Impact of Patenting on Profitability of Firms

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Abstract

This research paper analyzes the effect of patents on firm profitability. To be more precise, net income, return on assets and Tobin's q. In order to investigate the relationship, a sample of 2,488 publicly traded U.S. firms for the period of 2000-2008 was gathered. Variables such as net income, return on assets, Tobin's q, research and development expenses, number of patents and employees, total assets and market value were used in pooled ordinary least squares regressions. The results indicated that patents only lead to higher net income, whereas the relationship between number of patents with return on assets and Tobin's q is negative. Therefore it leads to a conclusion that while patents lead to higher net income, it might negatively affect other profitability measures of a firm.

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1. Introduction

21st century has seen an evolutionary breakthrough in a lot of industries. In 2001 the first artificial heart was successfully used in replacement operation. The year 2007 has brought the first touchscreen smartphone made by Apple, which reshaped the whole mobile phone industry (The Telegraph, 2016). In addition to that, in the end of 2015 Elon Musk, the CEO of Tesla, made an announcement that in two years' time there will be fully autonomous cars available for consumer markets (Korosec, 2015). These innovations are just a small part of all the developments that have been made in technology, medicine, food and other industries. Looking from consumers' and society's perspective, they provide people with higher quality goods and services, better efficiency at workplaces, and even broader range of consumption choices if the invention creates a completely new market. Not only consumers, but also firms can reap huge benefits through commercialization of the invention. This could be done through the first-mover advantage, which means that the firm initially gets ahead in a certain market and achieve a monopoly-like status, through the established control of resources and demand (Porter, 1976). However, some scholars tend to have dubious opinion on the matter. In the article *Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy* David. John Teece argues why some innovating firms actually fail to obtain significant economic returns (1986). One of the main reasons that Teece mentions are availability of capital, firm size and the environment in which the firms operate, to name a few. According to author, a lot of firms do not manage to benefit from their new inventions if the conditions are not perfect and investing into research and development can simply end up as a wasteful expense.

In order to make the analysis, the definition and the application of innovation has to be provided. In simple terms, it means a new idea, method or product, however this can be difficult to measure when it comes to statistical analysis. For that reason, this empirical research will solely focus on patents, which are the exclusive, law-protected rights given to an inventor to manufacture, use, or sell an invention for a certain number of years. Therefore this research paper aims to investigate, whether innovation is a rational choice from a financial perspective of a firm, by answering the research question:

To what extent do patents impact profitability of firms?

This research paper is will try to answer how financially credible it is for firms to actually patent and prevent competitors from using their inventions. As mentioned previously, new inventions lead to advancement in society, whether it is entertainment, technology, medicine or other industries. A successful use of patent also helps firms to develop and grow. However, patents grant monopoly rights to the firm. This could lead to hold-up cases of intentional prevention of new goods, or even worse – exploitation of the consumer market. Recently the pharmaceutical sector observed a scandalous acquisition of the patent to AIDS drug. An ex-hedge funder Martin Shkreli bought the rights to AIDS drug and increased the price by 5500% overnight, from $13.50 to $750.00 per pill (McLaughlin, 2015). On one hand, his drug company achieved enormous profits in a short period of time, but on the other, people who were in need of medication had encountered much higher expenses. Therefore these reasons make the research of high social relevance.

Regarding the scientific relevance, this thesis focuses on recent figures of US firms, obtained from the years 2000 to 2008, which makes the findings more relevant to the current financial and economic conditions of the world. What is more, this research could be used as a foundation in order to develop more extensive models with variables from the year 2008 onwards.

The findings of this paper are that patents only lead to significantly higher net income, however when it comes to return on assets and Tobin's q, the relationship is negative and minute.

This empirical research paper will be divided into separate parts. First, a theoretical framework will be provided, which will provide required definitions needed for better understanding of the connection between innovations and profitability. In addition, previous literature, on which this research paper is based, will be analyzed. After that, three hypotheses will be stated, which are the main interest of this paper and which will help to answer the research question about patents effect on profitability. Following theoretical framework, data section will describe the database retrieved from Compustat and will go more into depth with innovation and profitability variables, their descriptive statistics, transformations and motivations behind it. Then, methodology part of the paper will give step-by-step explanation and assumptions of the statistical procedures undertaken, particularly pooled ordinary least squares regression. Separated into three parts, these procedures and findings will be given in the results section, together with economic implications and rejection or acceptance of the hypotheses raised in the theoretical framework. Finally, a brief summary of the paper and an answer to the research question of relationship between patents and profitability will be answered in the conclusion, together with limitations and recommendations provided for further research.

2. Theoretical Framework

This paper is based on previous research done under the topics of innovation, patenting and financial position of the firms. A good starting point is previously mentioned Teece's paper *Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy* (1986). In his paper, Teece focuses on the factors, which determine which firms win from innovation. According to author, it is not enough for the firm to be first-mover if it seeks to succeed. First of all, a very important role is played by regimes of appropriability, which refer to the protection of the new invention, or in other words, patent regulations. However, as Teece mentions, patents do not work in practice as they do in theory. A credible and often observed reason is that some innovations can be altered on a very minute, or even molecular level by imitators, which would make it difficult to claim a violation on the patent and exclusive rights. Another important factor is a dominant design. Once a new product is created, the innovator has to make sure that their design becomes the industry's standard. By establishing this position, the innovating firm can focus solely on other aspects such as customer service and cutting down costs, without worrying of losing demand due to design issues. Lastly, Teece points out complementary assets as being the final key to innovator's success. They are highly relevant for firms in order to bring the innovation to life – having a great idea is not enough, as the product needs to be manufactured, packaged, marketed and sold, and all of these steps require vast amount of resources.

Consequently, a big firm will have the advantage over a small one with regards to complementary assets.

