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Patent expiration as a decisive factor in pharmaceutical firms’ M&As

Marta Fernandez De Arroyabe Arranz
University of Luxembourg
Management Department/CREA
marta.arroyabe@uni.lu

Abstract
This study contributes to the literature on the motives behind M&As by considering how patents, as key resources of pharmaceutical firms, influence firms’ acquisition decision. This paper complements current studies by deeply exploring the innovation motives behind firms’ acquisition strategies. Framed in the resource-based view of the firm (RBV) of the firm, this paper analyzes to which extent patent expiration is a good predictor of pharmaceutical M&A activity, and to which extent firms’ innovation capabilities moderate this effect. Using a sample of U.S. pharmaceutical firms for the period 1980-2010, I find that firms are more prone to engage in horizontal M&As when they face high rates of patent portfolio expiration, which is explained by the short term necessity of firms to fill the pipeline gaps to maintain revenue streams. I find this effect to be lessened by firms’ R&D intensity and basic research base, which facilitate firms’ research process and capability to internally generate new innovations, reducing the dependency on external technology sourcing strategies.

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INTRODUCTION

Prior literature points out that patents as indicators of the technological value of firms’ knowledge base with rare, valuable, inimitable and non-substitutable characteristics provide firms’ with the basis for achieving a competitive advantage (Adegbesan and Higgins, 2010; Ahuja and Katila, 2001; Henderson and Cockburn, 1994; Markman et al., 2004). Patents are particularly important in the pharmaceutical industry, as they endow pharma firms’ with competitive advantage through exclusionary rights (Yang and Maskus, 2000), legal monopolies and legal barriers for substitution that translate into superior performance (Markman et al., 2004). Patents behind successful drugs are responsible for high levels of revenue, which are quickly captured by generic substitutes when these patents expire (Barret et al., 1999; Gambardella, 1992; Ravenscraft and Long, 2000).

The fact that patents’ life is limited to a maximum of 20 years implies that, to maintain high levels of profitability over time, pharmaceutical firms need to constantly develop or acquire new patents to substitute those which are expiring. The problem of patent life length is of particular relevance in the pharmaceutical industry, where the lag between patent filing, at the time of invention, and commercialization effectively reduces the effective time of patent protection to half (Budish et al., 2015; 2016), making it even more necessary for firms to quickly find substitutes for the expiring patents. Externally sourcing of technology development is particularly attractive in the pharmaceutical industry, where the process of drug discovery and patent generation takes considerable risk, time and investment (DiMasi, 2001; LaMattina, 2011; Rothaermel and Hess, 2007). In this context, given that pharmaceutical patents’ development entails tacit knowledge and is surrounded by uncertainty, several authors indicate that managers may opt for a strategy based on the acquisition of the firm possessing the technology; this strategy avoids excessive transaction costs and permits the full internalization of the acquired technologies (Leonard-Barton, 1995; Schilling and Steensma, 2002). M&As activity has been substantial in the pharmaceutical industry over the last couple of decades; it has witnessed a trend in which pharmaceutical firms were merging with each other, leading to an industry consolidation (Comanor and Scherer, 2013; La Mattina, 2011; Rafols et al., 2014).

1 For example, the expiration in 2011 of the patent behind the anti-cholesterol drug Lipitor, one of the top selling drugs of Pfizer, responsible for over 16% of the firms’ total revenue, left a sales gap of over $10 billion (Kenley, 2011).
However, despite the importance of M&As as a strategy to fill the gaps left by expiring patents, the number of studies exploring the motivations behind firms’ M&A decisions (Andrade et al., 2001; Higgins and Rodriguez, 2006) is little as compared to the vast number of studies on the consequences of M&As on firms’ performance (e.g. Ahuja and Katila, 2001; Cassiman et al., 2005; Cloodt et al., 2006; King et al., 2004). Existing literature points out that firms may decide to acquire another firm to strengthen their market power, to deal with overcapacity and to search for efficiency gains by obtaining economies of scale and scope (e.g.: Caves 1989, Röller et al. 2001; Jensen, 1986; Holmstrom and Kaplan, 2001; Cassiman et al., 2005); to access new geographical, technological and product markets (Anand and Singh, 1997; Barkema and Vermeulen, 1998; Wernerfelt, 1984); to correct for internal inefficiencies, agency problems and capital market imperfections (Cassiman et al., 2005; Manne 1965; Jensen and Ruback, 1983); and to access the preemptive power of target firms’ patent portfolio (Grimpe and Hussinger, 2014).

From the innovation point of view, the loss of strategically key innovation resources pushes firms to undertake M&As to fill the gaps in firms’ product pipelines left by expiring patents (Comanor and Scherer, 2013; Danzon et al., 2007; Grabowski and Kyle, 2008; Higgins and Rodriguez, 2006; Rafols et al., 2014). There are very few studies, however that directly assess the impact of the loss in key resources, in this case in the form of patent expiration, on firms’ decision to undertake an M&A strategy (e.g. Higgins and Rodriguez, 2006 or Danzon et al., 2007). These studies however do not provide a systematic analysis of the implications of patent expiration on acquisitions decisions, as the study of patent expiration only represents an intermediate step to analyze post-M&A performance.

