ERASMUS UNIVERSITY ROTTERDAM

Erasmus School of Economics

The profitability of high-tech acquisitions and the effect of acquired patents on returns

Student: Victor Schipper

Student ID: 449180

Bachelor thesis: Bachelor International Economics & Business Economics

Bachelor Specialisation: Financial Economics

Thesis supervisor: dr. R. de Bliek

Second assessor: dr. R. Quaedvlieg

Date final version: 31 August, 2019

Acknowledgements

I would like to thank my supervisor dr. Ruben de Bliek for his support and help with this thesis.

Compliance statements

Non-plagiarism statement

By submitting this thesis, the author declares to have written this thesis completely by himself/herself, and not to have used sources or resources other than the ones mentioned. All sources used, quotes and citations that were literally taken from publications, or that were in close accordance with the meaning of those publications, are indicated as such.

Copyright statement

Abstract

This paper investigates the post-acquisition abnormal returns of 164 M&A's in the U.S. high-technology industry. The industry's high-risk, high-growth and innovative nature give reason for takeovers to be profitable. However, the results show that the expected return without a merger is 51.3% higher than the realized return in the five years after the announcement date. This means that shareholders do not profit from high-tech M&A's. To test the effect of acquiring innovative firms on returns, the number of acquired patents are examined. After controlling for the method of payment, mode of payment, market-to-book ratio and firm size, the results indicate that the number of acquired patents does not have a significant effect. The abnormal returns differs largely among industries. Also after controlling for the industry effects, the role of patents remains non-existing. The conclusion is that high-tech M&A's are no exception to the negative abnormal returns generally found in research (King, Dalton, Daily, & Covin, 2004). Long-term investors should be critical to high-tech takeovers even when the acquired firm is considered relatively innovative.

List of Tables

Contents

1 Introduction

Mergers and acquisitions (M&A's)[1] have been a very popular form of corporate improvement for many years. However, Loughran and Vijh (1997) proved that mergers are not always profitable to shareholders and that for some mergers the abnormal returns are even negative. The paradox between the number of M&A's (especially in the high-tech industry) and the findings of Lougrhan and Vijh is remarkable. This paper will assess the long-run returns of high-technology firms taking over innovative firms.

There has been extensive research on M&A's in general and some research on high-technology M&A's. For mergers in general, Loughran and Vijh (1997)) found that the mode of acquisition and the method of payment play an important role in post-acquisition returns: a stock merger yielded a significantly negative abnormal return of 25.0 percent and a cash tender offer earned a positive abnormal return of 61.7 percent. Rau and Vermaelen (1998) found that there is a significant difference in abnormal return for value and glamour stocks, representing a high and low book-to-market ratio respectively. These two papers paved the way for researchers to look into other possible factors, like categorization of stocks or processes that might explain the differences in return. For high-tech firms, De Man and Duysters (2005) mention that the increasing competitive pressure, the constantly growing investments in research and developments (R&D) and declining technology life cycles increase the importance of innovation within the industry. Makri, Hitt, and Lane (2010) state that high-technology firms embrace M&A's as an effective tool to enhance resources and capabilities to compete in the market. Kohers and Kohers (2000) proved the profitability of high-tech M&A's in the short-run and made a suggestion for further research to investigate the long-run effects.

As this recommendation indicates, literature has not researched the existing theory concerning long-run abnormal returns with respect to the high-tech industry. The industry characteristics like its high-growth, high-risk and innovative nature are reasons for high-tech firms to engage in M&A's. This paper includes innovation (measured by the number of patents) as an explanation for abnormal returns. This will show whether the number of patents has a positive effect on returns. The large number of high-tech M&A's and their innovative purpose would suggest the abnormal returns to be positive. This leads us to the research question:

Do long-run shareholders profit from high-tech mergers or acquisitions on relatively innovative firms?

[1] Mergers and acquisitions are used interchangeably throughout this proposal.

The profitability of the merger will be assessed by the abnormal returns, which is the difference between the realized return and expected return. The monthly data comes from ThomsonOne, Datastream and Orbis. The time period covers M&A's of which the announcement and effective date lie in the range of the first of January 2003 till December 31, 2013. The returns are analyzed for five years after the announcement date. All firms are located in the United States of America as there is much information available. The dataset will contain only high-tech firms, for both acquirer and target. The deals need to be listed as completed and the acquirer has not issued a bond or performed a merger five years before or after the announcement date. This is done to isolate the effect of the merger. The expected return is determined by the standard market model, using the Standard Poor's 500 Equal Weighted High Technology CNY as market index. A t-test on the average abnormal return will show whether M&A's in the high-technology industry are profitable to investors in the long-run. The abnormal returns will be regressed on the method of payment, mode of payment, book-to-market ratio, the market value, the high-tech industries and the number of patents in order to look at the effect of patents on abnormal returns.

The expectation is that the takeovers are profitable in the long-run and that the effect of patents on abnormal returns is positive. The acquired innovation should be of great value for the acquirer and therefore high-tech M&A's should be profitable to investors in the long-run.

This paper is organized by first discussing the existing literature and presenting two hypotheses that will support the research question. Thereafter, the data and methodology are discussed. The results show the findings, followed by a conclusion. At the end the limitations and suggestions for further research are discussed.

2 Literature review

The literature review starts with the definition of and motivations for M&A's. Thereafter, the M&A performance measurement is discussed, followed by elaborating on the difference in the short- and long-run returns. Then the general findings and explanatory variables are reviewed. Lastly, the high-technology industry is discussed and the two hypotheses are presented.

2.1 M&A: definition and motivation

Before specifying M&A to the high-tech industry, the definition and reasons for performing takeovers are discussed. M&A's take place when independent companies integrate their corporate activity into one new entity. An integration can refer to merging two more of less equal companies where the target stops existing after being absorbed by the acquirer. It is required that the board of directors of both firms give their approval. An integration can also refer to an acquisition where the acquirer obtains the majority of the target's ownership. In this way, the buying firm acquires the target and manages its business activities (Hagedoorn & Duysters, 2002). Despite the differences, mergers and acquisitions are mentioned interchangeably because of the similarity in motivations and consequences.

