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How Does a Prior Alliance Between Target and Acquirer affect R&D Performance?

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Abstract

The pharmaceutical industry has been in the spotlight for the last decades regarding some conflicting trends. Despite a consistent increase in research and development (R&D) investment, the number of approved drugs has remained, at most, constant. In addition, the pharma industry has witnessed a large trend in consolidation through mergers and acquisitions (M&As), which has not always translated in an improvement in R&D productivity. The aims of this paper are to study the effect of a pre-acquisition alliance on the R&D productivity of the merged firm, as well as looking at specific alliance characteristics that may influence this outcome. This study looks at the pharmaceutical industry from 1981 to 2017 and finds that the existence of an alliance prior to a merger negatively affects the R&D productivity of the merged firm. Reasons for this relationship may be that the knowledge gained during the alliance period does not benefit the acquirer in a way that is significant enough to increase its R&D productivity, or even that this earned insight is not immediately reflected during the post-M&A period. The implications of these findings look to improve the understanding of the productivity crisis in the pharmaceutical sector.

Keywords: M&A, Merger, Acquisition, R&D, Alliance, R&D productivity, Pharmaceutical, Pharma

Table of Contents

Acknowledgements.....	iii
Abstract	v
Table of Contents	vii
List of Figures.....	ix
List of Tables.....	xi
1. Introduction.....	13
2. Literature review	17
2.1 Alliances.....	17
2.2 Advantage of collaborating before M&A.....	19
2.3 Mergers and acquisitions in pharmaceutical industry.....	20
2.3.1 Brief history.....	20
2.3.2 Determinants of Mergers and Acquisitions	20
2.4 Pipelines, patents, NME costs.....	23
2.5 Declining R&D productivity	26
2.6 Similar literature	28
3. Data and Methodology	31
3.1 Data.....	31
3.1.1 Data processing	31
3.1.1 Preliminary data.....	34
3.2 Methodology	39
3.2.1 Dependent variable.....	39
3.2.2 Independent variable.....	40
3.2.3 Control variables	41
3.2.4 Regressions	43
3.2.5 Summary Statistics.....	45
4. Results	46
5. Discussion.....	52
6. Limitations.....	57
References	59

List of Figures

Figure 1 - Approval timeline for new molecular entities (NMEs).....	26
Figure 2 - Volume of M&A deals (1981-2017).....	35
Figure 3 - M&A deal volume with and without previous alliance (1981-2017)	36
Figure 4 - Alliances vs M&A activity (1981-2014).....	37
Figure 5 - Relationship between R&D Productivity (sales) and alliance duration.....	49
Figure 6 - Relationship between R&D Productivity (shareholder returns) and alliance duration	49

List of Tables

Table 1 - Summary statistics	34
Table 2 - Summary statistics for key variables	45
Table 3 - Regression results showing the effect of a previous alliance on R&D productivity	50
Table 4 - Regression results showing the effect of alliance duration and number of drugs collaborated on R&D productivity	51

Chapter 1

1. Introduction

The pharmaceutical industry has seen some incredible breakthroughs in its recent years. For example, drugs and vaccines protecting against malaria have saved around 1.14 million children between 2011 and 2015, deaths from measles in Africa have been reduced by 79% between 2000 and 2014, the industry has been the third largest contributor towards the R&D of neglected diseases, and the number of deaths arising from HIV/AIDS has decreased by more than 50% from 2005 to 2015 alone (IFPMA, 2017). However, the pharma sector has also undergone significant change over the past decades; from suffering productivity shocks, seeing its research and development costs for new molecular entities soar, facing expiration of key patents and witnessing a wave of consolidation in the sector. The average R&D cost of producing a new drug and placing it on the market is estimated to be around US\$2.5 billion (2013 dollars) (DiMasi *et al.*, 2016), whereas the number of drugs that are approved for production are no higher this year than they were 50 years ago (Munos, 2009).

In a knowledge and research-intensive industry such as the pharmaceutical industry, when faced with declining R&D efficiency, changes in the firms' strategic outlook must be considered. Moreover, innovation becomes more efficient when firms collaborate instead of working in isolated environments; not only because of the high costs involved in R&D, but also in testing, manufacturing, and marketing the drugs. For this reason, many multinational pharmaceutical companies are looking at creating growth options by engaging in mergers and acquisitions with (usually) smaller firms to improve declining drug pipelines. However, M&As are often associated with integration problems

and cultural shocks (Thanos and Papadakis, 2012; Bauer and Matzler, 2014), which may not be desirable in the short-run. For this reason, firms look at establishing alliances and collaborations with other firms to improve their understanding of the targets' assets, competencies and knowledge, due to the inherent difficulty in valuing these assets quantitatively (Kogut, 1991; Higgins and Rodriguez, 2006; Meschi *et al.*, 2017). Balakrishnan and Koza (1989, p. 8) conclude in their study that, "the joint-venture affords opportunities for learning and gathering new information about the value of the partner's assets".

Two key studies have found that declining product pipelines and deteriorating R&D productivity are main drivers for M&A activity. The first study looks at a sample of 160 pharmaceutical firms from 1994-2001 and find a positive relationship between deteriorating product pipelines and propensity to engage in an M&A (Higgins and Rodriguez, 2006). The second study finds that small and large firms use mergers in different situations. Whereas for large firms, mergers are used mainly as a response to patent expirations and declining pipelines; small firms use mergers as an exit strategy due to financial issues (Danzon *et al.*, 2007). On the other hand, Porrini (2004) investigates the existence of a previous alliance between acquirer and target and investigates the effect it poses on post-acquisition performance. The author finds a positive relationship between the two variables.

Currently, the most similar study to this one is that of Danzon et al. (2005, p. 317), where it is found that products "developed in an alliance tend to have a higher probability of success". Nevertheless, the period studied is limited to 1988-2000 and there is no mention of the effect this has on the company's R&D productivity. Therefore, following a similar line of thought, the aim of this paper is to investigate what effect a pre-acquisition alliance between two firms in the pharmaceutical industry has on the future R&D productivity of the combined firm. Compared to other studies, this paper offers a more thorough investigation

due to the time period considered, 1981-2018. The goal of this paper is to fill an existing gap in the literature by focussing on a specific – pharmaceutical – industry to try and capture what effect collaborations (in the form of alliances) have on R&D. This paper then focusses on two alliance characteristics, namely alliance duration and number of drugs collaborated during the alliance, to try and capture more specific determinants of R&D productivity.

There are several reasons for choosing the pharmaceutical industry for this study. Firstly, it is one of the most research-intensive industries in the world, and the most research intensive in the US (PhRMA, 2018). Secondly, it has been in the forefront of every wave of mergers and acquisitions; with a very strong trend of consolidation in the last decade. Lastly, it is an industry that features a high number of inter-firm collaboration, showing an increasing trend of alliances serving as a complement to mergers. For example, GlaxoSmithKline is allocating around 50% of its R&D budget to establishing alliances with partners from academia and with the biotechnology industry (Schuhmacher *et al.*, 2016).

The main findings in this study include the observation of a negative significant relationship between alliances and R&D productivity at the time of the merger. In other words, the existence of a pre-acquisition alliance leads to a decrease in R&D productivity for the merged firm. Furthermore, a negative significant relationship was also found between the duration (number of years) of an alliance and its effect on R&D productivity. Finally, the number of drugs collaborated between firms in an alliance prior to a merger was found to contribute negatively towards R&D productivity; however, this result was not found to be significant.

As Ornaghi (2009) refers in his paper, it is impossible to exclude the possibility that any correlation that may arise from M&A outcomes is due to sources of unobservable factors. For example, if the reason behind the decision of a firm to merge is due to an anticipation of poor financial performance, the analysis in this

paper may not be picking out the effects of the merger. Instead, this paper follows the assumption that alliances established prior to a merger or acquisition allowed the acquiring firm to gain an insight into its target's characteristics, that would not be possible otherwise.

The remainder of this paper is organized as follows. Chapter 2 presents the theoretical assumptions and background of the concepts discussed throughout, including alliances, R&D productivity and M&As. Chapter 3 discusses the methodology used to explain the research questions, the sources of the data used, and what kind of empirical analysis will be performed. Chapter 4 presents and discusses the empirical findings. Chapter 5 introduces a discussion of the results. Finally, Chapter 6 points to the limitations of the study.

Chapter 2

2. Literature review

2.1 Alliances

Alliances are relationships between two or more firms that involve the exchange, sharing or co-development of resources and capabilities (Gulati, 1995) as well as the pooling of resources and skills in order to achieve mutually common goals (Varadarajan and Cunningham, 1995). Alliances introduce several advantages for organisations that engage in them: they stimulate the rate of entry of firms into new markets (Elmuti and Kathawala, 2001; Haase and Franco, 2015), allow firms to learn from each other (Hamel *et al.*, 1989; Anand and Khanna, 2000; Kale *et al.*, 2000), enable the access to complementary assets (Arora and Gambardella, 1990; Rothaermel, 2001), help to overcome market failures (Williamson, 1989), help to build new competences (Hennart, 1991; Varadarajan and Cunningham, 1995), facilitate entry into new markets and enhance knowledge about new technologies (Kogut, 1991; Mowery *et al.*, 1996; García-Canal *et al.*, 2002), allow sharing of risks, as well as costs that may originate from R&D or manufacturing processes (Ohmae, 1989; Varadarajan and Cunningham, 1995; Lu and Beamish, 2001), foster the development of new products (Rothaermel and Deeds, 2004) and improve market power (Porter and Fuller, 1986; Kogut, 1991).

Additionally, strategic alliances can take on several configurations depending on which part of the value chain they influence and to what extent equity plays a role. Whereas a joint venture will involve some equity share between two companies (say, a 50-50 share), a joint R&D contractual agreement does not have

to include equity. Instead, it may simply feature a written contract which is agreed by both parties (Kale and Singh, 2009). Nevertheless, this study shall be focussing on R&D alliances between two or more firms who jointly collaborate to research and/or produce a new drug. An example of an R&D alliance between two pharmaceutical firms was that of AstraZeneca with Cambridge Antibody Technology to collaborate on monoclonal antibodies (Ernst & Young, as cited in Jones and Clifford, 2005, p808).

