THE EFFECTS OF M&AS ON THE PATENT GROWTH OF ACQUIRERS

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Abstract

In this research the effects of mergers and acquisitions (M&As) on the long term (four year window) patent growth rate are tested. The areas of focus are the type of sector the acquirer operates in, whether the differences in sectors between the acquirer and the target are cause for differing performances in M&As in terms of patent output and whether a domestic M&A yields differing results from international M&As. Through a panel data analysis that utilizes data from DISCERN, Compustat and Zephyr, the effects are estimated. The findings are that there is a negative effect on patent growth rate for international horizontal M&As and for international conglomerate M&As in a four year window. Within the long term window, no other effects were found. When using a two year window, international M&As in general, also show negative effects on the patent growth rate of the acquirer.

Introduction

Innovation is one of the main drivers of firm growth, the way innovation is organized varies per firm (OECD, 2018). In order to make the best use of their innovation capacity, some firms might have a neatly structured innovation program, while others only focus on innovation that can be directly incorporated into their business activities (OECD, 2018). Some firms have a lower R&D intensity than their competitors, these firms turn out to be more likely to be acquirers (King, Bauer, & Schriber, 2019). Even though M&As in general terms are not solely motivated by innovation terms, as a large part of M&As is financially motivated (King, et al, 2019). This paper will focus on the effects an M&A has on the patent growth rate of acquiring firms, the effects of the M&A will explore the effects of firm-specific operating sectors and deal-specific details, such as the M&A type and whether the M&A was international or domestic.

M&As can have a positive impact on innovation (Puranam, et al., 2006), although innovation here was defined as the probability of launching a new product after acquisition. Another measure of innovation, the patenting speed of acquiring firms can increase after an M&A, given that they have had previous experience with M&As (Al-Laham, Schweizer, & Amburgey, 2010). Within the high-tech industry, the effects of M&As on innovation, depending on the acquirer's size, can result better innovation returns for the acquirerer (Lee, & Kim, 2016). Other research points out that firms with lower R&D expenses, which have a larger-than-average patent stock, are more likely to be acquirers, while firms with higher R&D expenses are more likely to target (Bena, & Li, 2014; Heeley, et al., 2006). Rozen-Bakher (2018) found that the M&A types also affect the degree of success an acquirer will experience after the M&A. There do seem to be effects of M&As on the innovative capacity of acquirers.

Focus has already been put on the effects of M&A on certain types of innovation and what determines a firm to be an acquirer (Puranam, et al., 2006; Bena, & Li, 2014). The problem still remains that innovation is a broad concept, and the definitions for it vary. When looking at innovation in terms of patents only a few articles can be found on the effects of M&A on innovation (Al-Laham, et al., 2010; Lee, & Kim, 2016; Cloodt, et al., 2006; Bena, & Li, 2014). While these articles focus on the effects of M&As on patents, each article also has a different viewpoint. Al-Laham, et al. (2010) focus on the pre-acquisition alliances between the target and the acquirer, whereas Lee and Kim (2016) show the differences in effects between the market- and technological-relatedness of firms on the patent output, after an M&A. The time window used in this type of research also varies, although the patenting process is generally longer than the time windows used in these articles. Less emphasis is put on the characteristics of the acquirer, regarding the effects of M&As in general and operating sector, in comparison to the non-acquiring firms and the specific characteristics between the target and acquirer in terms of what type of M&A is completed.

The research question for this thesis will revolve around the effects that firm acquisitions have on the change in patenting growth rate of the acquiring firm. And will try to provide insights into what factors impact the patenting growth rate of acquiring firms. And whether there are any differences present in the effects of M&A on patenting output in differing industries. It will also look into M&A-specific characteristics such as the M&A type effects described by Rozen-Bakher (2018) and test them on the acquiring firm's patenting ability, instead of general firm performance, and whether the M&A was international or domestic. As a whole, the research will also take the time it takes to properly integrate a firm and the time it takes to process a patent into account, by checking the effects of the M&A after four years. The main research question is: "What effects do M&As have on the patent growth rate of an acquiring firm?"

In order to test the effects of M&A on the change in the patent growth rate of acquiring firms, data is gathered on firms that have filed for patents in the period from 1997 – 2015, which is acquired from the DISCERN database. These firms are then linked to the M&A database from Zephyr and firm characteristics are acquired from Compustat. This combined dataset will then use fixed-effects (FE) and pooled ordinary least squares (OLS) models in order to test the effects of M&As and their characteristics on the patent growth rate of the acquirer.

In this research, the effects of M&A on innovation output will be compared within two sectors, as opposed to focusing only on one specific sector. As these types of activities could benefit some sectors more than others. Through these comparisons, it might become clear which sector is more likely to benefit from M&As with regards to R&D output. Within the research literature, the research generally

focuses on one aspect that affects the patent output or the change in patent output a firm experiences after an M&A. In this research, multiple hypotheses are made to highlight different types of firms and M&A characteristics that could impact the innovation output of the acquiring firm in terms of change in patents.

The models in this research show that most of the tested M&A characteristics do not have any significant effects on the patent growth rate of the acquiring firm. The only significant findings from the model, are that international horizontal M&As and international conglomerate M&As have a negative effect on the patent growth rate, in comparison to domestic horizontal M&As. After adjusting the long term window to two year, international M&As do also show significant negative effects on the patent growth rate. In general though, there does not seem to be any hard evidence that proves that M&As significantly impact the acquirer's patent growth rate either positively or negatively.

The rest of this paper is categorized in the following sections, in the next section the literature overview is presented. This is followed by the formulization of the hypotheses and the data section. Afterwards the method is presented and the regression results are shown and discussed. The paper will be closed off by some limitations, a conclusion and some possibilities for future research.

Literature overview

The main goal of this research is to check whether there are any factors surrounding an M&A that affect the degree in which a firm will increase their patent output. This section will discuss the literature regarding M&As and its potential effects on innovation and patent output of firms.

What is innovation?

Innovation covers a broad area of development of either products or services. The measurement of innovation depends on how certain developments are classified. The OECD guide on innovation (2018) defines innovation as the following: "An innovation is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)". This definition provided by the OECD (2018) gives a broad idea of what is meant by innovation, the type of innovation this research will focus on are the innovation activities. These innovation activities are defined as the developmental, financial and commercial activities that a firm is involved in that aim to achieve an innovation (OECD, 2018). A reason for firms to innovate is that innovative firms have better odds for longevity in comparison to non-innovative firms (Cefis & Marsili, 2006). As well as survivability, for smaller firms innovation is also linked to an increase in their productivity, when compared to larger firms that have a larger cost for innovation (Hashi, & Stojčić, 2013).