As compared to these studies where only the effect of patent expiration is considered, this paper provides a comprehensive framework in which the role of patents as sources of competitive advantage and as determinants of firms’ strategy is highlighted, and in which the interplay between firms’ innovation resources and capabilities in determining firms’ M&A strategy is considered. Resource-based view of the firm (RBV) literature points out the importance to analyze the impact of patents on firms’ strategic decisions in light of firms’ capabilities, as key resources and capabilities act together in providing and sustaining firms’ competitive advantage (Amit and Schoemaker, 1993; Barney, 1991; Powell, 2001; Guan and Ma, 2003) and in determining firms’ strategy (Grant, 1991).

To my knowledge, this is the first study in the RBV literature that explores the motives behind firms’ M&As decisions by taking into account the joint action of innovation resources and capabilities in determining firms’ strategy. This is an important question in the RBV
literature as critical resources and capabilities are considered determinants of a firm’s strategy (Grant, 1991). In this framework, RBV scholars highlight the role of innovative capability, as compared to other capabilities, in firms’ strategic competitiveness, particularly in high-tech industries such as the pharmaceutical (Conner, 1991; Sher and Yang, 2005). Based on previous literature, I characterized innovation capability as R&D intensity, basic research and innovation exploitation capacity.

Using a sample of U.S. pharmaceutical firms for the period 1980-2010, I show that pharmaceutical firms are more prone to engage in horizontal M&As when they face high rates of patent portfolio expiration. I also show that this impact is moderated by the innovative capability of the firm; I find that R&D intensity and basic research lessen the effect of patent expiration on the M&A decision.

This study contributes to the current literature on several ways. First, it adds to the RBV by highlighting a mechanism through which firms’ resources affect firms’ strategic decisions. Secondly, it stresses the importance of innovation as a resource and as a capability on firms’ M&As decision making process. Third, it provides practitioners and M&As scholars with a useful indicator, alternative to the existing financial-based indicators, that anticipates M&As’ decision. Finally, from the empirical point of view, it uses a novel tailor-made database that links pharmaceutical firms’ financial data with M&A information and innovation data, including patents and publications. The use of publications as a proxy for basic research is also new on M&As empirical literature; basic research conceptualized as publications has mainly been used in literature dealing with firms’ innovation productivity and knowledge generation (e.g.: Cardinal and Hatfield, 2000; Cockburn and Henderson, 1998; Fabrizio, 2009; Gambardella, 1992; Lim, 2004).

THEORETICAL BACKGROUND

RBV: firms’ resources and competitive advantage

This paper builds on the resource-based view of the firm, and specifically, on Grant’s (1991) work which emphasizes the role of firms’ resources and capabilities as foundations for firms’ strategies. Firms’ internal resources and capabilities provide the basic direction for firms’ strategy, and represent the primary source of firms’ profitability, through the attainment of competitive advantages (Grant, 1991). Barney (1991) points out that the heterogeneous distribution and imperfect mobility of resources and capabilities across firms grants them with the possibility of obtaining a competitive advantage over their competitors. In this sense, RBV
literature highlights that resources that are rare and valuable enable firms to achieve a higher performance (Amit and Schoemaker, 1993; Barney, 1991; Powell, 2001). Moreover, if these resources are non-substitutable, inimitable, appropriable, durable and superior this competitive advantage would be sustained over time (Amit and Schoemaker, 1993; Barney, 1991; Collis and Montgomery, 1995; Powell, 2001). Hence, firms’ capacity to secure difficult-to-imitate and difficult-to-substitute resources is the key for generating monopolistic rents and superior performance (Autio, Sapienza & Almeida, 2000; Markman et al., 2004).

Attending to these characteristics, several studies have pointed out that patents, as intangible resources and indicators for firms’ inventive capacity provide pharmaceutical firms’ with the basis for obtaining a sustainable competitive advantage (Henderson and Cockburn, 1994; Markman, Espina and Phan, 2004). This is because patents grant protection for up to 20 years, are legally associated to the firm and, compared to other IP protection mechanisms, they offer greater protection (Newbert, 2008). This protection implies that patents provide firms with technology-based first mover advantage (Markman et al., 2004) and prevent rivals from using the patented invention without permission, which further strengthens the first-mover advantage (Rivette and Kline, 2000). Given the importance of patents as source of competitive advantage and to secure the benefits derived from patented inventions, pharmaceutical firms often incur in high legal costs to first obtain and then maintain ownership of patent rights and to fight any patent infringements (Markman et al., 2004; Rivette and Kline, 2000).

Apart from providing firms with exclusive rights, patents facilitate the establishment of agreements with other firms. Nelson and Winter (1982) pose that as compared to other sources of competitive advantage, patents are particularly valuable in the establishment of inter-firm agreements because they are easily transferred and highly portable. These two characteristics provide the core for setting up joint ventures and cross-licensing deals based on intellectual property rights and, they provide the basis of technology licensing agreements, which generate cash flows for the owner of the patent (Markman et al., 2004).