However, it is crucial to mention that alliances also possess some disadvantages, especially if they are not managed correctly, which may lead to the destruction of core capabilities (Hamel, 1991). In his paper, Elmuti (2001) states that many researchers have come to the conclusion that the rate of success of alliances is quite low and many do not actually succeed. Bamford et al. (2004) and Kalmbach and Roussel (1999) go further and report that between 30% and 70% of alliances fail, whilst Das (2000) mentions that around half of alliances formed are actually stable or achieve satisfactory performance. Therefore, establishing collaboration deals is something that must be carefully planned and researched to avoid common mistakes such as the ones mentioned above. Moreover, the characteristics that make up the pharmaceutical industry intensify the probability that alliances could be less successful. The pharmaceutical sector is one of the sectors with the highest intensity of R&D (Ornaghi, 2009), it is surrounded by high degrees of uncertainty and riskiness (DiMasi *et al.*, 1991; Rothaermel and Boeker, 2008) and is a technology intensive industry (Orsenigo *et al.*, 2001). These set of conditions assist in the probability that alliances may be more prone to failure in relation to ones that are established in less technologically intensive sectors.

2.2 Advantage of collaborating before M&A

Market failure due to information asymmetry is frequent and a source of many problems, mainly because the acquiring firm tends to possess little or inaccurate information about its potential target (Porrini, 2004; Higgins and Rodriguez, 2006; Zaheer *et al.*, 2010); leading to situations of adverse selection where targets can turn out to be “lemons” (Akerlof, 1970). Higgins and Rodriguez (2006) find that in the situations where the target firm withholds information from the acquiring firm about the value of their assets, the acquirer “tends to succumb to the winner’s curse and overpay for the target” (Higgins and Rodriguez, 2006, p. 356). Furthermore, regular due diligence might not solve this issue because there is always a possibility that the target firm may distort the true valuation of its assets, whether intentionally or not. Coff (1999, as cited by Zaheer *et al.*, 2010) identified three types of information asymmetry that may arise when valuing assets of a target firm, these include: quality of assets; transferability of assets, and prospects for synergy.

For these reasons, when deciding on acquiring a firm, besides performing the regular corporate due diligence procedures, firms should engage in other activities which allow them to collect crucial information about the target firm. The proposal in this report is that alliances should be considered as a way of acquiring information that would otherwise be non-accessible to obtain better insight into the true value of the company.

2.3 Mergers and acquisitions in pharmaceutical industry

2.3.1 Brief history

The pharmaceutical industry has been characterized by various merger waves along the years, contributing to an increased concentration for the past 40 years. In his book focussing of mergers and acquisitions in the pharmaceutical industry, Rajesh Kumar (2012) found that in 1985 the largest ten pharmaceutical firms accounted for 20% of world sales and in 2002 this value increased to 48%. It would come as no surprise if today this value were to have increased even more. In addition, between 1985 and 2007, numerous M&As led to a consolidation of 51 companies becoming only 10.

The two largest M&As in the history of the pharmaceutical industry were consummated during the second merger wave, which began in the 1990s and went up until the 2000s, more specifically, both occurred in 2000. The first one was Pfizer's acquisition of Warner-Lambert for around US\$164 billion and the second was Glaxo Wellcome's merger with SmithKline Beecham for around US\$108 billion (values adjusted for inflation). To understand how prevalent M&A's are in the pharma industry, in 2013, 2014 and 2015, three out of the ten major deals during each of these years occurred in this sector (Bloomberg, 2018).

2.3.2 Determinants of Mergers and Acquisitions

The main motives behind M&A's in the pharmaceutical industry can usually be divided into five main categories, but I shall focus on the three most relevant ones for this study. These include, strategic response to environmental change, economies of scale and scope, and access to new technologies. Firstly, the idea that industry-wide shocks can lead to the creation of merger waves was firstly introduced by Gort (1969), and these help to understand how merger waves

could happen in other industries, such as banking and telecommunications (Grabowski and Kyle, 2012). During the 1980s, the pharmaceutical industry suffered an environmental transformation with R&D productivity falling as well as price competition becoming more intense due an increase in generic drugs, increased government pressure and a major crisis of patent expiration (Munos, 2009). With this in mind, firms had to reinvent their strategies to improve R&D productivity, limit buyer power and try to challenge generic drug producers. Thus, mergers and acquisitions turned into an attractive strategy that firms with large amounts of accumulated cash could pursue to face these challenges, which ultimately led to the first wave of M&A's in the pharma industry. Mergers and acquisitions are an efficient way to cut costs because they allow for consolidation of operations, departments and administrative functions such as HR, legal, marketing and R&D staff. An example of this can be seen in the merger between Ciba and Sandoz that led to the creation of Novartis. This merger allowed the merged entity cost savings of around CHF1.5 billion in its first year of existence (Rajesh Kumar, 2012) due to the cost reduction in their highly complex supply chain that was the backbone of their manufacturing business. However, in an analysis published by Munos (2009) focussing on the effect of M&As on NME (new molecular entity) output, it was found that M&As are an effective way of boosting NME output for small firms but the same is not true for large companies. More specifically, there is a 95% probability that an M&A will increase NME output for small firms, whereas for large firms it is 95% likely that an M&A will not affect NME output.

Economies of scale and scope can be categorized as proactive motives for M&As, and these may include achieving economies of scale in research and development processes to increase productivity. Citing a series of studies by Henderson and Cockburn, Grabowski and Kyle (2012) describe that when examining the effect of scale and scope on productivity, the authors find that

large firms engaging in a broader scope of R&D activities produce a higher drug output than focused firms; showing that there is a positive correlation between economies of scope and productivity. However, there are some limitations towards this study. Even though the authors use very detailed data, the sample is composed of only 10 firms, which is troublesome when attempting to generalize the results. The famous merger between Pfizer and Warner-Lambert, Inc. allowed Pfizer to broaden its product lines with products including *Listerine* mouthwash and *Wilkinson Sword* shaving products (Rajesh Kumar, 2012), and its R&D focus into new areas such as oncology and ophthalmology. In addition, Pfizer managed to obtain full ownership of *Lipitor* (a blockbuster cholesterol drug) that went on to become the best-selling drug in the world with sales exceeding US\$5 billion. However, Grabowski and Kyle (2012) argue that a point has been reached where the effect of diminishing returns may start to be noticed because both the benefits from economies of scale and scope become cancelled out. The increased bureaucracy and the various challenges arising from motivating large teams of individuals to foster their creativity may not be worth the increased breadth in R&D research.

Thirdly, pharmaceutical companies may turn to mergers and acquisitions to gain access to the source of new products in high-growth therapeutic areas. The process of producing and commercializing drugs consists mainly of three stages: drug discovery, development and commercialization. The drug discovery phase is composed of two sub-phases: basic research and preclinical research and development, which on average take around 6 years (DiMasi *et al.*, 2003; Lin, 2009). Thus, to accelerate entry into new therapeutic areas and to avoid drug development processes that may be unsuccessful, large pharmaceutical companies (Big Pharma) tend to establish alliances and/or merge with smaller research-based firms to access their new technologies. An example of this situation occurred when Hoffman-LaRoche acquired part of Genentech in 1990

to gain access to their products which Hoffman-LaRoche believed were innovative and had great potential (Rajesh Kumar, 2012). Finally, companies may wish to engage in M&As as a result of ageing product pipelines and patent expiration issues, but this shall be explored further below.

Moreover, mergers tend to have the ultimate goal of cost-cutting and slimming drug pipeline portfolios and when a merger actually goes through, the R&D portfolios of both firms are examined in order to “eliminate those they see as ‘duplicative’” (Comanor and Scherer, 2013, p. 110). Having said this, if firms decide to collaborate in cooperative agreements before immediately engaging in a merger or acquisition, the likelihood of pursuing new drugs will be lower because larger firms tend to be more risk averse. This may be due to regulators having become more risk averse over time (DiMasi *et al.*, 2016).

2.4 Pipelines, patents, NME costs

Various studies have been carried out regarding research and development costs of new drugs and biologics in the pharmaceutical industry. These studies look at the value of the resources used to discover and develop new compounds by focussing on the overall probability of clinical success of the different phases of the NME creation process. One possible explanation for the formation of alliances between firms in the pharmaceutical industry has to do with the ever-increasing R&D cost of developing new molecules. When observing a period between 1983-1994, DiMasi *et al.* (2003) obtained an out-of-pocket R&D cost estimate of US\$1.04 billion (adjusted to 2013 dollars). In the latest report, DiMasi and Grabowski (2016) estimated the cost to be of around US\$2.5 billion. This large increase in R&D costs (166% increase) can be explained by the different time periods studied by each paper. Whereas the first study involved NME approvals

in the 1990s, the latest study focussed on NME approvals in 2000s and 2010s. Subsequently, not many companies have enough resources to develop such expensive drugs by themselves, nor do they have the required marketing skills to promote and introduce these newly developed drugs into the everyday medical use (Comanor and Scherer, 2013). Therefore, firms tend to look for collaboration opportunities with other firms to finance and operate testing procedures prior to approval by regulatory authorities. These collaboration opportunities are usually in the form of licensing agreements, joint ventures or R&D alliances with smaller firms, usually small “biotech” companies or universities with their own research centres. If the partnership is seen as being successful, the larger pharmaceutical firm tends to acquire the smaller company. Consistent with literature, this increasing cost of R&D is reflected by a change in the industry environment and its trends, due to growing alliances between firms, enhanced power of buyers, major hubs shifting to hotspots, increased regulation, looming patent cliffs, as well as tailored pipelines (Munos, 2009; Gautam and Pan, 2016).

Patent expiration plays a crucial role in the decision of whether or not a company should engage in an M&A; when a patent expires, revenues tend to decrease drastically (Rajesh Kumar, 2012). As an example, *Prozac*, an anti-depressant drug discovered by Eli Lilly and Co., suffered a decrease in sales of around 22% the year after it came off patent and generics were introduced in the market. There are two main types of patent protections for pharmaceutical firms. The first type is the normal, generic patent which is granted by the United States Patent and Trademark Office (USPTO) (Higgins and Rodriguez, 2006) and the second type of protection is granted by the Food and Drug Administration (FDA) and is mostly known as *exclusivity*. However, the creation of the Hatch-Waxman Act of 1984 allowed generic drug manufacturers to obtain marketing approval by the FDA as long as they could prove that their drug had bioequivalence to

original product. Following the passage of this Act, competition from generic manufacturers thrived in such a way that, in 1984, 19% of US prescriptions were in the form of generic drugs and in 2013 these accounted for 86% of the market (Grabowski *et al.*, 2015). It was also expected that due to losses in market exclusivity, around US\$140 billion would be lost in 2013 (Rajesh Kumar, 2012).