Ibrahimi (2018) gives four motivations for M&A's. The most common motivation is the strategic objective. This objective entails increasing market power, production capacity and market share as well as to yield economies of scale and scope (Epstein, 2005). For the latter, economies of scope represent a cost advantage by means of a variety of products or services. For example, firms can reduce costs by sharing R&D and marketing costs. Economies of scale provide cost advantages by having a higher level of production. Thus, M&A's can enhance the economies of scale and scope and result in lower costs. The second motivation for an acquisition involves the financial benefits. Merging firms could create financial value, reduce risk of financial illiquidity and restructure their debt. Third, opportunistic objectives concern personal motivation of managers. In this case managers perform an acquisition because they are overconfident of their abilities or aim at increasing their own wealth. Lastly, firms could merger because of the resource-based view objectives. This means that firms can acquire skills, knowledge and new technology. This motivation is of main interest for this research as this includes the innovative purpose of mergers.

One paper that proved this theory of profitable M&A's was written by Brush (1996). He showed that resource and activity sharing resulted in positive post-acquisition returns. Andrade, Mitchell, and Stafford (2001) agree by stating that mergers reallocate resources more efficiently and which is profitable to investors. Also, the improved operational performance increases the belief of high future cash flows and subsequently increases investors' returns. In section 2.4, other research that verify, contradict and condition these findings will be discussed.

2.2 M&A performance: measurement

Mergers are said to create value when the return after the merger is higher than the return without the merger. The underlying reason is as follows: investors respond to the news that a merger will take place between two or more firms. Their reaction will be translated in the demand and supply of the stock, the stock price will adjust and the return will change. The efficient market hypothesis (EMH) states that all information is incorporated in the price and that stocks are traded at their fair value (Malkiel & Fama, 1970). Specifying this theory to M&A, the stock price will adjust to the merger announcement as this discloses information concerning the acquiring firm's value. This means that from the announcement onwards, there is a distinction between what the 'normal' return and actual return is. The normal return represents the return without the merger and there is no new information concerning the company. This return is not observable in the market and therefore needs to be estimated. The realized return is the return with the merger announcement and will be influenced by the market incorporating the news in the price. The difference in the returns from the announcement date onwards is called the abnormal return. If the realized return is higher (less) than the expected return, the abnormal return is positive (negative) and the merger creates (destroys) value. When a merger creates value, it is said to be profitable to the investor.

2.3 M&A performance: short- vs long-term

There is a difference in M&A profitability in the short- and the long-run. The short-run covers typically a couple of days after the announcement. Within that time range, the announcement of a merger is in general received positively in the market. The reason is that the acquiring firm is worth more and this is translated in a higher stock price. Polasky and Mason (1998) support this by stating that in general acquirers' stock price increase in the short-run. So, in the short-run the news and the prospects affect the return. In the long-run the actual implementation is of great importance. The merging firms should match at strategic, organizational and operational level (Cartwright & Schoenberg, 2006). Also, it is of concern to see whether the firms are complementary and that the efficiency gains actually hold (Glazer & Weiss, 1993). These two factors put more conditions on the profitability of mergers in the long run resulting in return differences per time range. This paper will focus on the long-run consisting of five years.

2.4 General findings and explanatory variables

One of the first to empirically doubt the profitability of M&A's in the long-run were Agrawal and Jaffe (2000). They showed that acquiring firms obtained a negative abnormal return of 10 percent in the five years following the announcement date. In other words, a merger decreases a firm's value. Various scholars investigated the same topic and also found negative abnormal returns for the acquirer (see: King et al. (2004); Datta, Pinches, and Narayanan (1992); Roll (1988); Capron and Pistre (2002)). Cartwright and Schoenberg (2006) review thirty years of M&A-related research and find more support for destruction of value through M&A than creation of value. There are four commonly used variables that explain any return differences. These variables will be discussed here:

2.4.1 Method of payment

Myers and Majluf (1984) tried to explain return differences by the method of payment. The reason is that the decision to pay with cash or stock discloses information to investors. A firm's management knows more about the business and its prospects than investors. This difference in information is called asymmetric information. Managers make decisions for a reason and investors can deduct information by observing these actions. In this way, the asymmetry in information between management and investors is diminished. Myers and Majluf (1984) proved this by finding that in case a firm needs money, managers issue stock (cash) when they think the firm is overvalued (undervalued). This also applies to the financing of mergers. Investors perceive the method of payment as a disclosure of information where stock (cash) offers are received negatively (positively) by the market (Brown & Ryngaert, 1991).

2.4.2 Mode of payment

The mode of payment also has an influence on returns in the long-run. A friendly takeover, typically a merger, involves cooperation and careful integration of the two firms. A tender offer is a form of hostile acquisition and is characterized by appointing new managers. The process of integration is considered to be more efficiently by replacing incumbent managers and is therefore less costly. Because of these reasons, Sudarsanam and Mahate (2006) state that hostile takeovers result in higher returns than friendly takeovers. Loughran and Vijh (1997) empirically verified the effect of the payment method and mode of acquisition by showing that a stock merger yields a negative abnormal return of 25.0 percent and a cash tender offer gives a positive abnormal return of 61.7 percent.

2.4.3 Book-to-market ratio

Rau and Vermaelen (1998) looked into firm attributes that might explain returns. They characterized firms with a low book-to-market (BM) ratio as 'glamour' firms and firms with a high BM ratio as 'value' firms. The rational is that the market extrapolates the past good (bad) performance of the firm which results in a higher (lower) market value and thus a low (high) ratio. Their findings show that glamour stocks underperform and value stock outperform in the long-run.

2.4.4 Market value

The market value of the firm explains returns as well and has been a widely-used control variable in the examination of returns (see: Rau and Vermaelen (1998); Loughran and Vijh (1997); Martin (1996)). Weitzel and McCarthy (2011) showed that small firms are better able to incorporate external growth by a merger due to their flexibility. Large firms are complex organizations where the integration requires more effort (Kuehn, 1975). Especially in the technology industry, innovation is harder to implement in large companies (Cloodt, Hagedoorn, & Van Kranenburg, 2006). Therefore, the market size of the acquirer will control for any size effects.