Innovation, for the economy as a whole, is important as it raises the general productivity of a sector (Aghion, & Howitt, 2009). These improvements can result in growth for companies as well. Innovation will not always give the same returns , depending on what type of firms commit to the innovation. Bhattacharya and Bloch (2004) observed that firms with similar characteristics in different industries yield different outcomes in regards to the innovation. For high-tech industries R&D intensity, concentration of the market and export intensity have a significant positive effect on innovation, while only profitability has a significant positive effect on innovation in low-tech industries. When considering the differences in the service and industrial sectors it turns out that the scope of R&D differs in regards to optimal usage (Leiponen, 2012). While both industries benefit from R&D activities, the service industry firms are more dependent on the managing capabilities in order to benefit from the R&D (Leiponen, 2012). Beyond R&D the differences in sectors persist, as knowledge depreciates in different rates over time depending on the sectors (Cloodt, et al. 2006). The types of sectors this research will focus on, are limited to the industrial and the service sector. These two sectors are, albeit very broad, distinct from each other due to the type of products or services they provide. Where industrial firms are mostly concerned with the production of goods and materials, service sector firms, as the name implies, are mostly concerned with providing services to either consumers or other businesses.

The way innovation is defined in research directly impacts the effectiveness of certain types of trends. A form of measurement for the innovative capacities of a firm are the number of patents a firm is granted each year (Al-Laham, et al., 2010). The grant of a patent is generally preceded by an innovation process (Fagerberg, 2013), which makes patents granted a proxy for a firm's innovation output. The patent data can also show information on the firm's innovative capacities and how likely the firms are to further innovate (Fabry, et al., 2006).

What are M&As?

The term M&A consists of two parts, the merger, when two firms of a similar size merge to form a new firm, and acquisition, when one firm acquires a smaller firm and integrates this firm into its own structure (Tremblay, & Tremblay, 2012). Although these two terms have different ways in which two firms will be merged, the actual differences between them are not important enough to make a distinction for in this research.

Why firms opt for M&As, can be for different reasons, Bower (2001) identified five distinct M&A strategies: 1) M&As can be completed in order eliminate their overcapacity, 2) the M&A is part of a geographical expansion, 3) the M&A extends a firm's product line or international coverage, 4) the M&A can cover for a lack of R&D within the firm, and 5) the M&A facilitates the convergence of industries by utilizing the acquired firm to enter a new or changing industry. These reasons are also

reflected by Christensen, et al. (2011) where it is further stated that the way an acquirer integrates its target also matters for the eventual performance of the M&A. King et al. (2019), specify that in order to measure the full effects of a firm's M&A activity, a long term approach in measuring is needed.

Effects of M&A on innovation

Integration of firms is seen as a way to make a company more competitive within a sector, or as a way to reduce agency costs. Reasons to integrate industrial and service sector firms are to increase their potential sales volume and to create barriers of entry (Schmenner, 2009). Besides the market oriented benefits for integration, there can also be advantages for innovative capabilities. The types of firms that partake in M&As, generally are different from the firms that are acquired. Acquirers, commonly, have large patent portfolios and low R&D expenses (Bena & Li, 2014). Indicating that the reason for the M&A can be the accumulation of patents, while not committing to the innovation process itself. The literature on M&As and innovation is less developed than other measures for M&A success in terms of firm performance (Meglio, & Risberg, 2011).

The technological similarity between firms was found to be a good indicator for merger pairs. A merger pair is the combination of a target firm and the acquiring firm in an M&A. The existence of the technological overlap is a good indicator for an improvement of a firm's post-merger patent output (Bena & Li, 2014). In Europe, when looking at the top 1000 European R&D companies, M&As usually result in a higher R&D intensity at companies in both short (two years) and long (five years)-term (Fernández, Triguero, & Alfaro-Cortés, 2019). On the other hand, Cassiman et al. (2005), found that, if the technology of the merger pair is complementary or substitutable, it will affect the degree of the post-merger R&D spending. The firm will either increase its spending in the case of technological complementarity or decrease when the technologies are substitutable.

These previously stated merger pairs do matter in terms of performance after the M&A. Firms that are too similar, will experience lower returns for their M&A (Cloodt, et al., 2006). These similarities within sectors in which firms operate also determine what the type of M&A is. When a firm operates in the exact same specialized sector, it will be classified as a horizontal M&A. If the target firm is operating a similar sector, it will be a vertical M&A. And if the two firms operate in a complete different sectors, it is a conglomerate M&A (Tremblay & Tremblay, 2012; Rozen-Bakher, 2018). The similarities between firms can also be a source of long term synergies in M&A (Homberg, Rost, & Osterloh, 2009). The way an industry or sector is defined is, usually, through Standard Industrial Classification (SIC) codes (King, et al. 2019). These SIC codes have multiple digits, that give differing levels of specification, with the 1-digit level giving a general indication of the industry and the 4-digit level being the most precise in giving what specific industry sector/niche they operate in. By comparing the SIC codes of the acquirer and the target firms, three definitions for M&A types can be defined. The horizontal M&A is an M&A

in which there is an overlap in industries, this overlap is usually based on matching SIC codes. Rozen-Bakher (2018) utilized overlapping two digit SIC codes between the target and acquiring firm. The vertical M&A is used in order to create a better supply chain for the firm. This can be defined as both the acquiring and target firm having overlapping single digit SIC codes. A conglomerate M&A can have a variety of motivations, one of the reasons can be in order to expand the portfolio of companies the parent firm has (Christensen, et al., 2011).

M&As are not only limited to domestic targets, they can also target firms in foreign countries. Although they may find some extra challenges in the integration of these foreign firms. Domestic acquirers in the UK tend to fare worse than international acquirers, although even foreign firms experience a negative impact on their wealth (Gregory & O'Donohoe, 2014). This seems to suggest that cultural differences do not matter as much for post-M&A performance of firms, this can also be true for cross-border acquisitions, where there is a lower level of integration needed (Stahl, & Voigt, 2008). On the other hand, US firms acquiring foreign targets, receive lower stock returns (Moeller, & Schlingemann, 2005). It should be noted, however, that stock returns do not necessarily indicate M&A success, but solely show the shareholder's confidence in this decision. Another aspect that can be cause for worse M&A returns, is the difference in cultures between the two countries (King, et al., 2019).

Hypotheses

The hypotheses are formulated in order to delve into possible relations that impact the degree of patent output of firms after an M&A. An important reason for firms to acquire more innovative firms is to supplement their lack of innovation, with the innovative capabilities of its target. However, the question still remains whether this is something that has an actual effect on the amount of patents that will be granted to the acquiring firm after the M&A is completed (Bower, 2001). All of the following hypotheses are formulated from the perspective of the acquiring firms. The main focus of the hypotheses will be the M&A-related effects on the difference in annual number of patents granted. The difference in annual number of patents granted will show the effects of the M&A on the innovative performance in the subsequent years.

Acquiring firms might utilize the benefits of economies of scale with regards to R&D, to achieve a higher R&D productivity (Desyllas & Hughes, 2010). However, the transfer of knowledge after an M&A, could still limit the proper use of the target firm's knowledge as the human integration of a firm can cause friction to the knowledge integration of an M&A (Bauer, Matzler, & Wolf, 2016). It is also shown that the effects of M&A can sometimes result in a lower R&D intensity (Hitt, Hoskison, & Ireland, 1990). Firms with low R&D expenditure are more likely to be acquirers (Bena & Li, 2014; Bower, 2001), which

could mean that their base number of patents granted is inherently lower than non-acquirers. Furthermore, from a resource-based view perspective, if between two firms of a similar size with similar characteristics, one acquires another firm, while the other does not, the non-acquiring firm could have more resources to commit to R&D and innovation. although it is observed that larger firms are less innovative (Hitt, et al. 1990). This does not necessarily take the gains after the integration into account, which is dependent on the way the two companies are integrated (Christensen, et al. 2011). This leads to H1 being formulated as:

> H1. The growth rate in the number of annual patents granted is positively associated with partaking in an M&A.