Looking back at the trend of diminishing returns that was mentioned earlier, the various merger waves that occurred throughout the last 30 years contributed to firms becoming bloated with manufacturing facilities, R&D laboratories and bureaucratic complexities spread around various places in the world. In addition, whenever a merger or acquisition involved a company in a foreign country, an added layer of complexity regarding cultural integration had to be considered. Consequently, a trend that big pharmaceutical companies began to adopt was that of becoming lean and focussed by “divesting non-core assets and focussing on areas of strength” (Gautam and Pan, 2016, p. 380). For example, in an effort to become more streamlined and focussed, Abbott decided to split into two separate companies in 2013: AbbVie became responsible for the innovative pharma business, whilst Abbott focussed on diversified healthcare products. Similarly, an unintended, or at least unforeseen consequence of the race towards economies of scale and scope was that multiple research hubs became dispersed across the world. For example, AstraZeneca had over ten R&D laboratories in countries such as the USA, UK, Sweden and Canada. Thus, since 2005, most Big Pharma organisations shifted their strategies by consolidating their R&D sites within innovation clusters in San Francisco, London and Shanghai. The main advantages of this strategy are the increase in access to external innovation through alliances, easier collaboration with universities and scientists, as well as providing a more collaborative environment.

2.5 Declining R&D productivity

Moore's Law – considered by many as the golden rule in the electronics industry – states that the number of transistors that can be placed onto an integrated circuit should double every two years. Over the years, this concept has been applied generally in the technology industry and has usually proved accurate due to the innovation and continuous improvement of this sector. Scannell et al. (2012) came up with a term to describe the opposite effect to that of Moore's Law. Eroom's Law is the name chosen to characterize the following trend. In their article, they found that the number of new FDA-approved drugs has “halved every 9 years, since 1950”, per billion USD of R&D spending.

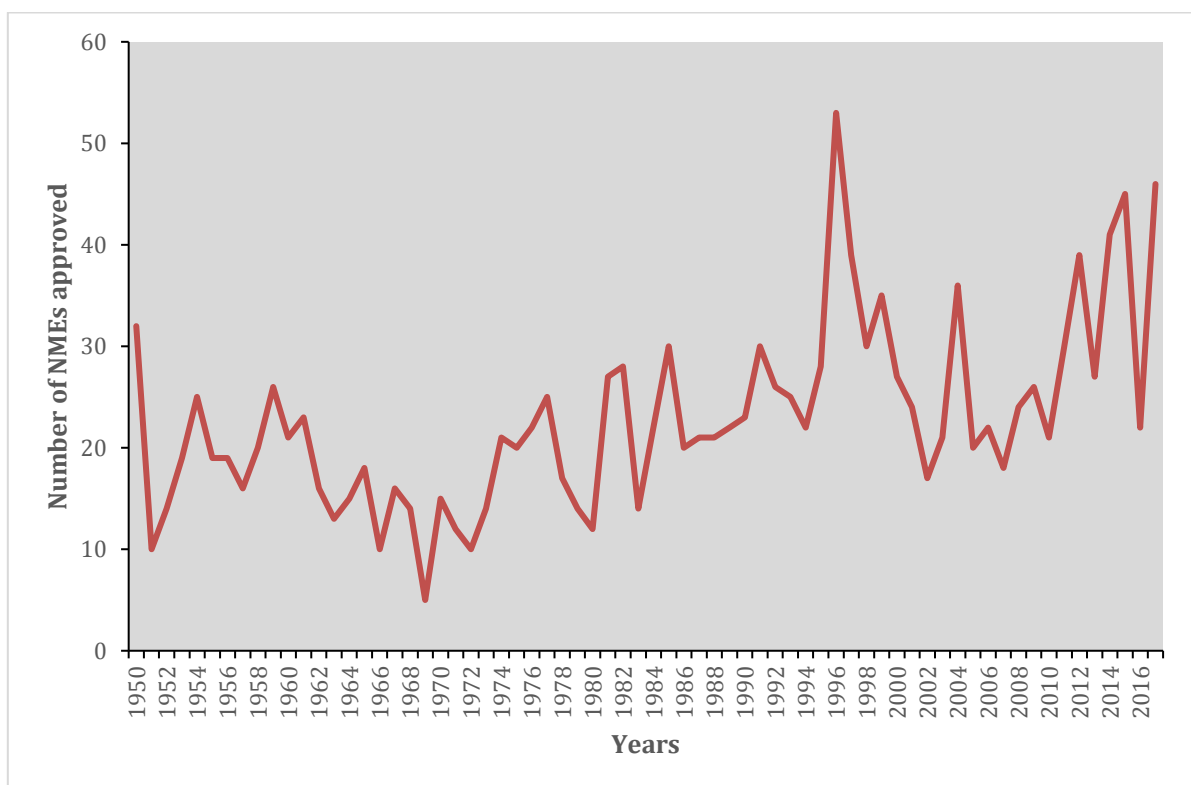


Figure 1 - Approval timeline for new molecular entities (NMEs)

Since 1950, around 1500 NME's have been approved by the FDA, which amounts to an average of 23 new drug approvals per year. As seen in Figure 1, the rate of approval has remained relatively constant until 1990, followed by a

large spike in 1996 due to the approval of the Prescription Drug User Fee Act (PDUFA). This law was created in 1992 to authorize the FDA to “collect fees from companies that produce certain human drug and biological products” (FDA, 2018, (4)). In addition, Munos (2009) postulates that the spike in 1996 was in part a consequence of this Act since user fees helped to speed up drug approval processes. From 1996 until today, the rate of drug approval has returned to its historical average.

The productivity crisis, namely, the R&D productivity crisis in the pharmaceutical industry has been a popular topic in research papers and opinion articles (Danzon *et al.*, 2007; Munos, 2009; Pammolli *et al.*, 2011; Scannell *et al.*, 2012; Schuhmacher *et al.*, 2016; Ringel and Choy, 2017). Even though the cost of developing NMEs as well as R&D expenditures have been consistently increasing, the rate of NME approval has stayed mostly constant. Thus, if the annual drug output of pharmaceutical firms has been constant for the better part of the last 50 years, and assuming they have been actively trying to improve these levels of performance, it is quite unlikely that there will be radical change (Munos, 2009). Consequently, firms have been resorting to merging with and acquiring smaller firms in hope that they can increase NME output.

When measuring R&D productivity, NMEs are usually one of the elements used because they are a good representation of the firms’ outputs. R&D productivity is usually measured as a ratio of inputs to outputs, however, quantifying what and how many inputs can produce a certain amount of outputs is very dubious, especially in the pharmaceutical industry (Pammolli *et al.*, 2011). Moreover, there is a high degree of uncertainty between the expenditure that is undertaken today to ensure future returns (Hall and Mairesse, 2009). For example, if the production of a drug is a product of an alliance between five firms and two universities, coming up with a number that can quantify the inputs invested may turn out to be a daunting task.

2.6 Similar literature

When studying strategic alliances between US and Japanese firms, Hurry (1993) recognizes that the steps taken by firms in the integration process from cooperation to acquisition entails some advantages since it allows time for firms to learn about each other. The author finds a positive link for acquisitions between firms in the same therapeutic category in that they generate higher average abnormal returns (5.08%) when compared to acquisitions within different therapeutic areas (3.24%).

A study by Danzon et al. (2005) shows that smaller firms have actually helped in the development of new drugs by licensing these drugs to larger pharma companies. These large firms then carry the drugs through the various procedures until they are ultimately approved by the regulatory authorities. In addition, they find that “drugs developed in alliances are more likely to succeed in clinical trials” (2005, p. 319) and that large firms experience higher rates of success for licenced compounds when compared to compounds that are developed in-house. However, their study is faced with a key limitation, in that data is insufficient to analyse alliance formation.

Higgins and Rodriguez (2006) find that if the acquiring firm can have access to more information during the pre-acquisition period, this will lead to greater probability of success of the R&D alliance. There is vast literature supporting the idea that bidding firms tend to overpay for their target when engaging in an acquisition and that its shareholders gain little value (Dodd, 1980; Asquith, 1983; Andrade et al., 2001). This becomes more evident for firms that possess many intangible assets, as they can be tough to value. Thus, Higgins and Rodriguez (2006) posit that forming pre-acquisition alliances may help in reducing this information asymmetry since firms will have more time to gather information before eventually merging or acquiring. In fact, for the cases in which the

acquiring company had engaged in an alliance before the acquisition, average abnormal returns amounted to 4.30%, whereas in the cases where an acquisition took place without previous cooperation between the two firms, the returns were of 3.36%. A possible reason for this effect has to do with the importance of the pre-acquisition phase in the overall M&A process. This phase is crucial due to the information that can be learnt and shared between the two companies and its staff, namely, information from relevant departments such as, human resources, financial, IT, tax and legal. In addition, strategic alliances may be used as a tool to evaluate the environment where the firms are conducting business in (Hagedoorn et al., 1999). The authors of this study found little evidence to support their hypothesis about strategic technology alliances acting as an originator to the formation of M&As; in fact, only 2.60% of the strategic technology alliances studied could be linked to a merger or acquisition.

Arora et al. (2007) use a sample of around 3000 drug-related R&D projects in the US between the years of 1980 and 1994 to “compare the innovation performance of pharmaceutical and biotech companies” and look at the role that licencing and alliances play in these projects. Arora et al. (2007) and Danzon et al. (2005) have complementary views regarding alliances as both studies find positive effects associated with alliances.

Siebert et al. (2017) found that the number of R&D projects as well as the number of drugs that are launched onto the product market increase if R&D partnerships are established in the beginning of the drug development process, and they attribute this to the effect of economies of scale. Conversely, in the cases where these collaboration partnerships are established in later drug development stages, the number of drugs that are launched on the market is significantly reduced. These results show that when firms collaborate in advance and without time constraints, they are able to rethink their drug pipeline portfolio to avoid overlap of similar R&D efforts and thus avoid destroying future sales.