2.5 High-technology industry

Despite the general findings of negative abnormal returns, this paper believes that the high-tech industry has great potential for positive post-acquisition returns. The belief is based on three industry specifics which are conducted from the definition of the high-tech industry.

The Organization for Economic Co-operation and Development (OECD, 2007) categorizes (high-)technology firms on their relative R&D intensities. The firms with relatively the highest intensity are considered to be high-tech firms. These firms are involved in, among others: pharmaceuticals, communication equipment, software and aircrafts. Kohers and Kohers (2000) give two important characteristics to this industry. They state that the industry is of a high-risk and high-growth nature. With their high intensity in R&D, high-tech firms are at the cutting-edge and have potential for great expansion. However, the risk within these firms is high as they are dependent on the uncertain outcomes of the investments in R&D. The risk increases with the market being very competitive. De Man and Duysters (2005) argue that high-tech firms are forced to innovate because of increasing competitive pressure, the constantly growing investments in R&D and de-

clining technology life cycles. This puts even more pressure on the innovative capacity of firms and results in the third industry characteristic.

In order to deal with the high-growth, high-risk and innovative nature of the high-tech industry companies embrace M&A or any other form of collaboration (De Man & Duysters, 2005). Makri et al. (2010) agree by stating that high-technology firms embrace M&A's as an effective tool to enhance resources and capabilities. Kohers and Kohers (2000) support these findings by showing that the industry's abnormal returns are positive in the short-run. Their recommendation on future research is to see whether these findings hold in the long-run as well. Therefore, there is much support for M&A's creating value in the high-tech industry. This results in the first hypothesis:

Hypothesis 1: Long-term shareholders profit from high-tech mergers or acquisitions.

As earlier stated, the high-tech industry is led by innovation. This paper will use the technological definition of innovation as this definition applies well to the high-tech sector. The OECD (2015) defines technological innovation as innovation that contains new products and leads to technological changes in goods and processes. De Man and Duysters (2005) provide arguments on why M&A's stimulate innovation and why it is beneficial. These arguments are on line with the motivations mentioned by Ibrihami (2018) but are specified to the high-tech industry. First, they find that mergers increase the R&D budget and therefore there are economies of scale. Two integrated firms could take on larger projects compared to doing them on their own. Secondly, by having more and different kinds of research projects, the risk of innovation decreases. This reduces uncertainty and should be positively perceived by investors. Lastly, by integrating firms that are complementary, new technologies and goods can be created. All three could lead to a more innovative and profitable firm which should be translated in a positive return.

In order to test this, innovation is measured in the same way as Hall, Jaffe, and Trajtenberg (2005). They use the number of patents as an indicator of innovative performance. A patent is defined by being a unique part of knowledge and is the output measure of inventions (Ahuja & Katila, 2001). The long-term effect of innovation on return is criticized by Glazer and Weiss (1993). They argue that the value of knowledge depreciates over time. However, Eberhart, Maxwell, and Siddique (2004) find that markets are slow in recognizing the benefit of R&D collaborations, especially in the high-tech industry. Besides, Coad and Rao (2008) argue that it takes time for converting innovation to economic performance. For example, firms might have obtained new patents, but it will take some

years before this will be commercialized and monetized. Bierly and Chakrabarti (1996) summarize the importance of innovation by stating that innovation is a key determinant in sustaining and creating a competitive advantage in the industry. This supports and leads to the second hypothesis:

Hypothesis 2: For high-technology takeovers, patents have a positive effect on shareholder profit in long-term.

3 Data

The data section provides insight in the data selection. After going over the selection process, the variables are further specified and the descriptive statistics of the variables is presented.

3.1 Data selection

The hypotheses are tested based on monthly data obtained from ThomsonOne, Datastream and Orbis. It will be a panel dataset because it contains cross-sectional data for multiple years. The dataset will be determined by a few criteria:

1. The announcement and effective date of the merger lies in the time period ranging from January 1, 2003 to December 31, 2013.
2. Both acquirer and target are selected from the high-tech industry.
3. Both acquirer and target are located in the United States of America.
4. The target is listed as a public firm.
5. The deal is listed as completed.
6. The acquiring firm has not issued any bond or stock and has not performed a merger in the five years before and after the announcement date.

The first and second criteria determine the timeframe and the category of firms. For the time range, the starting date is chosen to avoid any possible effects of the Internet Bubble. The ending date is chosen because the returns are investigated for five years after the announcement date. The market index estimates the expected return for five years after the announcement date. The index used is called The Standard Poor's 500 Equal

Weighted High Technology CNY. This index only includes high-tech firms listed on the S&P 500 and is an equally weighted index. For categorization of high-technology firms, the OECD (2007) classified high-tech firms on the following SIC-codes: 353 (aircraft and spacecraft), 2423 (pharmaceuticals), 30 (office, accounting and computing machinery), 32 (Radio, TV and communications equipment) and 33 (Medical, precision and optical instruments).

The last four criteria eliminate any possible factors that could interfere with returns. For example, the third criterion gets rid of any difference in culture or legal difference between countries that might affect returns. For the fourth criterion, Chang (1998) showed that acquiring a privately held firm results in a higher abnormal return than acquiring a publicly traded company. By selecting public targets, returns are isolated from this affect. The fourth criterion makes sure that returns are not affected by any negotiations that could affect returns. Lastly, returns should not be affected by published management decisions. Criterion five makes sure that returns are not influenced by other news events. These criteria set the timeframe, select the firms and eliminates any factors outside the interest of this paper.

3.2 Specification of variables

The number of patents is defined as patents obtained in the seven years before the announcement date. The time range for the obtained number of patents is set in order to isolate the most recent innovations and represent the most current innovative capacities.

