R&D MANAGEMENT

The role of patent expiration in acquisition decision and target selection in the pharmaceutical industry

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This paper addresses the calls for greater research on the antecedents of technological acquisitions by exploring a mechanism that drives both acquisition decision and target selection. Drawing from the RBV, this paper presents patent expiration as a driver behind pharmaceutical firms' acquisition decisions and target selection. This paper argues that patent expiration constitutes a disruption to pharmaceutical firms' pipelines and a threat to revenue and profit streams and that acquisitions represent a possible short-term solution for firms to replenish their patent portfolios and to ensure a continuous flow of revenues. Using a sample of US pharmaceutical firms, this paper shows that pharmaceutical firms engage in acquisitions when they face large amounts of patent expiration and when they are unable to internally replenish their patent portfolios. The results also show that acquiring firms have a preference for targets with resources similar to their existing portfolio of patents, which is explained by firms' desire to minimize post-integration problems and possible disruptions derived from the difficulties in assimilation and commercial exploitation of distant knowledge. This is in contrast with previous studies indicating that acquiring firms benefit from knowledge bases that are more distant.

1. Introduction

Mergers and acquisitions (M&As) are a highly popular strategy not only to access resources and capabilities but also as an important means of corporate development that permits firms' growth (e.g., expansion of customers' base and product diversification) and internationalization (Chakrabarti et al., 1994; Cartwright and Schoenberg, 2006; Ahuja and Novelli, 2014). In high-tech industries, M&As are an important way by which firms can access technological assets and know-how held by the acquisition target (Capron, et al., 1998; Arora et al., 2001; Graebner, 2004; Cassiman et al., 2005; Dao and Strobl, 2019), in particular when targets' resources and capabilities cannot be obtained through the factors market (Capron et al., 1998; Villalonga and McGahan, 2005; Capron and Mitchell, 2009).

Prior studies have provided important insights into the antecedents of acquisition behavior and post-M&A performance (Barkema and Schijven, 2008; Haleblian et al., 2009; Rogan and Sorenson, 2014; Meyer-Doyle et al., 2019; Arroyabe et al., 2020; Welch et al., 2020). Yet, Yu et al. (2016)

and Welch et al. (2020) indicate there is still little understanding of the antecedents of M&As and call for greater research on the areas of M&A initiation (acquisition timing and decision) and target selection. In particular, they indicate that prior research has mainly focused on exogenous factors (e.g., industry and financial market factors) as primary explanations for the timing of acquisitions, which while explaining the overall acquisition activity of an industry do not explain why individual firms might be more or less likely to engage in acquisitions at a particular point in time (Iyer and Miller, 2008; Shi et al., 2012; Welch et al., 2020). Similarly, when it comes to target selection, previous studies have provided an analysis of the trade-off between complementarity and similarity, providing mixed evidence of the benefits of each, but they have not indicated when a particular acquirer will prefer one over the other (Yu et al., 2016). These are important questions as understanding the motives underlying acquisitions decisions enables to explain acquisitions' outcomes and facilitates providing adequate recommendations and strategies aimed at acquisitions' success (Schweizer, 2005; Shi et al., 2012; Welch et al., 2020). Addressing this gap, this paper presents a mechanism that explains the timing of the acquisition decision and target selection in the context of the pharmaceutical industry, where acquisitions and industry consolidation have been predominant.

Drawing from the resource-based view (RBV), this paper explores the role of patent expiration as a driver behind pharmaceutical firms' acquisition decisions and target selection. RBV understands acquisitions as a means for bringing bundles of resources into firms and suggests that competitive advantage is derived from firms' resources and capabilities. Within this RBV context, this paper considers patents as key resources of firms and argue that patent expiration constitutes a disruption to pharmaceutical firms' pipelines and a threat to revenue and profit streams, where acquisitions represent a possible short-term solution for firms to replenish their patent portfolios and ensure a continuous flow of revenues (Ahuja and Katila, 2001; Ranft and Lord, 2002; Yu et al., 2016). The paper aligns with the RBV theory that suggests that competitive advantage originates from the resources (e.g., patents) and capabilities of the firm (Barney, 1991) and that acquisitions facilitate the exchange of firm-specific resources that otherwise cannot be redeployed (Capron and Hulland, 1999).

Using a sample of US pharmaceutical firms in the period 1985–2010, the empirical results show that pharmaceutical firms engage in acquisitions when they face large amounts of patent expiration and when they are not able to internally replenish their patent portfolios. Moreover, the results show that in these cases, pharmaceutical firms select targets with resources similar to their existing portfolio of patents; this is in contrast with previous studies indicating that acquiring firms benefit from knowledge bases that are more distant (Shelton, 1988; Larsson and Finkelstein, 1999; Kim and Finkelstein, 2009; Makri et al., 2010; Sears, 2017). The findings have important practical implications for managers, suggesting a proactive long-term innovation strategy and portfolio management.

This study makes two primary contributions to the literature on technological acquisitions. First, it broadens the explanation of motivation in technological acquisitions by incorporating patent expiration as a driver. Second, it contributes to sparse and inconclusive literature on target choice by showing that the choice of knowledge base-relatedness is contingent upon patent expiration.