In another paper written by Teece together with Grindley (1997), in the last decade of XX century business development has become of great importance. More and more firms started to have their own intellectual property (IP) management departments. That was only usual to chemicals and pharmaceuticals industries, however everything changed after the stronger patent enforcement starting in 1982. Such separation of intellectual and tangible property increased awareness of how important research and development is, therefore the top management began to get involved in IP decision making. Teece and Grindley mentions that even though patents were of secondary importance, by the end of XX century it had become a key element of competition in high-technology industries, providing firms with more capabilities to win their markets and harvest higher sales and profits.

Another paper, which started to empirically investigate the relationship between patents and profitability was written by Bronwyn Hughes Hall and Rosemarie Ham Ziedonis (2001). Their research was done in two steps: firstly, they conducted interviews with industry representatives, and then performed statistical analysis of how patenting affects profitability. The selected samples were intellectual property managers and executives from seven semiconductor firms, interviewed between April 1998 and November 1998, and financial reports of 95 U.S. semiconductor firms of period 1979-1995. Hall and Ziedonis came up with contradicting findings, as even though the industry representatives indicated that they do not rely on patents when it comes to making profits, yet the whole period of 1980s saw a great surge in the number of patents applied. The authors conclude that this paradox can be attributed to the stronger patent rights introduced in 1982 in the U.S., which led firms to the “patent portfolio races”.

Not only Hall and Ziedonis, but other scholars agree on the fact that the creation of the Court of Appeals of the Federal Circuit (CAFC) in 1982 with the follow-up pro-patent laws led to significantly better patenting conditions and consequently much more patents that firms apply for in general. According to a study done by Samuel Kortum and Lerner, the number of successful patent applications in U.S. grew from around 61,000-64,000 a year before 1983, to 104,000 in 1992, which is more than 50% increase in a decade (1999). In addition to that, their findings suggest that increased patenting is motivated by higher profitability and allows pro-patent firms to reap higher financial benefits compared to their competitors. However, it is worth to mention that increased patenting led to a drop in publications and knowledge spillovers (Bhaskarabhatla & Hedge, 2014). This means that while patenting could be a solution for firms to increase their profits, it also poses a negative social consequence of restricted knowledge sharing. In other words, there is a phenomenon that patents actually slow down the innovation and technology evolution process.

Extending from the previously mentioned articles Neuhausler, Frietsch, Schubert and Blind (2011) performed a statistical analysis to answer how far does research and development and acquired patents affect the market value of the firm. They used information of 479 firms, which were listed on DTI-Scoreboard, from 1990 to 2007. By using multivariate ordinary least squares regression, the authors found that number of patents is not a good predictor of a firm value, however there was a significant, yet very small effect of patents on return on investment. These findings only support the ideas that more patents do not necessarily lead to higher profits (Teece, Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy, 1986), as well as that there is a credible reason for managers depend on patents when it comes to making profits.

Similar to Neuhausler et al paper, another empirical study was carried out with Taiwan semiconductor firms (Tsai, 2010). The study focuses on 87 design, manufacturing, packaging and testing firms, from a sample period of 2001 to 2006. Interestingly, the author finds that there is a significantly higher rate of return on assets for firms which hold more granted patents. What is more, Tsai's research also supports Hall's and Ziedonis' findings that stronger patent rights encourage firms to get more involved into research and development activities. Thus in Taiwan, more and more patents are being successfully developed with financial benefits reaped by the firms.

It becomes evident that scholars and their findings tend to contradict each other both from hypothetical and from empirical perspective. Therefore the aim of this study is to answer the previously mentioned research question:

To what extent do patents impact profitability of firms?

This will be done through testing three different hypotheses. First one focuses on the relationship between patents and net income. It is important to note that this study treats only granted and verified patents. That is chosen due to a large number of patent applications being rejected. Even in 2015 alone, in the U.S. only 51.7% of patents were actually granted (Patent Technology Monitoring Team (PTMT), 2016). Therefore granted patents should only be treated and inspected, otherwise the study would have to deal with a lot of unnecessary and wasteful expenditures on those, which never got legally verified. Hence the first hypothesis goes as follows:

H01: Patents lead to higher net income

Another point of interest is the effect of patents on return on assets. As patents get verified, they become intangible assets, which are represented on the balance sheet of a company. Initially, the patent will require certain amount of expenditures to develop, apply and get verified for. So even if net income increases, the company might still experience a decrease in return on assets, given that capitalized expenditures are relatively higher than the profits gained. Therefore the second hypothesis tests the following:

H02: Patents lead to higher return on assets

The first two hypotheses solely focus on profit figures. However it is also important to note that sometimes companies secure a patent for other purposes. One of them is to prevent new products or competition from the market. What is more, firms might patent an idea as an option to use in the future – either as a back-up plan or as a delayed investment (Besanko, Dranove, Schaefer, & Shanley, 1996). By acquiring patents for such motivation, the company will not directly increase its net income. Regardless of that, the financial markets will recognize that the firm has increased it value and it will be reflected in the market expectations and valuation of the firm. Therefore a following hypothesis will check whether Tobin's q is affected by the number of patents that the firm has:

H03: Patents lead to higher Tobin's q

It is important to mention that Tobin's q is denoted by the ratio of total market value of the firm divided by the total asset value. A ratio of 1 means that the firm is valued as much as the assets it possesses, and does not generate any underlying value. If the ratio exceeds 1, then it suggests that there are promising expectations of future returns, which will be captured by the firm. Of course, for these clauses to hold and Tobin's q to be a plausible variable for this research, the efficient market hypothesis has to hold. According to Fama, efficient market hypothesis states that asset prices fully reflect all available information and stocks are traded at their fair value (1970). Henceforth, the variable of market value in Tobin's q reflects the actual true value of the firm, given all of its current and expected returns.

