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THE RELATIONSHIP BETWEEN PATENTS AND THE INCREASE OF INCOME IN INNOVATIVE COMPANIES

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1. INTRODUCTION

Thirty years ago, researches on patenting were not conducted with the same speed and methods available today. However, with the arrival of computers and Internet, the volume and dynamics to execute patenting researches have expressively increased (Baudour & Kuilen, 2015). As economies around the world change and evolve, the creation of new business models and, mainly, the technological advances in this last decade, patents applications took a different turn concerning the actors involved in this process, such as the main patenting offices, research companies and collaboration networks.

Application patents are part of the final stage of new products development process in which is the direction of our study, being essential to improve enterprises potential. In the last couple of decades, the process of product development has gone through modifications (Wang, Yeh & Chu 2016) and the success of a new product design or process aims to bring profits, knowledge, competences and the return of the investment in long term. (Yan & Wagner, 2017).

Product development is one of the aims of Research and Development (R&D). Arora, Ceccagnoli & Cohen (2008) state that patents results are positives in companies with specific sectors and sizes, especially in industry, where patent application stimulates the R&D cycle. Heikkilä & Lorenz (2017) highlight that the patenting system is one of the great incentives for innovation development, establishing itself as a valuable tool centralizing both technical specifications and innovation pattern.

Although there are divergences in interpretation over the rate growth of incomes in patents investing companies, Heikkilä & Lorenz (2017) reinforce the relevance of the patenting system, arguing that it is totally connected to the development and productivity of a country. For Chu & Cozzi (2018), subsidies destined to R&D and patents application increase companies incomes and disseminate innovation, but, on the other hand, there are strong indications of income inequity in the internal market of the patent application country. For Maskus, Milani & Neumann (2018), the more patents application, the greater increase in innovation and return of investments in R&D. Isguder (2017), also emphasizes that patents application generates part of the return in investment in R&D.

Altuzarra (2018) describes R&D as an important base for creating innovation through patents. The theme R&D and patents has a higher explanatory relevance in organizations operating in medium-low and low technology industries, more than in organizations belonging to high and medium-high technology industries (Altuzarra, 2018) and the reverse causality is more intense amongst enterprises of high and medium-high technology.

Through Chu & Cozzi (2018) recent study, the relevance of research and development (R&D) is highlighted for the technology generation and progress, mostly for the premise of economic growth for the patent's application holders. Rassenfosse, Guellec, & de la Potterie (2008) and Moehrle, Walter, & Wustmans (2017), corroborate with the study that patent licensing is a factor fomenting income growth for companies, besides being one of the main differentials of major industries investing in R&D.

In this sense, the aim of this paper is to investigate the relationship between the number of patents and the increase of income, as well as to verify the lag between patents application and

income. On the following sections of this paper are presented: theoretical foundation, methodology, results and the conclusion.

2. THEORETICAL FOUNDATION

The theoretical foundation presented in this section is about Innovation and Patents, Research and Development and Design of Product Development, detailed in the following subsections.

2.1. Innovation and patents

Patents can defend enterprises inventions and generate economic benefits (Nonaka et al., 2014). Therefore, they aim to protect an invention against imitation and a variety of other functions, such as, to generate income through licensing, as well as to collect information from competitors (Moehrle, Walter, & Wustmans, 2017).

Rassenfosse, Guellec, & de la Potterie (2008) investigate the motivations for patenting by companies and they conclude that, regardless of the country, industry or company characteristics, the main reason for patenting is to avoid imitation. Technological performance is measured by patent requests and patent request quote weighted (Czarnitzki & Hussinger, 2018). Another finding is the defensive patenting, where companies patent to preserve their operational liberty and pecuniary motivations, specially in biotechnology, pharmaceutical and computing industries.

There are many inventions that resulted in marketable innovations, and in this sense, patents can provide protection for new products (Artz, Norman, Hatfield, & Cardinal, 2010). On the other hand, the intention of many new patents is not necessarily to protect the innovative efforts of the company but to perform a strategic role for its competitiveness. (Artz et al., 2010). There are companies choosing to buy patents as a way to increase its intellectual property; however, this option barely increases the company experience in R&D (F.-J. Hsu, Chen, Chen, & Wang, 2013).

Patents as a competitive positioning combined with expanding courts of what can be patented has led many companies to patent things that, sometimes, have none or little impact on their performance (Artz et al., 2010). In this sense, some investments in inventions show decreasing returns but are still being made because part of portfolio value depends on including new patented inventions (Gambardella, Harhoff, & Verspagen, 2017).

