Propensity to Patent Brazilian Companies: importance of Economic and Financial Performance

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Abstract— The innovation process is a global phenomenon that affects the economic sectors, especially the companies. Patents help in the process of business competitiveness and serve as a business strategy. The objective of this paper was to investigate how the economic and financial factors affect the decision to deposit patents of publicly traded companies listed on the stock exchange Brasil, Bolsa, Balcão (B3). The data used are a fusion of the information provided by two sources: patent data provided by the National Institute of Industrial Property (INPI) and company data of the financial information system of the B3 Stock Exchange, in the period from 2010 to 2017. The data were analyzed using descriptive statistics and the logit econometric model. The results indicate that the companies with greater propensity to patent are characterized as being large, with lower general and short term indebtedness and with lower overall liquidity, together with a higher potential of the asset add value. They are also more likely to be assignor and assignees of technology transfer contracts, in addition to being generally in sectors of high or low technological intensity. The results also show that financial performance indicators have a significant negative impact on the probability of a company filing a patent application.

Keywords— industrial property, innovation, stock exchange.

I.   INTRODUCTION

Analyzing the indexes of innovation and protection of intellectual property, Brazil has inferior positions when compared to international ones. In 2018, according to the ranking of the Global Innovation Index (GII), developed in partnership between Cornell University, INSEAD and the World Intellectual Property Organization (WIPO), Brazil ranked 64th [1]. Regarding the Intellectual Property Protection Index (IPPI), according to the World Economic Forum, the country was in the 77th position among the 140 countries analyzed [2].

Brazilian companies have reduced participation among the leading patent filing organizations in the country. In a survey of the Foundation for Research Support of the State of São Paulo (FAPESP), 9 of the 15 leading organizations in the period 2000-2005 were companies, a figure that reduced to three in the 2013-2017 list [3]. Considering only 2017, the INPI report, which refers to the ranking of the ten main patent depositors resident in the country, only one company was included in the group, ranking 7th [4].

Brazil has low performance in the world rankings of innovation and presents a reduction of the participation of the companies among the main patent applicants in the country, in spite of the growth of the deposits. In this sense, it is necessary to understand how the economic and financial factors alter the propensity to patent the companies, that is, how these factors influence the probability of the company to patent. The patent is an industrial title of invention or utility model. The basic function of a patent, originally established by the intellectual property system, is to provide an effective instrument to prevent imitation by competitors. This can guarantee gains of innovative technologies for the inventor and cover their expenses [5].

The decisive factors in deciding whether or not firms have patents has been the subject of several studies, however, little attention has been given to economic and financial performance indicators. Data obtained from companies in the Netherlands from 1988 to 1992 allowed the identification of propensity to patent and how it varies between companies of different sizes and sectors, concluding that small firms are less likely to deposit patents and the sectors pharmaceuticals, chemicals and precision instruments is more likely to patent [6]. It has also been identified that the innovative effort and the degree of innovation codification affect the probability of

the company depositing patents through analyzes carried out in industrial companies in Spain [7].

Studies carried out with primary data in Belgium for the year 2001 indicate that the propensity to patent is affected by company characteristics (age, size, foreign subsidiary and degree of internationalization), sector characteristics (sector concentration, high-tech sector, service sector) and innovation strategy (new product or processes development, basic and applied research, collaboration partners). It was found that firms that have innovation strategies through partnerships are the ones that are most likely to patent [8].

Analyzing the food and beverage industry in the United States between 2000 and 2014, with variables of company characteristics (age and size) and financial characteristics (lagged income and debt ratio), it was concluded that the size, age and lagged income has a positive effect on the propensity to patent [9].

In general, the factors that influence a company's decision to patent an innovation vary among firms, industries and countries. The firms' propensity to patent is influenced by internal factors such as size, knowledge codified, internal R&D, firm's age, type of patent, and productivity output, and by external factors, such as international market, high price competition, collaboration with other entity and clustering area [10].

This article contributes the state of the art to determinants of propensity to patent in at least three different aspects. This article contributes the state of the art on patent application determinants in at least three different aspects. First, it reduced the lack of research on the relationship between economic and financial performance and the probability filing corporate patents. A second aspect is the construction of a new database that aggregates patent information with the companies' accounting statements. This allows the calculation of economic and financial performance indicators of companies in the Brazilian stock market. Finally, it complements the literature with data from Brazil, since previous studies are based mainly on data from North American or European companies. In this context, the objective of this study was to investigate how economic and financial factors affect the decision of companies to deposit patents.