3. Data

The dataset used in this research is retrieved from Compustat and consists of 585,218 firm and year specific observations, with 74 different variables. The time period under consideration ranges from the year 2000 to 2008. It is chosen in order to reflect the most recent and stable results of XXI century just before the collapse of *Lehman Brothers,* which led to worldwide financial crisis in 2008. Regarding the specificity of the firms, 2,488 publicly traded U.S. firms with patents are being statistically inspected.

For this research only a part of the database and variables will be used. Therefore the variables of interest are:

nbpatents – number of successful patents in question, needed to check whether there are significant relationship between profitability and the number of patents;

xrd (R&D Expense) – in order for patent to become an intangible asset on the balance sheet, it needs to be granted; however the process can take up a considerable amount of time and a variable of in process R&D expense is used as a control variable to reflect the patents which are still being developed and pending for verification;

year – the dataset has panel data, therefore year is an important variable to take into consideration; in addition, specific year effects will be investigated as a control variable to see whether certain periods of time had a positive impact on economic business cycles and therefore affecting profitability measures;

at (assets total) – in order to inspect how patents affect return on assets, total assets will be used together with net income to make a transformed ROA variable; in addition to that, total assets are also required in order to make a transformed Tobin's q variable; additionally total assets will be used as a control variable for size;

ni (net income/loss) – net income is the variable in consideration in two hypotheses and will be checked how patents affect net income directly, as well as transformed variable return on assets;

mkvalt (market value) – in order to be able to inspect the third hypothesis which investigates relationship between patents and Tobin's q, market value will be used in order to create Tobin's q; moreover market value will be used as a control variable for size;

emp (employees) – in order to control for size differences across firms, the number of employees will be used to check whether bigger firms really manage to exploit patents and first mover advantages in a more successful way then the smaller ones as Teece (1986) suggests;

tobinsq (Tobin's q) – a transformed variable of interest, found by dividing the market value of the firm over its total assets;

roa (Return on Assets) – a transformed variable of interest required for another hypothesis, found by dividing net income over total assets.

As previously mentioned, the dataset was altered in few manners. First of all, new variables had to be created such as Tobin's q and Return on Assets by using ratios with financial figures from the dataset. In addition to that, the dataset contained only the patent codes, therefore a variable called nbpatents was created in order to inspect how many patents each firm got granted for a particular year.

Looking at the descriptive statistics of the variables in question below, it is worthwhile to mention that only firms, which had at least 1 patent a year were included in the research. Another interesting point is that the mean number of patents per year reaches 1136,04, which means that on average a sample firm gets 3,11 patents granted per day. In addition to that, the maximum value of number of patents per year reaches a whopping 7995, leading to 21,9 patents per day or almost one patent granted per hour. This could only indicate a very strong research and development department with high expenditures and focused aim at achieving as many patents as possible for future use.
It is important to note, that while number of patents (nbpatents) is expressed in actual unit terms, research and development expenses (xrd), total assets (at), net income (ni), mkvalt (market value) are in terms of millions, except for employees (emp), which are expressed in thousands. Regarding tobinsq (Tobin’s q) and roa (Return on Assets), they are ratios as mentioned prior.

Another interesting observation of descriptive statistics shows that some sample firms in the period in question were very unprofitable. For instance, the minimum value of net income, or in this case, loss, attains a value as high as almost 99 billion dollars. Of course, the maximum value reaches an approximate net income of 45 billion dollars, which suggests that the range is quite wide, reaching nearly 150 billion. Such width is important in order to be able to inspect firms who were both practicing patenting, yet some of them were successful, yet others ineffective. Same results go for ROA. On average, the return on assets was as low as 2%, whereas in extreme cases it could stretch out from -13744% to 4645%.

Variable	Mean	Std. Dev.	Min	Max
nbpatents	1 136,04	1 405,91	1,00	7 995,00
xrd	2 201,03	2 062,16	-0,10	12 183,00
at	51 407,88	101 273,10	0,00	1 817 943,00
ni	2 259,11	4 306,72	-98 696,00	45 220,00
mkvalt	68 131,69	93 805,09	0,00	504 239,60
emp	109,79	121,87	0,00	2 100,00
tobinsq	2,02	4,62	0,00	2 513,43
roa	0,02	0,35	-137,44	46,45

Table 1: Descriptive statistics of researched variables

4. Methodology

In order to investigate the relationship between the patents and the variables in question, statistical measures have to be undertaken. This empirical study focuses on the different variables of the same entities, during the period 2000 to 2008, which means that the data comprises both cross-sectional and time-series elements. It is possible to run a regression for each period, or for each entity, but then it would need either 9 yearly or 2,488 firm specific regressions, which is not optimal. As the conclusion needs to be based on one single analysis, the following panel data model will have to be used:

$$y_{it} = c_i + \beta\, x_{it} + u_{it}\,,$$

$$\textit{given that} \qquad i=1,\ldots,n \quad \& \quad t=1,\ldots,T$$

where y_{it} is the explained variable of unit *i* in period *t*, x_{it} is a vector of explanatory variables, β is a coefficient vector and c_i is a firm-specific effect and u_{it} idiosyncratic errors. In this research, variable *y* would be Net Income, Return on Assets or Tobin's q respectively to the hypothesis tested. As for notations *i* and *t*, they stand for a specific firm and year period (2,488 firms in total and years 2000-2008 respectively).

This model can be estimated by using pooled OLS (ordinary least squares) estimator. However, certain assumptions have to hold:

1. $y_{it} = c_i + \beta\, x_{it} + u_{it}$
2. $E(u_{it}\,|x_i,\, c_i) = 0$
3. $Var(u_{it}\,|x_i,\, c_i) = \sigma^2 I$
4. $Rank(X) = Full\ rank$

The very first assumption, which is already mentioned, describes the relationship between the variables. As the equation states, the regressand y shares a linear relationship with the regressors x.