A sector benefiting from patent ownership is e-commerce, having valuable business processes. One patent of quality business method is considered a powerful and efficient tool to generate income and prevent competitors to copy the same practices (Hsu, Trappey, & Trappey, 2015). On the other hand, to understand the correlation between patents and sales income in a company dedicated to intellectual property rights in China, Li, Zhang, Yuan, Zhao, & Zhang (2015) used regression analysis methods and their results showed that there is no strong correlation between patents and sales in this particular telecom company.

Regardless of the company size, in some sectors they can benefit from patents presence. Andries & Faems (2013) study the impact of patenting on licensing, innovation and financial performance, for small and medium-sized companies as well as for large companies, demonstrating that they all benefit from commercializing products innovations, thus obtaining higher profit margins.

On the pharmaceutical sector, patents presence is so important that Jimenez (2012) conducted a study to analyze all the strategies adopted by Novartis to ensure its economic performance despite patent loss of its main medication in 2012, responsible for 20% of its income.

Ernst (2001) argues that the innovation process comprises the activities between idea conception and its marketing. The invention is the positive result of an idea generated by R&D attending technical requisites that may come to generate a patent application. In this context, he points out that the correlation between research and development (R&D), patents and several indicators of innovation success have been investigated and, in his study, he examines the relation between patent requests and subsequent changes in performance of machinery companies in Germany, concluding that the patents requests lead to a sales increase with a two- or three-year delay.

2.2. Research and development (R&D)

Literature addresses that Research and Development (R&D) influences company value, financial success, net sales and/or stock prices. The defense mechanism of intellectual property in patents form is being widely accepted as an indicator for performance measurement of R&D (Griliches, 1990).

Patents are like knowledge in stock of companies (Jones et al, 2001), that can be created from internal or external development within the company (Dirk & Hussinger, 2017), being the second option realized by the investment in R&D. It was noticed that external technology acquisition has a lower performance compared to the development of internal technologies (Dirk el at., 2017).

Technologies arising from R&D will not mandatorily transform themselves into successfully marketed products (Feng, Mu-Yen, Yu-Cheng & Wei-Chieh, 2013). Although, besides the possibility of non-successful marketing, Feng, et al (2013) state that the large investment in R&D does not influence patents generation and, moreover, it was not correlated to intellectual property influence (Hall et al, 2005), nor to the value of company stocks (Feng, et al, 2013; Hall, Jaffe, & Trajtenberg, 2005).

Disagreeing from the aforementioned authors, Jones, Lanctot, & Teegen, (2001) point out that stock value would be affected by patents, but being the moderator factor the quotes it possesses. These quotes indicate how valuable a patent is and aid investors to understand its differential factors, reflecting on market value of the holding companies, enabling to reach an increase of 3% (Jones et al, 2001).

Although Feng, et al (2013) stress that the investment in R&D influences net sales, they also signalize that stock prices are not altered, as formerly mentioned. This can be caused by the time lapse for a return on investment, occasioned by the patents (iron) period divided in two parts: the moment of patent concession and the one-year lag until it presents return (Feng, et al, 2013; Hall et al, 2005). Thus, the investment in R&D must be done in long term for its effect to be noticed in the company (Hall et al, 2005).

2.3. Product development design

The process of products development consists on phases and tasks determined by an organization to generate, design and sell the manufactured product (Ulrich & Eppinger, 1995). The process of product design collaborates so that no relevant characteristics are overlooked, establishes concrete solutions and brings forth group creativity (Sandal, Gupta, Sharma, & Kumar, 2017). Kotler (2006), highlights some factors that hinder the development of new products such as: shortage of ideas, fragmented market, social and government constraints, development cost, capital shortage, need of a shorter development time, shorter product lifespan.

The method of product development is accepted as an alteration or versioning of a business option in a marketed product (Krishnan & Ulrich, 2001). On R&D of new products, the designer must examine available information selected by several ways. One way to obtain information is through examining the existent related patents (Sandal et al., 2017). In Japan, for instance, it is possible to read the specifications of a competitor's patent and then to request its own patent, with the advantage of a better planning on the R&D approach. On the other hand, in the US, companies can only have an idea of the innovative products from the competitor application filed (Aoki & Prusa, 1996).

The research through patents base provides relevant product information, such as marketing potential, novelty options, technical information, that is, if it generates radial or incremental innovation (Sandal et al., 2017). This way, it assists on decision making to design and create the new product through patents search (Sandal et al., 2017). Moreover, it aids researchers to discover the state of the art in several fields, since 80% of all the technical information are stored and available in the patents (European Commission, 2007).