A similar study to this one is performed by Meschi, Metais and Shimizu (2017) on the acquisition by French firms in the US, where the duration of the pre-acquisition alliance is investigated as to whether having a beneficial or harmful impact on the performance of an ensuing acquisition. In addition, the authors study how alliance duration affects different types of alliances, including joint ventures, minority investments and non-equity collaborations. The argument put forth by these authors is that decisions that are taken to merge or acquire a firm during an early-stage of an alliance are biased by “honeymoon effects” and possible red flags are often overlooked. Their findings show that when joint ventures and minority investments have a duration between seven and eight years, they demonstrate a high probability of acquisition failure. Another interesting finding is that this probability of acquisition failure increases with alliance duration as it surpasses seven years.

Chapter 3

3. Data and Methodology

3.1 Data

3.1.1 Data processing

To obtain the necessary information for this investigation, data about both mergers and acquisitions and alliance activity between firms in the pharmaceutical sector was required. However, most databases (the ones that were accessible) either include information about M&As or about R&D alliances; no database was able to provide information about both. Therefore, a merger of the two databases would be needed to come up with a complete database that enables comparison and cross-referencing between them to run empirical testing and obtain results.

This study relies solely on secondary data which was obtained from two different databases. To obtain the M&A deals data, Thomson Reuters database was used via the Deal Screener productivity tool. This tool allows for the customization of search queries to select the most relevant data needed where some filters/criteria may be selected. Firstly, only deals under the completed category were selected, indicating the deals for which the transaction has closed. Secondly, the deal forms selected were the following: acquisition, merger, and acquisition of majority interest. This last category was chosen because it represents the situations in which the acquirer held less than 50% of the target company's stock before the deal and is seeking to acquire 50% or more (but less than 100%). No restrictions were placed on deal value since the sample should capture all deals regardless of size. In addition, to ensure that only firms

operating in the pharmaceutical sector were represented in the data, companies were selected based on their Standard Industrial Classification (SIC) codes. Following Danzon et al. (2007) and Higgins & Rodriguez (2006) search method, this range of SIC codes cover the pharmaceutical industry: 2833-2836. Thus, the transactions between companies with the aforementioned SIC codes were selected for the M&A database. Moreover, to maximise the probability of finding financial company information online, deals were selected if the target and acquiring firm were both public. Finally, the sample was restricted to transactions that occurred between 01/01/1981 and 01/07/2018 to match with the R&D database which shall be explained below. In all, the M&A sample was left with a universe of 635 deals.

Regarding the R&D alliance information, OVID's IMS Health (R&D Focus) database was used to obtain all data. This database contains (n = 7064) observations, each representing a specific molecule for which an R&D collaboration alliance occurred. Anatomical Therapeutic Chemical (ATC) codes are used to indicate which therapeutic area(s) each molecule targets. Using ATC codes as a classification method proves useful because besides being the standard classification method, it is tightly controlled by the World Health Organization (WHO), and it is usually how competition authorities define the market. In addition, for each observation there is an indication of the beginning and end dates of the R&D alliances, their duration, and which firms participated in the collaboration. The number of collaborating firms ranges from 2 to 23. In this database, information on R&D processes is available from 01/01/1981 up until 01/01/2011. However, the synergies gained throughout the alliance process may not lead to a merger or an acquisition by one of the collaborating firms immediately after the process is terminated, therefore all M&As occurring post-2011 were also selected to take part in the database.

Once the two databases were ready, they had to be merged to see whether any firms that have had a history of collaboration engaged in a subsequent merger or acquisition. To carry out this process, firms from the alliance database had to be divided into pairs to 'match' with the pairs of firms in the M&A database during the merger procedure. For example, if companies A, B, C, D collaborated to produce drug X, the possible collaboration pairs would have to be: AB, AC, AD, BC, BD, CD. This 'pairing' process was carried out using VBA in Microsoft Excel until all R&D processes were represented by pairs of companies. Unfortunately, firm names in each database were not the same - some firm names were abbreviated -, most likely because they originated from different sources, which made the merging process slightly more complex. Nevertheless, the Fuzzy Lookup Tool¹, a Microsoft Excel add-in, was used to find similar matches between firm names of both databases and produce an output table with a similarity probability index. Even though this tool did not provide a perfect merger between names, it definitely sped up the process and eliminated the need to go through each name individually hoping to find a match. Thus, only an overview check was required to see whether the matches were in fact correct. Unfortunately, a margin of human error throughout this process is inevitable since it is an individual and manual procedure.

¹ <https://www.microsoft.com/en-us/download/details.aspx?id=15011> (Fuzzy Lookup Excel Add-in; Accessed on 25/07/2018)

3.1.1 Preliminary data

Variable	Total	Merger = 1, Alliance = 1	Merger = 1, Alliance = 0	Merger = 0, Alliance = 1
Number of pairs	13789	51	547	13191
Average alliance duration (years)	5,89	5,84	N/A	5,89
Average number of drugs collaborated	2,27	21,10	N/A	2,19
Average M&A deal value (millions)	\$2 225,96	\$3 134,63	\$2 141,24	N/A
Average number of years between alliance and M&A	2,10	2,10	N/A	N/A

Table 1 - Summary statistics

The data in Table 1 shows some early preliminary statistics gathered from the merged database prior to performing any regressions. The first impression that can be noticed from this table is that the number of observations for the pairs of firms that engaged in an alliance followed by a merger is quite small (51 observations). However, a large difference is found when looking at the average number of drugs that firms collaborated on. In a regular alliance, more specifically in the situations where an alliance does not lead to a future merger between firms, the number of drugs that firms collaborate on is on average 2. Conversely, in alliances that led to a future merger, the number of drugs collaborated increases to 21! This is an extremely interesting result because it may suggest that a 'stronger' alliance, where more collaboration ensues and where firms get to work more with each other may lead to a future merger or acquisition by one of the parts. In addition, the deal value of an M&A is on average US\$1 million higher for firms that have engaged in an alliance with each other before the merger. Whilst this tendency may be explained by the idea that alliances can

help reduce information asymmetry that is usually present in M&A processes, supporting Higgins and Rodriguez's (2006) theory, without further control variables this statement becomes quite inconclusive.

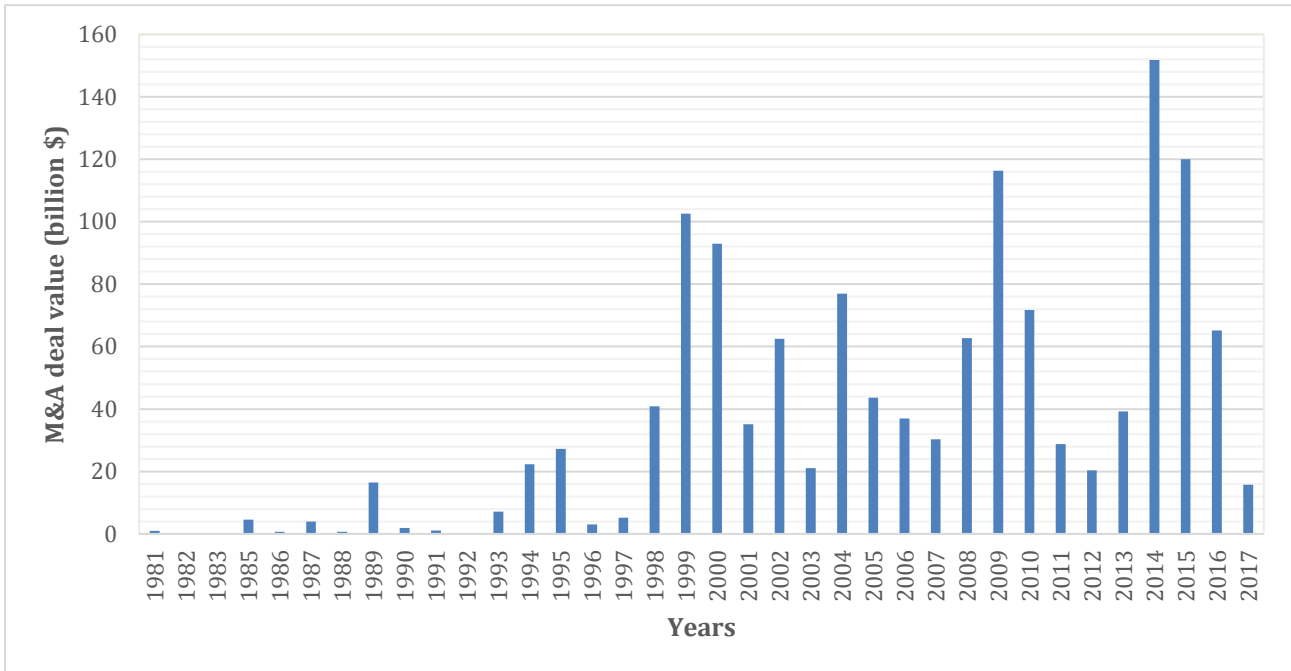


Figure 2 - Volume of M&A deals (1981-2017)

A clear trend can be seen throughout the years regarding the value of M&A deals when looking at Figure 2. Even though M&A activity was already prevalent during the 1980s and 1990s, it was not until 1998 that deal values exponentially increased to amounts that were higher than ever before. To better illustrate this point, until 1997 an M&A transaction had on average a value of US\$6 billion; whereas from 1998 until 2017 (latest data), this value increased to around US\$62 billion. This massive increase in deal value can be attributed to large pharmaceutical firms experiencing expiring patents which allows for an influx of competition. In turn, these firms may decide to overhaul their research and development pipelines by acquiring potential targets. Thus, it comes as no surprise that 2018 has been the year in which the pharmaceutical sector has experienced its strongest start in M&A in more than a decade (The Financial Times, 2018). By observing Figure 2, the major merger waves of the

pharmaceutical industry can easily be spotted, and coincidentally, each wave is characterized by a higher average deal value than the previous one. The first wave can be seen around 1999, where deal values surpassed US\$100 billion for the first time and was mainly amplified by Pfizer’s acquisition of Warner-Lambert Co. by US\$90 billion along with the merger of Glaxo Wellcome and SmithKline Beecham for US\$76 billion. Subsequently, the second wave took place around 2009 with M&A deal volumes reaching US\$120 billion, with deals such as Pfizer’s acquisition of Wyeth for US\$68 billion. Finally, the third merger wave occurred around 2014 with deal volumes surpassing US\$150 billion, with Actavis’ acquisition of Allergan being the most expensive one during this wave with a value of US\$68 billion.

