study, innovation is investigated at the industry level, specifically divided in groups of low-tech and high tech industries. Therefore, the primary focus is on technological innovation, which we define as the application and commercialization of new products and processes. Hence, the main study question: is there a difference in patterns of innovations between low-tech and high-tech industries?

The dominant explanation amongst researchers is for a positive answer, with the high-tech industries defining a more “advanced” innovation pattern. However, the results of the empirical research carried out so far, shed doubts on this conclusion. As Jensen and McGuchin (1997) pointed: as firms differ along practically any observable dimension, such as investment pattern, size, production technology, and wages, the “standard deviations”, as a unit of analysis, might be more important than the “average firm” in an industry. Despite this evidence that firms follow very different patterns of innovations, there has been a great effort to classify these different patterns into typologies, with the main goal to tailor public policies and firms strategies.

The positive answer to the question has a strong support in Pavitt's (1984) taxonomy. This taxonomy groups industries by pattern of innovations characterized by type of innovations (balance between product and process innovation), objectives of R&D, sources of information (internal versus external), size distribution of innovating firms, appropriate mechanisms, and technological diversification behaviour of firms (the nature and flow of innovations generated for other firms). From this definition and based on data related to significant innovations in Great Britain during the period from 1945 to 1979, Pavitt identified, as he had hypothesized, groups of industries following similar technological trajectories linked to common patterns of innovation. As a result of these observations, he proposed a taxonomy and a theory of sect oral pattern of technical change, suggesting three categories of technological trajectories namely supplier-dominated, production intensive(subdivided in scale intensive and specialized suppliers), and science-based. There after, Pavitt, Robson and Townsend (1989) suggested a fifth trajectory (information intensive).

Cabral (1999) summarized these five categories as below:

a. Supplier-dominated. Characterized by predominance of small innovating firms belonging to traditional sectors of manufacturing such as textiles, leather and footwear, clothing, printing and publishing, wood and also agriculture. In this category, innovations come mainly from suppliers of equipment and materials, but also from large customers, public research institutes and extension services. The major technological trajectory is cost-cutting (process innovations), originating from the trade-off between wages level versus price and performance of capital goods.

b. Scale-intensive. Incorporates large innovating firms in the food, metal manufacturing, shipbuilding, and motor vehicle industries. They have, as major source of innovation, the firms' functional departments of production and engineering, specialized in solving technical imbalances and bottlenecks through diverse forms of internal learning (e.g. learning-by-doing and learning-by-using). Specialized external suppliers of equipment and instruments comprise other sources. The technological trajectory is balanced between the motivation to cut-costs, through process innovations aiming economies of scale, and product-design, based on performance-increasing product innovation.

c. Specialized-suppliers. Relatively small innovating firms such as mechanical and instrument engineering firms fit into this category. They have large users and internal functional departments of design and development as sources of innovations. Their technological trajectory is characterized more toward performance-increasing product innovation and less toward cost-reducing process innovation. Their product innovations enter other sectors as capital inputs.

d. Science-based. The major source of innovation in this group is the R&D activities of large firms, belonging mainly to the chemical and electronics industries, hence closely linked to scientific advances. The technological trajectory is based on product innovations that have a pervasive use in other industrial sectors.

e. Information-intensive. Comprised by financial services and retailers which have software departments and specialized suppliers as main sources of innovation. The technological trajectory followed is cost cutting, attainable through improved efficiency in service and cost transactions minimization.

In turn, OECD (2011), based on the ratio of business expenditures on research and development to production or value-added, classified the industries patterns of innovation in four classes: high-tech, medium high-tech, medium low-tech and low-tech industries. The high-tech group is defined as those with high measured R&D intensity, and high shares of technology-intensive resources. It groups aircraft, pharmaceuticals, office, communications equipment, and instruments. In the extremity of the continuum, low-tech classifications groups traditional industries, like as wood, food, and textiles.

This OECD's (2011) taxonomy of industrial patterns of innovation suits our objective to analyze if there are differences in patterns of innovation between low-tech and high-tech industries, based on data of two industries by each cluster.

The capacity to develop and, mainly, to implement innovations is for a long time recognized (e.g. Kreinsen-Hirsch et al., 2005; Santamaria, Nieto, & Barge-Gil, 2009,) as important for firms in all industries, regardless of the sector of actuation. However, traditionally there has been more interest in researching the behavior of innovative companies known as high-tech than of the low-tech companies. This lack of interest in the investigation of the innovative behavior of firms of low-tech is one more bias created by the dominance of the linear model of innovation and the general proposition that innovation is a function of R&D investment.

However, according to Hirsch-Kreinsen, Hahn and Jacobson (2008), while the attentions of policymakers, academics and the public in general has been focused disproportionately on the high-tech industries, the importance of the activities of innovation in sectors established that comprise the mass of economic activity, as it is the case of low-tech companies, has been ignored.

The fact that these industries are not intensive in research is not well understood in terms of their specific innovative capabilities, their role within the

economy, current technologies or their future prospects of development. In this scenario, these industries are considered to offer limited prospects for growth in comparison to the sectors of high technology and, as a result, receive less attention and political support. However, as stressed by Koehler and Schmierl (2008), low-tech firms actually produce very little scientific knowledge, but are big producers of practical knowledge. The main sources of knowledge are the processes of learning (by doing, by using, etc.) which increase and deepen its knowledge base and permit them to react to the market, customers, and other environmental pressures.

Therefore, it seems that the best approach is to broken down the innovation process in low-tech and high-tech industries into various subtopics. As one example, we have the low-tech industries where firms invest less as a percentage of revenues and are less innovative in other respects than high-tech firms, but they, nevertheless, generate new products and, specially, production processes that have considerable aggregate impact (Kaloudis, Sandven and Smith (2005).