2. Theory and hypotheses

2.1. The impact of patent expiration on pharmaceutical firms' acquisitions decision

Since Barney's (1991) pivotal work, the RBV of the firm has received widespread support in the strategy literature (Capron and Hulland, 1999). At the center of the RBV is the idea that resources and capabilities are heterogeneously distributed across firms and imperfect mobile, granting firms with the possibility of obtaining a competitive advantage (Barney, 1991; Peteraf, 1993). Firms' resources are collections of knowledge and other tangible and intangible factors that firms possess that provide firms with the basis for obtaining a sustainable competitive advantage. Patents are legal rights that protect the knowledge generated and exclude others from the use of proprietary inventions (Henderson and Cockburn, 1994; Markman et al., 2004). RBV theory highlights the protection that patents provide against product rivals through greater control over distinctive product offerings (Hsu and Ziedonis, 2013). RBV regards patents as isolating mechanisms against the imitation in product markets (Hsu and Ziedonis, 2013). As such, patents represent the most important mechanism for IP appropriation in the pharmaceutical industry and the most effective and the most often used IP mechanism for both product and process invention (Reitzig and Puranam, 2009; Holgersson, 2013). Patents behind successful drugs are responsible for

high levels of revenue (Gambardella, 1992; Barret et al., 1999; Ravenscraft and Long, 2000).

While patents are a key resource for pharmaceutical firms, their life is limited to a maximum of 20 years, which means that firms can lose up to 80% of its revenue income to generic substitutes when these patents expire (Barret et al., 1999; Song and Han, 2016). For instance, 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). For the period 2018–2024, Deloitte (2019) has forecasted that over $251 billion in drug revenues will be at risk because patents expiring.

Since patent expiration is a predictable event, it is expected that firms will put into place strategies and policies that will anticipate patent expiration and internally replenish the patent portfolios, avoiding disruptions in revenue streams at the time patents are due to expire (Gambardella, 1992; Ravenscraft and Long, 2000). This process of internal replacement is feasible for those firms with innovative capability. Innovative capability, manifested through firms' basic research and internal R&D efforts, permits the generation of knowledge which is protected by patents (Elmquist and Le Masson, 2009; Puranam et al., 2009; Martínez-Román et al., 2011; Cheng and Yang, 2017). Basic research is essential for the knowledge creation process of firms (Griliches, 1990; 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 toward promising drugs in the drug discovery process (Fleming and Sorenson, 2004). The discovery and development process of drugs is a long and complex process that requires significant internal R&D efforts such as the establishment of R&D labs, the hiring of scientific personnel, and large investments in R&D (Cardinal and Hatfield, 2000). Nevertheless, this process of replenishing the patent pipelines via internal development is long and entails significant amounts of R&D expenditures and high uncertainty (Frantz, 2006). 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 (PhRMA, 2015) and the probability that the drug will be eventually approved by the FDA is less than 12% (PhRMA, 2015).

Firms failing to fully replenish their patent portfolio can expect gaps in their product portfolio, a decrease in their revenue streams, and an excess capacity, as specialized human and physical capital becomes redundant and unproductive (Danzon et al., 2007). In the long term, the immediate decrease in their revenue streams will also disrupt the future capacity of the firm to afford R&D activities, as current sales are the main source of firms' finance for R&D (Vernon, 2005). Thus, firms that are experiencing poor R&D results or with weak innovation capabilities might anticipate a further deterioration of their innovation performance resulting from patent expiration (Ornaghi, 2009).

RBV theory sustains that due to the difficulty and cost of in-house new patent development, firms often view acquisitions as a mechanism to achieve competitive advantage (Wernerfelt, 1984). Moreover, since firms' resources are not readily exchanged on the market, acquisitions represent the main means for bringing bundles of resources into firms (Wernerfelt, 1984; Yu et al., 2016). In the context of patent expiration, pharmaceutical firms might engage in horizontal acquisitions, which provide access to specific technologies that are owned by the target firm (Birkinshaw et al., 2000; Ranft and Lord, 2002; Graebner, 2004).[1] Acquiring firms can exploit the capabilities and the know-how of the target firm that will allow them to develop further innovations (Ranft and Lord, 2002; Lamont et al., 2019).

Hence, since the process of drug discovery and patent generation takes a considerable risk, time and investment, and success rates are low (DiMasi, 2001; Rothaermel and Hess, 2007; LaMattina, 2011), pharmaceutical firms unable to internally replace their expiring patents are expected to have a higher probability of engaging in acquisitions. Thus, the following hypotheses are derived:

Hypothesis 1a*: Patent expiration positively influences firms' decisions to engage in horizontal acquisitions.*

Hypothesis 1b: *Newly generated patents negatively moderate the effect of patent expiration on firms' decisions to engage in horizontal acquisitions.*

Hypothesis 1c: *Internal R&D efforts negatively moderates the effect of patent expiration on firms' decisions to engage in horizontal acquisitions.*

Hypothesis 1d: *Basic research negatively moderates the effect of patent expiration on firms' decisions to engage in horizontal acquisitions.*

2.2. The impact of patent expiration on pharmaceutical firms' target selection

RBV understands acquisitions as opportunities to redeploy strategic resources both to and from targets

(Capron, 1999). 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). In the context of patent expiration, pharmaceutical firms looking to replenish their patent portfolio and maintain their revenue streams might engage in acquisitions to gain access to technological assets held by the target firm (Birkinshaw et al., 2000; Ranft and Lord, 2002; Ahuja and Katila, 2001; Graebner, 2004). They will look for target firms for which they can immediately exploit their resources and capabilities, in particular, for targets with rich patent portfolios to prevent the above-mentioned disruptions (Ranft and Lord, 2002; Cloodt et al., 2006; Lamont et al., 2019). Thus, the following hypothesis is derived:

Hypothesis 2a: *In the presence of patent expiration, acquiring firms will be more likely to choose a target with a high patenting output.*

In order to capitalize on the targets' resources, previous studies examining post-M&A performance have indicated the importance of target selection. These studies emphasize the strategic fit between target and acquirer as the main driver of the success of acquisitions, and in particular, the combination of distinct yet related resources and capabilities of both entities (Shelton, 1988; Larsson and Finkelstein, 1999; Kim and Finkelstein, 2009; Makri et al., 2010; Sears, 2017).