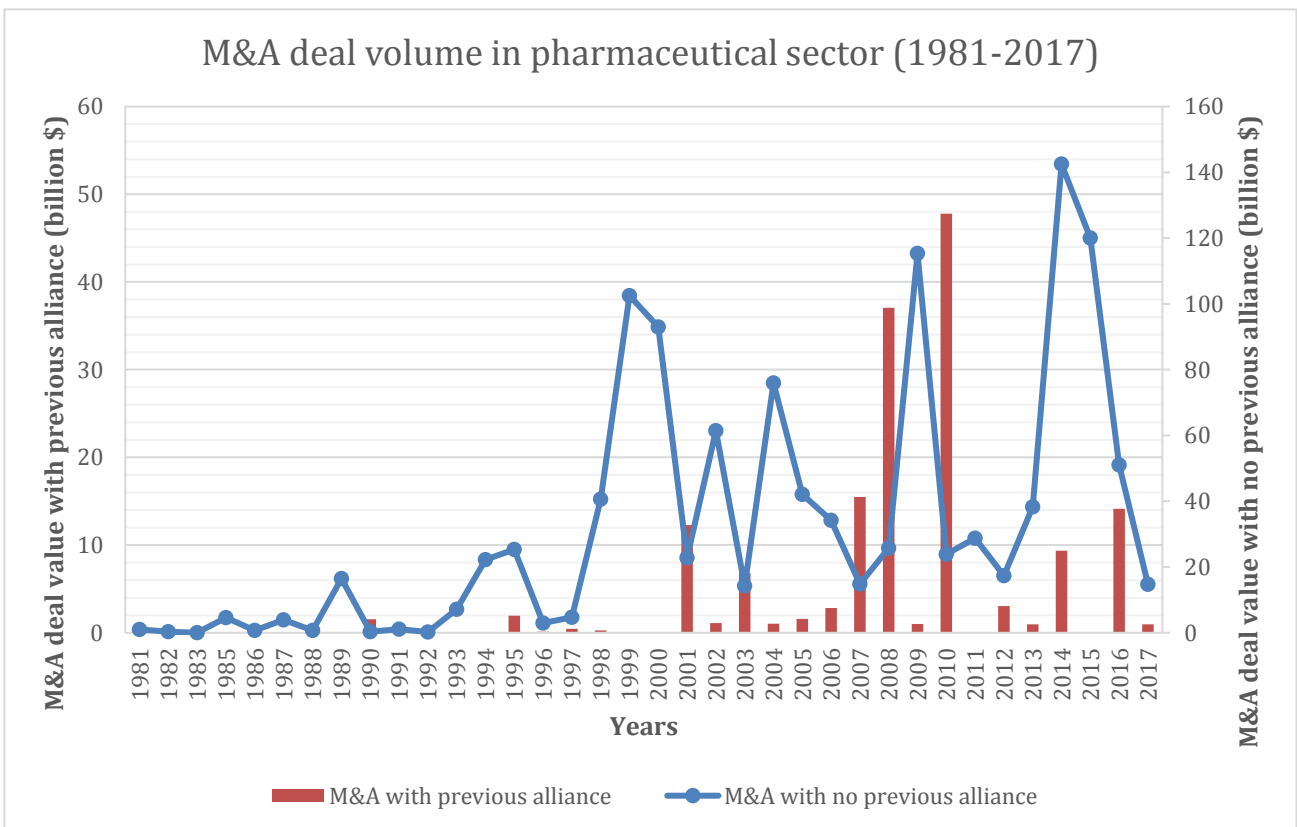


Figure 3 - M&A deal volume with and without previous alliance (1981-2017)

The information present in Figure 3 is particularly useful since it provides a comparison between the value of the M&A deals that occurred after two firms collaborated on the development of a drug and of those firms who had no history

of collaboration with each other. However, it also allows to see if these two types of M&As occur during identical time periods. If they do, then we can say that mergers are simply linked to the merger waves previously explained; but if not, then it is possible that the merger or acquisition is connected to the alliance and not solely to the merger wave. From the information present in Figure 3 there seems to be a somewhat negative correlation between deal values of M&As with and without previous alliances throughout the years. Namely, between 2007 to 2010 this pattern is evident because 2008 and 2010 are the years with the highest deal values of M&As with a previous alliance and, simultaneously, deal values for M&A with no previous alliance are found to be remarkably low. The opposite however, can be seen in 2009, with a high deal value for M&As with no previous alliance and very low deal values for M&As with previous collaboration. Consequently, a quick examination of this trend supports the idea that these M&As are increasingly linked to the previous alliance established between the firms rather than the merger wave itself.

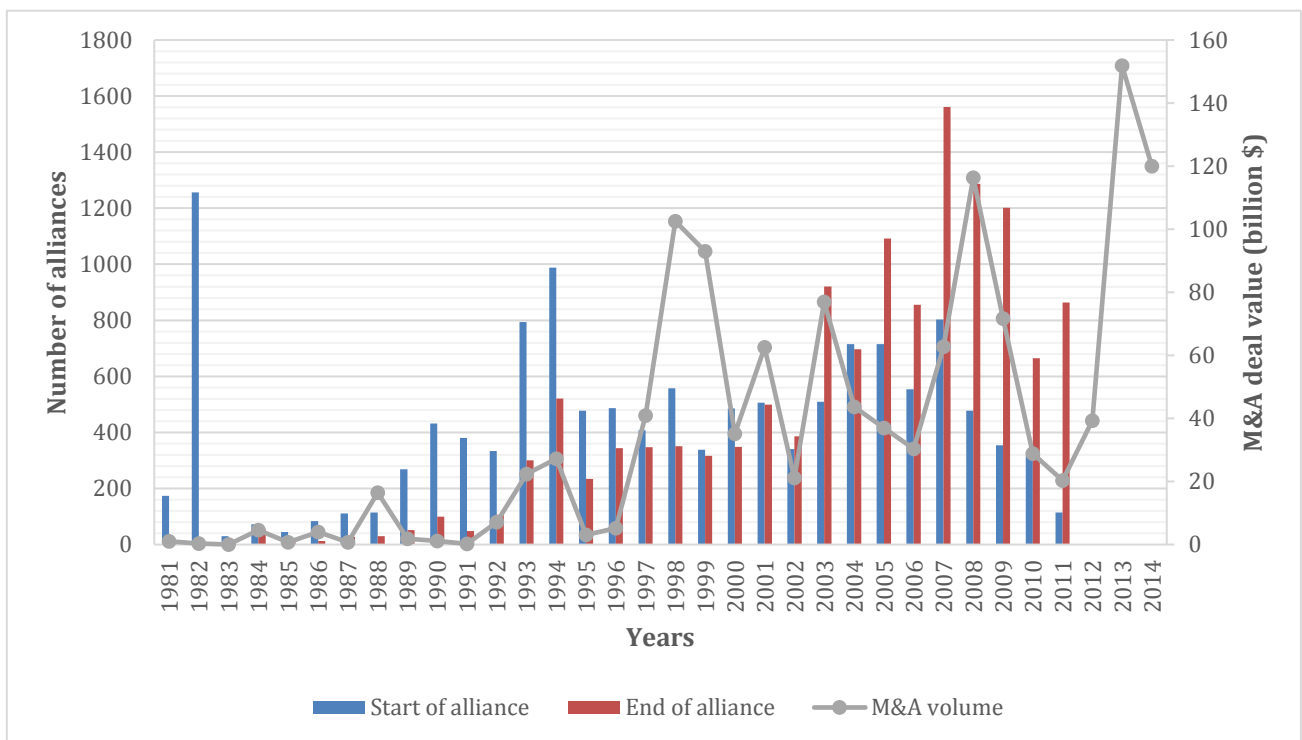


Figure 4 - Alliances vs M&A activity (1981-2014)

Figure 4 graphs a comparison between number of alliances established, number of alliances terminated and M&A activity per year between 1981 and 2014. Even though alliance data is only available until 2011, M&A data until 2014 was included since the decision to acquire or merge with another firm may not be done immediately after the alliance is ended. The main patterns that can be perceived in Figure 4 somewhat corroborate the idea that alliances act as a precursor for a future merger or acquisition. Firstly, when looking at the data from 2003 it is clear that a large number (~900) of alliances were ended that year, and at the same time M&A activity intensified. A similar trend happens between 2007-2009, where a record number of alliances are ended during those years and M&A activity is also quite prevalent. However, according to the data in **Erro! A origem da referência não foi encontrada.**, the average time period between the end of an alliance and a future M&A is of around 2 years. By taking this into consideration and looking at Figure 4 once again, the large peak in M&A activity in 2013 may be a (somewhat delayed) result of the large number of alliances that ended during the previous years. Moreover, around 1998 (the first big merger wave of the pharmaceutical industry) M&A activity was becoming quite intense, which, following the same line of thought as above may indicate that this could have been the outcome of all collaborative alliances that were ended throughout the preceding years.

Chapter 4

3.2 Methodology

3.2.1 Dependent variable

Research and development productivity

The dependent variable for this study must be one which measures the performance of a company but also captures the particularities of operating in the pharmaceutical sector. Measuring R&D productivity is seen by many researchers as a tricky matter to quantify (Pappas and Remer, 1985; Hannon *et al.*, 2015) because it is usually calculated using a ratio of inputs to outputs. Looking at the pharma industry, inputs can easily be measured by seeing how much each company spends in R&D each year, however, the outputs are usually intangible and tough to quantify as a number. For this reason, a simplistic approach towards a productivity ratio based on R&D was selected. This ratio is calculated by dividing the net sales of the acquirer in the acquisition year and the R&D expenditure of the acquirer four years before the acquisition takes place. Since these values represent a function of the historical contribution of pharmaceutical companies towards R&D, the ratio was calculated with a time lag of four years (Schulze *et al.*, 2014). A time period of four years was selected because most recent studies have pointed out that overall development time for a new drug (Phase I-III) to be on average eight years (Mc Namara and Baden-Fuller, 2007; Mestre-Ferrandiz *et al.*, 2012; Schulze *et al.*, 2014; PHRMA, 2015). In addition, the future benefits that may arise from current R&D investments are subject to time lags and therefore become hard to accurately measure. Having

said this, an alternative measure of R&D productivity is also used to understand to what extent the end results are influenced by the way this variable is calculated. The two simple measures of R&D productivity are shown below:

$$RDProd_{t,i}^S = \frac{S_{t,i}}{RDexp_{t-4,i}} \quad (1.1)$$

$$RDProd_{t,i}^R = \frac{R_{t,i}}{RDexp_{t,i}} \quad (1.2)$$

$RDProd_{t,i}$ represents R&D productivity in year t for firm i

$S_{t,i}$ represents net sales in year t for firm i

$RDexp_{t-4,i}$ represents R&D expenditure in year t-4 for firm i

$R_{t,i}$ represents returns to shareholders in year t for firm i

3.2.2 Independent variable

Previous alliance

The chosen independent variable for this study is a dummy variable that takes the value of 1 if there has been a previous alliance between the acquirer and target firm. If more than one alliance has been established between the two firms, the dummy variable takes on the value of 1. To control for these cases where the number of alliances is higher than 1, some control variables have been selected and will be explained in greater detail below. Data regarding alliances comes solely from the R&D alliance database.