As mentioned earlier, there are four commonly used variables that explain difference in abnormal returns. The definition and specification of the variables are needed for the tests and results. The first variable is the method of payment. This variable will be either cash or stock. When a deal is financed for more than 95 percent cash (stock), it will be characterized as a full cash (stock) payment. The reason is that the payment method contains information and the disclosure of information is the same whether a deal is financed by cash for 100 or 95 percent. Secondly, the mode of acquisition also plays a role. As stated earlier, a friendly or hostile takeover disclose information on the probability of an efficient takeover. A friendly acquisition is described by the recommendation of the offer by the target's management. With a hostile acquisition, the board officially rejects the offer. The third variable is the market value of the acquirer. This is calculated by multiplying the number of outstanding stocks by the market price. This market value is also used for the fourth variable, namely the market-to-book value. Rau and Vermaelen

(1998) used the book-to-market ratio but this paper will use the market-to-book ratio due to the availability of data. The exchange of nominator and denominator changes the interpretation: a low (high) book-to-market ratio will become a high (low) market-to-book ratio where both represent a glamour (value) stock. Both the third and four variable are measured one month before the announcement.

An summary and overview of variables and their definition is provided in table 7 in the appendix.

3.3 Descriptive statistics

The descriptive statistics covers all variables. Also, the mean of acquired patents and the abnormal return per industry and year are reviewed in order to get a better understanding of their distribution in the high-tech industry over time.

3.3.1 All variables

After selecting, filtering and cleaning the database, there are 164 mergers and acquisitions. This number is heavily influenced by the fact that many firms were involved in at least one takeover. Table 1 shows the descriptive statistics without transformations.

Some of the variables' minimum and maximum are remarkable and therefore should be watched carefully. For the abnormal returns, the minimum value is extremely low. This can be explained be either the realized returns being very low, the expected return estimate too high or both. The extremes for market capitalization is remarkable as well. The largest acquirer in the sample has a market value of 26 8096.8 million US dollars. For the number of patents, there are also some very high values. These extreme values could

Table 1: Descriptive statistics I
This table shows the number of observations, the mean, standard deviation, minimum and maximum of the corresponding variables.

Variable	Obs	Mean	Std. Dev.	Min	Max
Abn. return	164	-0,561	1,895	-5,382	3,617
Stock (1 = yes)	164	0,232	0,423	0	1
Hostile (1 = yes)	164	0,024	0,155	0	1
Market-to-book	164	2,993	6,294	-54,400	43,300
Market value ($)	164	7.037,070	23.792,970	3,010	268.096,800
Patents	164	37,274	93,011	0	879

heavily affect and bias the returns. Some tools to tackle potential problems are provided in the methodology section.

3.3.2 Patents and abnormal returns per industry

Table 2 shows the mean and frequency of acquired patents and abnormal returns. The mean of patents shows that in industry 'Pharmaceuticals' and 'Medical, precision and optical instruments' the number of acquired patents is twice as large as for industry 'Air- and spacecraft' and 'Office, accounting and computing machinery'. Also, the abnormal returns per industry is quite different. 'Medical, precision and optical instruments' has a very negative and 'Air- and spacecraft' a positive mean. The number of takeovers per industry is not consistent as well. The number of acquisitions in 'Pharmaceuticals' is ten times larger than 'Air- and spacecraft'. These differences across industries are in line with the findings of industry effects by Fernández, Iglesias-Antelo, López-López, Rodríguez-Rey, and Fernandez-Jardon (2019). Industry effects imply that there are some characteristic differences between industries and they are translated in return differences. These differences should be watch closely in the methodology.

Table 2: Patents and abnormal returns per industry
This table shows the mean and frequency of the number of acquired patents and of the abnormal retuns per high-tech industry.

Variable	Mean Patents	Mean Abn. Return	Freq.
Air- and spacecraft	15,714	-0,108	7
Pharmaceuticals	47,138	-0,832	80
Office, accounting, computing machinery	20,700	-0,124	40
Radio, TV and communications equipment	32,522	0,415	23
Medical, precision and optical instruments	46,857	-2,093	14
Total	37,274	-0,561	164

3.3.3 Patents and abnormal returns per year

Table 3 shows that the data also differs a lot per year. The mean of acquired patents is very different per year. For example, the number of acquired patents changed from 106,583 in 2009 to 12,058 in 2010. Besides, for some years the mean of abnormal returns is positive and for some negative. Lastly, the number of M&A's is stable from 2003 to 2010 thereafter the number of takeovers more than halves. These differences could relate to business cycles and need to be further investigated to examine their role in the analysis.

Table 3: Patents and abnormal returns per year
This table shows the mean, standard deviation and frequency of the abnormal returns per year.

Variable	Mean Patents	Mean Abn. return	Freq.
Year 2003	22,875	-0,464	24
Year 2004	26,435	0,387	23
Year 2005	7,467	-0,081	15
Year 2006	43,684	-0,742	19
Year 2007	76,600	-1,593	15
Year 2008	38,850	0,307	20
Year 2009	106,583	-0,810	12
Year 2010	12,058	-1,284	17
Year 2011	22,000	-1,794	7
Year 2012	9,167	-1,289	6
Year 2013	6,333	-0,822	6
Total	37,274	-0,561	164

4 Methodology

The methodology section shows the formulas for determining the abnormal returns. Then the transformation of the data is discussed. This will be followed by presenting the method of testing the hypotheses.

4.1 Determination of abnormal returns

The hypotheses will be tested by a buy and hold strategy where the stock is hold for multiple months. The acquirer's abnormal returns provide insight on the profitability of the merger and is determined by comparing the realized return to the expected return. The realized return ($R_{i,t}$) for stock i in month t is calculated by the following formula with ($P_{i,t}$) being the stock price at the first day of month t:

$$R_{i,t} = \frac{P_{i,t+1} - P_{i,t}}{P_{i,t}}$$

A security's expected return is determined by the standard market model. The $R_{MI,t}$ represents the market index (MI) return for month t. Both $\hat{\alpha}_i$ and $\hat{\beta}_i$ are calculated per firm by an ordinary least-squares regression. The coefficients will be determined in the control period which ranges from 36 months prior to the announcement date (t = -36) till one month before the announcement date (t = -1). Thus, the expected return is cal-

culated as follows:

$$R^*_{i,t} = \hat{\alpha}_i \ + \hat{\beta}_i R_{MI,t}$$

The buy and hold abnormal returns are represented by $bhar_{iKL}$ and cover the test period [K, L] ranging from the announcement date (K = 0) till 60 months after that date (L = 60) . The abnormal returns are determined by subtracting the expected return from the realized return:

$$bhar_{iKL} = \prod_{t=K}^{L}(1 + R_{i,t}) - \prod_{t=K}^{L}(1 + R^*_{i,t})$$

The abnormal returns [2] show the following: assume someone who buys a stock for 1000 U.S. dollars one month before the merger announcement and keeps the stock for five year. After one month, the $1000 is multiplied by the return of that month. For the second month, the $1000 plus return is multiplied by the return of the second month. This continues till the sixtieth month and represents the realized return. This number is compared to the return if that person had put the money in the market index in the first month. The difference between these two returns is the abnormal return (bhar). In this example, an abnormal return of -0.25 is the result of the realized return being 15 percent and the market index being 40 percent. The investor made $150 but could have made $400 by investing in the market index. Therefore, the abnormal returns times the investment (-0.25*1000) is the difference between what an investor has made and what he/she could have made in monetary terms. In this way, it can be shown whether the merger was relatively profitable or not.

4.2 Transformations

As described by the descriptive statistics, there are some extremes for variables like the abnormal return, market capitalization and the number of patents. As the extremes for the abnormal returns are mostly negative, the mean of the abnormal returns could be biased downwards. In order to control for this, the abnormal returns are winsorized. This means that the returns are transformed by limiting extreme values. This paper applies a 90% winsorization which means that the abnormal returns below (above) the 5th (95th) percentile are converted to the 5th (95th) percentile. This eliminates the most extreme values and diminishes a negative bias. When the abnormal returns are discussed in the methodology and results section, they refer to the winsorized abnormal returns unless

[2] The $BHAR_i$ is equal to the $BHAR_{KL}$ with K = 0 and L = 60 as the test period is constant throughout this paper.

mentioned differently.

For the market value and number of patents, this paper uses the natural logarithm of the variables to correct for large extremes. The natural logarithm reduces large differences in quantities to smaller scopes (Yermack, 1995). With the transformation, the economic interpretation changes: a one percent increase (decrease) in market value or the number of patents results in an increase (decrease) of abnormal return by the variable's coefficient times one percent. Lastly, the method of payment and the mode of payment will both be a dummy variable where merger is either paid by stock (1) or cash (0) and the mode is either hostile (1) or friendly (0). In case industry and/or year are included in the regression, they will be treated as categorical variables.

The descriptive statistics of transformed variables are shown in table 4:

Table 4: Descriptive statistics II
This table shows the number of observations, the mean, standard deviation, minimum and maximum of the corresponding variables.

Variable	Obs	Mean	Std. Dev.	Min	Max
Abn. return (winsorized)	164	-0,513	1,487	-3,041	1,510
Market value (ln.)	164	6,936	2,104	1	12
Patents (ln.)	121	2,710	1,642	0	7

4.3 First hypothesis

The first hypothesis will be tested by examining whether the average abnormal return (BHAR) is significantly different from zero at a 5% significance level. The BHAR will be determined by summing the abnormal returns and dividing them by the number of stocks. For the test statistic, this number will be divided by the standard deviation of the abnormal return (S_{bh}) and by the root of the number of M&A's (N). The sign of the return is of great importance as this shows whether the mergers is profitable or not. The test statistic of the buy and hold abnormal returns (TBHAR) is computed as follows:

$$TBHAR_{KL} = \frac{BHAR_{KL}}{S_{bh}/\sqrt{N}}$$

The BHAR takes the average of the abnormal returns across industries and years. As shown earlier, the data shows differences in returns between industries and years. One potential problem is that a few very bad (good) performing industries or years could negatively (positively) affect the results. Therefore, the same t-test is performed per industry

and year. The mean and the test statistics combined will provide insight into whether the means are actually statistically different from each other. This will be tested by means of a two sample t-test where the mean of the significant industries or years are compared. These t-tests shows whether industry or year should be included in the analysis to control for potential omitted variables.

4.4 Second hypothesis

For the second hypothesis, a regression model is used to investigate the effect of patents on the abnormal returns. Before performing this regression, endogeneity and heteroscedasticity are reviewed. At the end the two regressions are presented.

4.4.1 Endogeneity and heteroscedasticity

Before any inferences are drawn from the regression, the endogeneity and heteroscedasticity are discussed. Endogeneity means that an excluded independent variable co-varies with the error term. This results in the coefficients to be biased and inconsistent. This is of great concern for the number of patents, as this is the main variable of interest and an accurate estimate is required. One of the few variables that could correlate with patents and abnormal returns is the market value. As earlier stated, size correlates with abnormal returns. Besides, it likely that large firms have more patents than small firms. Market value controls for the endogeneity.

One condition for interpreting the variables' coefficient is that the coefficients are significant at a 5% level. This involves the requirement of homoscedasticity where the variance of the residuals is the same for all stocks. If this is not the case, there is heteroscedasticity. This means that the default standard errors are no longer valid. This subsequently affects the test statistic of the variables and their significance. A White Test will show whether there is heteroscedasticity and whether there is need for robust standard errors.

4.4.2 Regression I

The following regression will be used to explain the differences in abnormal returns between firms:

$$Abn.\ returns_i = \alpha + \beta_1 * Stock_i + \beta_2 * Hostile_i + \beta_3 * Market - to - book_i + \beta_4 * Market\ Value(ln.)_i + \beta_5 * Patents(ln.)_i + \epsilon \quad (1)$$

Where:

$Abn.\ returns_i$	= the abnormal return of bidder i at the end of year five
$Stock_i$	= 1 if at least 95% of the deal value was financed by stocks; 0 otherwise
$Hostile_i$	= 1 if the mode of acquisition is considered to be hostile; 0 otherwise
$Market - to - book_i$	= the ratio of the acquiring firm's market-to-book ratio
$Market\ Value\ (ln.)_i$	= the natural logarithm of the acquirer's market value one month before the announcement
$Patents\ (ln.)_i$	=the natural logarithm of acquired patents by means of the merger

After performing this regression, the p-value of the patents will be reviewed. When this value is smaller than or equal to five percent, the number of patents has a significant effect on the abnormal returns. The sign of the coefficient will determine whether the patents have a positive or negative effect on abnormal returns.