In technological acquisitions, the relatedness of acquirer's and target's technological knowledge has been identified as a determinant of acquisitions' innovation outcomes (Ahuja and Katila, 2001; Cassiman et al., 2005; Cloodt et al., 2006; Makri et al., 2010). On the one hand, similarities between acquirers' and targets' knowledge bases promote economies of scale and scope of R&D (Gerpott, 1995; Hagedoorn and Duysters, 2002), smooth the integration of the knowledge bases (Kogut and Zander, 1992; Grant, 1996), and facilitate the evaluation and utilization of the acquired knowledge (Cohen and Levinthal, 1990; Cloodt et al., 2006). Because of the similarities between the knowledge bases, a related target might fail to contribute to the expansion of the knowledge base and innovation of the acquiring firm (Ahuja and Katila, 2001; Cloodt et al., 2006). On the other hand, differences between the knowledge bases of acquirers and targets may enrich the acquiring firm's knowledge base and facilitate learning (Hitt et al., 1994; Cloodt et al., 2006). Unrelatedness of the knowledge bases might spur innovation through the combination of acquirers' and targets' knowledge (Cohen and Levinthal, 1990) and through an improved capacity to absorb knowledge from the firms' external environment (Ahuja and Katila, 2001).

Complementarity in acquisitions might be attractive to pharmaceutical firms as a way to enter new pharmacological areas and commercialize new products (Yu et al., 2016). For example, many studies have reported the acquisition of biotech firms as a way to access their specialized knowledge and their molecules and compounds (Schweizer, 2005; Malerba and Orsenigo, 2015). Nevertheless, the success of these acquisitions is partly based on the capacity of pharmaceutical firms to absorb and exploit the newly acquired knowledge and innovation products (Ahuja and Katila, 2001; Yu et al., 2016).

This paper argues that acquirers facing patent expiration will prefer similar over complementary targets to ensure sustained performance. While complementarity can offer the above-mentioned benefits, targets that are too dissimilar would make it difficult for the acquirer to assimilate and commercially exploit the new knowledge (Lane and Lubatkin, 1998; Cohen and Levinthal, 1990), as the process of integration of knowledge is resource- and time-consuming (Haspeslagh and Jemison, 1991; Graebner et al., 2017). Acquirers facing patent expiration will focus on avoiding gaps in their pipelines and drop in their revenue streams, aiming for business continuity (Fernald et al., 2017). By selecting similar targets, acquirers minimize the post-integration problems and possible disruptions derived from the difficulties in assimilation and commercial exploitation of distant knowledge, ensuring an immediate use of acquired resources. Hence, pharmaceutical firms looking for replacing their expiring patents will most likely target firms with a large patent portfolio and similar characteristics. Thus, the following hypothesis is derived:

Hypothesis 2b: *In the presence of patent expiration, acquiring firms will be more likely to choose a target with a greater similarity in their patent portfolio.*

3. Data and methodology

3.1. Dataset

I constructed a dataset of 93 horizontal acquisitions among publicly listed US pharmaceutical firms (as

defined by firms in SIC 28) during the 1985–2010 period. It includes information on all publicly listed US firms involved in acquisitions over the period 1985–2010 where at least one of the acquisition 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 acquisition 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, and also excluded minority deals, acquisition of assets (same target and acquiring firm), deals with more than two parties and uncompleted deals. The acquisition data were linked to firms' financial records that were retrieved from Compustat. 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). The information on firms' basic research activities is extracted from the Medline-Science Citation Index (Web of Science) from Thomson Reuters that contains information on publications.

3.2. Variables

A description of the variables is displayed in Table 1. I conceptualized the decision of pharmaceutical firms to undertake an acquisition with a dummy variable that takes the value one when the pharma firm acquires another pharmaceutical firm and zero otherwise; that is, the dependent variable is equal to one only on the year of the acquisition.

The main independent variable, patent expiration, is measured as the stock of expiring patents in any given year. Following previous studies, I proxy innovative capability with R&D efforts and basic research (see e.g., Baden-Fuller and Pitt, 1996). R&D efforts are measured as the yearly R&D expenditures of the firm. Previous studies have pointed out the importance of R&D expenditures in the generation of innovation and patents, finding a strong relationship between R&D expenditures and patenting output (e.g., Pakes and Griliches, 1980; Hausman et al., 1984; Jaffe, 1986). Basic research is measured 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 (Gambardella, 1992; Fabrizio, 2009), particularly of firms' investments in basic science (Gambardella, 1992; Cockburn and Henderson, 1998). Firms' publication stock in year *t* is calculated as the number of publications in year *t* plus the publication stock in year *t-1*, which is multiplied by 0.85 to reflect a 15% depreciation rate (Hall, 1990).

Since patent expiration may not be the only reason for engaging in acquisition activities, I control for several firm characteristics that indicate alternative explanations for firms' acquisition decisions. Thus, in line with previous studies, I include firms' size to capture the possibility of firms' merging to achieve economies of scale, sales, to contemplate

Table 1. Definition of variables

Variables	Definition
Dependent variable	
M&A	Equals one if the pharma firm acquires another pharmaceutical firm in year *t* and zero otherwise
Independent variables	
Assets	Log of assets in year *t* (in millions)
Sale	Sales in year *t* (in millions), as a ratio of assets
Cash	Cash in year *t* (in millions), as a ratio of assets
Debt	Debt in year *t* (in millions), as a ratio of assets
New patents	Number of granted patents applications over the publication stock in year *t*
Expiring patents	Stock of expiring patents in year *t* (in thousands)
R&D	R&D expenditures of the firm in year *t* (in millions of dollars), as a ratio of assets
Publications	Number of publications in year *t* over the publication stock in year *t* (with a 15% depreciation rate)
Target assets	Log of assets in year *t* of target firm (in millions)
Target sales	Sales in year *t* of target firm (in millions), as a ratio of assets
Target patents	Number of target's granted patents applications in year *t*
Overlap	Number of patent classes in which both target and acquirer firms patent over the total number of patent classes the acquirer firm is active in year *t*