Based on the review above, to lead to arguments about the innovation patterns in companies in low-tech and high-tech industries of Brazil, we raised some research hypotheses that guide this work and will be verified.

As low-tech firms are often major customers of high-tech innovators. However, an innovation does not need to be developed by the firm itself but can be acquired from other firms or institutions through the process of diffusion. So, the hypothesis 1 will test if "High-tech firms have a higher degree of product innovations and the low-tech industries present a higher level of process innovations.

Regarding sources of knowledge to innovate, Escribano *et al.* (2009) found that high-tech firms achieve to tap into external knowledge sources to complement their internal R&D activities. Hence, they can better evaluate and assimilate knowledge from external environment. New knowledge can be combined with a solid existing technology knowledge base, which could bring additional opportunities and insights for new products and markets.

A firm's stock of knowledge allows firms to perform two crucial activities. First, it enables to develop and produce new products and processes to better compete and survive in the market. Second, and more importantly for the argument of this hypotheses, it allows to evaluate the relationship between external source of knowledge and R&D intensity. So, we formulate the hypothesis 2 as: High-tech industries present a broader level of sources of information that the Low-tech industries.

The role of Government funding in the form of Tax credits for R&D or direct subsidies of private R&D projects are policies tools available to governments, which contribute to leverage the countries innovative output. Hall and Van Reenen (2000) survey overall conclusion was that tax credits can have a significant positive effect in innovation. In turn, Becker (2012)claims that the government funding for R&D efforts may be more important for low-tech industries than high-tech ones, as R&D investment in low-tech sectors may rely more heavily on external funds. Hence, the hypothesis 3: Government funding is more directed to R&D efforts by firms in the low-tech sector than in the high-tech sector.

Methodology

The research was conducted in two stages. The first is characterized as qualitative research, comprising the bibliography selection, literature review and documentary analysis, which product was the definition of analysis to be made. The second stage is essentially quantitative and comprises descriptive data analysis and correspondence analysis (CA) to examine the relation indicated in the conceptual framework and related hypotheses.

The quantitative methodological approach was first based on descriptive analysis of the data, followed by a correspondence analysis. The objective of descriptive analysis is to describe the statistical units in terms of their innovative activities. Correspondence analysis aims to transform the most part of the initial information in a reduced number of dimensions, focusing on the correspondence between the variables. This reduction is all the more important than the initial number of dimension. The "reduction "notion is common to all factorial techniques .The correspondence analysis offers the particularity –contrary to the Principal Component Analysis (PCA)- to asses a space representation common to the rows and the columns.

Each row and column will have factor scores for each reduced dimension (corresponding to the coordinates for the graphical representation). These factor scores give the best representation of the similarity structure of, respectively, the rows and the columns of the table. In addition, the factors scores can be plotted as maps that optimally display the information in the original table. In these maps, rows and columns are represented as points whose coordinates are the factor scores and where the dimensions are also called factors, components (by analogy with principal component analysis), or simply dimensions a (Greenacre ; Blasius, 2006; Hair *et al.,* 2010).

CA will allow us to determine if an industry is similar to another or rather different according to specific variables, it will also give information about the variables and particularly will help us to discover which variables are the most important in the differentiation of Low-tech

and High-tech industries. The software used for all analysis in this dissertation was R version 3.0.2. (R Development Core Team, 2011).

To test the hypotheses, we consider two sub-samples of firms, separating firms in high-technological-opportunity industries from those in low-technological-opportunity industries. In total, are analyzed four industries categorized in low-tech (food industry and textile industry) and high-tech (vehicles industry and electronic industry). In each industry was considered only innovative firms (product and/or process). The choice for that industries was due to: first because they were included inside the PINTEC survey and second because of theirs highest economic importance for the country, and third because they represent very well the groups of high-tech and low-tech industries. Actually, the vehicles industry is inserted into the medium high-tech sector in OECD's classification. Hence, we are comparing low, medium high-tech and high-tech groups, but considering the medium high in the group of high-tech.

Results and Discussion

We start by analyzing the descriptive results. The available data from PINTEC (IBGE, 2011) included 14013 firms belonging to food industry, 3968 firms belonging to textile industry, 1618 belonging to electronic industry and 2872 belonging to automobile industry.

Regarding types of innovations (Figure 1) we observe that the rate of process innovations is similar for Low-tech and High-tech industries, whereas the rate of innovations implemented only in product, and product and process is higher for high tech industries. Therefore, we observe that the innovative strategy adopted by firms in low-tech industries is larger in process than product innovations.

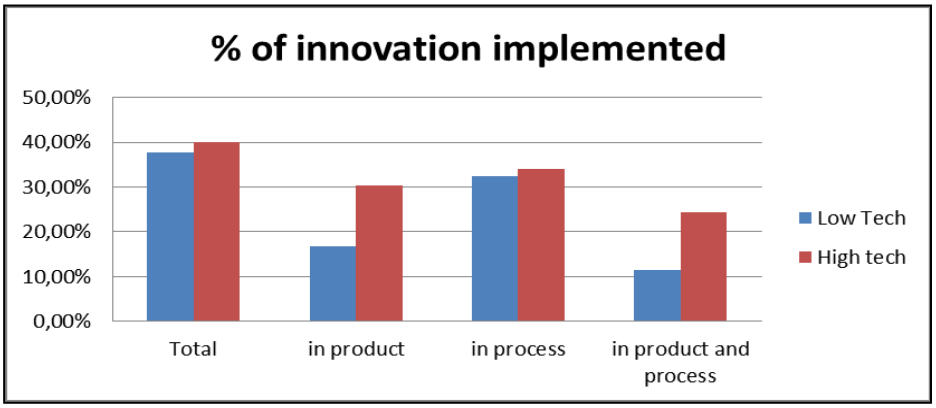


Figure 1 – % of innovation by type of innovations
Source: Own Elaboration, with data of Pintec (IBGE, 2011).