4.4.3 Regression II

The first regression examines the effect of patents on abnormal returns. Panel data provides the opportunity to use a general fixed effects model. The second regression will make use of this opportunity and will serve as a verification of the findings in regression I.

The general fixed effects model can control for time-invariant and time-variant effects. The t-tests performed for hypothesis 1 will provide insight on whether to include these effects. For now, it is assumed that only industry effects will matter. Proof of this assumption will be discussed in the results section.

In all, the industry fixed effect is added to the regression and that results in the following

regression:

$$Abn.\ returns_i = \alpha + \beta_1 * Stock_i + \beta_2 * Hostile_i + \beta_3 * Market - to - book_i + \beta_4 * Market\ Value(ln.)_i + \beta_5 * Patents(ln.)_i + \beta_6 * Ind2_i + \beta_7 * Ind3_i + \beta_8 * Ind4_i + \beta_9 * Ind5_i + \epsilon \quad (2)$$

Where:

$Ind2$	= 1 if firm i operates in industry 'Pharmaceuticals'; 0 otherwise
$Ind3$	= 1 if firm i operates in industry 'Office, accounting and computing machinery'; 0 otherwise
$Ind4$	= 1 if firm i operates in industry 'Radio, TV and communications equipment'; 0 otherwise
$Ind5$	= 1 if firm i operates in industry 'Medical, precision and optical instruments'; 0 otherwise

5 Results

This section will present the results, give interpretation of them and accept or reject the hypotheses.

5.1 Hypothesis 1

For the first hypothesis, table 5 shows the zero mean t-test on the abnormal returns for all observations, per industry and per year.

The overall sample gives a mean of -0,513. This is statistically different from zero with test statistic of -4,415 and a p-value of 0,000. The mean indicates that the expected return is on average 51,3% higher than the realized return. So, in the consideration of performing a takeover, the negative abnormal return shows that a merger does not create more value than expected without the takeover. This is in line with the findings of negative post-acquisition returns found by King et al. (2004), Roll (1988) and Capron and Pistre (2002). These papers investigated the profitability of M&A's in general (without specifying it to an industry). The results shows that the high-industry is no exception and so investors seem to lose money by keeping or buying an acquiring company's stock.

Looking at the mean per industry, panel B shows two significant means: the second industry (pharmaceuticals) has a mean of -0.830 and the fourth industry (medical, precision and optical instruments) has a mean of -3.044. To test whether the difference in mean is

Table 5: T-test on all variables, industries and years

This table shows the output of t-tests on the abnormal returns for five years after a takeover announcement. Panel A shows the test for all observations, panel B per industry and panel C per year. The null hypothesis is that the mean is zero and the alternative hypothesis is that it is different from zero. In the last row of panel B and C show whether the returns of industry 3 and 4, and of year 2007 and 2010 are significantly different from each other.

Panel A				
Variable	Obs	Mean	t-value	Pr(|T|>|t|) =
Abn. return (winsorized)	164	-0,513	-4,415	0,000
Panel B				
Abn. return (winsorized) per industry				
Air- and spacecraft	7	-2,208	-0,337	0,747
Pharmaceuticals	80	-0,830	-4,180	0,001
Office, accounting, computing machinery	40	-0,264	-1,177	0,246
Radio, TV and communications equipment	25	0,220	1,018	0,320
Medical, precision and optical instruments	14	-3,044	-3,474	0,004
Office, accounting, computing machinery = Medical, precision and optical instruments		-0,905	-3,331	0,002
Panel C				
Abn. return (winsorized) per year				
Year 2003	24	-0,464	-1,608	0,122
Year 2004	23	0,193	0,848	0,405
Year 2005	15	-0,088	-0,212	0,836
Year 2006	19	-0,583	-1,395	0,179
Year 2007	15	-1,399	-3,783	0,002
Year 2008	20	0,033	0,119	0,906
Year 2009	12	-0,587	-1,318	0,214
Year 2010	17	-1,037	-2,848	0,012
Year 2011	7	-1,203	-1,823	0,118
Year 2012	6	-1,105	-2,213	0,078
Year 2013	6	-0,822	-2,124	0,087
Year 2007 = Year 2010		-0,363	-0,699	0,489

statistically verified, a two-sample t-test is performed. This test shows that that means are significantly different from each other with a p-value of 0.002. This indicates that the high-technology sector includes very different industries. This is in agreement with the paper of (Fernández et al., 2019). The specified industries are likely to have different impacts and/or bias the abnormal returns and this needs to be controlled for in the second hypothesis.

Panel C shows two significant means of -1,399 and -1,037 for the year 2007 and 2010, respectively. A two-sample t-test examines whether the means are significantly different from each other. The p-value of 0,489 shows that they are not. As the other years are insignificant, the average abnormal return is assumed to be constant. This means that the data is not affected by any business cycles. Therefore, there is no need for a control variable with respect to time-varying fixed effects.

In all, the first hypothesis is rejected: long-term shareholders do not profit from high-tech mergers or acquisitions.

5.2 Hypothesis 2

The first regression shows the potential effect of patents on the abnormal return (see table 6). The coefficient is insignificant by a p-value of 0.320. This means that any relationship between the number of patents and abnormal return is due to chance. Therefore, the first regression shows that the number of patents does not have an effect on the abnormal returns. The rational of increasing returns by acquiring patents does not hold.

The second regression controls for any industry effects. Just like regression I, this regression also finds an insignificant coefficient for the number of patents. This verifies that the number of acquired patents do have an effect on the abnormal returns.

Both results from regression I and II show an insignificant coefficient for the number of patents. This means that any relationship between the number of patents and abnormal returns are a result of chance. Both Coad and Rao (2008) and Eberhart et al. (2004) state it takes time for innovation to be monetized. However, the presented results show that even in five year the number of patents does not matter for returns. Therefore, this paper supports the argument of Glazer and Weiss (1993) who say that innovation does not have a long-term effect on returns. This is concluded in the rejection of the second hypothesis: for high-technology takeovers, patents do not have a positive effect on long-term shareholder profit.