In the econometric results the financial performance indicators had a significant impact on the probability of a company filing a patent, indicating that this factor should be better studied by studies in which the determinants of the propensity to patent the firms are investigated. Among the indicators of economic performance, measured productivity was the only one that had a positive and significant effect.

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1.1 Hypotheses

The variables of economic and financial performance are accounting indicators that make it possible to analyze the company's situation in five aspects: liquidity, indebtedness, profitability, intangibility and productivity. To answer the problem question of how economic and financial performance indicators influence the propensity to patent companies, the following hypotheses have been constructed.

H1: Liquidity negatively influences the propensity to patent.

Liquidity refers to the ease with which a company can meet its financial obligations with available assets. Current Liquidity and General Liquidity index are used to measure liquidity. There are few empirical studies that investigate how liquidity relates to patent filing. However, it is noted that the increase in the liquidity of a company's shares causes a reduction in future innovation [11]. Thus, it is expected that the higher the accounting liquidity indices the lower the likelihood of filing patents.

H2: Indebtedness negatively influences the propensity to patent.

The General Debt Ratio and Short-term Debt Ratio indexes are used to capture corporate indebtedness. Companies that face high levels of indebtedness will find it more difficult to obtain financing and resources to apply for innovation and patent deposit because of the risky investment type [12], [13]. In this way, the indebtedness indexes are expected to have a negative relation to patent application.

H3: Profitability positively influences the propensity to patent.

The profitability of companies is measured by the Return on Asset (ROA) and Return on Equity (ROE) indexes. The relationship between profitability and corporate patent application is still not well established. While studies point out that firms' innovation activities, such as patent applications, are not necessarily associated with higher profitability [14], other studies indicate that profitability positively influences patent citation, and presents a mechanism that also explains the influence profitability on the patent application [15].

H4: Intangibility positively influences propensity to patent

Intangibility refers to the share of intangible assets in the company's investment structure. In Brazil, the Accounting Pronouncements Committee, based on the International Accounting Standard (IAS) 38 [16], establishes the accounting standard regarding the recognition and

measurement of intangible assets. According to this standard, the intangible asset is defined as a non-monetary, identifiable and non-physical asset. For an asset to be identifiable, it must be separable, and can be negotiated on an individual basis, and be the result of contractual rights. The concept of identifiable assets is mainly necessary to distinguish intangible assets from goodwill, which represent advantages that are not specifically identifiable [17].

There are many possibilities of investing in intangible assets by companies, such as softwares, patents, copyrights, trademarks, customer lists, licenses, franchises, among others. In all possibilities, knowledge is always linked to assets. However, to qualify for intangible assets, they should be identifiable, controlled and generate future economic benefits [16].

The Asset Intangibility (AI) and Equity Intangibility (EI) indexes measure the share of intangible assets in the company's capital. The intangible assets represent the stock of immaterial resources that characterize the process of production of new products or processes, and are therefore directly related to the innovation capacity of companies [18]. In this way, intangibility is expected to positively influence the probability of patent applications.

H5: Productivity positively influences the propensity to patent.

Firm productivity is expected to be positively related to patent filing [19]. More productive companies usually have more specific internal knowledge that can be protected by patent deposits. The Equity's Potential to Add Value and the Asset's Potential to Add Value indexes are used to measure corporate productivity. Figure 1 presents a research framework related to the aforementioned hypotheses.
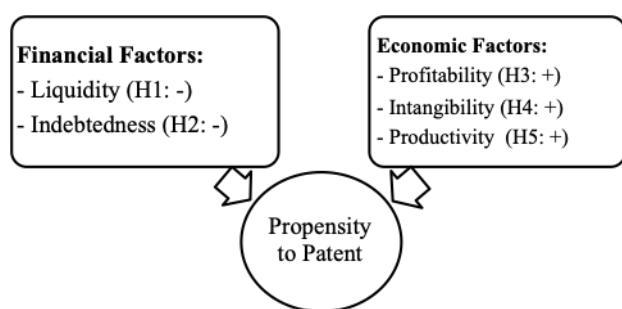

Fig1: Research framework of financial and economic factors in the propensity to patent companies.