This patents-based information also assists on recognizing possible partners in co-development of new products. The joint work of a patents expert with researchers provides more precise information, allocating resources on the starting point of new products development (Sandal et al., 2017).

The development process of new products integrates the investigation process and the patented products pattern analysis. This brings positive results, because both the sources of external knowledge acquisition and the disclosures of patents base are used (Großmann et al., 2016). Still according to Großmann et al. (2016), in the products development process, there are the phases of investigation, screening of recently applied patents and pattern settings, that can be distinct on specific fields, such as potential technology acquisition. After executing the phases of investigation and analysis of relevant patents for the segment, it is necessary to set up the final phases of products development process, which includes sales and marketing strategies.

The products development process requires large interaction and constant control to provide knowledge transfer. This way, the tacit knowledge acquired must be standardized so the products development process can be added to a base (Großmann, Filipović, & Lazina, 2016). In this context, patents bases may supply technologies and information for new products generation.

We observed that, during the product development process, patents analysis facilitates new technologies development. When a company considers the use of patented standards envisioning the whole ecosystem and in long term, it knows if it should protect the technologies or not, according to **Figure 1** (Großmann et al., 2016). The development of a patent-based product must have a considerable amount of time available; therefore, the cost must be calculated according to the time invested in the product and its innovation rate (Chou & Shy, 1991).

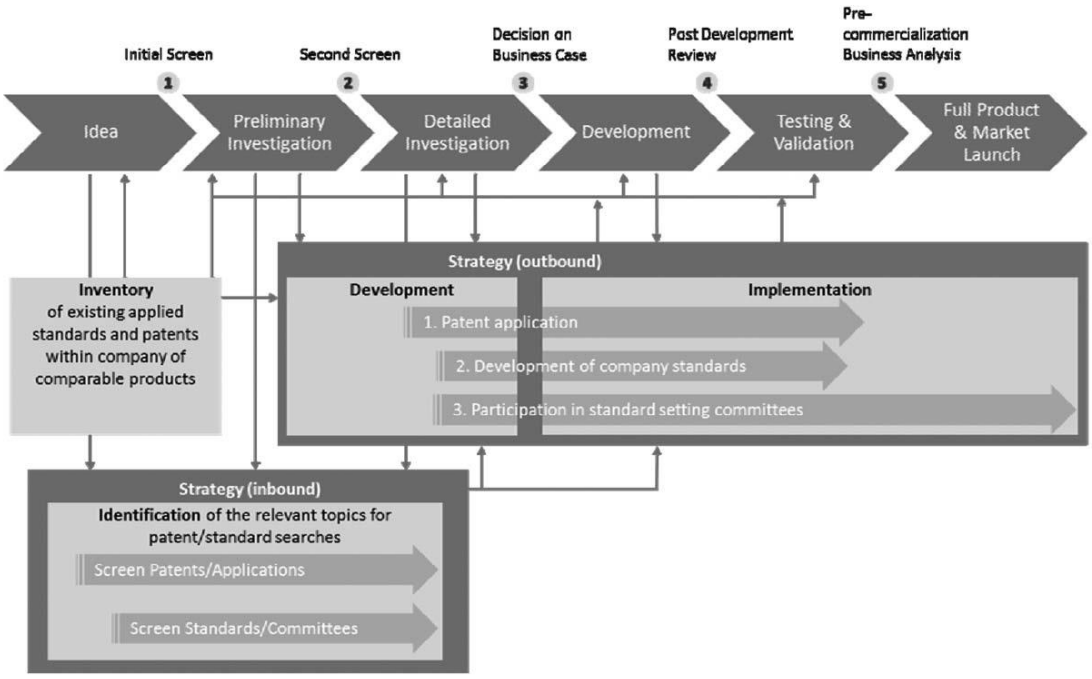

Figure 1. Process for standardization and patenting strategies along the new product development process
Source: Großmann, Filipović, & Lazina (2016)

3. METHODOLOGY

The aim of this paper is to investigate the relationship between the number of patents and the increase of income. As a secondary aim, we sought to verify the lag between patent application and income results. Thus, patents intellectual property as a sign of tangible results for manufacturing companies to obtain higher incomes, creating a profitable field of research and knowledge in its intersection.