3.2.3 Control variables

Change in debt to equity

The change in debt to equity is measured as the difference between the debt to shareholder's equity (D/E) ratio of the acquirer two years after the acquisition (t+2) and the D/E ratio of the acquirer one year before the acquisition takes place (t-1), and is divided by the D/E ratio one year before the acquisition (t-1). Porrini (2004) states that firms engaging in acquisitions (acquirers) tend to see their levels of debt increase after acquisitions take place. Since an increased amount of debt may influence how much a firm spends in R&D, I decided to control for this.

$$D / E = \frac{\text{Debt to shareholder equity}_{t+2}^{AQ} - \text{Debt to shareholder equity}_{t-1}^{AQ}}{\text{Debt to shareholder equity}_{t-1}^{AQ}} \quad (1.3)$$

ROA

This variable was selected to capture the change in ROA of the acquiring and target firm one year prior to the acquisition and two years after it occurred. It is measured as the difference between the ROA of the acquirer two years after the acquisition (t+2) and the weighted ROA of the acquirer and target one year before the acquisition takes place (t-1), divided by the weighted ROA of the acquirer and target one year prior to acquisition (t-1). Several researchers have used ROA as a measure of M&A performance (Meeks and Meeks, 1981; Harrison *et al.*, 1991; Hitt *et al.*, 1998; Papadakis and Thanos, 2010). Meeks and Meeks (1981) find that selecting return on assets as an indicator of pre and post-merger indicator is recommended because other indicators are more subject to potential biases.

$$\text{Return on assets} = \frac{ROA_{t+2}^{AQ} - ROA_{t-1}^{AQ/T}}{ROA_{t-1}^{AQ/T}} \quad (1.4)$$

Cross border

This is a variable that takes the value of 1 if the target firm is located in a different geographic region (i.e. country) than the acquiring firm and 0 if both companies operate within the same country.

Alliance duration

This variable (measured in years) measures the duration of the alliance established between two companies. It is calculated from the formation date until its date of termination, and for the companies that engaged in more than one alliance, an average duration of the alliances is computed.

Number of drugs collaborated

Similar to the previous variable, this variable measures the number of drugs that pairs of firms have collaborated on.

Finally, in a paper by Hou, Xue and Zhang (2015), the authors find that using a q-factor model which includes “a market factor, a size factor, an investment factor, and a profitability factor” is superior in capturing significant anomalies than using the Fama-French model. Thus, following (Lee, 2016), the following variables which represent important financial factors were selected to control for M&A activity: market capitalization, net income and return on invested capital.

3.2.4 Regressions

Having mentioned the independent, dependent and control variables that shall be used, the chosen regressions will be divided into two groups with four regressions each, yielding a total of eight regressions. The first group will feature the dummy variable “Previous alliance” as independent variable, whereas the second group will lose this variable in exchange for “Alliance duration” and “Number of drugs collaborated”. The reasoning behind this decision shall be explained below.

Equations 1.5 and 1.6 aim to show the effect of a previous alliance between two firms on the R&D productivity of the merged firm. Whereas equation 1.5 measures R&D productivity based on sales, equation 1.6 uses returns to shareholders.

$$RDProd_{t,i}^S = \beta_0 + \beta_1 ALL_{t,i} + \beta_2 DE_{t,i} + \beta_3 ROA_{t,i} + \beta_4 CB_i + \beta_5 NI_{t,i} + \beta_6 MC_{t,i} + \beta_7 ROIC_{t,i} + \varepsilon_{i,t} \quad (1.5)$$

$$RDProd_{t,i}^R = \beta_0 + \beta_1 ALL_{t,i} + \beta_2 DE_{t,i} + \beta_3 ROA_{t,i} + \beta_4 CB_i + \beta_5 NI_{t,i} + \beta_6 MC_{t,i} + \beta_7 ROIC_{t,i} + \varepsilon_{i,t} \quad (1.6)$$

$ALL_{t,i}$ represents a dummy variable that takes the value 1 if there has been a previous alliance between the acquirer and target firm

$DE_{t,i}$ represents the change in debt to equity for firm i in year t

$ROA_{t,i}$ represents the change in ROA for firm i in year t

$CB_{t,i}$ represents a dummy variable that takes the value of 1 if the target firm is located in a different geographic region (i.e. country) than the acquiring firm

$NI_{t,i}$ represents the year end net income for firm i in year t

$MC_{t,i}$ represents the year end market capitalization for firm i in year t

$ROIC_{t,i}$ represents the return on invested capital for firm i in year t

Equations 1.7 and 1.8 are identical to the ones above but these include year-fixed effects. Year-fixed effects were added as separate regressions to control for possible variations in the outcome that could happen over the years and that cannot be explained by any of the other explanatory variables.

$$RDProd_{t,i}^S = \beta_0 + \beta_1 ALL_{t,i} + \beta_2 DE_{t,i} + \beta_3 ROA_{t,i} + \beta_4 CB_i + \beta_5 NI_{t,i} + \beta_6 MC_{t,i} + \beta_7 ROIC_{t,i} + \beta_8 FE_t + \varepsilon_{i,t} \quad (1.7)$$

$$RDProd_{t,i}^R = \beta_0 + \beta_1 ALL_{t,i} + \beta_2 DE_{t,i} + \beta_3 ROA_{t,i} + \beta_4 CB_i + \beta_5 NI_{t,i} + \beta_6 MC_{t,i} + \beta_7 ROIC_{t,i} + \beta_8 FE_t + \varepsilon_{i,t} \quad (1.8)$$

FE_t represent the year fixed effects for year t

The following four equations are part of the second group of regressions where the independent variable becomes “Alliance duration” (ALLYRS) and “Number of drugs collaborated” (DRUGS). Since these two variables reflect particular characteristics of alliances, the inclusion of these variables in the regression may make it possible to narrow down what are the main factors within an alliance that affect R&D productivity. More specifically, this will help understand if the effect (whether it be positive or negative) of a previous alliance on R&D productivity is related to the number of years that the alliance lasted for or to the number of individual drugs that firms collaborated on. Therefore, Equations 1.9 and 1.10 aim to show the effect of these two variables on R&D productivity.

$$RDProd_{t,i}^S = \beta_0 + \beta_1 ALLYRS_i + \beta_2 DRUGS_i + \beta_3 DE_{t,i} + \beta_4 ROA_{t,i} + \beta_5 CB_i + \beta_6 NI_{t,i} + \beta_7 MC_{t,i} + \beta_8 ROIC_{t,i} + \varepsilon_{i,t} \quad (1.9)$$

$$RDProd_{t,i}^R = \beta_0 + \beta_1 ALLYRS_i + \beta_2 DRUGS_i + \beta_3 DE_{t,i} + \beta_4 ROA_{t,i} + \beta_5 CB_i + \beta_6 NI_{t,i} + \beta_7 MC_{t,i} + \beta_8 ROIC_{t,i} + \varepsilon_{i,t} \quad (1.10)$$

$ALLYRS_i$ represents the duration of the alliance between a pair of firms i

$DRUGS_i$ represents the number of drugs collaborated between pair of firms i

Finally, equations 1.11 and 1.12 are identical to the ones above but with the inclusion of year-fixed effects.

$$RDProd_{t,i}^S = \beta_0 + \beta_1 ALLYRS_i + \beta_2 DRUGS_i + \beta_3 DE_{t,i} + \beta_4 ROA_{t,i} + \beta_5 CB_i + \beta_6 NI_{t,i} + \beta_7 MC_{t,i} + \beta_8 ROIC_{t,i} + \beta_9 FE_t + \varepsilon_{i,t} \quad (1.11)$$

$$RDProd_{t,i}^R = \beta_0 + \beta_1 ALLYRS_i + \beta_2 DRUGS_i + \beta_3 DE_{t,i} + \beta_4 ROA_{t,i} + \beta_5 CB_i + \beta_6 NI_{t,i} + \beta_7 MC_{t,i} + \beta_8 ROIC_{t,i} + \beta_9 FE_t + \varepsilon_{i,t} \quad (1.12)$$

3.2.5 Summary Statistics

Variable	Mean	Standard deviation	Number of observations
R&D productivity (sales)	44.13	146.86	345
R&D productivity (return to shareholders)	18.14	48.25	345
Debt to equity	51.49	625.38	345
ROA	4.45	93.35	345
Net income	6,288,918	38,300,000	345
Market capitalization	132,000,000	639,000,000	345
ROIC	1.54	35.63	345
Cross border	0.39	0.49	345
Previous alliance	0.13	0.33	345

Table 2 - Summary statistics for key variables

4. Results

Overall, eight regressions were performed to investigate the effect of a previous alliance between two organisations on the future R&D productivity of the merged company. The results from first set of regressions (equations 1.5 – 1.8) can be seen in Table 3 and the results from the second group of regressions (equations 1.9 – 1.12) are presented in Table 4. The first set of equations is investigating the effect of the existence of a previous alliance on the future R&D productivity of the firm, whereas the final group of equations introduces some more specific alliance characteristics to try to isolate where the effects are coming from. Regarding year-fixed effects (dummies), the results in Tables 3 and 4 include regressions both without year-fixed effects (equations 1.5 – 1.6; 1.9 – 1.10) and with year-fixed effects (1.7 – 1.8; 1.11 – 1.12). The inclusion of year dummies in the regressions was done to control for possible temporal effects that could happen over the years and that, at the same time, cannot be explained by any other variable. Even though they are included, year-fixed effects are not presented in the tables of results. Likewise, firm-fixed effects were initially included in the regressions, however, this led to the model becoming overfit and producing an R-squared value that was too high to be considered significant. In other words, too many terms were added in proportion to the number of observations available per firm, which led to the fixed effect ‘pulling’ towards itself all the explanation of the model instead of reflecting the data of the overall population. Therefore, firm-fixed effects were excluded from the regressions.