Regarding personnel employed by the firm in R&D activity, we realize that the level of them in the low-tech industries (food and textile) are very low, relatively compared to the total of employees, while it is relatively high in the high-tech industries (Electronics and Automobile) (Figure 2). Also, in all industries almost all people occupied in R&D are exclusively dedicated to that.

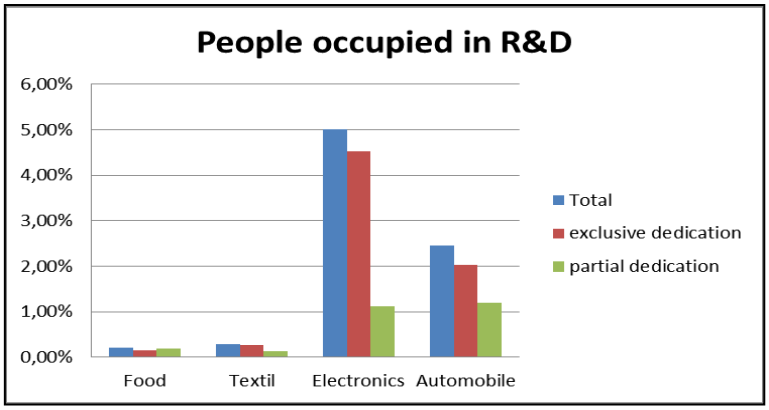


Figure 2 – Workers occupied in R&D
Source: Own Elaboration, with data of Pintec (IBGE, 2011).

Regarding the level of qualification of the personnel employed in R&D, we observe that the low-tech industries present a high relative level of unskilled labor compared to high-tech, where prevail researchers with post-graduation (Figure 3).

As heterogeneous segments of the economy, characterized by a variety of different types of work organization, the level of employees' qualification is determined by an interaction of many different factors – such as product complexity, types of machinery and automation in use, personnel policy, the market situation, quality requirements, and customer demands. This result shows the discrepancy among low-tech and high-tech sectors.

The relationship among skilled workers and innovation rate is also reflected in the number of skilled employees that are closely connected to innovation in process by low-tech firms.

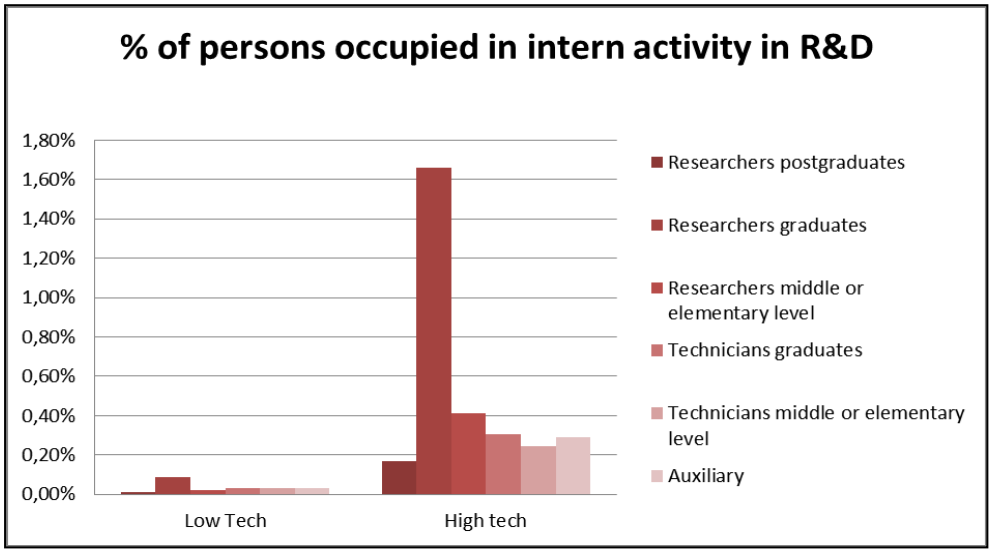


Figure 3 – Skilled Workers by Technological Intensity
Source: Own Elaboration, with data of Pintec (IBGE, 2011).

Figure 4 brings information about expenditure in innovative activities and its importance. The innovative effort that had the greatest level of expenditure, as proposed, was the acquisition of machinery and equipment to all industries. This kind of effort requires naturally higher level of spending and a good part of the firms that innovated stated that acquired some kind of machine or equipment specifically focused for innovation.

The rate of machinery and equipment acquisition were similar for textile industry with (14%) and vehicles industry, (17%) and higher for food industry (25%) and electronic industry (30%). Another important phase of the R&D is the development among the internal activity of R&D of the sample, the higher percentage over others is electronic industry with 30.64%.