1.2 Control Variables

Other variables are likely to influence the propensity to patent. The control variables used in this study are whether companies have a technology transfer contract as assignor or assignee and technology intensity sector, as well as their age and size.

Two main reasons are usually presented to explain why patent registration is positively related to company's size.

The first is that large companies have greater ability to manage information, maintain large R&D departments, and attract the best technicians and scientists. Thus, large companies introduce more often than smaller companies, original innovations that make it possible to register a patent [20], [21]. The second reason concerns the financial constraints faced by smaller firms, since the cost of patent protection - including the costs of obtaining and maintaining a record, monitoring whether a violation occurs and litigation - is relatively high for smaller firms [22].

The company's age represents the time in years of the constitution until the observed year and can be considered a factor favorable to the deposit of patents. One explanation is that the technological processes are cumulative and the time of experience favors the obtaining of innovative results that can be translated into patents [23]. Another factor is that the protection and appropriation of the value of innovation is a long-term process associated with organizational learning [24].

Technology transfer is the relationship between assignor - that transfers technology that develops or owns - and assignee - the one that gets a technology to use. Thus, assignor companies are those that assign or license intellectual property rights to other individuals, while assignee companies are those who buy or obtain a license to use the intellectual property of a third party.

It is expected that companies that have a technology transfer contracts registered with INPI, either as assignor or assignee, are more likely to hold a patent than other companies. The technological diffusion established by contracts between companies increases the competitiveness and the technological experience of both, because an innovation is being transferred and exploited. This encourages assignor and assignee firms to register their innovations through patent applications [25], [26].

The technological classification proposed by the Organization for Economic Co-operation and Development (OECD) groups the sectors of the processing industry according to their technological intensity in four categories (high, medium-high, medium-low and low). For this, the level of technology specific to the sector and the technology incorporated in the purchases of intermediate goods and capital are considered [27], [28].

II. MATERIALS AND METHODS

2.1 Sample

The analysis was based on administrative data from companies listed on the Brazil Stock Exchange B3, formerly *BM&FBovespa*, which are combined with National Institute of Industrial Property (INPI) data covering patent applications from 2010 to 2017.

The period chosen was due to the lack of financial information on intangible assets that were not mandatory before 2010 and by 2017 being the last available year. Data source providing economic and financial information collected from balance sheets and income statements.

The sample consisted of 337 companies operating in the Brazilian stock market. Financial institutions were not included in the sample due to their own regulations and specific patrimonial characteristics, which are not comparable to other types of companies [29], [7].

2.2 Variables

To measure the variables, we used secondary sources from the B3 stock exchange and from the INPI government agency. Specifically, the variables corresponding to the company's patent deposits and technology transfer contracts were measured based on the INPI's official information. The variables related to economic and financial performance and company demographics were measured based on the accounting and administrative reports of the B3 stock exchange. The corresponding definition for each of the variables is described in Table 1.

Table.1: Variables used to evaluate firms' propensity to patent

Variable	Description
Patent Application (dependent)	Binary variable coded as "1" for the companies that deposited one or more patents in the year and "0" otherwise.
Current Liquidity	It measures the company's ability to honor its short-term obligations.
General Liquidity	It indicates the broad relationship of the company's ability to pay all of its obligations.
General Debt Ratio	It measures the degree of participation of creditors in the company's total assets.
Short-term Debt Ratio	It indicates the percentage of the debts that are short-term.
Return on Assets (ROA)	It measures the company's ability to generate profits by considering available assets.
Return on Equity (ROE)	It informs the return that the company obtained in relation to the capital invested in it.
Equity Intangibility	Represents the percentage of intangible assets in equity
Asset Intangibility	Represents the percentage of intangible assets in total assets
Equity's potential to add value	It measures value added attributable to total equity.
Asset's potential to add value	It measures value added attributable to total assets.
Size	*Ln* (total asset)
Age	Number of years from the company's incorporation to the sampled year.
Technology assignor	Binary variable coded as "1" for the companies who transfers one or more technology in the year and "0" otherwise.
Technology assignee	Binary variable coded as "1" for the companies that granted the transfer one or more technology in the year and "0" otherwise.
High technological intensity	Binary variable coded as "1" if company belongs to an industry of high or medium-high technology industries and "0" otherwise.
Low technological intensity	Binary variable coded as "1" if company belongs to an industry of medium-low or low technology industries and "0" otherwise.