The next one is called the exogeneity assumption. This means that the explanatory variables are uncorrelated with the error term. If this assumption holds, then there is less likelihood for measurement errors, autoregression with autocorrelated errors and omitted variable bias, each of which influences and distorts the results.

The third assumption means that heteroscedasticity can be allowed. In other words, the variances do not necessarily have to be stable in order to achieve best linear unbiased estimators.

The last assumption states that independent variables do not have an exact linear relationship in between them. Otherwise the parameters of the model would have distorted and incorrect values (Brooks, 2008).

Looking from the economic point of view, we will be inspecting a linear relationship between the explained variable in question (either its net income, return on assets or Tobin's q) and the explanatory variable (number of patents). It is important to note that other controlled variables will be used, such as total assets, research and development expenses, and number of employees.

The first hypothesis will inspect the relationship between net income and patents. Several different pooled OLS regressions will be made to find the best suit, with research and development expenses, total assets, market value and number of employees as controlled variables.

The second and third hypotheses concerning the how number of patents affects returns on assets and Tobin's q respectively, will use the same controlled variables (research and development expenses, total assets, market value and number of employees) in order to find the best fitting regression line. However, as these regressands are ratios, it is better to use logarithmic transformation for them to find how they respond to changes in regressors. Therefore for these two hypotheses, the following logarithmic changes will be performed:

xrd → ln (xrd)

at → ln (at)

mkvalt → ln (mkvalt)

5. Results

5.1 Descriptive Results

In figure 1, the average yearly number of patents per firm and average yearly net income are plotted for the time of 2000-2008. Looking at the graph, small deviations and drops are visible, however it is evident that both mean number of patents and mean net income saw an increase throughout the whole period. In addition to that, considering figure 2, in which the average yearly number of patents per firm and average return on assets for each year are displayed, very similar interpretation could be made, as both variables move in an upward pattern with decreases once in a while. Therefore there is reason to believe that both net income and return on assets are positively correlated with the amount of patents that each firms gets granted.

However, looking at figure 3, the results give a completely opposite impression. The graph depicts mean Tobin's q for each firm and mean number of patents for the research period. It can be seen that while mean number of patents increase, Tobin's q goes down almost every year. This suggests a negative relationship between Tobin's q profitability ratio and the verified patents.

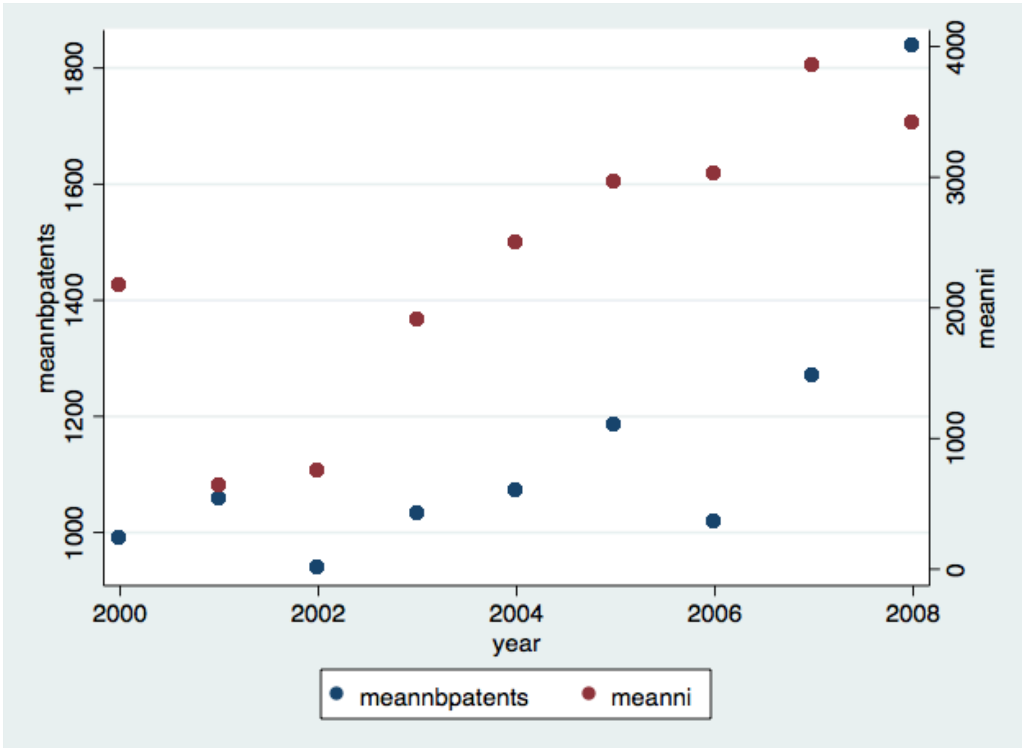

Figure 1: Scatterplot of mean number of patents and mean net income per firm for the period of 2000-2008

