Merger Waves and Innovation Cycles: Evidence from Patent Expirations*

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Abstract

We investigate the link between innovation cycles and aggregate merger activity using data on patent expirations. To isolate the treatment effect of patent expirations, we focus on *term expirations*, which mandatorily occur at a pre-specified date. We find strong clustering in industry patent expirations ("patent expiration waves"). These patent waves trigger industry merger waves with lower announcement returns and worse long-term performance for acquirers, but higher announcement returns and larger premiums for targets. Acquirers also experience declines in profit margins, cash holdings and investment opportunities, while cutting costs in the year prior to a merger. Overall, we put forth a possible link, unexplored in the literature, between merger waves and patenting activity.

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1. Introduction

It is well known that mergers and acquisitions are clustered by industry and through time, that is, that industry merger waves exist. Broadly speaking, two classes of theories have been put forth to explain their occurrence. On the one hand, authors such as Shleifer and Vishny (2003) and Rhodes-Kropf and Viswanathan (2004) develop behavioral theories where acquiring managers exploit the overvaluation of their firms. On the other hand, authors such as Gort (1969), Mitchell and Mulherin (1996), and Harford (2005) lean towards more neoclassical theories where merger waves result from shocks to an industry's economic, technological, or regulatory environment.

In this paper, we investigate an unexplored channel that contributes to merger waves, which lies at the intersection of an industry's economic, technological, and regulatory environment. Specifically, we explore the link between industry innovation cycles and merger waves using data on patent expirations. This method measures the variation in aggregate industry-level innovation using changes in intellectual property (IP) ownership determined by U.S patent laws. The identification strategy exploits patent *term* expirations, whose timing is set exogenously based on the timing of a patent's application and subsequent grant. This strategy allows us to separate the treatment effect of innovation on aggregate merger activity from other, potentially unobservable factors that may trigger merger waves.

We argue that firms often respond to the loss of IP ownership brought about by the mandatory expiration of patents by acquiring external innovation. Prominent examples are ubiquitous. For instance, a Wall Street Journal article in 2009 covering Pfizer's proposal to acquire Wyeth for $68 billion concluded that the deal "would come as the pharmaceuticals sector is struggling to find new sources of revenue amid a dearth of promising new drugs, increased competition from generic rivals and the looming expiration of patents on blockbuster treatments"

(Karnitschnig (2009)). Polaroid is another example. In 1997, it hired a merger and acquisitions specialist as part of a new growth strategy amid years of declining profits, cost-cutting, and layoffs. A Wall Street Journal article covering the story argued that: "Deals could be difficult for Polaroid. Many of its own patents are reaching expiration, and many other imaging companies are looking for acquisitions" (Kerber (1997)). Both examples highlight the industry-wide effects of expiring IP ownership, which extend beyond the individual firm. We therefore begin our analyses on the industry-wide effects of expiring IP ownership on merger activity.

Our first set of analyses investigates the dynamics of industry-level innovation cycles proxied by patenting activity. While patenting activity itself is likely correlated with other economic factors, the term expiration of patents is purely mechanical and follows a pre-determined schedule. We therefore investigate the cycles of industry patent term expirations. We find that patent term expirations are strongly clustered by industry and through time. We use Harford's (2005) method for constructing industry merger waves to identify industry waves in patent expirations ("patent expiration waves"). We document a total of 111 patent expiration waves, out of which 42 occurred in 1980-1989, 34 happened in the 1990-1999, and the remaining 35 took place in 2000-2009. Importantly, patent expiration waves are distinct from patent expirations triggered when inventors do not pay maintenance fees to renew a patent, which do not occur randomly. These patents are excluded from our measure of patent expiration waves.

While the timing of patent expiration waves is determined exogenously by patent expiration laws, and therefore is not set by firm-level, industry-level, or market-wide conditions, it could be preceded by a patenting wave that occurred approximately 20 years earlier. Thus, a natural question that arises is what caused the patenting wave in the first place. To answer this

question, we read the detailed descriptions of the expiring patents in the subsample of our patent expiration waves. We find, somewhat intuitively, that a typical patenting wave is generated by a burst of innovation surrounding a significant technological breakthrough. For example, there was a patent expiration wave in the business services industry at the end of the 1990s. The wave comprised more than 3,000 patent expirations, which included many of the original patents for personal computers, such as printing technology, hard drives, displays and circuitry.