**Patents as a source of competitive advantage in the pharmaceutical industry**

Relative to other industries, patents, as source of competitive advantage and superior performance, are particularly important in the pharmaceutical industry. Patents endow pharma firms’ with competitive advantage through exclusionary rights (Yang and Maskus, 2000), legal monopolies and legal barriers for substitution that translate into superior performance both in new products and revenue streams (Markman, Espina and Phan, 2004). Moreover, several studies find that patents are the most important mechanism for IP appropriation in the
pharmaceutical industry (Levin et al., 1987) as patents are the most effective and the most often used IP mechanism for both product and process invention, where approximately 80% of the patentable inventions are patented as compared to other industries in which this rate is 60% (Arundel, van de Paal and Soete, 1995; Arundel, 2000; Cohen, Nelson and Walsh, 2000; Hussinger, 2006; Mansfield, 1986).

The process of discovery and development of new chemical entities entails significant amounts of R&D expenditures and high uncertainty (Frantz, 2006). On the one hand, it takes an average of 10 years for a new drug to complete all the phases from initial discovery to its launch into the market with an estimated cost of $2.6 billion\(^2\) (PhRMA, 2015). On the other hand, the probability that a drug will be eventually approved by the FDA, so that it could be launched into the market, is less than 12% (PhRMA, 2015). Because only a few products make it to the market and the high cost of launching a new drug, stakes in the pharmaceutical industry are particularly high, as firms unable to secure their products by patents are severely punished in the marketplace and unable to recover their R&D investments (Cool et al. 1999; Markman et al., 2004). This is why after the discovery phase, pharmaceutical firms race to file patent applications at the USPTO to protect the potential value of their discovery (Daizadeh et al., 2002). On the other hand, the structure of the patent system, where the period of market exclusivity is fixed regardless of whether the firm files for the patent at the time of invention or commercialization shortens the time during which firms enjoy the benefits derived from patents (Budish et al., 2015). Since pharmaceutical firms file their patents at the time of invention and they must complete FDA-required clinical trials before they see their drug in the market, the long time lag between invention and commercialization effectively reduces patents’ terms (Budish et al., 2015; 2016).

This reliance of pharmaceutical firms on patents as source of profitability and superior performance is apparent on the gap left on firms’ revenue streams when the patent protection expires (Barret, Licking and Kerry, 1999; Gambardella, 1992; Ravenscraft and Long, 2000). Barret et al. (1999) report that strong patents are able to capture large amounts of value as firms can lose up to 80% of its revenue income to generic substitutes when these patents expire. For example, in 2010, big pharma companies such as Pfizer, Bristol or Lilly had over 30% of their sales coming from drugs whose patents were about to expire (Kenley, 2011); while between 2006-2011 patent expiration of top-selling drugs generated revenue loses of over $50 billion (Frantz, 2011).

\(^2\) This figure incorporates the cost of failures, i.e. compounds that at the end do not receive the approval to be launched into the market.
Given the importance of patents for pharmaceutical firms’ performance, and in line with Grant’s theoretical framework that firms adapt and build their strategy around critically important resources (Grant, 1991), it is not surprising that pharmaceutical firms’ strategies are substantially influenced by changes in the patent portfolio of the firm, and in particular by patent expiration.

**M&As and Patents**

The importance of patents to maintain high levels of profitability over time, translates into a continuous need to develop new patents that fill the gaps left by expiring patents (Kenley, 2011). When it comes to technology development, large innovative firms can decide between internal developing strategies or external sourcing strategies (Cassiman and Veugelers, 2006; Rigby and Zook, 2002). Firms may decide for an external technology sourcing strategy when they lack the capabilities to develop the technologies on their own or, as in the case in the pharmaceutical industry, when the process of drug discovery and patent generation takes considerable time and investment (Cassiman and Veugelers, 2006; DiMassi, 2001). In particular, firms can enter into a technology-sourcing agreement with an outside party, e.g. R&D outsourcing, licensing, joint ventures, company acquisitions or hiring of qualified researchers, to jointly develop or to buy an already developed technology (Arora and Gambardella, 1990; Cockburn and Henderson, 1998; Lambe and Speakman, 1997). Schilling and Steensma (2002) point out that given that pharmaceutical patents, as sources of competitive advantage, are specific, entail tacit knowledge and are surrounded by uncertainty, the best external sourcing strategy is the acquisition of the firm possessing the technology. This is because acquisitions grant the acquiring firm the possibility of applying control over the assets, human capital and technologies of the acquired firm, such as the patents portfolio, and use them in a way that satisfy its current needs (Folta, 1998; Schilling and Steensma, 2002), providing a greater potential for development of core technological capabilities and exploitation of competitive advantages (Leonard-Barton, 1995).

Even though the RBV literature suggests that pharmaceutical firms may engage in M&As activities when the competitive advantage provided by patents is about to expire, this mechanism and how firms’ resources relate to firms’ strategy us not very well understood. In a parallel line of research, industrial organization and financial economics literature have acknowledged the role of patent expiration on firms’ M&As decisions. On the one hand, industrial organization literature points out that firms may decide to acquire another firm to strengthen their market power, deal with overcapacity and search for efficiency gains by
obtaining economies of scale and scope (e.g.: Caves 1989, Röller et al. 2001; Jensen, 1986; Holmstrom and Kaplan, 2001; Cassiman et al., 2005). For example, for the pharmaceutical and biotech industries, Danzon et al. (2007) find that patent expirations generate gaps on firms’ product pipelines that make firms’ current levels of physical and human capital excessive, motivating firms’ capacity adjustment through M&As. On the other hand, financial economics literature explains M&As as an instrument to correct for internal inefficiencies, agency problems and capital market imperfections (Cassiman et al., 2005; Manne 1965; Jensen and Ruback, 1983). As an example of the internal inefficiencies in the pharmaceutical industry, Higgins and Rodriguez (2006) examine the state of firms’ internal productivity, by considering, among other factors, expected years of patent life to find that indeed higher patent expiration is conductive of M&As activity. These results are confirmed on a broader set up of 48 different industries by Zhao (2009).