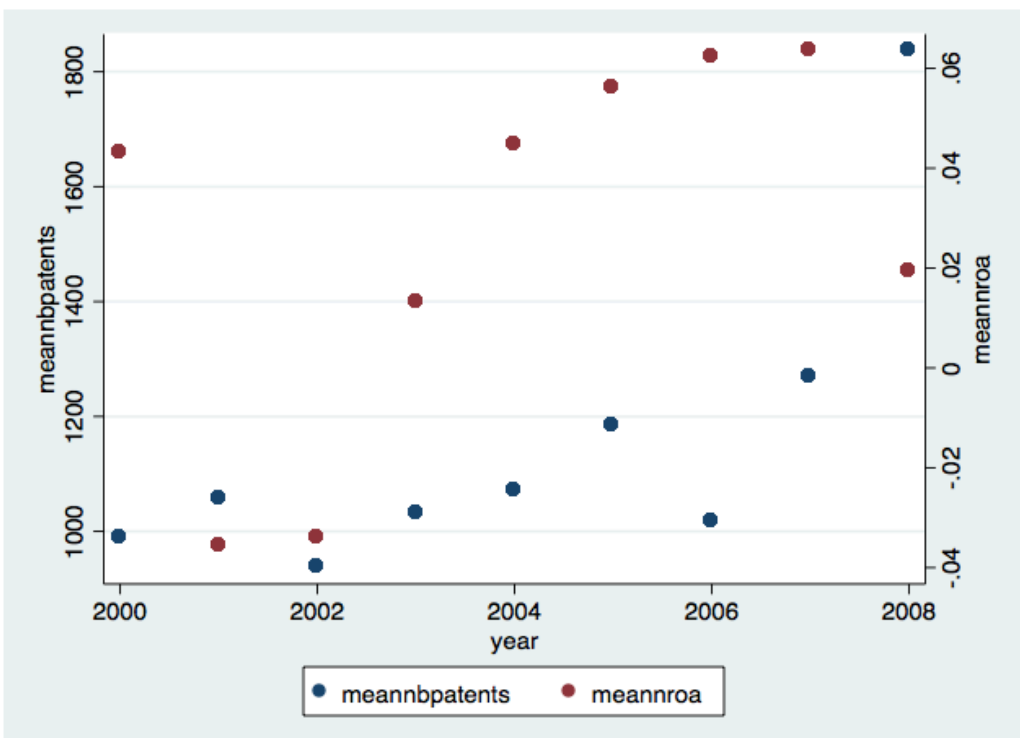

Figure 2: Scatterplot of mean number of patents and mean return on assets per firm for the period of 2000-2008

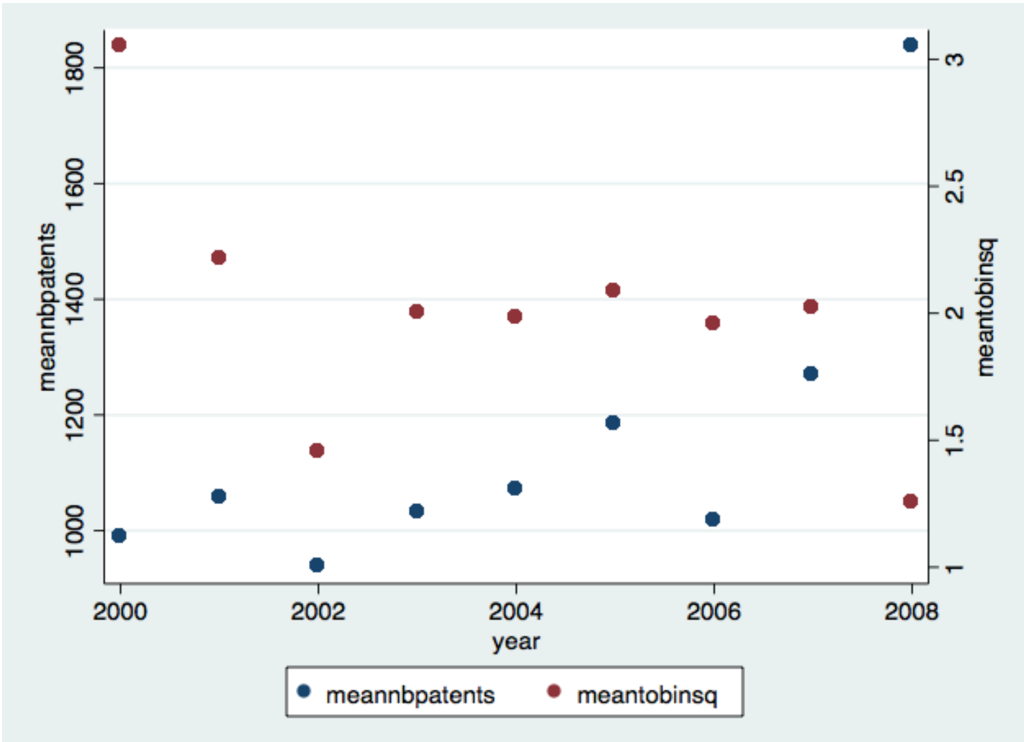

Figure 3: Scatterplot of mean number of patents and mean Tobin's q per firm for the period of 2000-2008

In order to have a more in-depth look into bivariate associations between variables, a correlation matrix, which is depicted in table 2, was created. As it was initially seen from the scatterplots, the correlation between number of patents and net income is positive (0,6163) and relatively high, whereas the relationship between patents and return on assets is positive as well, but very weak (0,0863). With regards to the relationship of number of patents and Tobin's q, the findings support initial interpretation of the scatterplot as well – the correlation is negative, yet very weak (-0,0215). Even though the correlation matrix supports conclusions drawn from figures 1-3, it is yet too early to jump into final conclusion about how patents affect profitability measures.

Looking at the other variables, it is apparent that all size control variables (number of employees, market value of the firm and total assets owned) have a positive relationship with net income and return on assets. This goes hand in hand with the findings of Teece who claimed that bigger firms have better capabilities of exploiting innovation due to more resources and complementary assets (1986). However, looking at Tobin's q, the relationship it has with number of employees and total assets is negative, and only market value has a positive one. Apart from the number of employees, it can be easily explained due to the formula of Tobin's q, which is market value divided by total assets. Therefore it is not surprising to end up with such figures.