3.1. Database

We used two secondary databases: one with the most innovative companies worldwide, according to their high investment in R&D and the other one of patents. The data used to identify innovative companies was taken from the database called Global Innovation 1000, from strategies consultant PricewaterhouseCoopers (PwC), that identified 1.000 companies worldwide that invested most substantially in R&D during the last tax year, in June 30th of 2018. These companies collectively represent 40% of worldwide expenditure in R&D, from all sources, including both corporate and government ones. The base encompasses R&D investment history and income (in billions of dollars) from 2011 to 2017. It also includes the country of origin, sectors and industry groups (subdivisions of acting sectors).

When choosing our sample, we selected a set of companies for which the parameters that influence patent request were more or less constant, in order to prevent distortions in our empirical findings. By doing so, we limited our investigation to companies of manufacturing sector. This approach ensured a sufficient number of available 165 companies to perform significant analysis. They represent 16,5% of the companies in the sample, 12% of the amount of investments in R&D and 17% of income (in dollars) of the last year researched (2017).

The patent data were extracted from the worldwide patents database European Patent Office (EPO). Neuhäusler, Frietsch, Mund, & Eckl (2016) use this database in their studies, for it provides

information about patents of 83 authorities all over the world. To establish the correspondence with the set of innovative companies, we extracted the information regarding the number of patents registered in the EPO, between 2011 and 2017. Adding the company name made possible to link the number of patents application published for each year with the set of selected industries. The query was performed manually, in October of 2018, on the Espacenet – Patent Search website, enriching 165 enterprises, from 2011 to 2017, resulting in approximately 534 thousand patents.

3.2. Hypothesis and model

Based on the aim to perform an empirical research concerning the correlation between patents and corporate performance by income, this paper tests the following hypotheses, as the following figures 1 and 2:

H1: The number of patents associated with the company income.

H2: There is a lag between patenting and increasing company income.