Taking as departure point the findings from studies in industrial organization and financial economics, this study contributes to the management literature, and specifically to the RBV of the firm, by considering how patents, as key resources of pharmaceutical firms, influence the acquisition decision given firms’ innovation capabilities. The inclusion of innovation capabilities into the analysis is novel in the literature, and it is important as resources and capabilities act together in providing and sustaining firms’ competitive advantage (Amit and Schoemaker, 1993; Barney, 1991; Powell, 2001; Guan and Ma, 2003) and in determining firms’ strategy (Grant, 1991). Evaluating the relevance of resources and capabilities enables a better understanding of firms’ (acquisition) strategies.

This paper focus its analysis on innovation capabilities; from a RBV, several authors highlight that innovative capability, as compared to other capabilities, is crucial for firms’ strategic competitiveness, particularly in high-tech industries such as the pharmaceutical (Conner, 1991; Sher and Yang, 2005). Innovative capability is related to the internal processes, organizational culture and the capacity of firms’ to respond to changes in the environment (Akman and Yilmaz, 2008; Neely et al., 2001). This ability to properly respond to changes in the environment is fundamental for achieving success in the market because it allows the firm to adapt to the market, the environment and the competition (Elmquist and Le Masson, 2009; Guan and Ma, 2003; Martinez-Roman et al., 2011).

As of the nature of innovative capability, several authors refer to firms’ ability to generate and apply new knowledge, in the form of new ideas and concepts, to obtain market value and to take advantage of market opportunities (Assink, 2006; Calantone et al., 2002; Elmquist and Le Masson, 2009; Zhao et al., 2005). Thus, innovation capability depends upon the knowledge
possessed by the firms that permits the generation of new technologies, or improve the existing ones (Romijn and Albadalejo, 2002; Wonglimpiyarat, 2010). In this sense, knowledge is a crucial aspect of innovation capability as it determines the development of patents (Chen and Yang, 2009; Puranam et al., 2000) and, in particular, the transformation of knowledge into patents (Martinez-Roman et al., 2011; Puranam et al., 2000; Romijn and Albadalejo, 2002). Likewise, the internal efforts, as an input of innovative capability, oriented to achieve knowledge and technological innovations are also an important determinant of the level of innovative capability (Elmquist and Le Masson, 2009; Kroll and Schiller, 2010; Martinez-Roman et al., 2011).

Given the above characteristics of innovative capability, specific factors that will act as moderating variables in the effect of patent expiration on firms’ strategic decision to engage in M&As can be derived. First of all, regarding acquiring firms’ technological efforts, I consider pharmaceutical firms’ R&D intensity conceptualized as R&D expenditures (Sher and Yang, 2005). The discovery and development process of drugs is a long and complex process that requires the establishment of R&D labs, the hiring of scientific personnel and large investments in R&D (Cardinal and Hatfield, 2000). Previous studies have pointed out the importance of R&D expenditures in the generation of innovation and patents, finding a strong relation between R&D expenditures and patenting output (e.g. Bound et al., 1984; Hausman et al., 1984; Jaffe, 1986; Pakes and Griliches, 1980; Hitt et al., 1997; Keizer et al., 2002). Second, regarding the knowledge underlying innovative capability, I consider firms’ basic research base. Basic research is essential for the knowledge creation process of firms (Griliches, 1980; Tijssen, 2004), and it is key for internalizing, modifying and applying external knowledge (Cohen and Levinthal, 1990). Basic research provides firms with a technological landscape in which they can search for new innovations, and guides them towards promising drugs in the drug discovery process (Drews, 200; Fleming and Sorenson, 2004). Finally, regarding the transformation of knowledge into patents, I include firms’ innovation exploiting capacity, i.e. firms’ experience in successfully applying for patents. The filing process for patents requires firms to demonstrate the usefulness, novelty and non-obviousness of their inventions. Previous studies have acknowledge the existence of cumulative patenting know-how, in which patent applicants learn over time to identify and prosecute intellectual property (Mowery, Sampat & Ziedonis, 2002; Owen-Smith and Powell, 2003). In this sense, patenting can be considered as the result or output of technically successful R&D activities (Ernst, 2001; Hauschildt, 1991; Griliches, 1990).