Finally, another control variable that might be of high importance in this statistical analysis is research and development expenses (xrd). The correlations between these expenditures and all profitability ratios in question are positive, having the strongest with net income and weakest with Tobin's q. It is known that part of money spent on research and development might become intangible assets, patents being one of them. As this process takes up time, the R&D expenses cannot be immediately recognized as patents. Nevertheless, assuming the efficient market hypothesis holds (Fama, 1970), R&D is already reflected in the value of the firm, whether or not its already capitalized on the balance sheet. Knowing that a significant part of research and development expenses are either not intended to be capitalized or do not make their way to the balance sheet, this variable can give very noisy results and therefore will be used only as a purpose of control.

	ni	roa	tobinsq	nbpatents	emp	mkvalt	at	xrd
ni	1							
roa	0,1719	1						
tobinsq	0,022	-0,5195	1					
nbpatents	0,6163	0,0863	-0,0215	1				
emp	0,6478	0,0775	-0,0932	0,7797	1			
mkvalt	0,8124	0,1183	0,0945	0,4738	0,5321	1		
at	0,6458	0,033	-0,0704	0,2442	0,5977	0,6333	1	
xrd	0,6407	0,1151	0,025	0,703	0,6677	0,6789	0,3423	1

Table 2: Pairwise correlations of profitability measures, explanatory and controlled variables

5.2 Multivariate Results

This section will be divided into three parts, each of which dedicated to separate null hypothesis. In each section, pooled ordinary least squares regressions models will help to analyze the variables of interest, particularly net income, return on assets and Tobin's q. Then, the best fitting and significant regression model will be chosen in order to be able to give interpretations of the findings.

5.2.1 Net Income

H01: Patents lead to higher net income

Starting with the relationship between net income and number of patents, it is visible that for every patent that a firm owns, its net income tends to be 1,11 million dollars higher (as all variables are in expressed in millions, except for employees which are expressed in thousands). Such relationship confirms the theory and findings of previous scholars, stating that more patenting results in better competitive edge and profit opportunities (Teece, 1986; Tsai, 2010; Neuhausler, Frietsch, Schubert, & Blind, 2011). Not only the acquired patents prevent competitors from using certain technology or production methods, but also provide the firm with monopolistic rights, giving easier access to reaping profits in the market. Research and development expenses, even though they are considered as quite a noisy variable, have a negative impact on net income, as for every million dollars spent on R&D, the net income tends to be approximately 26 000 dollars lower. This effect is not surprising as R&D is mostly instantaneous expense, which reduces profits. Nevertheless, it is important to understand that R&D might lead to higher future profits.

Regarding the control variables for firm size, both the market value and total assets of the firm lead to higher profits, with rounded coefficients being approximately 0,026 and 0,012 respectively. This suggests that bigger firms, with more resources, or as named by Teece (1986) complementary assets, have better capabilities of reaping profits.

On the other hand, another size variable for employees affects net income negatively. In particular, every additional employee in the firm leads to a 3049,87 dollar loss. This can have several explanations. First of all, a company with many employees usually requires more organization, which can become costly. Due to greater size, more control and strategic management has to be employed in order to avoid agency costs (Besanko, Dranove, Schaefer, & Shanley, 1996). Another reasoning is that a company with a high employee count is typically labor intensive and more related to the service sector, whereas patents are more relevant and important in capital-intensive firms, from industries such as manufacturing and electronics.

The following regression model can be used for particular year and firm in the research sample in order to find the value of net income:

$$ni_{it} = -402,859 + 1,110395*nbpatents_{it} + 0,0258698*mkvalt_{it} - 3,049867*emp_{it} + 0,011807*at_{it} - 0,025802*xrd_{it} + u_{it}$$

Therefore looking at the coefficients of the regression equation of net income and considerably high Adjusted R-squared, it can be said that there is significant evidence to state that the first null hypothesis (H01: Patents lead to higher net income) is not rejected.

ni	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
nbpatents	1,110395	0,0048553	228,7	0	1,100879	1,119912
mkvalt	0,0258698	0,0000751	344,33	0	0,0257225	0,026017
emp	-3,049867	0,0789487	-38,63	0	-3,204604	-2,89513
at	0,011807	0,000061	193,52	0	0,0116874	0,0119266
xrd	-0,025802	0,0032537	-7,93	0	-0,0321799	-0,0194255
constant	-402,859	5,656349	-71,22	0	-413,9453	-391,7727

observations	=	340 483
F (5, 340 477)	>	99 999
Prob > F	=	0
R-squared	=	0,7671
Adj. R-sqr.	=	0,7671
Root MSE	=	2407,5

Table 3: Results of the pooled OLS panel regression model with net income being as explained variable
* Due to usage of unbalanced panel, the number of observation between section 5.2.1 and sections 5.2.2 & 5.2.3 differ

5.2.2 Return on Assets

H02: Patents lead to higher return on assets

Looking at the table 4, it is important to mention that whereas return on assets (roa) is a ratio, all the explanatory variables except for number of patents, are natural logarithms. First thing that stands out and contradicts the results of descriptive is the coefficient of number of patents. Not only it is negative, but also very minute. In other words, number of patents barely affect the return on assets, and if they do – only in negative way. A possible explanation for such phenomena is that even if patents increase the net income of the company, the money spent and capitalized value of them is relatively higher, therefore bringing the ROA ratio down. In addition to that, it might take some time until a company can actually recognize the benefits of a verified patent, therefore net income might be lagging behind, leading to an increase of the denominator (total assets which include intangible assets), while the numerator remains the same. These findings are quite the opposite of Tsai's (2010), who found a positive relationship between return on assets and number of patents. However, it is important to note that Tsai included only capital-intensive manufacturing, design and packaging firms, which could have led to different results.

Paying attention to size control variables, it is clear that market value and number of employees all lead to higher ROA. However, according to De Marzo & Berk, this is no surprise, as bigger firms tend to keep higher ROA. The reasoning behind it lies in signaling the financial health of a corporation, which shows investors that the corporation is only undertaken high return projects (2014). Moreover, it is not surprising that total assets have a negative coefficient on return on assets, as it is in the denominator of the ratio. Therefore higher total assets naturally decrease ROA.