In economics, a distinction can be made between the service sector and industrial sector. For innovation, this distinction is especially important, as the role of patents differ in these sectors. Service sector firms tend to hold less patents than industrial firms, while they have similar odds to hold trade-secrets (Morikawa, 2019). This distinction is also reflected in the differences in how the need for innovation is expressed, industrial firms have greater importance for new products, while service firms need new ideas which can not necessarily be patented (Ettlie, & Rosenthal, 2011). Still, innovation is important for both sectors, although the degree of focus for innovation is different. It can be beneficial for industrial firms to spread their innovation activities along different types of products or processes, compared to service firms which experience a greater innovation utility by focusing their innovations efforts on only a select few products or processes (Leiponen, 2012). This narrower focus of innovation implies that service sector firms are less likely to hold a varied patent portfolio, as they benefit more from highly specific products and processes, which in turn might result in a lower number of patents held by service sector firms.

> H2. Acquiring firms from the industrial sector that partake in an M&A will have a larger patent growth rate in the subsequent period than acquiring firms in the service sector.

The following two hypotheses will be tested against other firms that have committed to an M&A, as only these observations will contain data on the target characteristics. These are needed to test the effects of the M&A on the acquirer.

Rozen-Bakher (2018) shows that the differences between horizontal, vertical and conglomerate M&As, lie in the connection, or lack thereof, between the acquirer and the target. An important factor in these differences are the distinctions between the industrial and the service sector. Integration success, defined as smoothness of integration, realized synergy potential, and the increase in profitability, for both the industrial and service sector is highest with conglomerate M&As (Rozen-Bakher, 2018).

Homberg, Rost, and Osterloh (2009) show that similarities in operating sectors, such as business activities and technologies, can create synergies for firms, given that their cultures and size are not related. These similarities are usually associated with horizontal M&As. Although the similarities in technologies can create synergies, they do not provide an increase in the innovation performance of the acquiring firm in terms of patenting activity, development of new technological competencies and speed in developing new technological knowledge (Colombo, & Rabbiosi, 2014). For vertical M&As trends are found for an increase in value after the M&A. Within the construction sector for example, it was shown that vertical M&As result in a strong increase in value as opposed to horizontal M&A, which yielded lower value returns (Raudszus, et al. 2014). The value creation with vertical M&As, however, is associated with removing cost restrictions in the supply chain, by acquiring either producers or consumers of the goods the firm is buying or selling (Tremblay & Tremblay, 2012).

H3. The type of M&A will affect the growth rate of patents granted for the acquiring firm in a subsequent period, with the conglomerate M&A type experiencing the largest increase in patent growth rate when compared to both horizontal and vertical M&A types.

M&As are a risky venture, resulting in M&As not providing the expected improvements (Bower, 2001). For international M&As the risks are greater in comparison to domestic M&As, due to more potential risk factors being present (Gubbi et al., 2010). The increase in risk factors is also reflected by the trend that international M&As are more likely in countries that have some form of investor protection in their legislation (Rossi & Volpin, 2004). Which raises the question whether this increase in risk is also observed when focusing on the patent output of acquiring firms. Besides the financial risk, the international M&As are also faced with cultural differences, although the effects of the cultural differences are not clear cut (Cartwright & Schoenberg, 2006). These cultural differences can range from institutional differences in how firms are run, to language or habitual differences, which can all contribute to lower returns for acquirers after an M&A (Zhu, Xia, & Makino, 2015). The degree of relatedness between firms is an important factor for whether the international acquisition will be a success (Stahl & Voigt, 2008). These extra risk factors introduce more points for potential failure in the M&A, which in turn could cause the innovation output of the acquiring firm to not increase. Therefore, the fourth hypothesis is formulated as:

H4. The positive relationship between the increase in the number of patents granted annually to an acquiring firm in the period after the acquisition compared to patents granted in the period prior to the acquisition is stronger for domestic M&As compared to international M&As.

Data

Dataset

In order to estimate the effects of M&A on patent output of firms, this research will utilize a combination of three datasets, the patent database from Duke Innovation & Scientific Enterprises Research Network (DISCERN) compiled by Arora, Belenzon and Sheer (2017), a Compustat dataset from the S&P from 1980-2015 and an M&A dataset from Zephyr. The DISCERN data is compiled as a means to account for firms changing their name, which occasionally causes their firm id's in Compustat to change, making it more difficult to track the companies in models. The dataset also shows the number of patents a firm is granted yearly. The Compustat database is a general dataset on S&P companies, which provides financial information on the financial statements and market data of US-based firms. The Zephyr database is a product from Bureau van Dijk, which compiles information on M&A deals, such as date of completion, value of the M&A deal and in which sectors the acquirer and the target operate.

The DISCERN dataset on patents is compiled by utilizing a combination of resources, this combination consists of six sources which are: accounting and company information from U.S. Compustat, scientific publications from Web of Science, patents and their non-patent (NPL) citations from PatStat, subsidiary data from historical snapshots of ORBIS files for 2002-2015, M&A data from SDC platinum and company name changes from WRDS' "CRSP Monthly Stock" (Arora, et al., 2017). This combination of sources leads to a comprehensive dataset that details the types of patents each firm has applied for in the period ranging from 1980 – 2015, while also taking into account the name changes of the firms during this period. The firms that are included in this dataset, however, do need to satisfy to certain needs. The threshold used by DISCERN is that firm need to have been granted patents at least 50 times over the period of 1980-2015, in order to be included in the dataset. This will result in the model having a limited scope in its results, as this sample will only contain firms that have been able to accumulate 50 patents in the time window of 1997 – 2015. This will cause the findings of this research to only be applicable to firms that are heavily involved with patenting.

The resulting dataset from DISCERN contains the annual number of patents granted per firm, the number of patents a firm has in stock (with discounted patent values to account for the patent lifespan), the identification variables of the firm, and information on when the firm was added to the dataset. The DISCERN data is merged with Compustat dataset in order to also control for firm specific characteristics. By using the identifiers from the DISCERN data, firm matches from the Compustat dataset are made.

The data regarding M&A activities is retrieved from the Zephyr database, by using the identifier (ISIN) of firms from the Compustat dataset, the M&A activities of the firms from 1997-2015 were retrieved. In this dataset, the sectors, the method of payment and the country the target firm is from were obtained. As this research focusses on the effects of an M&A on the amount of patents granted, the firms that have more than one M&A per year will be deleted. Furthermore, no data before 1997 is found through this dataset, which could provide a source of bias, as it is not known if firms have partaken in an M&A before the time window of this research begins. The observations of firms that were included in the Compustat dataset before 1997 are therefore deleted. The dataset contains 1,043 unique firms, over the period from 1997-2015 in which the firm characteristics and activities are recorded annually**.** It should be noted that not all firms are included in the dataset for the full 18 years, due to them being dropped by Compustat or being included at a later time. Of these 1,043 firms, 314 firms have been involved in an M&A during the time window. These 314 firms were responsible for 490 M&As. The firms in these observations are included for as long as they are listed in the Compustat dataset.