Table 2. Descriptive statistics

Variables	Obs.	Mean	Std. Dev.	Min.	Max.
Assets	169,613	1,467.408	6,295.903	0	212,949.000
Sale	169,613	1,000.372	4,005.341	−21.796	67,791.000
Cash	169,613	136.317	623.617	−0.476	19,355.000
Debt	169,613	201.350	896.460	0	43,193.000
New patents	169,613	29.550	205.191	0	5,088.000
Expiring patents	169,613	0.433	5.080	0	119.273
R&D	169,613	144.225	570.501	0	12,183.000
Publications	169,613	45.512	205.003	0	4,282.603
Target assets	169,613	1,375.656	5,401.308	0.113	44,031.720
Target sales	169,613	844.853	3,140.436	0	22,833.910
Target patents	169,613	26.957	87.801	0	561.000
Overlap	169,613	0.221	0.341	0	1

firms' excessive capacity as a driver of the acquisition decision, and cash and firms' debt to control for firms' ability to finance the acquisition (Higgins and Rodriguez, 2006; Danzon et al., 2007). Finally, I proxy the ability to generate new innovation output with the number of granted patents applications per year[2] (Griliches, 1990).

For the second part of the analysis, potential targets' characteristics are also included. Similar to the acquirer firms' measures, I include target firms' size, target firms' sales, and targets' number of granted patents applications in year *t*. Finally, to measure the similarity between targets' and acquirers' knowledge bases, I calculate the overlap of the patent portfolios as the number of patent classes in which both target and acquirer firms patent over the total number of patent classes the acquirer firm is active in year *t*.

3.3. Model and estimation technique

To analyze the impact of patent expiration rate on pharmaceutical firms' decision to acquire a potential target, I follow an approach similar to Kaul and Wu (2016) and include all possible combinations of acquirer-target. To mitigate concerns of sample selection, I include all US publicly listed pharmaceutical firms (SIC 283) that are active in the period 1985–2010, 427 firms, as potential acquirers. This yields 169,613 target-acquirer-year combinations, including the 93 actual acquisitions.[3]

This empirical set-up implies that the dependent variable will be one in very few cases (93 cases) so that the sample is dominated by zeroes in the dependent variable. Previous studies have shown that in these situations, traditional logit models tend to underestimate the probability of rare events, which produces biased estimates (King and Zeng, 2001; Allison, 2012). To avoid this problem, I make use of penalized maximum likelihood estimation (Firth, 1993; Heinze and Schemper, 2002).

4. Empirical results

Tables 2[4], 3, and 4 show the descriptive statistics, a comparison of means and medians, and the correlations of the variables of interest, respectively.

Table 5[5] presents the penalized maximum likelihood logit estimation results. The first column shows the basic specification that includes exclusively the effects of firms' characteristics on the probability of pharmaceutical firms to engage in acquisition activities. I find that larger firms are more likely to engage in acquisitions. A decrease in sales increases the likelihood of firms' acquisition decisions, while cash and debt have a positive effect. Moreover, firms with greater patenting output are less likely to engage in acquisitions. Column 2 displays the results when the patent expiration is included. I find a significant positive impact of the patent expiration on the likelihood to engage in acquisitions. Thus, this result supports hypothesis 1a.

Column 3 shows that the interaction term between expiring patents and new patents is negative, indicating that the positive effect of patent expiration on the decision to engage in acquisitions is diminished by the amount new patents the acquiring firm is internally producing, hence supporting hypothesis 1b.

Columns 4 to 7 build on specification 2 and include the moderating effect of firms' innovative capability on the decision to engage in acquisitions. The coefficients for R&D and the interaction of R&D with patent expirations are not significant, not supporting hypothesis 1c. In columns 6 and 7, I find that firms with a larger basic research base are

Table 3. Comparision of means and medians of main variables of interest

Variables	Acquiring firms		Non-acquiring firms		Diff.	Acquiring firms		Non-acquiring firms		Pearson Chi-sq
						Greater than the median		Greater than the median		
	Mean	SD	Mean	SD		Yes	No	Yes	No	
Assets	2,551.12	40.75	1,136.91	15.48	−1,414.2[1]	27,288	12,350	57,473	72,502	7,400[1]
Sale	1,712.78	25.03	783.11	10.06	−929.66[1]	29,667	9,971	55,118	74,857	13,000[1]
Cash	214.69	3.13	112.41	1.73	−102.28[1]	25,364	14,274	59,424	70,551	4,100[1]
Debt	375.20	5.71	148.331	2.22	−226.87[1]	27,233	12,405	57,447	72,528	7,300[1]
New patents	87.18	2.07	11.97	0.12	−75.21[1]	23,243	16,395	51,404	78,571	41.520[1]
Expiring patents	1.47	0.05	0.12	0.00	−1.36[1]	20,633	19,005	64,172	65,803	87.224[1]
R&D	237.25	3.61	115.33	1.46	−121.92[1]	24,822	13,901	56,867	67,794	4,000[1]
Publications	108.32	1.72	26.36	0.37	−81.97[1]	21,135	18,503	49,802	80,173	2,800[1]
Observations	39,638		129,975			39,638		129,975		

[1]Indicates significance at 1%.

significantly less likely to acquire other firms when faced with higher patent expiration rates, thus supporting hypothesis 1d.