Another important finding is the negative coefficient of research and development expenses. It shows that whenever R&D expenditures increase by 1%, return on assets decrease by 0,0527%. Even though the effect is statistically significant and negative, it is very small and yet relatively noisy, as these expenditures can simply be attributed to the instantaneous expenses, which decrease the numerator (net income) of the period in question.

The following regression model can be used for particular year and firm in the research sample in order to find the value of return on assets:

$$roa_{it} = 0{,}3729574 - 8{,}93 * 10^{-6} * nbpatents_{it} + 0{,}0758135 * lnmkvalt_{it} + 0{,}0284672 * lnemp_{it} - 0{,}008895 * lnat_{it} - 0{,}052745 * lnxrd_{it} + u_{it}$$

Therefore looking at the coefficients of the regression equation of return on assets, it can be said that there is significant evidence to state that the second null hypothesis (H02: Patents lead to higher return on assets) is rejected.

roa	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
nbpatents	-8,93E-06	5,05E-07	-17,69	0	-9,92E-06	-7,94E-06
lnmkvalt	0,0758135	0,0008217	92,26	0	0,074203	0,0774241
lnemp	0,0284672	0,0010715	26,57	0	0,026367	0,0305673
lnat	-0,008895	0,0014232	-6,25	0	-0,0116849	-0,006106
lnxrd	-0,052745	0,0008858	-59,54	0	-0,0544814	-0,0510091
constant	-0,3729574	0,0062841	-59,35	0	-0,385274	-0,3606408

observations	=	340 238
F (5, 340 477)	=	5 214,27
Prob > F	=	0
R-squared	=	0,0712
Adj. R-sqr.	=	0,0712
Root MSE	=	0,38865

Table 4: Results of the pooled OLS panel regression model with return on assets being as explained variable
* Due to usage of unbalanced panel, the number of observation between section 5.2.1 and sections 5.2.2 & 5.2.3 differ

5.2.3 Tobin's q

H03: Patents lead to higher Tobin's q

Finally, the third hypothesis inspects the impact of patents on Tobin's q. Same as with return on assets, this regression uses logarithmic values of total assets, market value, number of employees and research and development expenses. Contrary to findings in result section 5.2.2, it is visible that the outcome of descriptive results and multivariate results are supporting each other. The observed correlation in between number of patents and Tobin's q was -0,0215. As for the regression coefficients from table 5, it is also negative, meaning a higher number of patents lead to a lower Tobin's q. Even though this coefficient is statistically significant, it is very minor (-0,000094). Theoretically, given the efficient market hypothesis holds (Fama, 1970), more patents should be reflected as future prospects of the firm in its market value. It means that these findings contradict the initial expectation of the research. However, patents are intangible assets, which increase the denominator of Tobin's q, which makes it lower. In addition to that, financial markets are extremely volatile due to many possible factors, hence there is a high chance of omitted variables bias which could affect the variable of market value.

Naturally, the coefficients of market value and total assets correspond to the formula of Tobin's q, which is market value divided by total assets of a firm. To be precise, market value has a coefficient of approximately 1,63 and total assets is -1,59. This means that 1% increase in market value leads to 1,63% increase in Tobin's q, and 1% increase in total assets – a decrease of 1,59%. As these figures are pretty similar to each other, it would be safe to assume that market value and total assets cancel each other out and only show the effect to the formula of Tobin's q itself.

Paying attention to another size variable – employees – it has a negative impact on the profitability ratio in question. This may indicate financial markets' unfavorable perception of larger firms. Such relationship between Tobin's q and number of employees of firms is also supported by findings of Neuhausler et al (2011).

Finally, opposing to findings in 5.2.1 and 5.2.2, the research and development expenses have a positive impact on the explained variable, particularly being 0,0665% increase in Tobin's q, whenever R&D expenses increase by 1%. Such association can be the cause of the fact that the bigger the firm, the more it invests into research and development. Therefore market value moves in same direction as R&D.

The following regression model can be used for particular year and firm in the research sample in order to find the value of Tobin's q:

$$tobinsq_{it} = 1{,}173651 - 0{,}000094 * nbpatents_{it} + 1{,}627998 * lnmkvalt_{it} - 0{,}117634 * lnemp_{it} - 1{,}59149 * lnat_{it} + 0{,}066501 * lnxrd_{it} + u_{it}$$

Therefore looking at the coefficients of the regression equation of Tobin's q, it can be said that there is significant evidence to state that the third null hypothesis (H03: Patents lead to higher Tobin's q) is rejected.

tobinsq	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
nbpatents	-0,000094	5,81E-06	-16,22	0	-0,0001056	-0,0000828
lnmkvalt	1,627998	0,0094548	172,19	0	1,609467	1,646529
lnemp	-0,117634	0,012329	-9,54	0	-0,1417985	-0,0934696
lnat	-1,59149	0,0163756	-97,19	0	-1,623585	-1,559394
lnxrd	0,066501	0,0101921	6,52	0	0,0465247	0,0864772
constant	1,173651	0,0723045	16,23	0	1,031937	1,315366
observations	=	340 238				
F (5, 340 477)	=	8 173,9				
Prob > F	=	0				
R-squared	=	0,1072				
Adj. R-sqr.	=	0,1072				
Root MSE	=	4,4718				

Table 5: Results of the pooled OLS panel regression model with Tobin's q being as explained variable
* Due to usage of unbalanced panel, the number of observation between section 5.2.1 and sections 5.2.2 & 5.2.3 differ

6. Summary and Conclusion

The goal of this research was to analyze the question of to what extent do patents impact profitability of firms. Profitability was identified as three financial figures: net income, return on assets and Tobin's q.

For this analysis, a sample of 2,488 publicly traded U.S. firms was examined for the period of 2000-2008. All of these firms had at least one patent granted per year. The database of these firms included 76 different variables, out of which net income, return on assets, Tobin's q, number of patents per year, number of employees, total assets, market value and research and development expenses were used for statistical inspection.