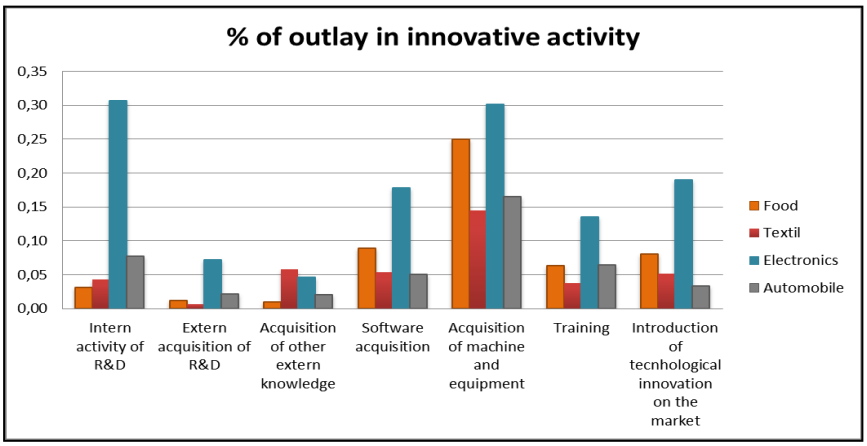
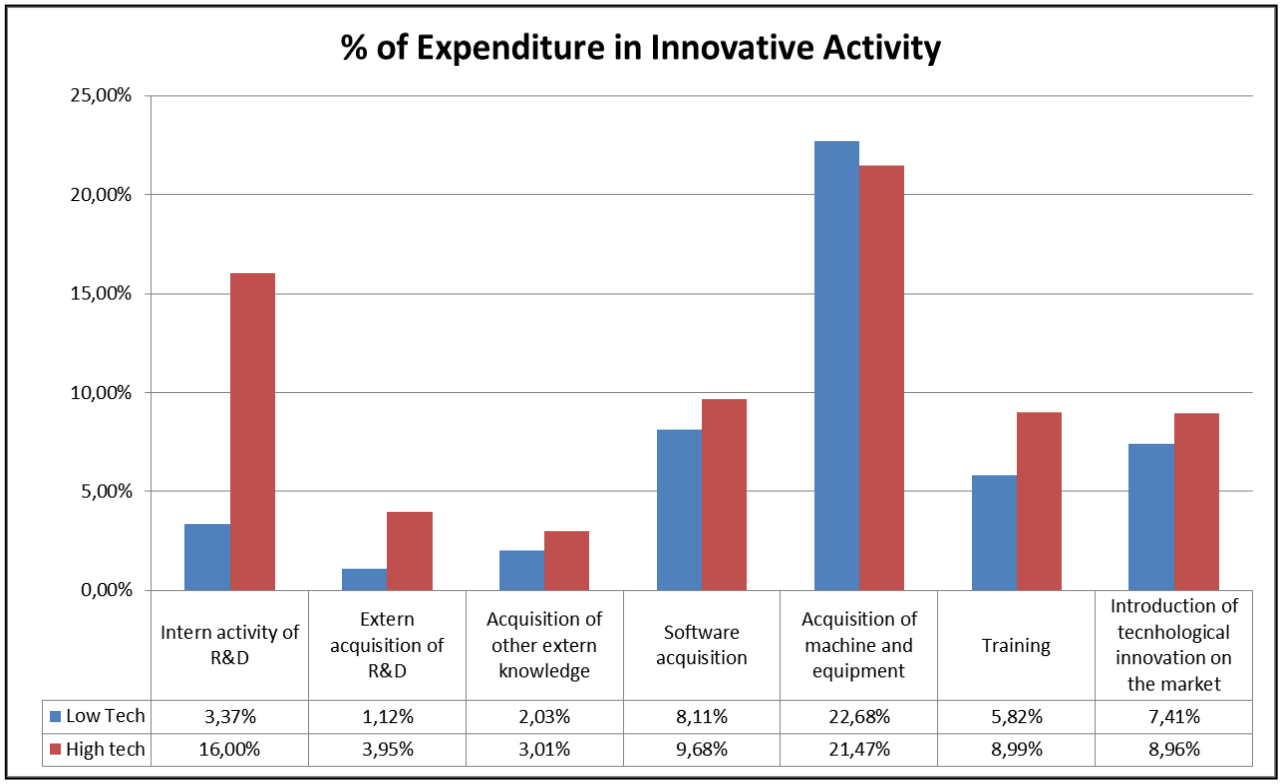


Figure 4 – Outlay % in innovative activity / sales revenue
Source: Own Elaboration, with data of Pintec (IBGE, 2011).

The Figure 5 shows the low-tech firms have almost the same percentage than high-tech (higher only 1%) in acquisition of equipment. All the other items (acquisition of other external knowledge, internal activity of R&D, external acquisition of R&D, software acquisition, training and introduction of technological innovation on the market) the low-tech percentage was below of the high-tech, without any surprise.

According Kannebley and De Negri (2008), in Brazil, the innovative activities of innovative firms are strongly marked by high expenditures on acquisition of machinery and equipment (low-tech and high- tech) by low levels of investment and human resources allocated to R&D internal and the very low investment in R&D external.

These characteristics support the hypothesis that the Brazilian technical change can be characterized as dominated by the process of technological learning typical of highly imitative economies, where technical change are largely restricted to the absorption and improvement of innovations generated abroad.



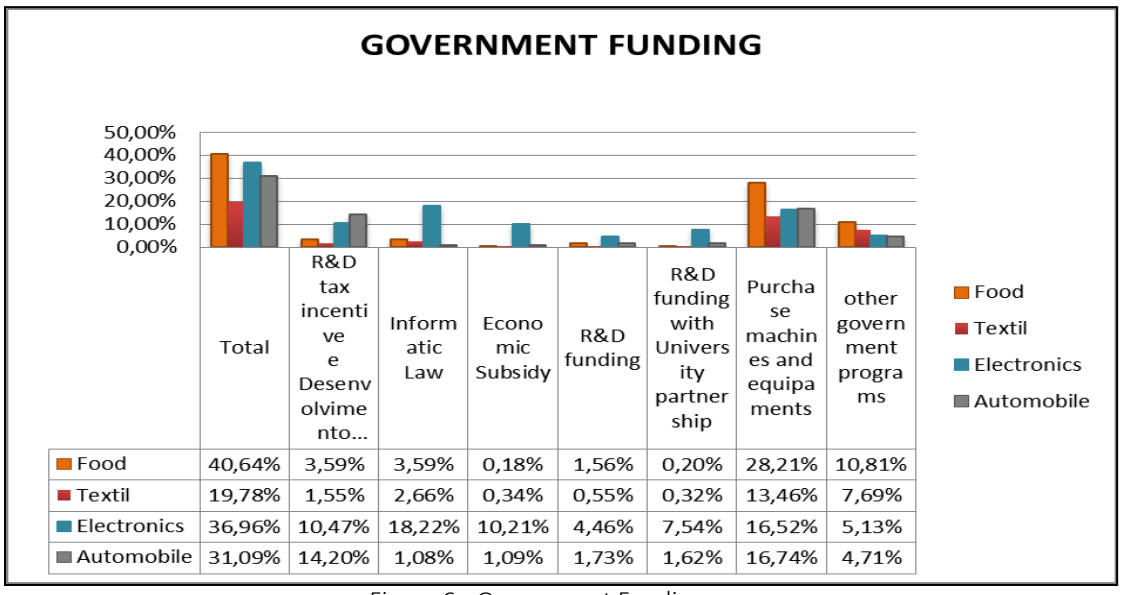
	Intern activity of R&D	Extern acquisition of R&D	Acquisition of other extern knowledge	Software acquisition	Acquisition of machine and equipment	Training	Introduction of tecnhological innovation on the market
Low Tech	3,37%	1,12%	2,03%	8,11%	22,68%	5,82%	7,41%
High tech	16,00%	3,95%	3,01%	9,68%	21,47%	8,99%	8,96%