In the above example, the clustering of patent expirations for personal computers was followed by a merger wave in the business services industry. Thus, our second set of analyses explores the link between patent expiration waves and merger waves. In parametric univariate tests, we find that the likelihood of industry merger waves increases by 4.4% following industry waves of patent expirations. In multivariate tests, which control for other determinants of merger waves such as investment opportunities, returns, liquidity and economics shocks, (see Harford (2005)), we find that the likelihood of merger waves increases by 4.6% following patent expiration waves. We also study the dynamic effect of patent expiration waves, and find that the effect is concentrated in the year immediately preceding a merger wave. Taken together, these findings put forth a novel link, unexplored in prior studies, between aggregate merger activity and expiring intellectual property.

Additionally, we examine heterogeneity in patent waves and the role of macroeconomic conditions. We find that patent expiration waves are more likely to trigger merger waves in industries with relatively high patenting activity. Further, we examine the importance of capital liquidity during patent expiration waves. We report that patent waves are significantly less likely to occur when capital liquidity is relatively low.

In our third set of analyses, we investigate the value of mergers consummated during waves triggered by expiring IP ownership ("IP merger waves"). We find that acquirers' announcement returns in IP merger waves are 1.1% lower compared to the average acquisition in a merger wave. Moreover, acquirers' operating performance in the one to two years following the acquisition is 2.6% to 8.5% worse in IP merger waves compared to the average acquisition in a merger wave, and the investment opportunities of acquirers continues to shrink after a merger. On the other hand, targets' announcement returns are 6.5% higher in IP merger waves compared to the average target in a merger wave. Furthermore, targets during a patent expiration wave receive 8.2% to 16.2% larger premiums, relative to an acquisition occurring in a merger wave that is not preceded by clustering in IP expiration.

These findings are consistent with the hypothesis that IP merger waves are "mergers of necessity," which reflect acquiring firms' failure to innovate in response to the impending term expirations of patents. Consequently, these mergers yield lower announcement returns and worse operating performance for acquirers. At the same time, patent expiration waves generate high demand for acquiring external innovation, and this high demand is reflected in higher announcement returns and premiums for the target firms.

To shed more light on the nature of IP merger waves, we also study the years leading up to the waves. We find that in the year leading up to patent expiration waves, an acquirer's profit margins and profitability declines, while it undergoes significant cost cutting. At the same time, the cash holdings of these firms and their investment opportunities are declining. These findings are consistent with the hypothesis that IP merger waves are triggered by downward trends in the IP cycle, which have detrimental effects on the firms in the industry.

Overall, our paper sheds new light on the determinants of merger waves and their link to innovation cycles. Our estimates suggest that IP merger waves are important, as over 10% of total merger waves in our sample period follow patent expiration waves. Thus, our findings provide further support for the importance of neoclassical theories in explaining merger waves.

Our paper adds to a large body of research on mergers and acquisitions. Some papers suggest that mergers are value-maximizing (Matsusaka (2001) and Jovanovic and Braguinsky (2004)), while others suggest they are inefficient, potentially driven by agency conflicts (Baumol (1959), Jensen (1986) Jensen (1993) and Stulz (1990)). We suggest that, while mergers consummated during IP merger waves may appear inefficient, they are mergers of necessity triggered by expiring IP.

There is also a vast literature on merger waves. Economic theory does not necessarily predict negative value implications. For example, if merger waves are driven by industry shocks that trigger restructuring and consolidation of industries (Mitchell and Mulherin (1996) and Jovanovic and Braguinsky (2004)), they may create value by facilitating efficient asset reallocation. If they are driven by stock market overvaluation (Shleifer and Vishny (2003) and Rhodes-Kropf and Viswanathan (2004)), they may benefit the acquirer's shareholders. Our results are more nuanced. While the acquisition of external innovation in response to waves of expiring IP appears to generate less value, it reflects firms' attempts to respond to the changing environment determined by patent laws that govern patent expirations.

Finally, our paper is related to an emerging literature on acquisitions and innovation. Bena and Li (2014) focus on the importance of technological overlap in generating innovation synergies from mergers. Sevilir and Tian (2012) show that acquisitions tend to increase the acquiring firm's innovation output and that announcement returns positively reflect this. In

contrast, this paper studies aggregate, rather than firm-level, patenting and merger activities. It focuses on the clustering of acquisitions driven by large-scale patent expirations, and finds that acquirers in IP merger waves pay more for targets, reversing the positive stock price reaction.