The results were inspected in few ways. Firstly, scatterplots of average values of net income, return on assets, Tobin's q and number of patents were made, to see the possible relationship path of the variables. As expected, average number of patents was increasing with certain deviations in the sample period, together with net income and ROA. However, the mean Tobin's q saw a slight overall drop. In order to get a more detailed and mathematical results, a correlation matrix was constructed which only supported the initial findings of the scatterplots.

Following the descriptive statistics, a multivariate analysis was undertaken by using pooled ordinary least squares regressions. For every variable in question (net income, ROA and Tobin's q), a separate regression was made. In section 5.2.1, the relationship between net income and number of patents was found to be significantly positive, verifying the initial impression made from the descriptive results and showing that patents lead to higher net income. However, in sections 5.2.2 and 5.2.3, the relationship between profitability ratios (return on assets and Tobin's q) and number of patents was found to be significantly negative, therefore rejecting hypotheses that patents lead to higher ROA and Tobin's q.

There are many possible explanations for these findings. To begin with, more patents give more flexibility and opportunities for firms to win the markets and therefore achieve greater net income figures. What is more, it is possible that companies, which are strongly positioned in markets, tend to reinvest their profits back into the company to maintain their dominance, partly into patents. Regarding the relationship between ROA and patents, it is possible that larger firms, who naturally have more patents, might push the ROA ratio down due to more intangible assets owned. In addition to that, return on assets might be a certain range of values that a company decides to keep for their projects, which is not related to patenting, leading to noisy results. Finally, as for negative association between Tobin's q and patents, the result was supported by previous research done by Neuhausler et al (2011), however it is quite surprising. Assuming that Fama's efficient market hypothesis holds, every patents that a firm owns has to be already reflected in the market value of it, as shareholders recognize the present and future opportunities provided by it. However, it is possible that patents required a vast amount of money spent, which resulted in high capitalized costs and overall greater amount of total assets increased compared to market value. Another possible justification would be to regard market value as a very volatile variable, depending on many outside factors out of the scope of this research.

Given these findings, it is possible to answer the research question:

To what extent do patents impact profitability of firms?

Patents do indeed lead to higher net income, which is the rawest and purest profitability figure. However, when it comes to financial ratios such as return on assets and Tobin's q, the relationship was found negative and negligible.

Such conclusions might seem dubious, as the research has certain limitations to it. Firstly, more controlled variables could have been used to avoid omitted variable bias, especially those which could affect the market value of the firms. Furthermore, the research could be carried out in a more extensive manner by splitting samples into certain categories. To be more precise, sample firms can be categorized by size, industry, patenting rate, etc. Additionally, it could be beneficial to used lagged values of patents. This means that granted patents often take time to be made full use of and become financially and strategically efficient. Finally, a different statistical approach could lead to other findings. For example, this paper assumed that the relationship between the variables was linear, when it might have been more appropriate to use a quadratic one.

Hence, future researches could benefit from this research as base findings and augment it by overcoming the abovementioned limitations by including more variables, using lagged values of patents and different statistical approaches and finally categorizing the sample to be able to give more direct results. Moreover, such analysis could be undertaken for other western world countries, such as U.K., the Netherlands or France, as different law systems and patent regulations might lead to completely contrasting choices of firms and therefore research results.

References

Berk, J., & De Marzo, B. (2014). *Corporate Finance.* Pearson.

Besanko, D., Dranove, D., Schaefer, S., & Shanley, M. (1996). *Economics of Strategy.* John Wiley & Sons.

Bhaskarabhatla, A., & Hedge, D. (2014, May 12). An Organizational Perspective on Patenting and Open Innovation. *Organization Science* .

Brooks, C. (2008). *Introductory Econometrics for Finance.* Cambridge University Press.

Fama, E. F. (1970). Efficient Capital Markets: A Review of Theory and Empirical Work. *Journal of Finance* .

Hall, B. H., & Ziedonis, R. H. (2001). The patent paradox revisited: an empirical study of patenting in the U.S. semiconductor industry, 1979-1995. *Journal of Economics* .

Korosec, K. (2015, December 21). Elon Musk Says Tesla Vehicles Will Drive Themselves in Two Years. *Fortune* .

Kortum, S., & Lerner, J. (1999). What is behind the recent surge in patenting? *Research Policy* .

McLaughlin, K. (2015, September 21). *Meet the most despised man in the world: Global outrage as 32-year old ex-hedge funder buys rights to AIDS drug and promptly raises* *price overnight by 5500% - from $13.50 to $750.00 per pill*. Retrieved from DailyMail: http://www.dailymail.co.uk/news/article-3243938/Ex-hedge-funder-32-hated-man-internet-defends-jacking-prices-AIDS-medication-5500.html

Neuhausler, P., Frietsch, R., Schubert, T., & Blind, K. (2011). Patents and the financial performance of firms – An analysis based on stock market data. *Fraunhofer ISI Discussion Papers Innovation Systems and Policy Analysis* .

Patent Technology Monitoring Team (PTMT). (2016). *U.S. Patent Statistics Chart Calendar Years 1963 - 2015.* U.S. PATENT AND TRADEMARK OFFICE.

Porter, M. (1976). *Interbrand Choice, Strategy and Bilateral Market Power.* Cambridge: Harvard University Press.

Teece, D. J. (1986, June). Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy.

Teece, D. J., & Grindley, P. (1997). Managing Intellectual Capital: Licensing and Cross-licensing in Semiconductors and Electronics. *California Management Review* .

The Telegraph. (2016, June 16). Most important inventions of the 21st Century: in pictures. *The Telegraph* .

Tsai, B.-H. (2010). Analysis of patent and profitability in Taiwan semiconductor firms. *PICMET 2010 TECHNOLOGY MANAGEMENT FOR GLOBAL ECONOMIC GROWTH.* IEEE.