Table 6[6] presents the results of the second part of the analysis. Columns (1) and (2) are the same as the first two columns of Table 5. Column 3 shows that targets' assets and patenting output significantly affect the acquisition decision. First, I find that targets' size negatively affects the probability of acquisition, suggesting that acquiring firms might prefer smaller targets. Second, firms with a larger patenting output are more likely to be acquired, suggesting that target firms with a pipeline full of new patents are more attractive for acquisition. In column 4, however, when interacting patent expiration with targets' patents, I do not find a significant effect, not confirming hypothesis 2a, meaning that expiration does not affect the preference for targets with a larger patent portfolio.

Columns 5 and 6 show the preference of acquiring firms for similar/dissimilar targets. Acquiring firms show a preference for firms with dissimilar knowledge bases, reflected in the negative coefficient of the overlap in the patent portfolios. However, as shown by the positive sign of the interaction term between overlap and patent expiration, they do prefer less distant targets when facing patent expiration, confirming hypothesis 2b.

Figures 1-3 display the marginal effects of patent expiration. The marginal effects are increasing with the number of expiring patents, meaning that firms with a larger amount of expiring patents have a higher probability of acquiring another pharmaceutical firm. Moreover, the marginal effects for internal basic research and new patents are decreasing, meaning that firms with a higher internal capacity to generate innovations and patents have a lower probability of engaging in acquisitions given patent expiration.

5. Discussion

The empirical results demonstrate that the loss of competitive advantage derived from the expiration of patents, a key technological asset of pharmaceutical firms, is a mechanism that drives pharmaceutical firms' acquisition decisions. As highlighted by previous literature, greater levels of patent expiration increase the exposure of pharmaceutical firms to disruptions in their product pipelines and revenues streams and urge them to come up with new patents (Gambardella, 1992; Barret et al., 1999; Ravenscraft and Long, 2000; Schweizer, 2005; Comanor and Scherer, 2013). This is in line with previous financial economics and industrial organization literature that finds a positive effect

Table 4. Correlation of independent variables

	Assets	Sale	Cash	Debt	New patents	Expiring patents	R&D	Publications	Target assets	Target sales	Target patents	Overlap
Assets	1.000											
Sale	−0.036[1]	1.000										
Cash	0.127[1]	−0.005[1]	1.000									
Debt	−0.066[1]	0.079[1]	−0.004	1.000								
New patents	0.080[1]	−0.050[1]	0.013[1]	−0.027[1]	1.000							
Expiring patents	0.082[1]	0.009[1]	−0.005[1]	0.002	−0.009[1]	1.000						
R&D	−0.300[1]	0.074[1]	−0.032[1]	0.512[1]	−0.007[1]	−0.020[1]	1.000					
Publications	0.163[1]	−0.031[1]	0.004	−0.020[1]	0.126[1]	0.028[1]	−0.012[1]	1.000				
Target assets	0.057[1]	−0.023[1]	0.061[1]	0.007[1]	0.029[1]	−0.025[1]	0.005[1]	0.006[1]	1.000			
Target sales	0.001	−0.000	−0.002	−0.002	0.000	0.004	−0.009[1]	0.002	0.035[1]	1.000		
Target patents	0.000	−0.007[1]	−0.005[1]	−0.006[1]	0.027[1]	−0.011[1]	0.000	0.020[1]	−0.001	−0.099[1]	1.000	
Overlap	−0.063[1]	−0.028[1]	0.020[1]	0.005	0.097[1]	−0.030[1]	0.032[1]	0.024[1]	0.350[1]	−0.015[1]	0.039[1]	1.000

[1]Indicates significance at 5%.

of patent expiration on acquisition likelihood (Higgins and Rodriguez, 2006; Danzon et al., 2007). The results suggest that the necessity to replace expiring patents as quickly as possible to minimize the disruptions increases the likelihood of undertaking an acquisition strategy. This is in line with previous literature that highlights the preference of firms for acquisitions when the desired technologies and resources at stake are characterized by high levels of uncertainty and tacitness (Folta, 1998; Hagedoorn and Duysters, 2002; Schilling and Steensma, 2002).

The paper also considers different moderators for the effect of patent expiration on firms' acquisition decisions. First, the results show that firms' internal basic research efforts negatively moderate the impact of patent expiration on the likelihood to engage in acquisitions. Higher levels of basic research correspond to higher levels of activity particularly in the early stages of the drug discovery process (Gambardella, 1992; Hicks, 1995). The results suggest that firms that have a strong basic research base possess the raw material necessary to come up in-house with new drugs and patents. Thus, even if the number of expiring patents increases, firms with high levels of basic research always have some molecules and compounds in their pipeline that can be further developed into drugs and be exploited in the form of patents, reducing their necessity of obtaining these new technologies and knowledge from outside the firm. This is consistent with the view that basic research facilitates the research process of firms, pointing them toward new and promising fields (Fleming and Sorenson, 2004), and increasing their absorptive capacity (Cohen and Levinthal, 1990). This means that firms with a higher basic research base, and thus a higher potential to internally generate new innovations and patents, have a lower preference for acquisitions when patent expiration rates increase.