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DATA AND METHODOLOGY

Dataset

I constructed a panel dataset of a 100 horizontal M&As among publicly listed US pharmaceutical firms (as defined by firms in SIC 28) during the 1980-2010 period. This dataset is tailor made and draws from several databases. It includes information on all publicly listed U.S. firms involved in M&As over the period 1980-2010 where at least one of the M&A parties is actively involved in innovation activities in the sense that it has applied for at least one patent at the United States Patent and Trademark Office (USPTO) since its foundation. Information about the M&A deals was extracted from the database Thomson One Banker provided by Thomson Reuters. I consider only those deals that were completed and which involved majority ownership. The M&A data was linked to firms’ financial records which were retrieved from Compustat. The match between the two databases is based on firms’ name, state, and the firms’ identifiers CUSIP and PERMNO (taken from the Center for Research in Security Prices (CRSP) database).

Information on the patent activity of firms is taken from the NBER patent database and the Coleman Fung Institute for Engineering Leadership database (Li et al., 2014). Patent information is matched to the firm data using each firm’s identifiers and name. The information on publications is extracted from Medline-Science Citation Index (Web of Science) from Thomson Reuters. Pharmaceutical firms’ publications were identified on firms’ name and firms’ address basis, and subsequently manually matched to the information on patents, M&As activity and firms’ characteristics. Throughout the whole data linking process, I conducted manual checks, especially for firms for which I discovered missing or ill-defined linkages between the datasets due to misspellings of firm names or identifiers.

Variables

I conceptualized the decision of pharmaceutical firms to undertake M&A strategies with a dummy variable that takes the value one when the pharma firm has acquired another pharmaceutical firm.

The main independent variable to explain the decision to buy another company is the patent portfolio expiration rate. This is measured as ratio of the number of patents expiring on the

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3 The CRSP database tracks firms (including their names and CUSIPs) throughout their life time and provides them with a unique identification (PERMNO). I matched the Thomson Reuters’ M&As database and Compustat to CRSP, assigning to both databases’ firms a PERMNO. In a next step, I matched Thomson Reuters’ M&A database to Compustat via PERMNO. This helped to recover deals for which the CUSIP changed over time.

4 Formerly the Patent Network Dataverse from Harvard Institute for Quantitative Social Science.
upcoming three years to the number of granted patents applications on the previous three years. This variable intends to capture firms’ ability to generate innovation output in the light of continuous patent expiration. In line with previous literature, I proxy the ability to generate new innovation output with the number of granted patents per year. Patents are commonly used as innovation indicator (e.g. Archibugi, 1992; Cohen & Levin, 1989; Griliches, 1990) because they reflect the immediate result of R&D activity and hence depict successful R&D projects before the market introduction of the product (Ernst, 1995; Griliches, 1990). In the context of the pharmaceutical industry, Cockburn, Henderson and Stern (1999) point out that patents match quite closely the output of the discovery phase (i.e. end of the pre-clinical phase). In the pharmaceutical industry, due to the nature of the sector’s research activities and inventions, the rate of inventions that is protected by patents in this sector is about 80%, much higher than in other industries (Mansfield, 1986).

As for the firms’ innovation capabilities, I first consider firms’ R&D intensity, measured as the yearly R&D expenditures of the firm (in millions of dollars). The second innovation capability, basic research, is proxied with the number of firms’ scientific publications in Journal Citation Reports (JCR) journals. The number of scientific publications has been shown to reflect the underlying research activity of pharmaceutical firms (Fabrizio, 2009; Gambardella, 1992), particularly of firms’ investments in basic science (Cockburn and Henderson, 1998; Gambardella, 1992). Pharmaceutical firms have been found to publish heavily, with a volume comparable to that of similar size institutions or universities (Koening, 1983; Hicks, 1995; Cockburn and Henderson, 1998). In the pharmaceutical industry, scientific publications legitimate and provide credibility to drugs’ efficacy and potential side effects (Kleschick et al., 2001; Balter et al., 2003). Scientific papers influence authorities’ drug assessment by reducing the uncertainty that surrounds drugs’ unobserved side effects (Olson, 1999; Azoulay, 2002; Bodewitz et al., 1987; Pisano, 2006). Scientific publications have the possibility of shorting firms’ clinical trial process, speeding up commercialization and increasing the effective patent term.

I define the basic research base as the stock of firm’s publications. I calculate the publication stock as follows:

\[
\text{Publication stock}_t = \text{publication stock}_{t-1}(1 - \delta) + \text{published papers}_t
\]

I consider granted patents on the year of their application because I want to measure successfully finished projects as close as possible to their completion date. Moreover, I use granted patents and not patent applications because the former is an indicator of successful innovation (Ahuja & Katila, 2001).
where $\delta$ is a constant representing the knowledge depreciation rate that weights the importance of older publications. Following previous patent literature (e.g., Hall, 1990), the depreciation rate, $\delta$, is set equal to 15%. Finally, I proxy innovation exploitation capacity as the ratio of the number of firms’ granted patents per year to the firms’ R&D efforts, measured as R&D expenditures. This measure has been used in previous studies (see e.g. Scherer 1965; 1983; Arundel and Kabla, 1998) as an indicator for both innovative activities and appropriation conditions.

I control for several firm characteristics that may affect the innovation activities of the firm and its decision to engage in M&As. Thus, in line with precious studies, I include firms’ size, measured as the log of assets, and firms’ market capitalization to capture the possibility of firms’ merging to achieve economies of scale; to contemplate firms’ excessive capacity as a driver of the M&A decision, I include the percentage change in sales between years $t-1$ and $t-3$, and the percentage change in operating expenses between years $t-1$ and $t-3$ are included. Further, I use a set of year dummies in order to control for time trends in corporate patenting and M&As waves. All independent and control variables are lagged by one year in order to limit endogeneity concerns.