2. Institutional Details on Patent Expirations

Since 1790, the United States government has provided inventors exclusive rights to their creations through the patenting system. This system offers legal protections and monopoly claims to inventions with the tradeoff that these rights expire after a limited period of time. The term of a patent granted in the United States has varied historically. The Patent Act of 1836 set the term of a patent to 17 years from the date of issuance. Starting on June 7, 1978, patent term expirations were adjusted to be the maximum of 20 years from the application (or filing) date or 17 years from grant date. This change extended a patent's term and could provide an incentive for a patent applicant to file a patent, but strategically delay its issuance to extend the expiration date. With the formation of World Trade Organization (WTO), the United States agreed to alter its patent term expiration as part of the Uruguay Round Agreements Act and the General Agreement on Tariffs and Trade (GATT). Passed into law on December 8, 1994, this changed the patent term expiration date to 20 years from the filing date.

There are primarily two reasons that why a patent's term expiration date could change. First, patent grantees are required to pay maintenance fees 3.5, 7.5 and 11.5 years after a patent is issued. If a maintenance fee is not paid, the patent will expire prior to the end of its term. Second, the American Inventors Protection Act was signed into law on November 29, 1999. It protected inventors from processing delays initiated by the United States Patent and Trade Office (USPTO). Patent grantees were more affected by these delays as expiration started at the time of

filing an application, rather than its issuance, with the passage of the Uruguay Round Agreements Act and GATT. Patent term adjustments alter the term expiration to account for delays by the USPTO in reviewing and responding to an applicant.

3. Data

We link data on patents, merger activity, and characteristics on acquirers and targets from several sources. First, detailed information on patents is provided by the USPTO. We use the mapping of patents to Compustat firms from 1926 to 2010 provided by Kogan et al. (2017). We augment this data with patent maintenance fee events starting on September 1, 1981 to the end of the sample period. This data provides a list of each maintenance fee paid or patent expired because of a failure to pay. This allows us to determine when patents expire based on term expirations or maintenance fees. Further, we merge data on patent term adjustments. The Office of the Chief Economist at the USPTO aggregates this data by patent in the Patent Examination Research Dataset (Graham, Marco and Miller (2018)).

We obtain data on merger activity from SDC Platinum starting in 1981 until 2010, since our sample of patents ends in this year. This dataset provides deal-level data on the acquirer and target for completed and withdrawn bids. It includes the date of the announcement, the acquirer and target names, and the premium paid for a target relative its pre-bid price. We extend these data with Compustat to study firm-level variables before and after the merger, in addition to data from CRSP to construct announcement returns.

Table 1 provides summary statistics for the sample of waves and acquirers from 1980-2009. Panel A details merger and patent wave activity, in addition to neoclassical determinants of merger waves. This unit of observation for this sample is an industry-year. We find that the

frequency of merger waves is about 5.2%. The likelihood of a patent wave due to term expirations is 7.6%, while the probability of a wave based on either a term expiration or maintenance fee is 7.9%. The remaining variables in this panel are previously-studied neoclassical determinants of merger activity.

Panel B provides a summary of acquirer characteristics. We report that the average *Cumulative Abnormal Return* (CAR) is 90 and 70 basis points for one day before the event to three days after and for one day before the event to the following five days, respectively. The *1-day Premium* for a publicly-traded target is 33.0%, which increases to 39.5% and 47.0% for a week and four weeks following a bid, respectively. The next set of variables details the change in profitability, expenses, cash holdings and investment opportunities. This will allow us to study differences in acquirer characteristics in patent waves relative to those outside of patent waves, both before and after an acquisition.

4. Merger Waves and Innovation Cycles

This section studies the link between cycles of innovative activity and merger waves. Section 4.1 documents the construction of patent waves and merger waves. Section 4.2 examines the relation between clustering in merger activity and the concurrent expiration of patents. Section 4.3 evaluated heterogeneity in patenting intensity. Section 4.4 explores the relation of patent waves to macroeconomic conditions.

4.1 Waves of Mergers and Patent Expirations

Merger activity at the industry level often clusters in time (Mitchell and Mulherin (1996)). To identify whether clustering in merger is a wave, we follow Harford (2005), which builds on Mitchell and Mulherin (1996). We use data on merger and tender-off bids from SDC Platinum

from 1981 to 2010, where the end year is determined based on the last full decade of data available. A wave is designated as a 24-month period. We calculate the highest 24-month concentration of merger bids by industry and decade. An industry is defined using the Fama-French 49-industry classification. A merger wave is defined to occur when this concentration is higher than the 95th percentile of a simulated uniform distribution of all mergers in an industry occurring in a particular decade.

We form waves for patent expirations using the same methodology as for merger waves. Most of our analysis focuses on the term expirations of patents, which occurs when the life of a patent expires. This type of patent wave is referred to as a *Patent Expiration Wave*, and accounts for patent term adjustments and remove patents that expire based on maintenance. In robustness tests, we separately define patent waves based on expirations due to non-payment of maintenance fees, which we denote as *Patent Maintenance Fee Wave*. Additionally, we refer to *Combined Patent Wave* as when a patent expires based on its term or due to maintenance fees. To correspond with patent waves and based on data availability, we focus on patent expirations from 1981 to 2010.