However, the results do not find support for a moderation effect of the R&D efforts (measured as R&D expenditures). This is surprising given that R&D expenditures have been traditionally linked with a higher capacity to develop innovations internally (Hausman et al., 1984; DiMasi et al. 2003). This apparent contradiction might be explained by the fact that R&D expenditures are the input for innovation, so that higher levels of R&D may not necessarily indicate progress in developing compounds (DiMasi et al., 2003). In particular, recent research indicates that attrition rates, development times, and R&D expenditures have all increased since the mid-1990s (Cockburn, 2006; Pammolli et al., 2011). This lack of a correspondence between the increase in the

Table 5. Logit for the probability of engaging in acquisitions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Baseline model	H1a	H1b		H1c		H1c
Variables		***Effect of expiring patents***	***Moderating effect of new patents***		***Moderating effect of R&D***		***Moderating effect of basic research***
$Assets_t$	0.235***	0.229***	0.230***	0.216***	0.216***	0.227***	0.227***
	(0.009)	(0.009)	(0.009)	(0.010)	(0.010)	(0.009)	(0.009)
$Sale_t$	−0.538***	−0.562***	−0.558***	−0.500***	−0.501***	−0.556***	−0.551***
	(0.059)	(0.059)	(0.059)	(0.060)	(0.060)	(0.060)	(0.060)
$Cash_t$	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Debt_t$	0.092***	0.090***	0.091***	0.108***	0.108***	0.090***	0.090***
	(0.019)	(0.020)	(0.020)	(0.025)	(0.025)	(0.020)	(0.020)
New $patents_t$	−2.253***	−2.277***	−2.241***	−2.298***	−2.298***	−2.290***	−2.294***
	(0.135)	(0.137)	(0.137)	(0.137)	(0.137)	(0.137)	(0.137)
Expiring $patents_t$		0.017***	0.044***	0.016***	0.014***	0.017***	0.021***
		(0.002)	(0.008)	(0.002)	(0.005)	(0.002)	(0.002)
$Expiring_t \times New\ patents_t$			−0.147***				
			(0.043)				
$R\&D_t$				−0.063	−0.064		
				(0.060)	(0.060)		
$Expiring_t \times R\&D_t$					0.022		
					(0.042)		
$Publications_t$						0.114*	0.153*
						(0.061)	(0.082)
$Expiring_t \times Publications_t$							−0.014**
							(0.006)
Constant	−4.893***	−4.872***	−4.884***	−4.788***	−4.788***	−4.885***	−4.892***
	(0.050)	(0.050)	(0.050)	(0.061)	(0.061)	(0.051)	(0.051)
Number of observations	169,613	169,613	169,613	169,613	169,613	169,613	169,613
Log likelihood	−11,256	−11,214	−11,206	−11,154	−11,151	−11,211	−11,202

Standard errors in parentheses.
***$P < 0.01$, **$P < 0.05$, *$P < 0.1$.

Table 6. Logit for target selection

	(1)	(2)	(3)	(4)	(5)	(6)
	Baseline model	H1a		H2a		H2b
Variables		***Effect of expiring patents***		***Moderating effect of target patents***		***Moderating effect of similarity***
$Assets_t$	0.235***	0.229***	0.231***	0.231***	0.223***	0.224***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
$Sale_t$	−0.538***	−0.562***	−0.570***	−0.570***	−0.610***	−0.615***
	(0.059)	(0.059)	(0.060)	(0.060)	(0.060)	(0.060)
$Cash_t$	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Debt_t$	0.092***	0.090***	0.092***	0.092***	0.098***	0.099***
	(0.019)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
New $patents_t$	−2.253***	−2.277***	−2.282***	−2.282***	−2.206***	−2.207***
	(0.135)	(0.137)	(0.136)	(0.136)	(0.136)	(0.136)
Expiring $patents_t$		0.017***	0.017***	0.017***	0.016***	0.015***
		(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Target $assets_t$			−0.017*	−0.017*	0.015	0.014
			(0.010)	(0.010)	(0.011)	(0.011)
Target $sales_t$			0.004	0.004	−0.001	−0.001
			(0.023)	(0.023)	(0.024)	(0.024)
Target $patents_t$			0.280***	0.280***	0.282***	0.282***
			(0.074)	(0.075)	(0.073)	(0.073)
Expiring$_t$ × Target $patents_t$				0.000		
				(0.005)		
$Overlap_t$					−0.694***	−0.700***
					(0.084)	(0.084)
Expiring$_t$ × $Overlap_t$						0.022*
						(0.013)
Constant	−4.893***	−4.872***	−4.876***	−4.876***	−4.883***	−4.783***
	(0.050)	(0.050)	(0.066)	(0.066)	(0.066)	(0.066)
Number of observations	169,613	169,613	169,613	169,613	169,613	169,613
Log likelihood	−11,256	−11,214	−11,195	−11,190	−11,155	−11,159

Standard errors in parentheses.
***$P < 0.01$, **$P < 0.05$, *$P < 0.0.1$.

input–output indicates that innovation has become more challenging and thus, R&D expenditures no longer necessarily translate into patents (Pammolli et al., 2011; Scannell et al., 2012).

The results for target selection analysis suggest that firms engage in acquisitions to gain access to technological assets held by the target firm, which is in line with the literature on technological acquisitions (e.g., Birkinshaw et al., 2000; Ranft and Lord, 2002; Ahuja and Katila, 2001; Graebner, 2004). First, the results show that independent of the patent expiration of acquiring firms, pharmaceutical firms have a preference for targets with rich patent portfolios, which coincides with the findings of mainstream studies on technological acquisitions (Cloodt et al., 2006). Surprisingly, the results did not show any impact of patent expiration on the preference for targets with greater patent portfolios. This might be because, in the pharmaceutical industry, patents are the main output of innovation, with innovation being the primary activity in the industry, so that patents could be seen as a pre-requisite for acquiring firms, regardless of the motives behind the acquisition.