Financial performance represents the repayment capacity that companies present in relation to their creditors and is formed by the groups of liquidity and indebtedness. In turn, economic performance refers to equity variations and wealth generation over time and is composed of profitability, intangibility and productivity groups [30], [31].

Based on the OECD's technological classification, this study groups the four categories into two only to identify the technology sector of companies (it uses the term "high intensity" for high and medium-high intensity, and "low intensity" for medium- low and low intensity). Thus, companies that are in the high or medium-high sectors were classified as high technological intensity. And companies in the mid-low and low sectors were classified as low technological intensity.

2.3 Model

In order to investigate how the economic-financial variables influence the decision of a company to deposit or not patents, a discrete-choice econometric modeling was presented for variables of a binary nature. This modeling is generally applied to firms' patent applications [9], [8], [6]. The logistic regression model (logit model) is used to estimate the probability of a patent application occurring given the values of the explanatory variables of the company:

$$P(y_{it} = 1 | x_{it}) = F(\beta' x_{it}) \tag{1}$$

where:

P(y_{it}=$1/x_{it}$) is the probability of firm i having one or more patent filing requests in year t;

y_{it} is the binary variable that is equal to 1 if there is one or more patent filing application and 0 otherwise;

x_{it} is the vector of explanatory variables for firm i in year t;

β is the parameter vector to be estimated;

F denotes the logistic function which ensures that the estimated probabilities are strictly between zero and one.

The model assumes that the expected return y_{it}^* of depositing at least one patent for firm i in year t is influenced by a set of explanatory variables x_{it}:

$$y_{it}^* = \beta'x_{it} + \varepsilon_{it} \qquad (2)$$

where:

y_{it}^* is the latent variable that represents the expected return;

ε_{it} is the stochastic error term.

Although the return y_{it}^* is not observed, the variation in the company's patent deposit is observed and is related to the expected return as follows:

$$y_{it} = \begin{cases} 1 \ se \ y_{it}^* > 0 \\ 0 \ se \ y_{it}^* \le 0 \end{cases} \qquad (3)$$

In this way, it is assumed that when the expected return of depositing a patent is positive, the company decides on the deposit. Although the data structure is in panel, the model is estimated with grouped data and maximum likelihood. The pooled model was chosen for analysis in the present study because the data are extremely unbalanced, e.g., some companies exist only one observation.

III.   RESULTS AND DISCUSSION

The descriptive statistics for the variables are shown in Table 1. It can be noted that of the total number of publicly traded companies analyzed, an average of 11% deposited one or more patent applications per year.

In the United Kingdom during the period 1998-2006 only 1.6% of all registered companies had at least one patent. Even in high-tech industrial sectors, the share of firms that deposit patents in the UK does not exceed 10% [32].

An explanation for why the percentage of companies with patents on the Brazilian stock exchange (11%) is greater than that found for the United Kingdom occurs because of the samples used. Whereas, in the last mentioned country the sample represents all the companies of the United Kingdom, in this study the sample represents only companies of Brazil that have shares traded in the stock exchange.

When comparing the use of formal contracts for transfer of technology registered at INPI, it should be noted that B3 companies classified as assignor, that is, that licensed some intellectual property, accounted for 8% of the sample.

For the assignee companies, those who bought the right or the license to exploit some intellectual property registry with the INPI, have a representation of 37% in the sample, a higher percentage when compared to the assignor companies. This discrepancy between the percentage of companies assignee (37%) and assignor (8%) indicates that most companies in the Brazilian stock exchange prefer to buy the right or license to use a registered technology, rather than to develop innovation.

Comparing the economic-financial variables, it can be seen that for the Equity Intangibility, Current Liquidity, ROA, ROE, Short-term Debt Ratio and Equity's Potential to Add Value indexes, the standard deviation is three times or more the mean value, indicating that there is a large discrepancy between the companies that found in the sample. Although the average age of companies is 35.71 years, which refers to the period of incorporation of the company up to the present, there are newly incorporated companies, such as Movida SA, to 126-year-old companies such as CIA Tecidos Santanense .

Table 1: Summary of the variables studied of Brazilian publicly traded companies, regarding the propensity to patent.