**Model and estimation technique**

To analyze the impact of patent expiration rate on pharmaceutical firms’ decision to engage on M&As, I estimate the following equations:

(1) $M&A_{it} = \log \text{Assets}_{it} + \Delta \text{Sales}_{it} + \Delta \text{Op. Exp}_{it} + \text{MarketCap}_{it}$

(2) $M&A_{it} = \log \text{Assets}_{it} + \Delta \text{Sales}_{it} + \Delta \text{Op. Exp}_{it} + \text{MarketCap}_{it} + \text{PatentExp}_{it}$

(3) $M&A_{it} = \log \text{Assets}_{it} + \Delta \text{Sales}_{it} + \Delta \text{Op. Exp}_{it} + \text{MarketCap}_{it} + \text{PatentExp}_{it} + R&D_{it} + \text{PatentExp} \cdot R&D_{it}$

(4) $M&A_{it} = \log \text{Assets}_{it} + \Delta \text{Sales}_{it} + \Delta \text{Op. Exp}_{it} + \text{MarketCap}_{it} + \text{PatentExp}_{it} + \text{PublicationStock}_{it} + \text{PatentExp} \cdot \text{PublicationStock}_{it}$

(5) $M&A_{it} = \log \text{Assets}_{it} + \Delta \text{Sales}_{it} + \Delta \text{Op. Exp}_{it} + \text{MarketCap}_{it} + \text{PatentExp}_{it} + \text{Patents}/R&D_{it} + \text{PatentExp} \cdot \text{Patents}/R&D_{it}$

I estimate first a basic specification (1), which includes the impact of the factors considered by prior literature (i.e. size of the firm, change in sales, change in operating expenses and market capitalization) on the likelihood of engaging in M&As. Specification (2) includes as well the main explanatory variable of interest, patent expiration rate. Specifications (3) to (5) build up on specification (2) by including firms’ innovation capabilities, each on a different specification to avoid problems of multicollinearity. Since this main interest lies on exploring the impact of
patent expiration on firms’ acquisition decision, taking into consideration the moderating role of firms’ innovation capabilities, I also include an interaction term between each of the innovation capabilities and the patent expiration rate. These interaction terms aim to capture the joint effect of innovation capabilities and patent resources in determining firms’ M&A decision.

The empirical strategy to estimate these equations is based on a panel logit model with fixed effects fitted by maximum likelihood (Wooldridge, 2010). The inclusion of fixed effects allows to control for the unobserved firm characteristics, such as managerial quality, that may affect the M&A decision. I also include time dummies in all specifications to capture the possible cyclicality in the decision to engage in M&As. The estimation using panel logit with fixed effects, however, involves several challenges in the interpretation of the interaction terms and on the computation of marginal effects.

First of all, the interaction effects for fixed effects logit models cannot be computed without further assumptions because they are conditional on the sum of the dependent variable within each group, so that the fixed effects are eliminated (Cameron and Trivedi, 2009; Karaka-Mandic et al., 2012). Thus, the absence of a constant term makes it impossible to predict the conditional expected value of the dependent variable (Karaka-Mandic et al., 2012). To overcome this problem, I follow the solutions proposed by Buis (2010) and Karaka-Mandic et al. (2012) and present the main results in terms of the odds-ratio.

On top of this, unlike the case of linear models, the marginal effect of an explanatory variable in a non-linear model is not constant over its range (Greene, 2010). This is because calculating the interaction effect requires computing the cross-partial derivative, which is conditional on all the independent variables of the model, so that the marginal effect may actually have different signs for different values of the covariates (Ai and Norton, 2003; Greene, 2010). Unfortunately, without imposing further assumptions, such as the fixed effects are zero, it is impossible to compute the marginal effects for the fixed effects logit model (Ai and Norton, 2003; Karaka-Mandic et al., 2012). Thus, as an alternative I also estimate a pooled logit specification with individual dummies (see Appendix, Table A1), and then compute the marginal effects.

Further, as robustness checks, I re-estimate the model on a fixed effects probit set up (See Appendix, Table A2).
EMPIRICAL RESULTS AND DISCUSSION

Descriptive statistics
Table 1 shows the descriptive statistics of the variables of interest.

Pharmaceutical firms have an average rate of patent expiration of 1.24, which means that they have more patents expiring than patent applications. Pharmaceutical firms have an average of 5420 millions of dollars in assets. As for the main financial indicators, pharmaceutical sales are on average 4343 millions of dollars with operating expenditures around 3377 millions of dollars and a market capitalization of 11900 millions. Pharmaceutical firms expend around 375 millions in research and development activities.

The pharmaceutical firms of this sample have an average of 14 publications per year and a publication stock of 26 publications. As for the patents, pharmaceutical firms file around 42 patent applications per year, with a patent stock of 281 patents. A characteristic of the distribution of the innovation output, both patents and publications, is the large standard deviation; this is in line with previous studies that have noted the right skewness and the large number of zero observations in the distribution of patents (Blundell, Griffith & Van Reenen, 1995). Finally, the success ratio of patents applications is around 0.37, that is, for every three millions invested in R&D, pharmaceutical firms are on average able to successfully obtain one patent.