Finally, the results show that acquiring firms prefer for targets with a more distant knowledge base, emphasizing the importance of accessing

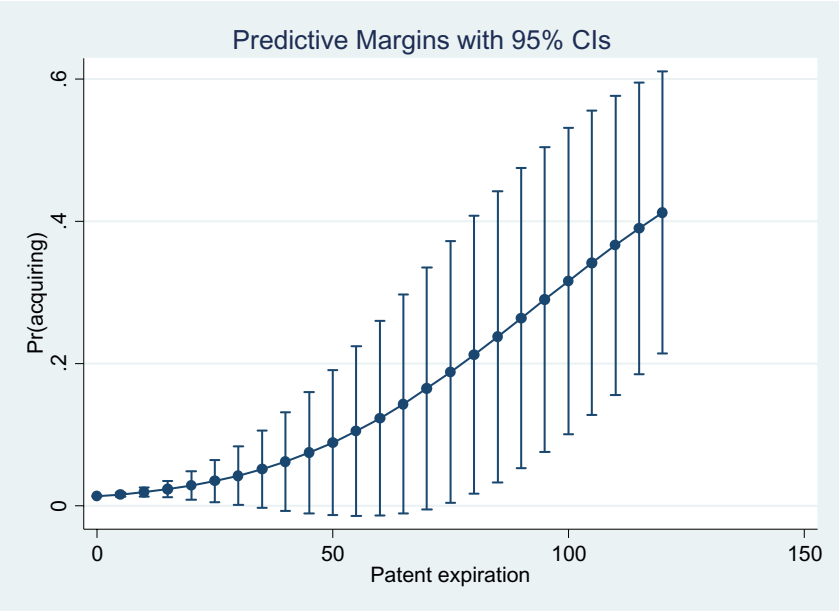

Figure 1. Marginal effects of patent expiration on the probability of acquiring.

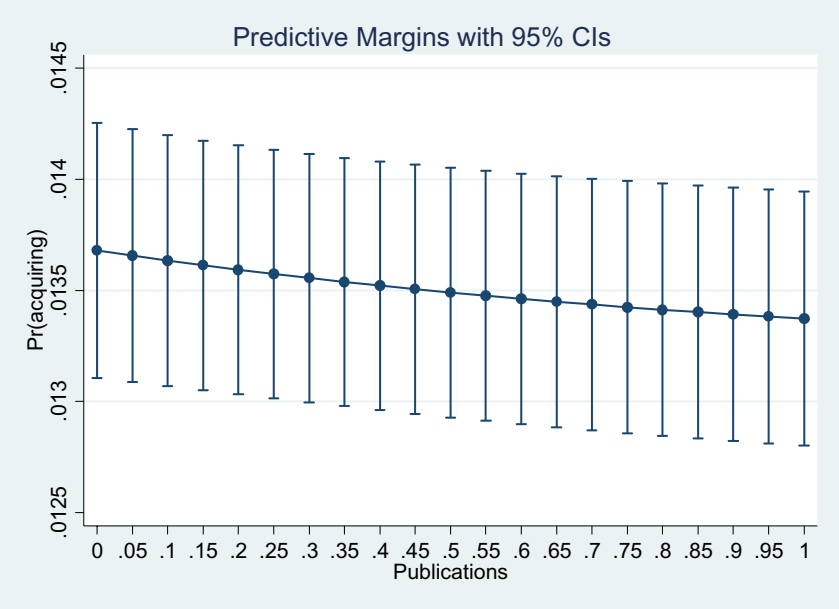

Figure 2. Marginal effects on the probability of acquiring given internal basic research efforts.

new knowledge, technologies, and possibilities for recombination of knowledge for potential acquiring firms. This is in line with the literature supporting complementarities as a key for successful acquisitions (Shelton, 1988; Larsson and Finkelstein, 1999; Capron and Mitchell, 2009; Kim and Finkelstein, 2009; Makri et al., 2010; Kaul and Wu, 2016). However, I also find that firms facing patent expiration prefer less distant targets as a way to secure their revenue streams and substitute existing knowledge and patents, rather than to explore new knowledge or get access to knowledge that eventually can lead to new technologies. By selecting similar targets, acquirers minimize the post-integration problems and possible disruptions derived from the difficulties in assimilation and commercial exploitation of distant knowledge, ensuring an immediate use of acquired resources. In this sense, the findings on the

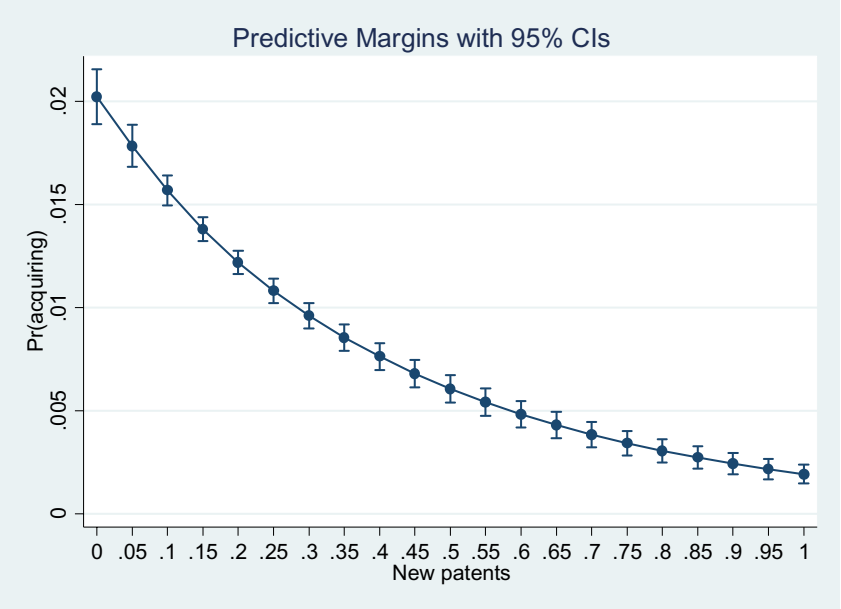

Figure 3. Marginal effects on the probability of acquiring given number of new patents.

interaction of patent expiration and the overlap of technological portfolios support the literature indicating that acquirers benefit from similar targets (Baum et al., 2000; Schildt and Laamanen, 2006; Berchicci et al., 2012; Chakrabarti and Mitchell, 2013).