Variable	Mean	S.Dev.	Min.	Max.
Patent Application	0.11	0.31	0	1
Current Liquidity	37.14	1146.9	0.005	39077
General Liquidity	2.09	2.26	0.01	31.29
General Debt Ratio	0.45	0.22	1.3e-07	1
Short-term Debt Ratio	0.86	2.52	0.03	70.37
Return on Assets (ROA)	-0.01	0.49	-11.19	11.89
Return on Equity (ROE)	0.14	2.19	-15.17	75
Equity Intangibility	0.62	2.08	-25.4	44.56
Asset Intangibility	0.17	0.23	0	0.97
Equity's Potential to Add Value	0.86	2.52	0.03	70.37
Asset's Potential to Add Value	0.31	0.48	-7.18	15.68
Size	14.38	2.09	3.25	20.62
Age	35.71	25.84	0	126
Technology Assignor	0.08	0.28	0	1

Technology Assignee	0.37	0.48	0	1
High Technological Intensity	0.11	0.31	0	1
Low Technological Intensity	0.21	0.41	0	1

Table 1 also shows the proportion of firms in the high and low technology sectors according to the OECD (Organization for Economic Co-operation and Development) classification. It is observed that 32% of the companies are in sectors of high or low technological intensity, while the other companies, which represent 78% of the sample, do not fall into either category. This is expected given that the OECD classification groups only the sectors of the manufacturing industry as can be seen in [33] e [28].

Table 2: Distribution of Brazilian publicly traded companies and the propensity to patent by sectors - period 2010 to 2017

Sector	Num. of companies (% of total) A	Num. of companies with one or more patents (% of total) B	Propensity to patent C= B/A
Capital Goods and Services	71 (21.6)	15 (20.3)	0.21
Consumer Cyclical	80 (24.4)	5 (6.8)	0.06
Consumer non-Cyclical	25 (7.6)	7 (9.5)	0.28
Basic Materials	31 (9.5)	12 (16.2)	0.39
Others	16 (4.9)	0 (0)	0.00
Oil, Gas and Biofuels	11 (3.4)	1 (1.4)	0.09
Health	19 (5.8)	3 (4.1)	0.16
Information Technology	7 (2.1)	3 (4.1)	0.43
Telecommunications	5 (1.5)	0 (0)	0.00
Utilities	63 (19.2)	28 (37.8)	0.44
Total	328 (100)	74 (100)	0.22

Note: B3's industry classification structure.

Table 2 shows the distribution of firms and the propensity to patent by sectors for the period 2010-2017. The first finding is that most publicly traded companies listed on B3 are not involved in official patent registration. Of the 328 companies in the sample, only 74 filed one or more patents during the period 2010-2017, which creates a propensity to patent of 0.22, i.e. out of every 100 companies in B3, it is expected that only 22 of these companies patent.

Analyzing the distribution, it stands out that the Cyclical Consumption sector concentrates the majority of the companies, with almost 25%. However, considering only the companies with one or more patent deposited, the same sector concentrates less than 7%. Consequently, the data suggest that manufacturers of cyclical consumer goods do not necessarily depend on official patent registration for creation, protection or value appropriation, which is indicative of price-versus-quality competition [34].

It should also be noted that the Public Utility, Information Technology and Basic Materials sectors are the ones that present the highest estimates for the probability of filing patents, with 0.44, 0.43 and 0.39. The Public Utilities sector is comprised of the Water and Sanitation, Electric Energy and Gas subsectors. Following this, the Basic Materials sector is composed of the Sub-sectors of Packaging, Wood and Paper, Chemicals, Mining and Steel and Metallurgy.

3.1 Econometric Modeling

The propensity to patent is studied in terms of patents filed and aims to identify how the specific characteristics of companies influence the decision to deposit or not patent with the official body of registration of intellectual property INPI. Thus, the logit regression clustered model was chosen since the dependent variable deposited patent consists of a binary variable with value 1 for companies that have one or more patent filing in the year and the value 0 for corporations without filing in the year.

Table 3 presents the results of the logistic model estimation. Because the model is nonlinear, the estimated coefficients only indicate whether an explanatory variable has a positive or negative impact on the probability of filing a patent. The mean marginal effect measures the change in probability when the explanatory variable increases by one unit, thus providing an interpretation similar to that used in linear models.

According to the results of the logit model, the firms with the highest propensity to patent are characterized by their large size and lower general and short-term indebtedness and lower overall liquidity, together with a greater potential to generate wealth through assets . They are also more likely to be transferors and assignees of technology transfer contracts, in addition to being generally in sectors of high or low technological intensity.