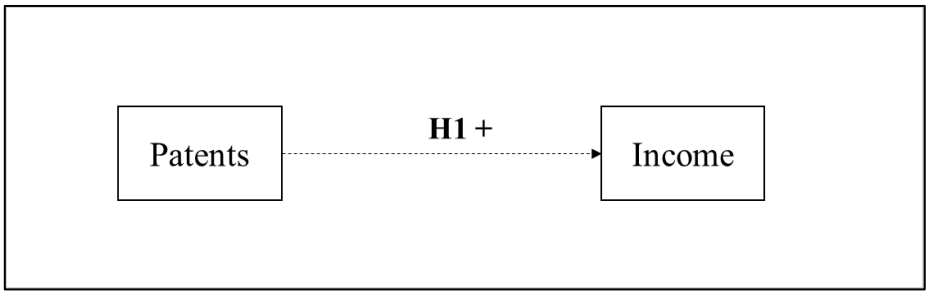

Figure 2. H1 Conceptual Model
Source: Authors

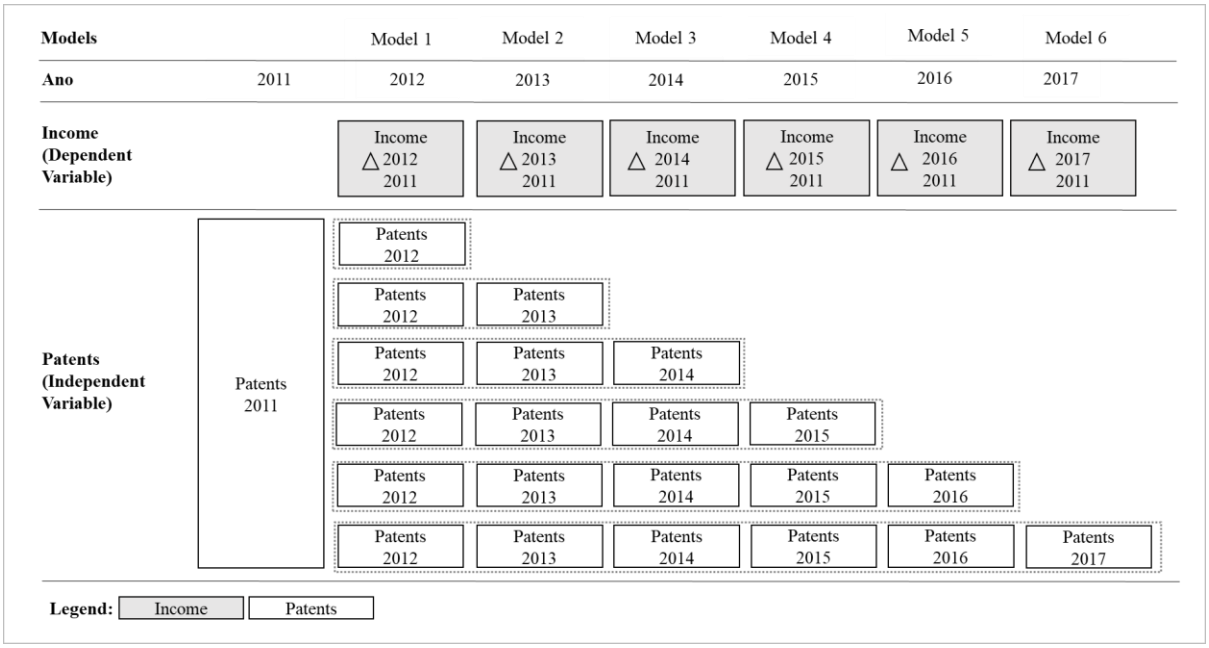

Figure 3. H2 Conceptual Model
Source: Authors

These hypotheses were created based on theoretical references, where Ernst (2001) argues about the correlation between research and development (R&D), patents and innovation success

indicators, such as sales increase. Neuhäusler et al. (2016) used patents data, sales income and investments in R&D, between 2003 and 2012 to create a regression analysis, through coefficient calculation, Pearson correlation and dispersal diagram to reveal the correlation between patents production and economic efficiency of a company.

3.3. Variables

For the H1, the dependent variable considered was the income of the whole period presented in the database, that is, the incomes sum of each industry between the years of 2011 and 2017. The income was log-transformed so that the residuals of the adjusted model are approximately normally distributed. Ernst (2001) analyses the sales, for this is a direct feedback market measurement and he states that returning fees can be influenced by a plethora of accounting proceedings, depending solely on the company motivation. The independent variable is the number of patents during the period.

Investment in research and development was associated with income it was not added as a covariate to avoid collinearity, since it is strongly associated with the number of patents (p-value <=0.05).

For the H2, the dependent variables were calculated from the difference between each year income and the 2011 income (first year of the database). That variable was converted to positive values (by summing the maximum value and a constant) and then log-transformed so that the residuals of the linear model were approximately normally distributed. The independent variables were the number of patents from 2011 until the year evaluated, which varied from 2011 to 2017.

4. RESULTS

Considering patents as being potentially responsible for increasing income it was possible to correlate these efforts with the actual reality of the most innovative manufacturing companies. The results of this research show that innovative companies who invest in patenting have their incomes influenced by these efforts. It is important to highlight that companies from manufacturing sector describe by database were reclassified by us, as companies from manufacturing sector.

In the database, were searched 21 countries of origin in the most innovative industries. The countries that stand out with the larger volume of innovative companies are United States, China and Japan, representing, approximately, 61% of the companies. When we analyze the data gathered in the period from 2011 to 2017, these countries also stand out concerning the amount of investment in R&D and income. However, when we analyze the correlation between R&D investments over the income, we observe that the countries presenting above average investments are: Italy, Israel, Netherlands, Germany, Belgium, Hong Kong, Sweden, Switzerland, India, United States, France and Japan.

United States, Japan, Germany, Netherlands and China add up over 80% of the patents total from 2011 a 2017 of the countries with the most innovative companies.

Table 1
Countries with the most innovative companies – data referring to the years from 2011 to 2017

Countries	Country Company (Number)	% Company (Number)	% R&D Expense (USD)	% Total Income (USD)	% R&D Expense/ Total Income (USD)	% Patents (Number)
United States	40	24.2%	35.1%	33.1%	3.2%	29.9%
China	31	18.8%	10.3%	18.1%	1.7%	7.1%
Japan	30	18.2%	16.0%	15.8%	3.1%	25.9%
South Korea	9	5.5%	1.6%	4.7%	1.1%	3.1%
France	9	5.5%	5.7%	5.6%	3.1%	4.7%
Germany	8	4.8%	7.9%	4.5%	5.3%	10.9%
Sweden	6	3.6%	3.8%	2.8%	4.1%	2.8%
Britain	6	3.6%	3.1%	3.1%	3.0%	2.7%
Switzerland	5	3.0%	2.4%	2.3%	3.3%	0.3%
Ireland	3	1.8%	1.7%	2.9%	1.8%	2.6%
Netherlands	3	1.8%	7.3%	3.6%	6.2%	7.7%
Finland	3	1.8%	0.5%	0.6%	2.1%	0.2%
Canada	2	1.2%	0.5%	0.8%	1.7%	0.1%
Italy	2	1.2%	2.5%	0.8%	9.6%	0.0%
India	2	1.2%	0.3%	0.3%	3.2%	0.1%
Israel	1	0.6%	0.3%	0.1%	8.0%	0.1%
Hong Kong	1	0.6%	0.1%	0.1%	4.4%	0.6%
Brazil	1	0.6%	0.2%	0.2%	2.9%	0.0%
Denmark	1	0.6%	0.3%	0.3%	2.9%	0.6%
Belgium	1	0.6%	0.2%	0.1%	4.5%	0.4%
Spain	1	0.6%	0.1%	0.2%	1.0%	0.2%
Total	165	100.0%	100.0%	100.0%	3.0%	100.0%