Figure 5 – Expenditure % in innovative activity by Technological Intensity
Source: Own Elaboration, with data of Pintec (IBGE, 2011).

The Figure 6 shows the percentage of companies that have received Government support for the achievement of their innovative activities. When all types of incentives are considered, it is observed that the percentage of companies that have received support from the government was 40.64% for food industry, 19.78% for the textile industry, 39.96% for the electronics industry and finally, 31.09 % for the vehicle industry.

Among the different types of government support, the one that most stands out is the financing to R&D and purchase of machinery and equipment to innovate. The industry that has obtained a great support of the government to this point was the food industry with 28.21 %, far ahead other industries.

Few industrial firms have received public funding for the completion of Research projects with universities and research institutes: only 0.20% for food industries; 0.32% for the textile industry. The electronics industry has had a good participation with 7.54% and the industry of vehicles participated with 1.62% of its companies doing research in partnership with universities.



	Total	R&D tax incentive e Desenvolvimento...	Informatic Law	Economic Subsidy	R&D funding	R&D funding with University partnership	Purchase machines and equipaments	other government programs
Food	40,64%	3,59%	3,59%	0,18%	1,56%	0,20%	28,21%	10,81%
Textil	19,78%	1,55%	2,66%	0,34%	0,55%	0,32%	13,46%	7,69%
Electronics	36,96%	10,47%	18,22%	10,21%	4,46%	7,54%	16,52%	5,13%
Automobile	31,09%	14,20%	1,08%	1,09%	1,73%	1,62%	16,74%	4,71%

Figure 6– Government Funding
Source: Own Elaboration, with data of Pintec (IBGE, 2011).

Regarding the program of fiscal incentive to undertake research, the textile industry present the lowest participation in this funding (1.55%) and also in the incentive of the law of informatics (2.66%), followed by the food industry for both incentives (3.59% for research and law of informatics). The industry of vehicles and electronics presented the highest participation in incentive for research (10,47% and 14.2 % respectively for electronics and vehicles) and the highest participation of funding from to the law in informatics was for the electronic industry (18,22% while the percentage for the vehicle industry is near 1%).

Among the various industrial activities standing out in Brazil, vehicles and electronic industries are composed by large companies controlled by foreign capital. These companies are the one that receiving more government funding–whatever the type of the funding.

The Figure 7 shows the division of the government funding according to industries (low-tech and high-tech). High-tech industry receives more funding from the government –whatever the type of support- than low-tech industry, excepted for "funding for the acquisition of machinery and equipment" and "other program".

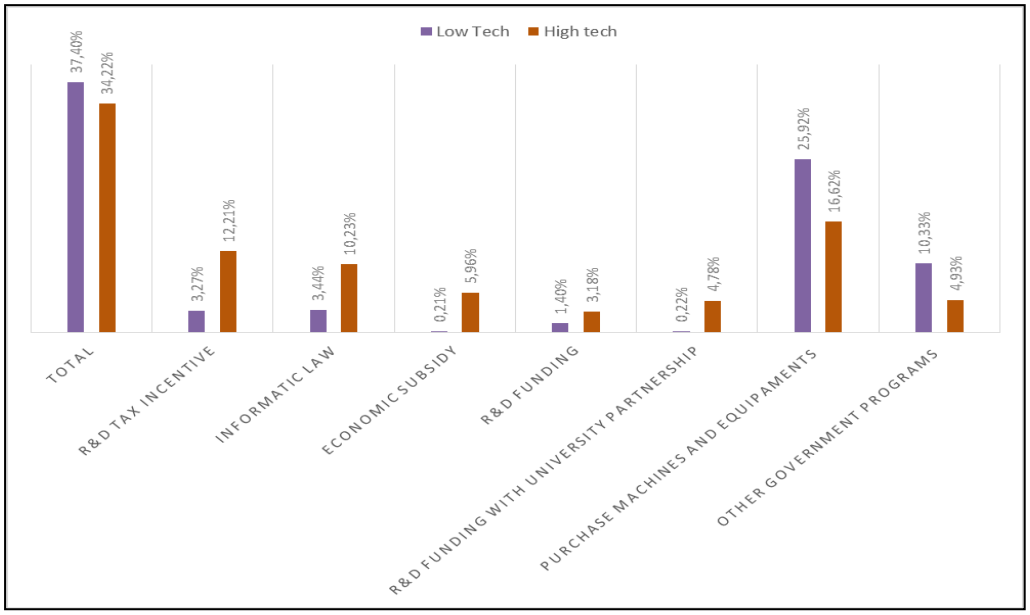


Figure 7 – Government Funding by Technological Intensity
Source: Own Elaboration, with data of Pintec (IBGE, 2011).