Table 2 presents the number of patent expiration waves due to a patent's term expiration and merger waves by decade. We identify a total of 111 patent expiration waves, which are relatively equally spread across the decades 1980-1989, 1990-1999, and 2000-2009. We find that the average number of patent term expirations occurring during a year in a patent expiration wave is 453, while the average count of expirations in a year drops to 341 outside of these waves. Similar to Harford (2005), we identify a total of 77 merger waves, with an increase in merger wave activity during the 1990-1999 decade. About 73 acquisitions occur in the average year of a merger wave, and only 24 deals are completed on average outside of these waves.

While waves of expiring patents and merger activity occur throughout each decade in our sample, it is not ex-ante obvious whether there is a relation between clustering in these patent expirations and merger deals. We now turn to studying this question.

4.2 Do Patent Waves Predict Merger Waves?

The neoclassical hypothesis suggests that economic, regulatory and technological shocks underlie clustering in mergers by industry. In this paper, we focus specifically on a particular type of technological shock: the simultaneous expiration of patents within a certain industry.

First, we examine univariate evidence from logit regressions on the relation between industry merger waves and patent expiration waves. The unit of analysis is an industry-year. The dependent variable is an indicator that equals one if an industry-year is inside a merger wave and zero for industry-years outside merger waves. *Lagged Patent Expiration Wave* is defined as an indicator variable equaling one if a patent wave based on term expirations occurred in the previous year. Similarly, *Lagged Patent Maintenance Fee Wave* is a binary variable equaling one if a patent wave happened because of the non-payment of maintenance fees. Lastly, *Lagged Combined Patent Wave* is an indicator variable equaling one if a patent wave occurred because of either term expirations or maintenance fees.

Table 3 provides the univariate relation between patent waves and merger waves. Column 1 reports that the likelihood of a merger wave increases by 4.4% following patent term expiration waves. This relation is highly statistically significant at the 1 percent level. Since the likelihood of a merger wave in our sample is 5.2%, this finding is also highly economically significant. In contrast, Column 2 suggests that expiration waves based on maintenance fees do not predict merger waves. A possible explanation is that choosing not to pay the maintenance fee

implies that the firm views the patent as technically or economically obsolete. Since the patent could have become obsolete at any time since the last maintenance fee payment, concentration in maintenance fee expirations do not have the same implications for industry conditions as term expirations. When we combine expirations based on a patent's term and those due to non-payment of maintenance fees, we do not find a significant association with merger waves, which is reported in Column 3.

Next, the literature suggests that merger waves are a consequence of shocks to an industry's economic, technological or regulatory environment. To account for previously studied explanations of merger wave activity, we include common determinants of merger waves, based on Harford (2005), and include the following variables. *Market-to-Book* is the median industry ratio by year. *Returns* is the median return in an industry for the three previous years, and *SD(Returns)* in the standard deviation of this return. *Rate Spread* is Moody's Seasoned Baa Corporate Bond Yield relative to the yield on the 10-Year Treasury Constant Maturity. *Economic Shock Index* is the first principal component of the seven shock variables in Harford (2005), which are defined as net income relative to sales, asset turnover, R&D, capital expenditures, employee growth, ROA and sales growth. *Tight Capital* is an indicator variable equaling one when the *Rate Spread* is above its median value, and proxies for times of low liquidity.

Table 4 repeats the specification in Table 3 and additionally includes neoclassical determinants of merger waves. Column 1 reports that a patent expiration wave tends to increase the likelihood of a merger wave by 4.6%, which is a slight increase compared to the univariate estimate of 4.4%. Column 2 provides the estimate for patent waves originating from failure to pay maintenance fees, and finds that the estimate remains statistically insignificant and economically small. Further, Column 3 reports that *Combined Patent Wave* does not relate to

industry-level merger activity. Taken together, we find that patent waves based on term expirations are an important determinant of merger waves. Subsequently, we will focus on this type of patent wave for the rest of the paper.

We conclude this subsection by studying the dynamic effect of waves in patent term expirations. To examine the lag structure of patent expiration waves, we include indicators for the 1- to 4-years lags of these waves. Table 5 reports the coefficients for these specifications. Column 1 examines the relation between merger waves and the preceding four years of patent expiration waves. We find that patent expiration waves in the prior year continue to be a significant predictor of merger waves in the following year. We do not find evidence that IP waves in the two to four preceding years are related to clustering in industry mergers. Further, we incorporate neoclassical determinants of merger waves in Column 2, and find that patent expiration waves are 4.5% more likely to be followed by merger waves in the following year. This effect is strikingly similar to those reported in Tables 3 and 4, and is highly statistically significant at the 5% level or better.