6. Conclusion

Framed in the RBV literature, this paper contributes to previous research on acquisition motives and target selection by studying the impact of patent expiration on pharmaceutical firms' acquisition timing and target selection. The results show that patent expiration is a triggering factor of firms' acquisition 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' innovative capability. In particular, for firms with a stronger basic research base and newly generated patents, the effect of patent expiration on the acquisition decision is not as pronounced. This is because innovative capability facilitates firms' research process, providing them with a higher capability to internally generate new innovations, thus reducing the external dependency. The results also show that pharmaceutical firms facing patent expirations prefer targets with a strong patent portfolio and with a certain level of similarity in their knowledge bases. Pharmaceutical firms sacrifice potential gains in innovation from distant targets to ensure a quick and easy integration that facilitate the exploitation and commercialization of the target's knowledge, avoiding disruptions in the pipelines and revenue flows.

6.1. Managerial and policy implications

This study suggests that managers should pay attention to and plan for long-term innovation strategies. Patent expiration is a highly disruptive event in the pharmaceutical industry that can erode firms' competitive advantage. The results show that clever patent portfolio management can avoid the so-called 'patent cliff' and the consequent disruption in revenues (Kenley, 2011; LaMattina, 2011). In particular, the strategic timing of patent applications as well as strong internal research capabilities can avoid depletion of firms' patent portfolio and the associated disturbances in the pharmaceutical pipelines. This is particularly important in light of the innovation output declines reported by the post-M&A literature, which suggests that because of their complexity M&As do not always bring the intended positive outcomes. Thus, managers should carefully manage their patent portfolios to avoid having to undertake M&As as a response to patent expiration.

The results provide policymakers and practitioners with a set of indicators that helps to explain the acquisition behavior and target choice of pharmaceutical firms. For its vast majority, the existing indicators are based on firms' financial information (e.g., market capitalization, ratio cash to sales, Tobin's q), or trends (e.g., industry trends or acquisition waves).

As compared to these, patent expiration does not rely on the financial situation of the firm but rather on the innovation portfolio, which from the empirical point of view is less problematic in terms of causality and endogeneity.[7] Thus, policymakers and practitioners should closely monitor innovation indicators as a way to anticipate the acquisition activity of pharmaceutical firms.

6.2. Limitations and further research

As any, this study is not free of limitations. First, these results refer to the pharmaceutical industry, and thus, cannot be translated into low innovative industries or industries in which trade secrecy is the major strategy to protect innovation breakthroughs. Second, this paper focuses on acquisitions of new patents through acquisitions, ignoring other mechanisms such as patents' rights transfers[8] or patent licensing. Thus, it may be interesting to complement the current study with patent transfer and patent licensing data.

Future research could also investigate how much does patent expirations weight in the decision to engage in acquisitions as compared to other factors such as financial performance (Meyer-Doyle et al., 2019). Future research could also complement the current patent-level analysis with a drug-level study, by, for example, matching individual patents to different drugs. Another topic of relevance would be to investigate the role that marketing might play in mitigating the losses derived from patent expiration (Jain and Conley, 2014).

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Notes

[1] While firms can also resort to internal development, alliances, R&D outsourcing, licensing or joint ventures to develop new technologies (Arora and Gambardella, 1990; Cockburn and Henderson, 1998; Xu and Cavusgil, 2019), in high-tech industries acquisitions might be preferred (Arora and Gambardella, 1990; Haspeslagh and Jemison, 1991; Hitt et al., 1994). In particular, when firms are seeking for technological resources that provide with a sustainable competitive advantage and above-normal economic rents, acquisitions offer greater potential for core technological capability development (Leonard-Barton, 1995; Hagedoorn and Duysters, 2002). Acquisitions and internalization of key technological resources facilitate the coordination of asset-specific activities (Schilling and Steensma, 2002) and provide a better governance mechanism (through the share routines, knowledge and language developed within firms) for resources that are unique, tacit, and difficult to imitate (Kogut and Zander, 1992; Grant, 1996).

[2] Granted patents are preferred to other patent indicators such as patent applications because the former is an indicator of successful invention (Ahuja and Katila, 2001).

[3] Note that while all possible combinations of target-acquirer-year are considered, only those years' combinations for which data on the target and acquirer are available are included.

[4] Note that for those variables for which I have taken the log (e.g., size) or taken the variable as a ratio, the table of descriptive statistics refers to the variables before being transformed.

[5] In the appendix, Tables A1 and A2 show the robustness checks for this part of the analysis. Table A1 displays the results with the lagged variables of the financial variables. Table A2 displays the results with the citations-weighted expiring patents, calculated as in Trajtenberg (1990), as main independent variable. The results are in line with the main analyses.

[6] In the appendix, Table A3 shows the robustness checks for this second part of the analysis. Table A3 displays the results with the citations-weighted expiring patents, calculated as in Trajtenberg (1990), as main independent variable. The results are in line with the main analysis.

[7] 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 since changes in firms' financial statements may be a response to firms' acquisition decision, through for example a managerial change in strategy or as a consequence of markets' rumors about the acquisition.

[8] The USPTO Patent Assignment Dataset collects information on patents' transfers (either individually or in a bundle). These datasets, however, suffer from several limitations that complicate the analysis: (1) names of buyers and sellers are not standardized on the dataset, which makes tracking a very difficult task; (2) the database does not allow distinguishing 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, does not 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 acquisition dataset.

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