Source: Authors

For H1 we adjusted a linear model in which the total income between 2011 and 2017 is the dependent (response) variable the number of patents is the independent (explanatory) variable and the country is a control variable (covariate). The adjusted model does not present any significant difference of income between the countries. But the number of patents is significantly associated to the income (p-value regression <= 0.05).

For H2, for each year between 2012 and 2017, we adjusted a model in which the dependent variable is the difference between the income during a given year and the income during 2011. We considered the number of patents in 2011 as the independent (explanatory) variable and the number of patents between 2012 and the evaluated year as covariates.

Therefore, for each year, between 2012 and 2017, we evaluated the relation between patent numbers in 2011 and the number of patents of related to analysis up to the year of 2012, with the difference between the income related to the year of 2011.

Table 2
Hypothesis H2 – There is a lag between patenting and increasing company income

	2012	2013	2014	2015	2016	2017
P-value	0.000	0.000	0.000	0.000	0.000	0.000
F	12.744	18.457	20.969	18.374	17.932	15.904

Source: Authors

We noticed that in 2014 (highest F value) was obtained the major association between the patents of 2011 and the income variation, which suggests that 3 years after patenting, there is association peaks. After the peak, the effect of patenting on income variation decreases gradually.

5. CONCLUSION

The conducting of this study presented themes related to research and development (R&D), product development and patenting and how they are associated with company performance, specially the innovative ones, deserving all the attention from researchers, public policies developers and companies. Another issue raised in this study is about the lag between patenting and company performance, in this case, its relation to the income.

The aim of this paper was to investigate the relationship between the number of patents and the increase of income. As a secondary aim, we sought to verify the lag between patent application and income results. To reach the aim proposed in this work, two hypotheses were tested by the regression model: H1 - The number of patents associated with the company income and H2 - There is lag between patenting and increasing company income. The results suggest that there is a significant association between the number of patents and the income. Furthermore, we found out that the association peaks 3 years after patenting.

With the analysis of the last research edition of Global Innovation 1000, from strategies consultant PricewaterhouseCoopers (PwC), published in 2018, it was possible to explore the scenario of worldwide companies that most heavily invested in innovation and to add information concerning patents model owned by these companies through database querying on the European Patent Office (EPO) worldwide patents database. The results achieved may show us that the effort of the most innovative industries (slot proposed in this research) seeking patenting has presented itself in direct association with the amount of income obtained. Besides, from the length analysis of historical data concerning R&D investments, patents number and income, from 2011 to 2017, it is suggested that in three years it is possible to observe a higher influence.

Additionally, it was possible highlight that the companies from manufacturing sector in general are concentrated in three countries: United States, China and Japan. These companies most innovative from manufacturing sector, in average, invest the equivalent of 3% of its income in expenditures related to R&D. United States, Japan, Germany, Netherlands and China deserve attention for they accumulated more than 80% of the total patents from 2011 to 2017.

We can conclude that patents as result of R&D process and product development processes are directly associated with performance through income in the companies. We observed that major increasing of income occurred in third year. This analysis is considered an effort in the literature to comprehend the patenting theme in the worldwide from companies of manufacturing sector, and it contributes, in practice, in means that similar companies will evaluate the attractiveness of patents filing and the investment lag, thus guiding its strategic planning.

This paper presents some limitations. The data source used to calculate the lag between patenting and company performance was the income, considering the period from 2011 to 2017. Future researches may incorporate a longer time span. We suggest future researches related to studies performed in other sectors, such as: Information Technology, Healthcare, Materials, Energy

and Commercial Services and Supplies in order to compare results and findings with the reviewed bibliography aiming to advance on this theme analysis.

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