Now, we pass to present the results obtained with the correspondence analysis, beginning with the general segmentation of the researched industries based on all the variables of interest (Figure 8) and after we present the results of each "group" of analysis: innovation rate, sources of information and government funding.

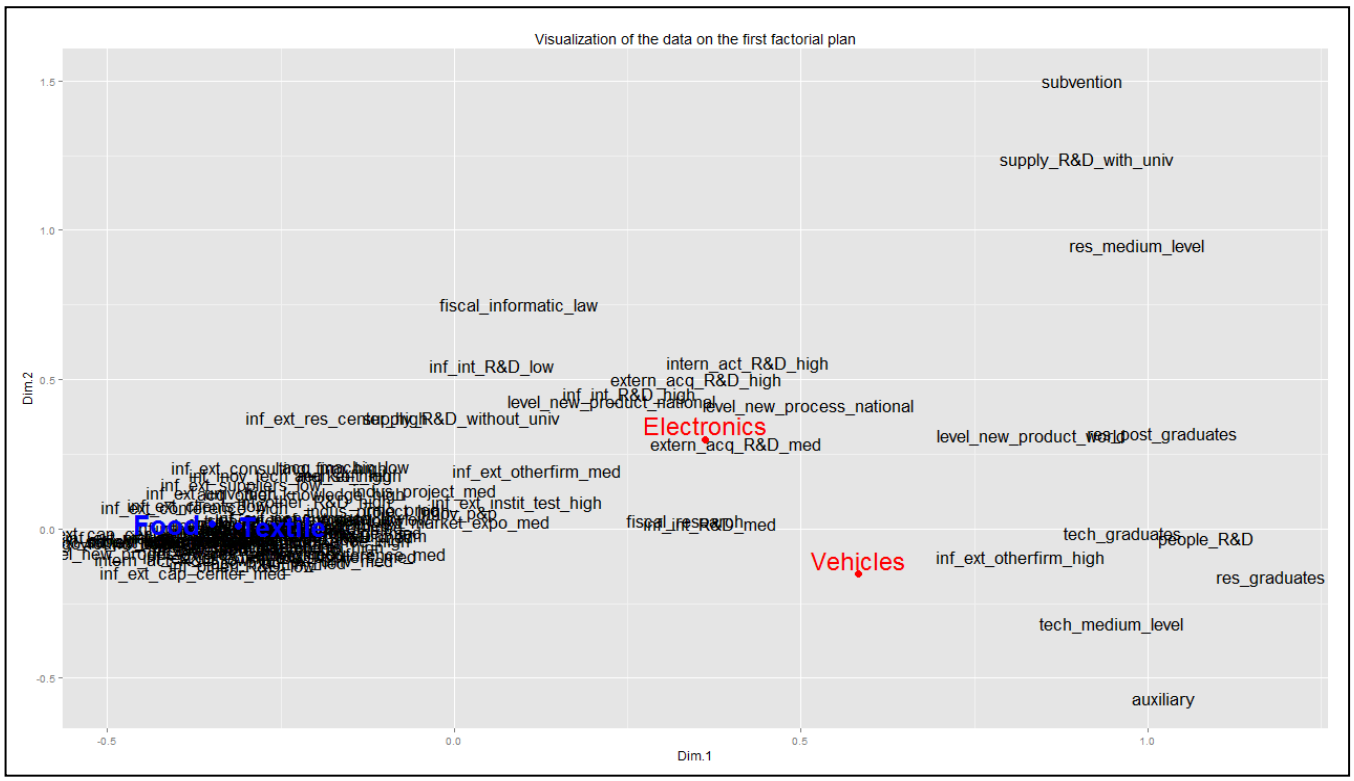


Figure 8 – Correspondence Analysis - General Results
Source: Own Elaboration.

The two first dimensions represents more than 97% (89.2% for the first dimension, 8.2 for the second) of the initial information, we will then analyze only the first plan. On the first dimension, the food and textile industries are very close of each other with negative coordinates whereas the electronics and vehicles industries have positive coordinates and are close of each other. Thus, we have already a clear separation between high-tech and low-tech. The second dimension doesn't give information on food or textile industry but separate the vehicles industry (negative coordinates) of the electronics one (positive coordinates).

This first dimension opposes two patterns of firms:

Pattern 1 (positive coordinates) is characterized by people dedicated exclusively in R&D (whatever the qualification or study level), by innovation in product and novelty of the product at an international level and a high external acquisition of R&D. This pattern is also characterized by incentive tax for R&D and by a high level of extern information coming from other firms.

Pattern 2 (negative coordinates) is characterized by innovation in process, with novelty of the process at an international level but also at firm level, by low internal activity of R&D and low external acquisition of R&D. This pattern represents firms with acquisition of software, machine and training (whatever the level of the acquisition: high, medium or low). This pattern is also characterized by government funding and particularly "supply to buy machine" and "other funding".

The electronics and vehicles industries have a profile similar to the pattern 1 whereas food and textile industries have a profile similar to the pattern 2.

Analyzing these results in term of group of industries (low-tech or high-tech), the pattern 1 seems to describe the low-tech firms and the pattern 2 the high-tech ones.

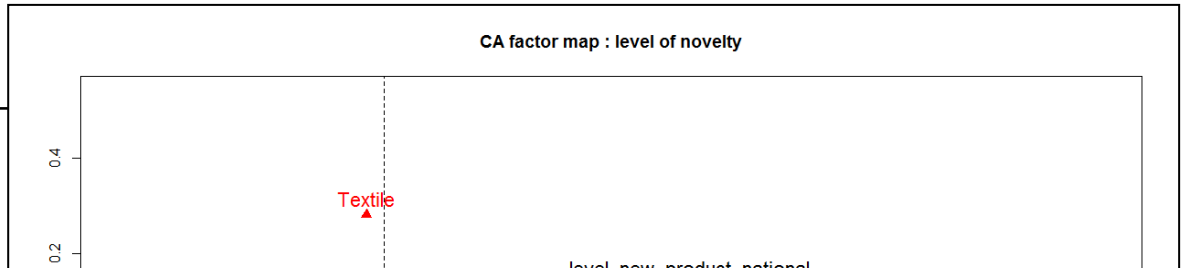


Figure 9 – Correspondence Analysis - Innovation novelty
Source: Own Elaboration.