Analyzing the marginal effect of the variables, we can observe that the economic-financial indicators were statistically significant and presented the following

variables: (a) greater marginal effects when compared to the other variables of the model. This shows the importance of the company's capital structure in the decision to file a patent.

Table 3: Results of the logit model estimation with clustered data for Brazilian companies in the stock exchange regarding the propensity to patent

Explanatory Variables	Coefficients	Marginal effects
Constant	-5.532***	-
	(1.886)	
Current Liquidity	-0.079	-0.006
	(0.111)	
General Liquidity	-1.181***	-0.086***
	(0.418)	
General Debt Ratio	-2.982***	-0.217***
	(0.601)	
Short-term Debt Ratio	-4.863***	-0.353***
	(1.375)	
Return on Assets (ROA)	1.170	0.085
	(1.146)	
Return on Equity (ROE)	-0.004	0.000
	(0.148)	
Asset Intangibility	0.435	0.032
	(0.498)	
Equity Intangibility	-0.094	-0.007
	(0.101)	
Asset's Potential to Add Value	1.886***	0.137***
	(0.410)	
Equity's Potential to Add Value	-0.003	0.000
	(0.022)	
Age	-0.002	0.000
	(0.004)	
Size	0.540***	0.039***
	(0.059)	
Technology assignor	0.408*	0.030*
	(0.231)	
Technology assignee	0.911***	0.066***
	(0.173)	
High technological intensity	2.465***	0.179***
	(0.262)	
Low technological intensity	0.689***	0.050***
	(0.218)	
Number of observations	2269	
McFadden's Pseudo R^2	0.341	
Nagelkerke's Pseudo R^2	0.419	
Percent correctly predicted:		
for file patent application (y = 1)	58.333	
for non-file patent application (y=0)	91.767	
for all observations	90.176	

It should be noted that profitability (ROA and ROE) and intangibility indicators (Asset's Potential to Add Value and Equity's Potential to Add Value) presented insignificant marginal effects, indicating that the level of profitability and intangibility of the company has no influence on the process of registration of intellectual property by means of a patent.

An explanation for intangibility has no impact on the probability of filing patents may be the fact that the companies listed on the Brazilian stock exchange are reporting in the financial statements amounts of intangible assets that do not conform to the official standard of the Accounting Pronouncements Committee [25], [35].

The size of the firm, measured by the logarithm of total assets, showed a positive relation with the propensity to patent, that is, everything else constant, the probability of filing a patent increases with the size of the company. This corroborates the hypothesis that, for smaller companies, high costs may discourage the use of the official INPI patent register..

One way to evaluate the performance of logit model is to allow the prediction of which companies must deposit patents in a given year and comparing this prediction with the actual patent applications. The last lines of Table 3 denoted as "hit percentage" shows the percentage of firms in the sample that were correctly classified by the logit regression as possessing or not patent filing. In spite of only 50.6% accuracy for companies with patent deposits, the model had more than 92% in relation to companies that did not file a patent.

IV. CONCLUSION

This paper provides an analysis of the determinants of a company's patenting decision and assesses the implications for the official intellectual property protection system. The analysis is based on a new integrated dataset that combines a variety of sources by forming a dashboard with information at the firm level.

The descriptive analysis shows that, on average, only 10% of the non-financial companies listed in Brazil's Bolsa Balcão (B3) filed at least one patent application per year. In particular, considering all the period from 2010 to 2017, companies that have one or more patents in the period represent only 22% of the sample, indicating that they are generally the same companies that are depositing patents with the INPI, with low annual turnover between depositors.

When analyzing the characteristics of the companies that influence the decision to deposit or not patent, it is found that the companies with greater propensity to patent are characterized by being large and have lower general and short term indebtedness and lower liquidity general, along with a greater potential to generate wealth through the

asset. They are also more likely to be transferors and assignees of technology transfer contracts, in addition to being generally in sectors of high or low technological intensity.

One explanation for the fact that so few companies patent, even if it restricts only listed non-financial corporations listed in B3, is that companies may consider the use of the official IP system to be very expensive, since the use of any mechanism of intellectual property protection costs companies time and money, and in the case of patents, the expected benefits may not exceed the patent filing costs with the INPI.

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