Finally, by using the ISIN of the companies in the dataset, the M&A activities of the firms can be retrieved from the Zephyr database. Observations from 1980-1996 are deleted, as the Zephyr database is only able to access data from 1997 onwards. The final dataset contains data from the period of 1997 – 2015, only including firms that were added to the Compustat database in 1997 or later, in order to avoid having to deal with unobserved M&As. The variables are shown in Table 1.

Variable description

This research consists of two parts, in the first part the effects of an M&A are also compared to firms that do not partake in M&As are also included in the dataset. The data that is gathered for this research can be categorized into two sections: data on firm sectors and their effects on the *growth rate in patents granted* they are granted annually after an M&A (for testing H1 and H2), and into the effects of M&A characteristics on the change in patents annually granted after an M&A (for testing H3 and H4). This will allow for comparisons between firms that have committed to M&As, and those who have not, in order to see what effects the M&A might have on the change in granted patents in subsequent years compared to the year the M&A was completed (H1, and H2). The models that use target firm characteristics are limited to the years where a firm completed an M&A, which results in less observations, this can be seen in Table 1. where M&A characteristics such as *M&A type* and *International M&A* only have 490 observations.

Dependent variable

The dependent variable in this research is *'growth rate in patents granted'*, in order to calculate this variable the following growth rate formula was used:

$$growth\ rate\ in\ patents\ granted = \frac{(patents\ granted\ at\ t{=}4 - patents\ granted\ at\ t{=}1)}{patents\ granted\ at\ t{=}1} * 100\%$$

The growth rate percentage has a range of -100% to 11000%, in which most of the large growth percentages are caused by firms being granted one patent at t = 1 and the number of patents being granted at t = 4 being larger. For the largest value of growth rate patents granted, a 11000% increase in granted patents, this meant that at t = 1 only one patent was granted, while at t = 4 111 patents were granted.

The growth rate will reflect to what degree a firm has relatively experienced changes in their patenting output, over a period of four years after completing an M&A. A four year window is chosen for multiple reasons, the first reason is that the effects of an M&A take a while to manifest, due to the integration process. Another reason is that the process for being granted a patent is slow and can take between 17-23 months to get approved (USPTO, 2021). Furthermore, in M&A research the time periods in which the effects of M&As are measured vary. This is shown in an analysis of 101 M&A research articles, by Meglio and Risberg (2011), which found that most research was in the medium- (>1 year <= 3 years) and long-term (3> years) time scale. The most common (21 of 101 articles) reasoning for the longer term, is that most of the M&A integration should be finished after three years. Besides, research that focusses on short term results (<1 year), is more concerned with market and investor expectations of an M&A, instead of the actual results of the M&A itself (Zollo & Meier, 2008).

As the dependent variable will utilize the growth rate in patents in four years from when the M&A was completed relative to the number of patents the firm was granted in the year of the M&A, the number of observations will be lower than the 8,212 observations in which patents were granted to firms that were previously stated. Another reason for lower observations, is that firms with zero patents granted in the base year, will not be included, as it would result in a division by zero, which is not possible. This results in the *growth rate of patents granted* variables having 3,299 data points for the *four years* window in which the firm characteristics and patent growth are recorded.

Table 1: Descriptive statistics of variables and descriptions

Variable	Obs.	Mean	Std. Dev.	Min	Max	Description
Number of patents granted after 4 years	4,302	11.68	29.15	0	358	Change in number of patents the acquiring firm was granted two years after an M&A
Patent growth rate at t = 4	3,299	109.47	525.75	-100	11000	Percentage growth rate in patents granted between t=1 and t=4 for the acquiring firm
M&A activity	8,143	0.06	0.24	0	1	Binary variable with a value of '0' if no M&A activities took place and '1' to mark a year in which a firm has completed an M&A
Industrial sector	8,143	0.71	0.46	0	1	Binary variable with a value of '0' if a firm is in the service industry and '1' if the firm is in the industrial sector
M&A type	490	0.78	0.59	0	2	Nominal variable to make a distinction between horizontal (0), vertical (1) and conglomerate (2) M&As
International M&A	490	0.26	0.44	0	1	Binary variable with a value of '0' for domestic M&As and '1' for cross-border M&As
Total employees	7,965	2.89	18.92	0	539	Continuous variable showing the total number of employees a firm has in thousands
Deal value of M&A	365	75.49	211.15	0.05	2,500.00	Value of M&A deal in millions USD
Patent stock of acquiring firm	8,140	33.24	91.80	0.09	1,543.93	The total number of patents the acquiring firm has in its possesion
M&A in four year period	8,212	0.11	0.31	0	1	Binary variable taking on the value of '1' if the acquiring firm completed at least one more M&A in addition to the *M&A activity* variable within the four year period following an M&A and '0' otherwise

Independent variables

For H1, the effects of *M&A activity* will be estimated. The *M&A activity* variable, is a binary variable, which takes on a value of '1' if the company has completed an M&A in the year of observation, and '0' if no M&A took place in the year of observation.

For the second hypothesis, the binary variable *industrial sector* will indicate what type of general sector the firm is operating in. By using the SIC codes provided through the Compustat dataset, the firms will get one of two values: '1' if the firm is from the industrial sector or '0' if the firm is from the service sector. The distinction between the two sectors is based on the SIC codes of the firms, the firms with SIC codes ranging from 10 through 39 will be labeled as industrial sector. Firms with a SIC code between 40 and 99 will be labeled as service sector. The observations that do not match these classifications, the agrarian SIC codes 01 to 09, are excluded as they do not fit within either sector, which means 16 observations were dropped from the sample. Of the firms in the dataset, 70.5% are from the industrial sector, with only 29.5% of firms being from the service sector.

The categorical variable *M&A type* is created to answer the third hypothesis, by creating three different categories, based on the similarities in the SIC codes of the acquirer and the target firms. Even though this does not always properly reflect the actual overlap as other measures may give (Fan & Lang, 2000), it does provide an indication of whether the target and the acquirer operate in a comparable industry. The number of observations for this and the following variables will be 490, as these variables are limited to the observations in which an M&A took place. The categories are based on the horizontal, vertical and conglomerate levels as used by Rozen-Bakher (2018). Horizontal M&As are based on the overlap of the two digit SIC code of the two firms. Vertical M&As are defined as the overlap between the acquirer and the target on the one digit SIC code level, with exclusion of exact matches of two digit SIC codes. And the conglomerate M&As are defined as the M&As that do not have any similarities in their SIC codes. For example, if the acquiring firm has SIC code 45 and the target has SIC code 45 as well, the M&A will be marked as a horizontal M&A as the two digit SIC level is an exact match. If the target firm has the SIC code 4x with 'x' being any digit the M&A will be marked as a vertical M&A as the single digit SIC codes match up to the acquirer's SIC code of 45, except if x = 5 as it would be an exact match and will therefore be marked as a horizontal M&A. If the target firm has a single digit SIC code that does not match the acquirer's single digit SIC code, the M&A will be marked as a conglomerate M&A.