Before going into more detail about the values in the various models that were regressed, it may be compelling to look at Figure 5 and 6 which graphically demonstrate the relationship between R&D productivity and the number of years spent in an alliance. Figure 5 shows this relationship using R&D

productivity calculated using sales whilst Figure 6 uses R&D based on shareholder returns. In general, there appears to be a very slightly positive relationship in both situations between R&D productivity and alliance duration. In both cases data is mostly concentrated in the left half of the graph, indicating that the majority of alliances has a duration of less than ten years. However, the data present in Figure 6 follows the linear fit trendline much more closely than in Figure 5, which indicates that R&D Productivity based on shareholder returns is more correlated with alliance duration. Also, Figure 6 shows evidence that the added benefit of engaging in a longer-term alliance (+10 years) is poorly reflected on increased R&D productivity. This tendency is even more clear in Figure 5 where some alliances lasting 6 years lead to a higher R&D productivity than 20-year-old alliances. Whilst this may be an indication that there are other (more relevant) factors that can explain this relationship, there is also a possibility that there is an optimum amount of time that an alliance should last for that can benefit firms in reducing information asymmetry (Meschi *et al.*, 2017), such as valuing intangible assets (i.e. workforce knowledge and skills) backing up the literature by Higgins and Rodriguez (2006).

Table 3 presents the regression results for each variable in the first four models presented (equations 1.5 – 1.8). In these four models, the dependent variable, previous alliance, presents a negative coefficient and is statistically significant ($p < .01$). Even though the coefficients are all negative, the two equations using R&D productivity based on sales (1.5 and 1.7) exhibit much higher values. Nevertheless, they are consistent with each other, thus, when all other variables are held constant, a previous alliance between two firms can have a negative impact on future R&D productivity. When looking at the control variables, only ROA and ROIC have positive coefficients through all four models, however, whereas ROA is statistically significant ($p < .01$) in the four models, for ROIC this is only the case in the models without year-fixed effects; when year-fixed effects

are introduced its statistical significance is reduced ($p < .1$). Regarding the remaining control variables, they are all either negative or negligible and statistically significant ($p < .01$, $p < .05$) when R&D productivity is calculated using sales. When shareholder returns are used, results become insignificant. This may be an indication that the control variables, which are mostly financial indicators, are more closely related to sales than to shareholder returns. Finally, R-square values increase when year-fixed effects are added to the models; model 1.7 has an R-squared of 17.2%, model 1.8 has an R-squared of 10.9%.

The regression results for the next four models (equations 1.9 – 1.12) can be seen in Table 4. These models are testing the effect of alliance duration and number of drugs collaborated on the R&D productivity of the firm. Consequently, in these equations the alliance variable must be dropped. Interestingly, the drugs variable is negative and insignificant in all models, whereas the alliance duration variable is also negative but significant in 1.9 and 1.10 ($p < .01$) and 1.11 and 1.12 ($p < .05$). As in the first group of equations, when looking at the control variables, only ROA and ROIC variables display positive coefficients. In addition, ROA is once again statistically significant ($p < .01$) and ROIC's statistical significance ranges from $p < .01$ to $p < .1$. Concerning the remaining control variables, most were found to be negative or negligible and, once again, statistically significant only when R&D productivity was measured using sales as an indicator. R-squared values increase when year-fixed effects are added to either model 1.9 and 1.10, to 16.9% and 10.5%, respectively.

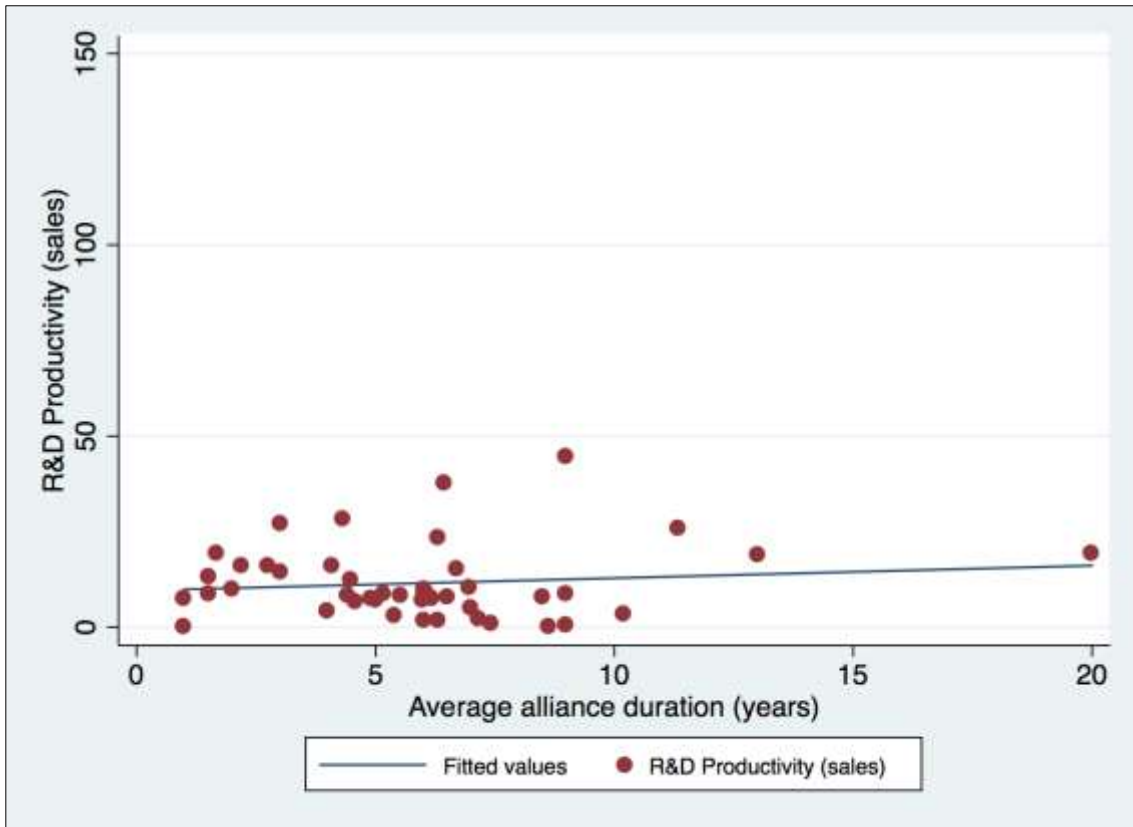


Figure 5 - Relationship between R&D Productivity (sales) and alliance duration

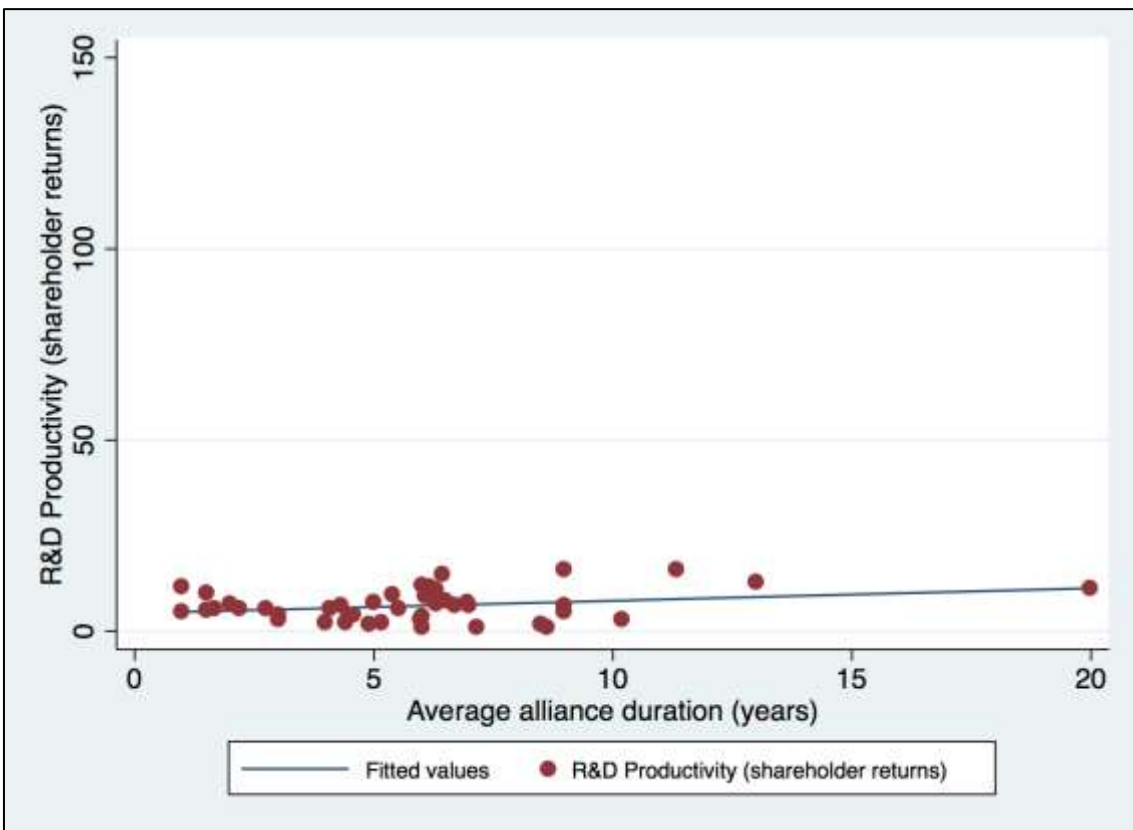


Figure 6 - Relationship between R&D Productivity (shareholder returns) and alliance duration