Table 6: Regression I and II

This table shows regressions that are performed in order to test the effect of patents on abnormal returns in the five years after a takeover announcement date. Stock is a dummy variable being 1 when the deal was stock financed and 0 when cash financed. Hostile is also a dummy variable being 1 when the deal was hostile and 0 when friendly. Market-to-book represents the market-to-book ratio of the acquirer. Market value (ln.) and Patents (ln.) are the natural logarithms of the acquirer's market capitilization one month before the event and the number of acquired patents. The other variables are high-tech industries where air- and spacecraft is the base industry.

Dependent variable: Abn. return (winsorized)	Regression I	Regression II
Stock (1 = yes)	-0.531**	-0.506*
	(0.267)	(0.270)
Hostile (1 = yes)	1.803***	1.230***
	(0.234)	(0.335)
Market-to-book	-0.041**	-0.032*
	(0.017)	(0.017)
Market value (ln.)	-0.255***	-0.227***
	(0.066)	(0.061)
Patents (ln.)	0.083	0.133
	(0.083)	(0.081)
Pharmaceuticals (1 = yes)		-0.946**
		(0.453)
Office, accounting, computing machinery (1 = yes)		-0.195
		(0.477)
Radio, TV and communications equipment (1 = yes)		0.015
		(0.487)
Medical, precision and optical instruments (1 = yes)		-1.725***
		(0.648)
Constant	1.328**	1.644**
	(0.525)	(0.633)
Observations	121	121
R-squared	0.253	0.357

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In all, the second hypothesis is rejected: For high-technology takeovers, patents do not have a positive effect on shareholder profit in long-term.

Despite the fact that the number of patents does not effect on abnormal returns, this paper does confirm the importance of the method of payment (Myers & Majluf, 1984), mode of acquisition (Loughran & Vijh, 1997), market-to-book ratio (Rau & Vermaelen, 1998) and firm size (Weitzel & McCarthy, 2011). These variables are statistically significant at 5% and 1% level in regression I. In regression II they are significant at a 10% percent or lower.

6 Conclusion

This paper investigates the post-acquisition abnormal returns of 164 M&A's in the U.S. high-technology industry. The industry's high-risk, high-growth and innovative nature give reason for takeovers to be profitable. However, the results show that the expected return without a merger is 51.3% higher than the realized return in the five years after the announcement date. This reject the first hypothesis meaning that shareholders do not profit from high-tech M&A's. To test the effect of acquiring innovative firms on returns, the number of acquired patents are examined. After controlling for the method of payment, mode of payment, market-to-book ratio and firm size, the results indicate that the number of acquired patents does not have a significant effect. T-tests show that the abnormal return differs significantly between the industries but not between years. Also after controlling for the industry, the role of patents remains non-existing. Therefore, the second hypothesis is rejected meaning that patents do not have a positive effect on shareholder profit in the long-term. The conclusion is that high-tech M&A's are no exception to the negative abnormal returns generally found in research (King et al., 2004). Long-term investors should be critical to high-tech takeovers even when the acquired firm is considered relatively innovative.

7 Limitations and further research

This research is subject to some limitations. The first limitations is that the selection criteria might have resulted in a negative bias. The criterion of the acquiring company not issuing new equity or performing another takeover has reduced the number of observations largely. The reason for excluding these firms is to isolate the effect of the event. However, these firms involve in these activities because, for example, they need cash to make new investments and/or acquire new firms as they are expanding. In other words, these firms are likely to be well-performing. Excluding these firms limits the number of possible profitable mergers. Therefore, the presented profitability might be more negative than the actual profitability. A suggestion for further research is to look into a method that includes these firms and controls for the different events.

The second limitation concerns the determination of expected returns. This is crucial to the quality of an event study when long-term returns are investigated. When the expected returns are estimated too high (low), the abnormal returns give a negative (positive) value, meaning that mergers destroy (create) value even though they do not. A model that calculates the expected returns generally more accurate than the market

model is the three-factor model by (Fama & French, 1993). Using this model or using it as a robustness check would have increased the validity of the results.

A third limitation is that the connection of patents to returns is more complicated than described in this paper. For example, Cloodt et al. (2006) show that when the size of the obtained knowledge is large, it is harder to integrate the firms efficiently. Besides, Makri et al. (2010) argue that the similarity or complementarity of the knowledge plays a role in the usefulness and profitability of the mergers. It's up to further research to delve deeper into determinants that play a role in innovation and the lacking profitability in the high-technology industry.

References

Agrawal, A., & Jaffe, J. F. (2000). The post-merger performance puzzle. In *Advances in mergers and acquisitions* (pp. 7–41). Emerald Group Publishing Limited.

Ahuja, G., & Katila, R. (2001). Technological acquisitions and the innovation performance of acquiring firms: A longitudinal study. *Strategic management journal*, *22*(3), 197–220.

Andrade, G., Mitchell, M., & Stafford, E. (2001). New evidence and perspectives on mergers. *Journal of economic perspectives*, *15*(2), 103–120.

Bierly, P., & Chakrabarti, A. (1996). Generic knowledge strategies in the us pharmaceutical industry. *Strategic management journal*, *17*(S2), 123–135.

Brown, D. T., & Ryngaert, M. D. (1991). The mode of acquisition in takeovers: Taxes and asymmetric information. *The Journal of Finance*, *46*(2), 653–669.

Brush, T. H. (1996). Predicted change in operational synergy and post-acquisition performance of acquired businesses. *Strategic Management Journal*, *17*(1), 1–24.

Capron, L., & Pistre, N. (2002). When do acquirers earn abnormal returns? *Strategic management journal*, *23*(9), 781–794.

Cartwright, S., & Schoenberg, R. (2006). Thirty years of mergers and acquisitions research: Recent advances and future opportunities. *British journal of management*, *17*(S1), S1–S5.

Chang, S. (1998). Takeovers of privately held targets, methods of payment, and bidder returns. *The Journal of Finance*, *53*(2), 773–784.