In order to test whether international M&As affect the amount of patents a firm will be granted, the variable *international M&A*¸ is created. This binary variable will take on the value of '1' if the target firm is from outside the US, the value will be '0' if the target firm is from within the US. Table 1 shows with a mean value for *international M&A* of 0.26 that only a quarter of the M&As from the sample were international M&As.

Control variables

The following variables are used in the model in order to control for certain characteristics that can (in)directly impact the patent growth rate of a firm or any of the independent variables used in the research.

The first control variable will be *patent* stock, this variable will be able to indicate whether a firm already has a portfolio of patents. A firm's intent to innovate, can be deduced from their patent portfolio (Lin, Chen, & Wu, 2006), which could indicate that it is also more active in developing technology that will be patented later. The number of patents held in stock varies greatly among firms, due to some firms having substantially more patents held in stock than others, to an extent that it does not follow a normal distribution. By log transforming *patent stock* the values become normally distributed. The wide range of values for *patent stock* would otherwise be subject to outliers. The values for *patent stock* sometimes are decimal numbers, this is due to the way DISCERN has calculated the patent stock. In DISCERN's methodology it is explained that the diminishing value of patents as they near their date of expiration by depreciating the patents is also accounted for in *patent stock*.

Consecutive M&A in the four year window, is a binary variable that controls for whether another M&A took place within the four year time window, in addition to the M&A used for estimating the change in the dependent variable. *Consecutive M&A in the four year window* takes on the value of '1' if there is at least one other M&A frame completed by the acquiring firm within the time, and '0' otherwise. *Consecutive M&A in the four year window* had 876 instances where at least one additional M&A took place within the four year period after the first M&A. From a resource-based view (Wernerfelt, 1984), it makes sense to control for these concurrent M&As, as resources can only be used on one activity at a time. However, the specific effects of concurrent M&As on firm performance are not heavily researched, causing a lack of theoretical support for the specific relation of the control variable.

Another control variable will be *years listed in the S&P*, which is equal to the amount of years a firm is included in the Compustat dataset at the time of the M&A. This is a crude alternative for firm age, as the actual firm age could not be retraced through Compustat. A firm's initial public offering date, the date a firm's stock was publicly traded for the first time, was considered as an alternative for firm age,

but less than 50% of observations had their IPO date available, which is too few to be properly utilized. In the form of *years listed in the S&P* it will at least be able to give an indication for how long the firm has approximately been active. The likelihood of a successful M&A is lower for younger firms than their older counterparts in the high-tech sector, an explanation for this can be found through lack of investor support (Ragozinno, 2006). Another aspect where firm age controls for, is the innovativeness, as older firms are less likely to bring innovations to market (Puranam, Zollo, & Singh, 2006).

The *number of employees* will be used to control for the firm size of the acquirer. Larger firms are more likely to invest into R&D (Shefer, & Frenkel, 2005) and the size of the firm also helps with the integration of M&As (Lee, & Kim, 2016). Although the benefits of an M&A seem to have diminishing returns when compared to firm size (Homberg, et al. 2009). This variable, like some of the previous variables, has a wide range of values where the larger values skew the distribution of the values, which causes it to not be normally distributed. After log transforming all the values of *total employees*, the distribution does seem to follow a normal distribution.

The models that focus on the M&A characteristics themselves will include an extra control variable, as the characteristics of the target and relations between the acquirer and the target can also impact the amount of patents granted. The *deal value* will be a control variable for the M&A characteristics, as the deal value will give an estimate for the expected value of the target firm, which could be related to the amount of knowledge a firm will acquire through the M&A. The base value for this variable is in millions of USD. The value of the deals has a wide range, although it does not follow a normal distribution. Which causes issues for modeling the potential effects of the control variable. After being log transformed, the observations for the *M&A deal value* do follow a normal distribution. A higher deal value, indicates that the target had room for negotiations and could prove to be a more difficult integration (Högholm, 2016).

Correlation checks

In order to check for any possible correlations that could negatively impact the models, two correlation matrices are made. One matrix is for H1 and H2, which can be seen in Table 2, the other correlation matrix is for H3 and H4, this can be found in Table 3. The decision to include two separate matrices, is due to the differing number of available observations. This could cause some correlations to be wrongly calculated for either of the hypotheses if only one matrix were to be used.

For the first two hypotheses, there is only one set of variables that has a correlation larger than 0.40. This set of variables is *log total employees* and *log patent stock of acquiring firm*, the correlation coefficient for this set is 0.47. The second highest correlation is between *log patent stock* and *years*

listed in the S&P, with a correlation coefficient of 0.37. The correlation between these sets of variables is below 0.50, which does not raise concern for some possible correlation issues within the model. The correlation between *M&A activity* and *patent growth rate* does seem to be negative, albeit small at -0.01. Indicating that M&As could have a negative impact on the *patent growth rate*. The variance inflation factor (VIF), for these variables will also be used in order to check whether these two variables might affect each other through multicollinearity. The results from the VIF show that the highest VIF is for *log patent stock* in all models with values of 3.84 for Model 1, 5.12 for Model 2a and 5.13 for Model 2b, which are all well under the usual threshold of 10.

The correlation matrix made to estimate the effects of the target firm's characteristics on the *patent growth rate* in order to test H3 and H4, can be seen in Table 3. The correlation matrix shows that there is one pair with a correlation coefficient higher or equal to 0.40. *Log total employees* has a correlation of 0.40 with *log deal value*. For Models 3 and 4 the VIF of each variable below 1.27.

Table 2: Correlation matrix H1 and H2

	Patent growth rate	*M&A activity*	*Industrial sector*	*Log total employees*	*Log patent stock of acquiring firm*	*Years listed in S&P*	*Consecutive M&A in four year period*
Patent growth rate	1.00						
M&A activity	-0.01	1.00					
Industrial sector	-0.02	-0.03	1.00				
Log total employees	0.08	-0.04	0.00	1.00			
Log patent stock of acquiring firm	-0.09	-0.04	0.20	0.47	1.00		
Years listed in S&P	-0.01	0.16	-0.06	-0.09	-0.07	1.00	
Consecutive M&A in four year period	-0.09	-0.03	-0.06	0.14	0.37	-0.08	1.00

Table 3: Correlation matrix H3 and H4

	Log patents granted after four years	*M&A type*	*International M&A*	*Log total employees*	*Log patent stock of acquiring firm*	*Years listed in S&P*	*Consecutive M&A in two four year period*	*Log M&A deal value*
Log patents granted after four years	1.00							
M&A type	-0.15	1.00						
International M&A	-0.03	0.04	1.00					
Log total employees	0.03	0.20	0.05	1.00				
Log patent stock of acquiring firm	-0.14	0.20	0.05	0.14	1.00			
Years listed in S&P	0.21	-0.16	0.17	-0.09	0.02	1.00		
Consecutive M&A in four year period	0.17	0.17	0.00	0.40	0.22	-0.02	1.00	
Log M&A deal value	-0.23	0.07	-0.03	-0.16	0.29	-0.06	-0.09	1.00

Method

Models H1 and H2

Due to type of data available, the first two hypotheses can be tested through either fixed effects (FE) or random effects (RE) models. As every firm has multiple years in which they are recorded with their firm characteristics, the time series data can be used in order to estimate the effects of M&A activities on *growth in annual patents granted*, and the interaction between M&A activities and the sector in which the firms operate, both in comparison to non-acquiring firms.