Variable	(1.5) Model1	(1.6) Model2	(1.7) Model3	(1.8) Model4
<i>ALL</i>	-37.345*** (9.813)	-13.558*** (3.463)	-41.899*** (12.688)	-14.345*** (4.229)
<i>DE</i>	-0.004** (0.002)	-0.001 (0.001)	-0.018 (0.012)	-0.003* (0.002)
<i>ROA</i>	0.019*** (0.004)	0.011*** (0.001)	0.028*** (0.005)	0.015*** (0.004)
<i>CB</i>	-33.704** (13.283)	-6.946 (4.596)	-30.093** (13.229)	-5.824 (3.576)
<i>NI</i>	0.000*** (0.000)	-0.000 (0.000)	0.000*** (0.000)	-0.000 (0.000)
<i>MC</i>	0.000*** (0.000)	0.000 (0.000)	0.000*** (0.000)	0.000 (0.000)
<i>ROIC</i>	0.246*** (0.087)	0.065*** (0.024)	0.172* (0.096)	0.053* (0.030)
<i>ALLYRS</i>				
<i>DRUGS</i>				
<i>Constant</i>	56.196*** (13.538)	22.463*** (4.815)	40.298** (19.968)	16.692** (7.614)
<i>Observations</i>	344	345	344	345
<i>R-squared</i>	0.112	0.016	0.172	0.109
<i>Year-Fixed effects</i>	NO	NO	YES	YES

Standard errors are in parenthesis

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 3 - Regression results showing the effect of a previous alliance on R&D productivity

Variable	(1.9) Model5	(1.10) Model6	(1.11) Model7	(1.12) Model8
<i>ALL</i>				
<i>DE</i>	-0.004* (0.002)	-0.001 (0.001)	-0.017 (0.012)	-0.003* (0.002)
<i>ROA</i>	0.020*** (0.004)	0.011*** (0.001)	0.029*** (0.005)	0.015*** (0.004)
<i>CB</i>	-32.631** (13.255)	-6.606 (4.604)	-28.871** (13.196)	-5.418 (3.572)
<i>NI</i>	0.000*** (0.000)	-0.000 (0.000)	0.000*** (0.000)	0.000 (0.000)
<i>MC</i>	-0.000** (0.000)	0.000 (0.000)	-0.000** (0.000)	-0.000 (0.000)
<i>ROIC</i>	0.241*** (0.086)	0.063** (0.025)	0.166* (0.096)	0.051* (0.031)
<i>ALLYRS</i>	-3.863*** (1.379)	-1.441*** (0.523)	-4.414** (1.939)	-1.427** (0.565)
<i>DRUGS</i>	-0.106 (0.092)	-0.025 (0.033)	-0.112 (0.171)	-0.029 (0.055)
<i>Constant</i>	54.180*** (13.144)	21.742*** (4.686)	37.473* (19.937)	16.250** (7.643)
<i>Observations</i>	344	345	344	345
<i>R-squared</i>	0.109	0.012	0.169	0.105
<i>Year-Fixed effects</i>	NO	NO	YES	YES

Standard errors are in parenthesis

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 4 - Regression results showing the effect of alliance duration and number of drugs collaborated on R&D productivity

Chapter 5

5. Discussion

The pharmaceutical industry is a unique sector driven highly by research and development, that allows for an investigation on the effect that engaging in an alliance prior to an acquisition has on R&D productivity. This sector is noticeably dependent on its research departments to improve pipeline diversity, allowing firms to remain competitive. However, even though investment in R&D has been dramatically increasing over the past decades, output rates have not been following the same trend, as discussed in Chapter 2. In turn, this has caused uncertainty and raised questions regarding the sustainability of the industry (Munos, 2009) as well as the effectiveness of the current R&D model (Pammolli *et al.*, 2011; Schuhmacher *et al.*, 2016). In response to these mounting issues, pharmaceutical firms have looked at options to fight against these struggles. Such options include increasing their R&D operations by engaging in research collaborations, acquiring and/or merging with other firms to broaden their drug pipelines, and engaging in horizontal M&As to achieve economies of scale and scope. To further investigate and to try to understand the main drivers for this current state of the industry, the goal of this study is to advance the understanding of the relationship between an alliance that is established among two or more pharmaceutical firms and the effect that this will have on the R&D productivity of the merged or acquired firm.

This study uses panel data from 1981 to 2017 and a series of OLS regressions to investigate the existence of any relationships and trends. As found in Chapter 4, when the effect of a previous alliance or its determinants – alliance duration and number of drugs collaborated - on R&D productivity is being investigated,

negative coefficients are obtained, and results are significant for all variables except for the number of drugs collaborated. This result goes against the study by Porrini (2004) and Higgins and Rodriguez (2006) who find that a previous alliance between an acquirer and target firm generally improves acquisition performance. However, Porrini's study has some particularities that may explain the conflicting results. Firstly, it focusses on a different time period (stops at 1997) and secondly, there is no focus on a specific industry, instead, the dataset includes public American firms. Regarding Higgins and Rodriguez (2006), even though their report is based on the pharmaceutical industry, they are not measuring any kind of R&D performance. Instead, the authors are looking at the change in cumulative abnormal returns around the time of the announcement of the merger or acquisition. Obviously, this is not an attempt to dispute the findings in these studies, nevertheless, it is important to note that different conclusions have been obtained from similar research questions.

On the other hand, our findings are consistent with Uhlenbruck et al. (2006) and Zaheer et al. (2010) who find that alliances established prior to an acquisition do not pose a significant contribution towards future performance of the merged or acquiring firm. Additionally, Ornaghi (2006) finds that mergers and acquisitions lead to a negative effect in R&D productivity and intensity in the three years succeeding it. The author also posits that the general trend of consolidation in the pharma industry has contributed to a decrease in innovation capacity due to integration issues and loss of human capital that arise from M&As. Finally, Meschi et al. (2017) finds some mixed results showing that the effect of pre-acquisition alliances on future performance can either have a positive or negative effect depending on when the decision to acquire occurs.

The existence of contradictory finding among scholars indicates that further research in this area should be pursued. Still, one explanation for the negative relationship between alliance and future R&D productivity may have to do with

the idea that the knowledge gained during the alliance period does not significantly benefit the acquirer firm in a strong enough way to support an increase in R&D productivity. Secondly, as mentioned during this report, an advantage of engaging in alliances is to foster information gathering similar to what happens during due diligence processes. However, if the alliance synergies are weak, little knowledge can be transferred and the acquiring firm becomes unable to access information that will allow it to identify the value of the target's intangible assets. Zaheer et al., (2010) actually identify that the negative impact on acquisition performance is aggravated if the alliance is considered to be 'weak' in contrast to engaging in no alliance at all. Possible reasons for this may be that the administrative costs incurred in establishing and running the alliance are higher than the confidential information that is gained from it. Furthermore, LaMattina (2011) raises an interesting point to describe how research and development is one of the most vulnerable sectors during an organization's M&A process. Due to intellectual property rights, patent protection, and sensitive data that are embedded in the R&D departments of pharmaceutical firms, these will be the last ones to engage in the integration processes. These departments will also have to undergo review processes which are extremely time-consuming to determine which projects will remain in the firms' pipeline. This will ensure there is no process duplication and that the drug pipeline of the new company is aligned with its strategic direction. The author even states that during M&A proceedings, which may take 9 months, "generally no new programmes are started" (Lamattina, 2011, p. 560).

In addition, the results yielded some strongly negative and significant results for cross border M&As, showing that R&D productivity is lower for M&As that occurred between firms from different countries. These results are consistent with Stiebale (2013), who finds that a cross-border M&A can produce a negative effect on R&D intensity if domestic activities are replaced with investments in

the target country. Looking back at the analysis by Munos (2009), he finds that M&As increase NME output for small firms but not for large firms. Since R&D productivity is calculated as the percentage of sales that is spent in R&D, both NME cost and output are accounted for in this ratio. However, even though this report finds a negative significant relationship between prior alliance and R&D productivity, it would be interesting to understand whether this is because fewer NMEs are being researched, whether the cost per NME is lower, or even both.

Above all, the findings in this study confirm some existing empirical evidence regarding the effects of alliances on R&D productivity in the pharmaceutical industry, even though it is clear we are far from reaching a consensus on why this is the case. It may be that research and development expenditures fluctuate excessively, and in such a way that drawing relationships from its behaviour is reduced. On the other hand, it may be that engaging in M&As as a strategy for expansion, drug pipeline improvements, economies of scale and scope or tax savings is being cancelled out by the negative effects associated with M&As. These negative results may include integration problems, cultural shocks or lack of vision. Hence, the same can be inferred for the effect of alliances on future performance. Even though alliances clearly offer numerous advantages to an organisation, more specifically to its R&D departments, the effects they may reproduce in the post-M&A period may not be reflected immediately. It may be that a drug that is developed during an alliance between two firms prior to a merger will only have an impact on the firm's R&D productivity some years later. Indeed, it may even be that it does not have any impact whatsoever. Consequently, it is clear that there is no definite relationship to be inferred from the effect of a pre-acquisition alliance on R&D productivity and this can be seen from the different conclusions reached by existing literature.

In conclusion, by incorporating the concept of a pre-acquisition alliance and evaluating its effects on the R&D productivity of the subsequent merged or

acquired firm, and applying this concept to the pharmaceutical industry, this paper fills a gap in the existing literature. This study highlights the importance of collaborating prior to an M&A to minimize information asymmetry, and to what extent the duration of this collaboration process influences a firm's R&D productivity.

Chapter 6

6. Limitations

As already mentioned, measuring R&D productivity still proves to be quite uncertain due to the difficulty in quantifying its determinants. Nevertheless, many researchers have chosen to use patent approval as a proxy for R&D productivity. This study uses a ratio of shareholder returns and sales over R&D spending instead, which may have had some influence in the results. If possible, future studies should include R&D productivity using patent approvals as a measure to account for this.

Secondly, the alliance database used in this report had no unique identifiers (i.e. stock tickers) for the firms engaging in the alliances which hindered the retrieval of data from financial databases (e.g. Bloomberg, Thomson Reuters). Instead, most observations had to be manually matched to their identifiers in order to make data retrieval possible, which besides being time-consuming, increases the probability of human error. Following this limitation, the sample used in this study was limited to public firms to maximise the possibility that data could be easily found online. Clearly, the sample would become richer if private firms were to be used even though finding data might prove harder. Nevertheless, researchers with fewer time constraints should look into this limitation.

Moreover, the data used for the empirical investigation is a panel dataset to allow for a dynamic relationship between the variables, since different variables reported to different time periods. However, since the effects from M&A activity may not be immediately reflected in the time period selected by this paper, a model with year-lags may be useful for implementation in future studies.

Finally, it would be interesting to have information detailing the nature of the alliances, more specifically, if they are equity or non-equity based. This would allow researchers to draw conclusions about whether the type of alliance is related to the degree of commitment towards the collaboration process, which may in turn influence the R&D productivity of the merged or acquired firm.

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