Cloodt, M., Hagedoorn, J., & Van Kranenburg, H. (2006). Mergers and acquisitions: Their effect on the innovative performance of companies in high-tech industries. *Research policy*, *35*(5), 642–654.

Coad, A., & Rao, R. (2008). Innovation and firm growth in high-tech sectors: A quantile regression approach. *Research policy*, *37*(4), 633–648.

Datta, D. K., Pinches, G. E., & Narayanan, V. K. (1992). Factors influencing wealth creation from mergers and acquisitions: A meta-analysis. *Strategic management journal*, *13*(1), 67–84.

De Man, A.-P., & Duysters, G. (2005). Collaboration and innovation: a review of the effects of mergers, acquisitions and alliances on innovation. *Technovation*, *25*(12), 1377–1387.

Eberhart, A. C., Maxwell, W. F., & Siddique, A. R. (2004). An examination of long-term abnormal stock returns and operating performance following r&d increases. *The Journal of Finance*, *59*(2), 623–650.

Epstein, M. J. (2005). The determinants and evaluation of merger success. *Business Horizons*, *48*(1), 37–46.

Fama, E. F., & French, K. R. (1993). Common risk factors in the returns on stocks and bonds. *Journal of financial economics*, *33*(1), 3–56.

Fernández, E., Iglesias-Antelo, S., López-López, V., Rodríguez-Rey, M., & Fernandez-Jardon, C. M. (2019). Firm and industry effects on small, medium-sized and large firms' performance. *BRQ Business Research Quarterly*, *22*(1), 25–35.

Glazer, R., & Weiss, A. M. (1993). Marketing in turbulent environments: decision processes and the time-sensitivity of information. *Journal of marketing research*, *30*(4), 509–521.

Hagedoorn, J., & Duysters, G. (2002). External sources of innovative capabilities: the preferences for strategic alliances or mergers and acquisitions. *Journal of management studies*, *39*(2), 167–188.

Hall, B. H., Jaffe, A., & Trajtenberg, M. (2005). Market value and patent citations. *RAND Journal of economics*, 16–38.

King, D. R., Dalton, D. R., Daily, C. M., & Covin, J. G. (2004). Meta-analyses of post-acquisition performance: Indications of unidentified moderators. *Strategic management journal*, *25*(2), 187–200.

Kohers, N., & Kohers, T. (2000). The value creation potential of high-tech mergers. *Financial Analysts Journal*, *56*(3), 40–51.

Kuehn, D. (1975). *Takeovers and the theory of the firm: an empirical analysis for the united kingdom 1957–1969*. Springer.

Loughran, T., & Vijh, A. M. (1997). Do long-term shareholders benefit from corporate acquisitions? *The Journal of Finance*, *52*(5), 1765–1790.

Makri, M., Hitt, M. A., & Lane, P. J. (2010). Complementary technologies, knowledge relatedness, and invention outcomes in high technology mergers and acquisitions. *Strategic management journal*, *31*(6), 602–628.

Malkiel, B. G., & Fama, E. F. (1970). Efficient capital markets: A review of theory and empirical work. *The journal of Finance*, *25*(2), 383–417.

Martin, K. J. (1996). The method of payment in corporate acquisitions, investment opportunities, and management ownership. *The Journal of finance*, *51*(4), 1227–1246.

Myers, S. C., & Majluf, N. S. (1984). Corporate financing and investment decisions when firms have information that investors do not have. *Journal of financial economics*, *13*(2), 187–221.

OECD. (2007). *Oecd science, technology and industry: Scoreboard 2007*. Organisation for Economic Co-operation and Development.

OECD. (2015). *Frascati manual 2015: Guidelines for collecting and reporting data on research and experimental development*. OECD Publishing.

Polasky, S., & Mason, C. F. (1998). On the welfare effects of mergers: Short run vs. long run. *The Quarterly Review of Economics and Finance*, *38*(1), 1–24.

Rau, P. R., & Vermaelen, T. (1998). Glamour, value and the post-acquisition performance of acquiring firms. *Journal of financial economics*, *49*(2), 223–253.

Roll, R. (1988). Empirical evidence on takeover activity and shareholder wealth. *Knights, raiders and targets: The impact of the hostile takeover*, 241–252.

Sudarsanam, S., & Mahate, A. A. (2006). Are friendly acquisitions too bad for shareholders and managers? long-term value creation and top management turnover in hostile and friendly acquirers. *British Journal of Management*, *17*(S1), S7–S30.

Weitzel, U., & McCarthy, K. J. (2011). Theory and evidence on mergers and acquisitions by small and medium enterprises. *International Journal of Entrepreneurship and Innovation Management*, *14*(2/3).

Yermack, D. (1995). Do corporations award ceo stock options effectively? *Journal of financial economics*, *39*(2-3), 237–269.

Appendix

Table 7: Definition of the variables
This table gives the definition of the variables used throughout this paper.

Abn. return	Buy and hold abnormal return over 60 months
Abn. return (winsorized)	Buy and hold abnormal return over 60 months (by a 90% winsorization)
Stock	A dummy variable where a deal was payed for more than 95% in stock (cash) is represented by a 1 (0)
Hostile	A dummy variable where a hostile takeover (friendly) is represented by a 1 (0), meaning that the board officially rejects (agrees) the deal
Market-to-book	Market-to-book of the acquirer ratio one month before the announcement date
Market value ($)	Market value of the acquirer in millions of U.S. dollars one month before the announcement date
Market value (ln.)	The natural logarithm of the market value of the acquirer in millions of U.S. dollars one month before the announcement date
Patents	The number of acquired patents by means of the takeover
Patents (ln.)	The natural logarithm of the number of acquired patents by means of the takeover
Ind2	A categorical variable which industry is called: Pharmaceuticals
Ind3	A categorical variable which industry is called: Office, accounting and computing machinery
Ind4	A categorical variable which industry is called: Radio, TV and communications equipment
Ind5	A categorical variable which industry is called: Medical, precision and optical instruments
Year 2003	A categorical variable categorizing the year 2003. The years 2003 to 2013 are represent by the variable name Year2003 to Year2013