In order to properly utilize the available data for H1 and H2, the choice can be made between FE and RE models. The FE model is able to address the unobserved factors that can impact the model. This is done by averaging out the original model over time and afterwards calculating the differences of each variable from the time mean. By doing these calculations the fixed unobserved factors in these models are eliminated, which for larger firms can result in a large number of fixed unobserved variables being eliminated. The alternative, RE, utilizes quasi-demeaning to eliminate serial correlation. RE is better to be used, when unobserved variables are likely to be uncorrelated to the model (Wooldridge, 2020). Although it is unlikely to assume that unobserved variables are uncorrelated to the model, as most firms are a complex environment where many subtleties can affect its performance. Such as the location of the firm, in relation to knowledge clusters or how the work culture affects the employees. Which makes the FE model, the preferred model for this research. Nonetheless, both models will be estimated and compared, in order to be certain that the model with the best fit will be selected.

The differences in the models are mostly in how they are able to cope with certain biases in the data. For FE and RE the choice for the model depends on whether the unobserved time-invariant heterogeneity are significant in this model (Wooldridge, 2020). This can be tested by using a Hausman test in order to control if the unobserved components significantly affect the models. If the null hypothesis for the Hausman-test is rejected, the FE model will be preferred (Wooldridge, 2020). The preference before conducting the Hausman test, is for the FE model, as this model will allow the unobserved firm characteristics to be taken care of in the model estimation. The results for the Hausman-test show that for both models 1, 2a and 2b the FE models are preferred. As the values of the Hausman-test in Stata give probabilities of 0.00 for the null hypothesis that the difference in coefficients is not systematic for each of the models, which means the null hypothesis is rejected for each model.

For the first model, the effect of an M&A activity on patent growth rate is tested by using the variable *M&A activity* and controlling for the firm characteristics. In Models 2a and 2b for H2 complexity will be introduced in two steps, Model 2a will add the effect of *industrial sector* to Model 1, in order to test

the effects this binary variable will introduce. For Model 2b, an interaction between *M&A activity* and *industrial sector* will be introduced, which will allow for testing the actual effects between operating sector and M&A activity on the patent growth rate. The interaction results in four possible categories between *M&A activity* and *industrial sector* for a potential acquirer: *Industrial sector acquirer, service sector acquirer, industrial sector non-acquirer,* and *service sector non-acquirer.* The base category in this model will be *service sector non-acquirer*.

Models H3 and H4

The data on the M&A characteristics contains less observations, as the information on M&A characteristics is limited to instances in which an M&A was completed. As a result, the years in which firms did not complete an M&A will not have any information regarding M&A characteristics. This restriction causes the data to not be fit for a FE or RE type of model, what is possible, however, is a pooled cross-sectional data model, as this data structure will create a larger sample size to work with. However, these observations are evenly distributed over the 18 year window from the dataset, which causes a normal cross-sectional model to be lacking in the number of observations. Therefore, the preferred model, is a pooled OLS model, as this will give 111 observations. The original sample size would be 490 observations, but due to the way the dependent variable is constructed for which the data of the firm at t = 4 is needed, only 111 usable observations remain.

For H3, Model 3 in Table 6 will test the effects of M&A type on the patent growth rate of the acquiring firm. The *M&A type* is a nominal variable of which *horizontal M&A* will be the base category, the other types are: *vertical M&A* and *conglomerate M&A*. The test for H4, will test the effects of *international M&A* on the patent growth rate.

Finally, an additional model will be estimated that combines the effects of H3 and H4, in order to test whether there are any combined effects between *M&A type* and *international M&As*. To properly evaluate the effects, the variables will first be added alongside each other in Model 5a, and afterwards an interaction effect will be utilized in Model 5b, to see the interaction between these two variables. The interactions are: *domestic horizontal M&A, domestic vertical M&A, domestic conglomerate M&A, international horizontal M&A, international vertical M&A,* and *international conglomerate M&A.* Of which *domestic horizontal M&A* will be the base category of Model 5b.

The models are also tested for whether they are correctly specified by using a Ramsey-RESET test. The results of the tests for the models of H3 and H4 indicate that the models are well-specified, as the test indicates that there are no missing variables in either models. The models for H1 and H2, were not able to be tested using a RESET-test, due to the structure of the panel data models.

Results

Main results

Table 5 shows the fixed effects models for hypotheses 1 and 2, in which the effects of *M&A activity* and the effects of *industrial sector* on *patent growth rate at t = 4* are modeled. In Model 2b the interaction effects are estimated, which are shown in the rows below *M&A activity* and *industrial sector*.

The first hypothesis is tested with Model 1, which is shown in column 1 of Table 5. This shows that the effect of *M&A activity* on the change in *patent growth rate at t = 4* is not significant at the 10% significance level. Therefore no support for Hypothesis 1 is found.

Models 2a and 2b, which are shown in columns 2 and 3 of Table 5, show the effects of adding an acquiring firm's operating sector to Model 1. The difference between Models 2a and 2b, is that Model 2a is without an interaction between *M&A activity* and *industrial sector*, while Model 2b does include this interaction. In rows 1 and 2 of Table 5, the effects of *M&A activity* and *industrial sector* are shown without the interaction effect between them, both these effects are not significant at the 10% significance level. For Model 2b, the interaction effects can be seen in rows 3, 4 and 5 of Table 5, in column 3, with a non-acquiring service sector firm as the base category. All of these interaction effects, are not significant at the 10% significance level. Both Models 2a and 2b, fail to provide any support for H2.

In order to estimate the effects of the M&A characteristics on the *patent growth rate at t = 4* and test Hypotheses 3 and 4*,* Models 3 and 4 are estimated, these are shown in Table 6. For Hypothesis 3, the effects of *M&A type* on *patent growth rate at t = 4* are shown in column 1, with horizontal M&A as the base category. Both coefficients for vertical and conglomerate M&As are not significant at the 10% significance level. No support for Hypothesis 3 is found in Model 3.

The final hypothesis, Hypothesis 4, is tested through Model 4, which is shown in column 2 of Table 6. Here the effects of *international M&A* on *patent growth rate at t = 4* are shown. The effect of a firm opting for an international M&A, in comparison to a domestic M&A, does not show any significant effects at the 10% significance level. For Hypothesis 4, no support is found in Model 4.

Models 5a and 5b are added, in order to test whether any interaction effects between *M&A type* and *international M&A* are significant, these results can be found in Table 6. Model 5a combines the independent variables of both Models 3 and 4. Model 5b also adds an interaction effect between these two independent variables. In Model 5a the effect of a conglomerate M&A shows a negative change

in patent growth rate at t = 4 of 110.89 percentage points compared to a horizontal M&A, ceteris paribus, which is significant at the 10% significance level.

It should be noted that a negative growth rate beyond a 100% is not possible, due to the patents granted variable not being able to get any values below zero. The values seen in this sections for certain coefficients exceeds the value of -100%, which is not immediately an issue, as the constant is still larger than the value of the coefficients. Although it is possible to exceed the value of -100% through a combination of certain values for the coefficients. This is due to limitations of the OLS model and it only being able to calculate the linear effects. But it is not necessarily a problem for this research, as the goal here is to find the general relations between the variables, meaning that the specific details of the relations between the variables could be further looked into in later research.