On the first dimension, food and textile have similar negatives coordinates, vehicles and electronics industries are at different level but both with positive coordinates. The second dimension separates the textile industry of the automobile industry but doesn't give information about the two other.

The first dimension shows that food industry is characterized by novelty in process at firm and world level whereas the vehicles and electronics industries are characterized by innovation in product at national and world level but also innovation in process at national level.

The second dimension separate textile industry, with innovation in process at firm level of the vehicle industry with innovation in product at firm level.

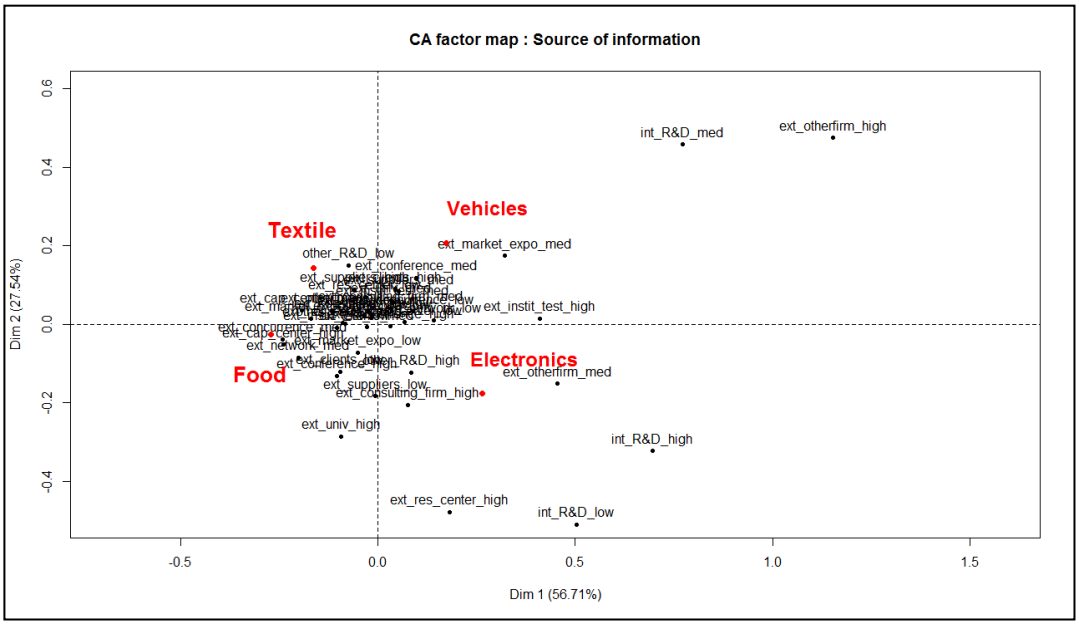


Figure 10 – Correspondence Analysis - Sources of information
Source: Own Elaboration.

The Figure 10 presents that on the first dimension, Food and textile industries have similar negative coordinates and vehicles and electronics industries similar positive coordinates. The second dimension separates the electronic industry of the textiles and vehicles industries. This second dimension will then give information not related to the level of technological intensity.

The first dimension shows that high-tech firms is characterized by these sources of information: internal R&D, high external source from other firms, low external sources from capacity center, high external source from test institutions, and low external sources from network.

The low-tech firms are characterized by: low external sources from other firms, medium external sources from clients and concurrence, high external source from capacity center and high external sources from market exposition and network.

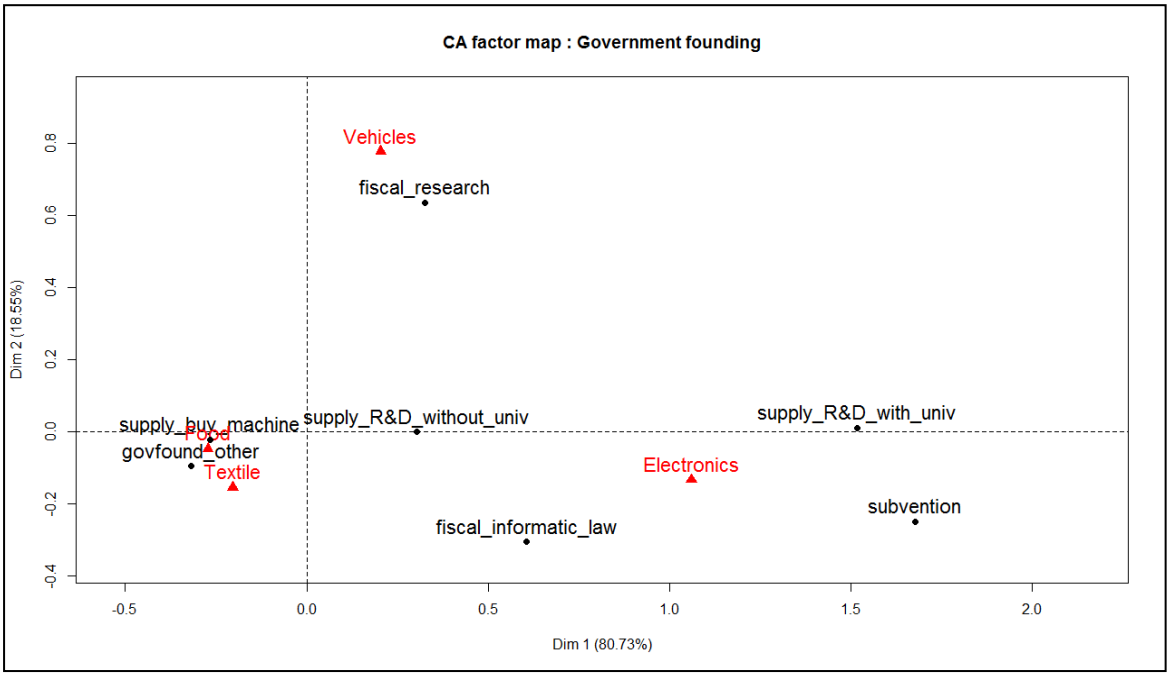


Figure 11 – Correspondence Analysis - Government funding
Source: Own Elaboration.