Regression results

Table 2 presents the odds ratio of the fixed-effects panel logit estimation results. The first column shows the basic specification that includes exclusively the effects of firms’ financial characteristics on the probability of pharmaceutical firms to engage in M&A activities. In line with previous studies, I find that larger firms are expected to be more likely to engage in acquisitions. Both a decrease in sales and a decrease in operating expenditures increase the likelihood of firms’ acquisition decision. As for the market capitalization, I find a very small positive effect. These coefficients are all significant (with the exception of sales) and support previous studies that point towards firms’ excess capacity as triggering event of the M&As (Danzon et al., 2007). Specification 2 displays the results when the patent expiration rate is

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6 The odds ratio presents the exponentiated coefficients of the logit estimation. It measures the multiplicative effect of a unit change in a particular explanatory variable on the odds ratio of firm’s engaging in M&As (Cameron and Trivedi, 2009). If the coefficient of the odds ratio is above 1, the probability of engaging in M&As increases, while if the coefficient is below 1, the probability decreases.
included. I find a significant positive impact of the patent expiration rate on the likelihood to engage in M&As, that is, when firms’ proportion of expiring patents to new granted patent applications increases, this generates a gap in the firms’ patent portfolio and pipeline that favors firms’ M&A activities. This is in line with the findings of Higgins and Rodriguez (2006) and Danzon et al. (2007). Specifications 3 to 5, build on specification 2 and include the moderating effect of firms’ innovation capabilities on the decision to engage in M&As. In specification 3, I find a significant and negative effect of the interaction of patent expiration and R&D expenditures on the decision to acquire another firm. This means that firms that invest more on R&D activities, when faced with higher patent expiration rates are less likely to engage in M&As as compared to firms with lower R&D expenditures. This supports the idea that firms investing in R&D have a higher capacity to generate innovations internally (Hausman et al., 1984), which confers them with a lower reliability on external technology, so that their necessity to acquire other firms to get access to their technology is lower (Cassiman and Veugelers, 2006; Hagedoorn and Wang, 2012). In specification 4, I find that firms with a larger basic research base are significantly less likely to acquire other firms when faced with higher patent expiration rates. This is consistent with the view that basic research facilitates the research process of firms, pointing them towards new and promising fields (Fleming and Sorenson, 2004), and by increasing the absorptive capacity of external knowledge (Cohen and Levinthal, 1990). This means that firms with a higher basic research base, also have a higher capacity to internally generate new innovations and patents, thus reducing the need to opt for external technology sources when patent expiration rates increase. Finally, in specification 5, I find that patent exploitation capacity has a positive, albeit non-significant, impact on the acquisition likelihood; even though the interaction effect is significant, the levels term for the patent exploitation capacity is not significant.

The next step in the analysis is to obtain the marginal effects of the significant innovation capabilities of firms on the likelihood of engaging on M&As, in the event of higher patent expiration rates. Figure 2 displays the results of the interaction effect of R&D expenditures with patent expiration rate. The main effect, as shown on Table 2 is negative, i.e.: pharmaceutical firms that have higher R&D investment are less likely to engage in M&As in the event of higher expiration rates. However, on Figure 2 I find that the interaction effects vary widely, for some observations it is positive and for other observations is negative. For firms whose predicted probability of engaging in M&As is around 0.2 (left part of Figure 2), the interaction effect between R&D and patent expiration rate is positive, while for firms with a higher predicted probability of M&As (bigger than 0.4), the interaction effect is negative.
This means that when firms’ characteristics make it more likely to engage in M&As, the R&D intensity level of the firm, reduces this likelihood. As for the interaction effect of basic research base and patent expiration rate, the main effect on Table 2 is negative, however, as shown on Figure 3, this effect varies according to the predicted probability of engaging in M&As. Those firms whose predicted probability is around 0.2 the effect is positive, while for firms with a predicted probability between 0.5 and 0.9 the effect is negative. Similarly to R&D intensity, this means that for firms whose characteristics make them more prone to engage in M&As, basic research lessens this probability.

CONCLUSION

Despite the topic of technologically related acquisitions has been exhaustively studied by previous management and economics literature (see Veugelers, 2006, for a survey), these studies have mainly focused on the post-acquisition performance of firms (e.g. Ahuja and Katila, 2001; Cassiman et al., 2005; Cloodt et al., 2006; King et al., 2004), devoting very little attention to the reasons behind firms’ decisions to engage in acquisition activities (Andrade et al., 2001; Higgins and Rodriguez, 2006). Framed in the RBV literature, this paper aims at filling this gap by studying the impact of patent expiration on pharmaceutical firm’s likelihood of undertaking an M&A strategy, taking into consideration the moderating role played by firms’ innovation capabilities in this process. The results show that indeed patent expiration is a triggering factor of firms’ M&As decision, which is explained by the short term necessity of firms to fill the pipeline gaps left by expiring patents and to maintain revenue streams. This effect is moderated by firms’ innovation capabilities. In particular, I also find that for firms with a stronger basic research base or with a higher R&D intensity the effect of patent expiration on the M&A decision is not as pronounced. This is because R&D and basic research base facilitates firms’ research process, providing them with a higher capability to internally generate new innovations, thus reducing the external dependency.