The final column shows interactions between *international M&A* and *M&A type*s, the base category is or domestic firms that commit to a horizontal M&A, for two of the interactions there are significant effects. The first interaction, between international M&A and horizontal M&A, a firm that commits to an international horizontal M&A, shows a decrease in patent growth rate at t = 4 of 156.781 percentage points in comparison to the base category, ceteris paribus, this effect is significant at the 10% significance level. The second significant effect, is for the interaction between international M&A and conglomerate M&A, here an international conglomerate M&A will result in a decreased patent growth rate at t = 4 of 365.4, when compared to a domestic horizontal M&A, ceteris paribus. These three effects, however, go beyond the scope in which the patent growth rate can go. A patent growth rate of -100% is the lowest value it can reach, as it indicates that the acquiring firm got no patents at t = 4. Even taking into account the constant of the models, it could be possible for firms within this model to patent growth rate values below -100%.

Robustness checks

In order to check whether the models are robust when changing certain dimensions or control variables, two separate tests were conducted. For the first test, the dependent variable was changed to *patent growth rate at t = 2*, the results can be found in Tables 7 and 8. Based on the theory specified in the data section, the four year window should have shown some results, however, it could be that certain effects only happen in a shorter time frame. After running the models, it turns out that the effects of certain models have significant effects in comparison to the four year models. The models for which this is the case all are models involving *international M&A,* the models with different results are: Model 9 and Model 10a. Model 10b also has significant results, but they are in line with the results of Model 5b. The coefficient for *international M&A* is significant at the 5% significance level in models 9 and 10a, with an effect of -54.0 and -55.4 percentage points on the patent growth rate at t = 2

respectively, ceteris paribus. Which indicates that H4 could hold for the two year window, instead of the four year time window. Model 10b, which includes the interaction between *international M&A* and *M&A type*, has an effect of 10% significance for horizontal international M&As and 5% significance for international conglomerate M&As, albeit with lower coefficients for patent growth rates at t = 2 of -83.1 and -142.4 percentage points in comparison to domestic horizontal M&As, ceteris paribus. Indicating that the two year window does exhibit some effects of M&A on a firm's patent growth rate.

The second robustness check was conducted by changing the control variable for firm size from *log employees* to *log turnover of the acquirer,* while keeping every other variable the same as in the main research models. This resulted in qualitatively the same results, the only difference in significances by conducting this robustness check, is that the coefficient for conglomerate M&A, in Model 3 became significant at the 10% significance level, due to the p-value dropping from 0.100 to 0.095, meaning that the actual change in significance is very small. This robustness check seems to indicate that there are no problems, even though there is a change in the actual significance level of one of the coefficients. Another aspect of this robustness check, is that three of the models (Models: 3, 5a and 5b) fail to pass the RESET-test, suggesting that the *log turnover of the acquirer*, fails to capture certain dynamics that affect the patent growth rate.

Table 5: Fixed-effects models estimating the effects on change in patent growth rate at t = 4

N =		3,230	3,230	3,230
Model		1	2a	2b
	Interaction effects			
M&A activity (M&AA)		-1.660	-1.805	
Industrial sector (IS)			-128.264	
Interaction effects *M&A activity* and *industrial sector*	No M&A activity for industrial firm			-128.224
Base category: No M&A activity for service sector firm	M&A activity service firm			12.773
	M&A activity industrial firm			-135.543
Log Patent Stock		-336.308***	-336.777***	-336.802***
Consecutive M&A in four year period		8.732	7.773	7.627
Log total employees		113.823 ***	112.928**	113.038**
Years listed in S&P		50.306***	50.581***	50.572***
Constant		604.694	702.239	702.237

*: 10% significance level, **: 5% significance level, ***: 1% significance level

Table 6: Pooled OLS models estimating the effects on change in patent growth rate at t = 4

N =		111	111	111	111
Model		3	4	5a	5b
	Categories				
M&A type; base category: horizontal	Vertical	-26.137		-23.994	
	Conglomerate	-112.486		-110.886*	
International M&A			-35.555	-33.713	
Interaction effects for international M&A	Domestic vertical M&A				-72.180
and M&A type.	Domestic conglomerate M&A				-83.771
Base category: horizontal domestic M&A	International horizontal M&A				-156.781*
	International vertical M&A				-18.666
	International conglomerate M&A				-365.492***
Log Patent Stock		-11.111	-21.148	-17.623	-23.303
Consecutive M&A in four year period		88.836*	101.760**	94.051*	103.777**
Log total employees		-18.094	-15.521	-9.483	0.820
Years listed in S&P		-11.272*	-11.472*	-11.425*	-10.682*
Log total deal value in millions USD		0.937**	0.885**	0.926**	1.226***
Constant		142.317	132.837	145.883	160.824

*: 10% significance level, **: 5% significance level, ***: 1% significance level

Table 7: Robustness check on fixed-effects models estimating the effects on change in patent growth rate at t = 2

N =		4,510	4,510	4,510
Model		6	7a	7b
	Interaction effects			
M&A activity (M&AA)		3.412	3.434	
Industrial sector (IS)			-32.580	
Interaction effects *M&A activity* and *industrial sector*	No M&A activity for industrial firm			-32.491
Base category: No M&A activity for service sector firm	M&A activity service firm			18.982
	M&A activity industrial firm			-35.727
Log Patent Stock		-160.837***	-160.930***	-160.956***
Consecutive M&A in two year period		7.744	7.751	7.491
Log total employees		158.618 ***	158.423**	158.474**
Years listed in S&P		20.649***	20.703***	20.692***
Constant		229.057	253.385	253.372

*: 10% significance level, **: 5% significance level, ***: 1% significance level

Table 8: Robustness check on pooled OLS models estimating the effects on change in patent growth rate at t = 2

N =		175	175	175	175
Model		8	9	10a	10b
	Categories				
M&A type; base category: horizontal	Vertical	13.484		13.240	
	Conglomerate	-48.757		-52.206	
International M&A			-53.988**	-55.382**	
Interaction effects for international M&A	Domestic vertical M&A				3.825
and M&A type.	Domestic conglomerate M&A				-52.281
Base category: horizontal domestic M&A	International horizontal M&A				-83.123*
	International vertical M&A				-35.819
	International conglomerate M&A				-142.433**
Log Patent Stock		-9.945	-11.270	-9.749	-10.032
Consecutive M&A in two year period		11.399	16.521	14.145	16.235
Log total employees		23.315	27.010	25.250	26.369
Years listed in S&P		-5.176	-5.410	-5.764	-5.847
Log total deal value in millions USD		0.013	0.022	0.022	0.028
Constant		74.179	91.322	86.686	92.346

*: 10% significance level, **: 5% significance level, ***: 1% significance level

Discussion

When starting with the comparison between acquiring firms and non-acquiring firms, no evidence was found to support the first hypothesis that acquiring firms would experience a larger growth in patents granted in the subsequent period. This indicates that the growth in innovation, in terms of granted patent growth rate, does not seem to be particularly influenced by M&As. Which is contrary to the findings of Desyllas and Hughes (2010) for the effects of high-tech acquisitions R&D productivity. One of the explanations for this could be that acquiring firms are more interested in the existing patents the target firm holds, instead of the in process R&D that the target firm is involved with (Bower, 2001). Or that the motives acquiring firms have, are not focused on the innovation capacity of the targeted firm (King, et al., 2019). This could be tested in future research, by also controlling for the number of patent the target firm has. This data, however, was not available for this research.