On the first dimension, food and textile have similar negatives coordinates, vehicles and electronics industries are at different level but both with positive coordinates. The second dimension separates the vehicle industry from the others and will not be developed because it does not seem relevant for this dissertation.

The first dimension separates high-tech firms – and particularly electronic- with funding coming from tax incentives (informatics law), funding to support R&D project -with or without university partnership- and economical subvention.

Low-tech firms having received funding in order to buy machine and other type of government support.

Final Considerations

Now, from the results obtained in the descriptive statistics and correspondence analysis, we present the main findings of the research. In addition, we present the theoretical and managerial implications arising from the research results. Finally, the limitations of the study are presented, in addition with some recommendations, in order to direct future studies that match with the theme.

The results about the analysis of type of innovations show that high-tech firms clearly innovate more in product whereas low-tech firms innovate more in process. This result is also confirmed by the fact that the two industries (textile and food) in the low-tech group are more related to process innovations at world and firm level and process (vehicles and electronics)in the high-tech group are related to product innovations at world and national level but also to process innovations at national level.

Hence, we can conclude that the type of innovation (product and/or process) is a major differentiation factor in the direction of innovation between low-tech and high-tech industries.

Regarding the relationship between qualification of workers and R&D intensity, we have confirmed that there

are major differences between high-tech and low-tech industries. The first presents a higher level of employees occupied in R&D, with exclusive or partial dedication. It presents more skilled than unskilled workers occupied in R&D.

Thus, we can affirm the positive relationship between qualification of workers among low-tech and high-tech industries.

The results also confirmed that the low-tech industries have weak in-house R&D capabilities; they rely on the competences of external technology suppliers in order to produce a product as cheaply as possible, or a design-intensive product. It confirms that the firms at the core of low-tech industries might be shaped by the Pavitt (1984) taxonomy. The low-tech, then, are mainly characterized by process innovations by weak internal activity of R&D, lower external acquisition of R&D and a high external provision of machines, equipment and software. The high-tech industries, in turn, innovate mainly through their internal R&D laboratories.

Regarding sources of information, high-tech industries are characterized by the intensive use of the internal R&D department, but the main and relevant external sources of information are: customers or clients; competitors; consulting firms; research institutes or technological centers and institutes of certifications and another group company. Low-tech industries give low importance for sources of information from another firms and medium importance for clients and competitors. The relevant sources of information for its firms are: suppliers and capacity centers; fairs and exhibitions; and conferences, meetings and socialized publications.

Regarding the government funding and tax incentives for research we have confirmed that the Brazilian government, in the researched period, were more utilized by high-tech sector than in the low-tech sector.

However, it seems that the effect of government funding is significant for the low-tech industries. The high proportion accessed from low-tech sector to buy machines and equipment and other government programs make the percentage of government support superior for low-tech industries while it was not so meaningful for the high-tech industries.

From the discussion above, we stress as the main conclusions:

- Low-tech industries innovate more in the process and have fewer people dedicated in R&D. The most significant source of information is their suppliers and they are large users in funding for the purchase of machinery and equipment.

- High-tech industries are more innovative in products and have more people dedicated in the R&D department. Firms in High-tech industries look for information on other groups of firms, customers and competitors. In addition, they also obtain more government tax incentives to invest in R&D.

We stress that the major limitation of this study is that we could not work with the non-aggregated data from IBGE. With them, the researcher could include in his/her methodology a greater number of analytical techniques from the data base to find more explicative results.

Also, as this research is aimed to contribute to the understanding of the patterns of innovation in different groups of industries by technological intensity, considering these factors and results, it is possible to make decisions at a national level in order to encourage technological innovation and promote the Brazilian economic development, as well as,at the firm level, to demonstrate how different determinants of innovation act and influence the innovative intensity of firms.

Still based on the results obtained by this research, some managerial implications are proposed which can assist in making decisions of public and private organizations for the innovation concerns. For low-tech companies, it is necessary to connect more systematically the sources of knowledge in order to seek new solutions and develop new products that make them more competitive. However, it is essential that these companies improve their ability to absorb external knowledge, either by intensification of R&D or hiring more skilled people (e.g., masters and doctors).

The low-tech companies also have to improve external partnerships with customers, suppliers, research centers and universities, among others.

It is indispensable to promote a greater participation of all sectors to reach the government support for R&D in Brazil. About half of the funds invested in innovative activities are aimed at the acquisition of machinery and equipment, which is widely used by low-tech industries.

Secondly, tax incentives and informatic law are used most by high-tech companies. The percentage of firms that used tax incentives for realization of innovations is very small. When the entire industry is considered, only about 1% of companies received incentives from the Informatics Law. Only 0.7% of the Brazilian companies that innovated received tax incentives for R&D.

Government initiatives, such as those conducted by the BNDES and FINEP, have a fundamental role to the growth rate of innovation of the Brazilian companies. It is expected that the Government work towards not only stimulating access to credit in the economy, but also enabling the reduction of the cost and increasing the term to finance R&D.

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