This study contributes to the current literature on several ways. First, I add to the RBV by highlighting a mechanism through which firms’ resources affect firms’ strategic decisions. Previous RBV literature has remained silent regarding the motives behind firms’ M&As decisions. In this paper, I provide an explanation of why firms, in the event of a loss of the competitive advantage provided by patents, which represent a key resource, may choose to engage in an M&A strategy to re-fill their patent portfolio. Secondly, I present a link between resources and capabilities, and strategy that leads to important insights into firms’ innovation
management and highlights M&As as an important means of innovation management. On the empirical results section, I showed that the decision to engage in M&As is not alone determined by a particular resource, but also by the firms’ capabilities, as seen by the significance of the interaction effects. Third, I stress the importance of innovation indicators as anticipating factors of M&A activity. For its vast majority, indicators used in the literature to monitor firms’ decision to engage in M&As are based on firms’ financial statements (e.g. market capitalization, ratio cash to sales, Tobin’s q) or on trends (e.g. industry trends or M&As waves). As compared to the current indicators, patent expiration does not rely on the financial situation of the firm but rather on the innovation portfolio of the firm. This is particularly interesting from the empirical point of view as the use of patent expiration is less problematic in terms of causality and endogeneity. This is because patent expiration is exogenous to the firm since patents’ life duration is externally fixed by the USPTO; exogeneity, however, cannot be ensured with financial indicators as changes in firms’ financial statements may be a response to firms’ M&A decision, through for example a managerial change in strategy or as a consequence of markets’ rumors about the M&A. Finally, from the empirical point of view, I use a novel tailor-made database that links pharmaceutical firms’ financial data with M&A information and innovation data, both on patents and publications. The inclusion of publications as a proxy for basic research is new on M&A literature, and can be particularly useful when examining technological M&As.

As any, this study is not free of limitations. First of all, these results refer to the pharmaceutical industry and could potentially be extended to industries in which patents are also a key source of competitive advantage and patenting is the preferred IP protection method. Thus, these results cannot be translated to low innovative industries or industries in which trade secrecy is the major strategy to protect innovation breakthroughs. Secondly, this paper focuses acquisitions of new patents through M&As, ignoring other mechanisms such as patents’ rights transfers or patent licensing. Thus, it may be interesting to complement the current study with patent transfer and patent licensing data. For future research it would also be interesting to investigate how much does patent expirations weight in the decision to

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7 The USPTO Patent Assignment Dataset collects information on patents’ transfers (either individually or in a bundle). These dataset however suffer from several limitations that complicates the analysis: (1) names of buyers and sellers are not standardized on the dataset, which makes tracking a very difficult task; (2) the database doesn’t allow to distinguish between patents acquired to be exploited or patents acquired to be licensed out (Serrano, 2010). Moreover, in his study of patent transfer, Serrano (2010) indicates that for the drugs and medical industry, patent transfer represents only about 16%. He also recognizes that this dataset, however doesn’t distinguish between the acquisition of a bundle of patents from the acquisition of a firm, meaning that there are large amounts of overlapping between the USPTO Patent Assignment Dataset and the M&A dataset.
engage in M&As as compared to other factors such as financial performance or assets of target and acquiring firm.
REFERENCES


Cameron, A. C., & Trivedi, P. K. 2009. Microeconometrics using stata (Vol. 5). College Station, Texas: Stata Press.


### Table 1. Descriptive statistics.

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<th>Max.</th>
<th>Obs.</th>
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Table 2. FE panel logit for the probability of engaging in M&As.

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<th>(3)</th>
<th>(4)</th>
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Observations          | 832       | 832       | 828       | 832       | 828       |
Number of firms        | 61        | 61        | 60        | 61        | 60        |
Firm FE                | YES       | YES       | YES       | YES       | YES       |
Year Dummies           | YES       | YES       | YES       | YES       | YES       |
Log likelihood         | -145.7    | -116.2    | -103.7    | -109.1    | -103.1    |
Model chi-square       | 435.1     | 494.1     | 514.3     | 508.3     | 515.4     |
Prob > chi2            | 0         | 0         | 0         | 0         | 0         |

Odds ratio reported. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1
FIGURES

Figure 1. Conceptual model

Resources
- Patents

Capabilities
- R&D intensity
- Basic research
- Innovation exploitation capacity

Competitive Advantage

Strategy
- M&A

Figure 2. Interaction effects of patent expiration rate and R&D
Figure 3. Interaction effects of patent expiration rate and publication stock

Interaction Effects after Logit

Interaction Effect (percentage points)

Predicted Probability that y = 1

Correct interaction effect
## APPENDIX

### Table A1. Pooled logit for the probability of engaging in M&As.

<table>
<thead>
<tr>
<th>VARIABLES</th>
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**Observations** 832 832 828 832 828 828 828 832 832 828

**Firm Dummies** YES YES YES YES YES YES

**Year Dummies** YES YES YES YES YES YES

**Log likelihood** -198.8 -164.6 -148.9 -156.2 -148.3

**Model chi-square** 754.4 822.8 848.6 839.6 849.8

**Prob > chi2** 0 0 0 0 0

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1