The addition of *industrial sector* to Model 1, with the distinction being made between industrial and service sector firms. The inclusion of this interaction effect also fails to show any differences in results for the change in patent growth rate. Indicating that the combination of M&A activities and the sector of operation for the acquiring firm, do not seem to have any significant impact on the change in patent growth of the acquiring firm. The fact that there does not seem to be a difference between the two sectors without any M&A activity, is particular. As the importance of innovation for the industrial sector is higher than in the service sector (Ettlie, & Rosenthal, 2011). Thus, no support is found for the second hypothesis. Although it should be noted that the distinction in sectors here is broad, and the results for more specific sectors could yield different results.

In this research of M&A effects on the patent growth rate of acquiring firms, some effects could only be estimated within firms that committed to M&As, as non-acquiring firms would fail to have the required data on the target firm. With the first model within this section, Model 3, the effect of *M&A type* was estimated. The effects between horizontal, vertical and conglomerate M&As, do not seem to indicate that there are any significant effects regarding the similarities or the differences between operating sectors of the acquirer and the target firm on the change in patent growth rate for the acquiring firm. This lack of effect between the different M&A types on the patent growth rate, could be explained through the general lack of effect that M&As seem to have on the patent growth rate. In short, no support is found for the third hypothesis.

For the final hypothesis, the effects of *international M&As* on patent growth rate are estimated and compared to domestic M&As. No significant relation between the international aspect of the M&A and the patent growth rate is found. Which could implicate that the acquiring firms look for the best match in the M&A and do not make distinctions between domestic and international firms. An interesting

note here, is that the robustness check, which calculates the effect on patent growth rate after two years, did estimate a significant effect, which, keeping all else constant, would result in firms that commit an international M&A having a decrease in patent growth of 54 percentage points in comparison to firms that acquire a domestic firm. Indicating that certain aspects in this M&A, could affect the patent growth rate in a shorter time frame, but fail to show results in the longer term. Which could be explained through the in-process R&D at the time of acquisition of domestic firms possibly being continued, causing the patent growth at t = 2 not to drop, while the in-process R&D will most likely be finished at t = 4.

Finally, two additional models were estimated, which combined the effects of *international M&A* and *M&A types*, this results in Models 5a and 5b. Model 5a only has the two variables as separate effects, while Model 5b combines the effects with an interaction term. The intuition between these interaction is that the types of M&A could be affected through potential arbitrage opportunities (Herger, & McCorriston, 2016), when compared to their domestic equivalents. The results from these models indicate that there seem to be some interactions between international M&As and both horizontal and conglomerate M&As. Both of these interactions have a negative effect, of respectively a 10% and 1% significance level, on the patent growth rate of the acquiring firm, when compared to a firm that commits to a domestic horizontal M&A. This negative effect, however, falls below the minimum value of -100% for growth, which means that the model fails to predict a realistic outcome. The excessive value of -365.5 percentage points is very odd, as the value strongly exceeds the realistically reachable value, but it indicates that the patent development for conglomerate M&A firms, is not deemed important. The results further indicate that the patent growth rate for domestic horizontal M&As is rather large. This could show that international M&As, generally are less interested in improving their patenting output.

When considering the results for the models, the main trend shows that there does not seem to be any significant effect between an acquiring firm's M&A activity and their growth rate in granted patents at t = 4. Which, as previously stated, could imply that the general reasons firms commit to M&As are not too concerned with improving their own innovative capacity, in terms of patenting ability. Or that the knowledge acquired by these firms, cannot be reflected by the change in growth rate of patents granted. It is also remarkable that there was no difference between industrial and service sector firms, but that lack of significance could also be explained, by general lack of effect M&As have on the patent growth rate. Only for the short term window an effect for international M&As was found that negatively affects the patent growth rate of the international acquirers. With an additional effect, with the interaction between international M&As and both horizontal and conglomerate M&As.

Limitations

This research also had some limitations. The dataset was specific in what types of firms were included, as the original DISCERN dataset was focused on firms that already possessed a number of patents. Due to this prerequisite, the research is only able to focus on firms that already were involved with patents. In the same line, no data was found on the patents held by the targets, which could also give more information on the underlying goals of the M&A. Furthermore, the variable *industrial sector*, was intentionally defined in a broad manner, however, it could be that certain specific sectors within these two categories value patents higher and could have different results their patent growth rate, after they complete an M&A. Patents are not necessarily as important in each sector (Al-Laham, et al., 2010), which might cause certain findings to be biased, due to the generalization made for sectors in this research. One also has to take into account that the patents or the innovative output of a firm, might not necessarily be the reason a firm commits to an M&A. Therefore this research might not give a proper insight in the motivations of firms for M&A. Lastly, the pooled OLS models used to answer H3 and H4 also failed to give realistic values for the effects of international M&As in some cases, for this research it did not matter too much, as it gave an indication of the type of relation that exists. But for further research a different type of model might be better suited for the analysis.

Conclusion

The field of M&As is a difficult field to make conclusive findings, as the process and the variables in an M&A are so diverse. What might qualify as a success by one stakeholder, could be deemed a failure by another. This is also reflected in the different types of M&A performance measures and the time windows in which these effects on company performance after M&As are measured. In this research, the effects of firm and M&A characteristics on the acquiring firm's patent growth rate were tested, with the aim to discover whether M&As do affect an acquiring firm's innovation performance. The findings help to answer the research question: "What effects do M&As have on the patent growth rate of an acquiring firm?". The results of this research point towards that M&As activities in general do not have any significant effect on the acquiring firm's patent growth rate in a four year window. A firm's operational sector does not seem to affect the patent growth rate either, regardless of any M&A activity. Regarding M&A characteristics, it was found that international horizontal and conglomerate M&As do seem to have negative effects on the patent growth rate in comparison to domestic horizontal M&As, but these were the only effects that were found. After conducting a robustness check along the two year time window, most findings remained the same, however, it showed that in addition to the effects of both international horizontal and conglomerate M&As, that international M&As as a variable without an interaction, also showed negative effects on the patent growth rate. Which indicates that in the shorter term, international acquirers are more likely to be granted less patents.

These findings seem to imply that the motives for M&A are not necessarily focused on the increase in patenting activity of the acquiring firms. Which corresponds to the concept explained by Bower (2001) that acquisition as a substitute for R&D is mostly for R&D that is already completed, instead of acquiring the capacity to commit to more R&D. It also shows that one should not expect. The only effects this research seemed to find, is that international M&As, with horizontal and conglomerate M&As in particular, will have a negative impact on the acquiring firm's patent growth.

Further research could delve deeper into the sectors, in order to see whether there might be any effects of M&A on patent growth rate in more specific industries, as opposed to a general sector as a whole. It could also be interesting to look into the reasons as to why the international M&As showed significant results in the two year window and not in the four year window of the model.

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