4.3 Patenting Intensity

There is substantial heterogeneity across industries in patenting activity. While some industries such as electronic equipment produce many patents, other industries such as real estate generate relatively few patents. We predict that patent waves are more likely to initiate merger waves in industries where patenting plays a larger role. To test this hypothesis, we define high patenting industries as those with aggregate patenting activity in the top quartile of the distribution. The remaining industries are classified as low patenting.

Panel A of Table 6 reports the difference between industries based on patenting intensity. Column 1 finds that the likelihood of a merger increases by 6.0% following a patent wave based

on term expirations in high patenting industries. The likelihood is just 3.6% for industries with low patenting activity, which is nearly 40% lower relative to the estimate in Column 1. We find quantitatively similar estimates when we include the neoclassical determinants of merger wave activity in Columns 3 and 4. Taken together, this supports the hypothesis that IP waves of term expirations are an important driver of merger activity in industries with higher patenting activity.

4.4 Macroeconomic Conditions

Reallocation of assets through mergers is facilitated through capital liquidity. Intuitively, mergers are relatively large economic activities that reconstitute the boundaries of a firm. These activities are costly and rely on relatively low transaction costs to produce a sufficient number of transactions, resulting in clustering at the industry level. Previous studies suggest that merger activity is curtailed during times of low capital liquidity (Harford (2005)). We study the role of capital liquidity on the likelihood of a merger wave being preceded by patent wave.

Panel B of Table 6 reports estimates on the relation between patent waves and merger waves during times of tight capital liquidity. We include an interaction term of lagged patent expiration waves and tight capital, as defined in Section 4.2. Column 1 finds that merger waves are 11.5% less likely to follow patent waves when capital liquidity is low, while the average likelihood that a merger wave follows a patent wave is 9.2%. Column 2 reports quantitatively similar estimates when including neoclassical determinants of merger waves. Taken together, we find strong evidence that capital liquidity is a necessary condition for a patent wave to trigger a merger wave.

5. Deals and Acquirers During Patent Waves

This section examines how merger deals completed during patent waves and acquiring firms differ from those outside of patent waves. Section 5.1 studies deal-level characteristics. Section 5.2 analyzes firm characteristics before and after acquiring a target.

5.1 Deal Characteristics

The findings above focused on the role of clustering in industry-level patent expirations on merger waves within an industry. Next, we turn to deal-level characteristics. We narrow our sample to those deals consummated within a merger wave. This allows us to understand how variation in whether a patent expiration wave precedes a merger wave relates to announcement returns and premiums paid by acquirers for target firms.

A large literature on merger activity documents negative average returns for acquirers, with positive and relatively larger returns for targets. Using a market model, we construct expected returns around the announcement of a completed merger. We form cumulative abnormal returns (CARs) by subtracting the expected return from the realized return. CARs are estimated using an event window of one day before the announcement of a merger until three days after the event, and from one day before to five days after the merger announcement.

Table 7 reports the CARs for acquirers and targets for deals occurring in merger waves, and studies how announcement returns relate to patent expiration waves. Column 1 finds that CARs for one day before to three days after a merger announcement are -60 basis points in patent expiration waves, but this effect is not statistically significant. Column 2 reports that CARs for acquirers are, on average, 110 basis points lower during IP merger waves, relative to mergers occurring in other merger waves. This effect is significant at the 5% level. Columns 3

and 4 show that the average CAR for a target during a patent expiration wave is 6.5% to 6.6% higher. These estimates are statistically significant and economically large. This evidence suggests that acquirers pay relatively more for targets in IP merger waves.

Next, we study premiums for targets during patent expiration waves. Using data provided by SDC Platinum, we measure *1-day Premium* as a deal's offer price relative to the target's stock price 1-day before the announcement. *1-week Premium* and *4-week Premium* are defined similarly, and relative to the stock price one week and four weeks before the announcement, respectively. These measures allow us to examine if acquirers pay relatively differentially for targets purchased during patent expiration waves.

Table 8 reports our findings on deal premiums. Column 1 examines the difference in 1-day premium for IP waves. We find that acquirers pay about 8.2% more for targets during IP merger waves, relative to deals occurring in merger waves and not during an IP wave. This effect is statistically significant at the 5% level and a 24.8% increase relative to the sample mean. Column 2 and 3 increase the relative stock price in the premium measure to 1-week and 4-weeks before the deal announcement. We find that the estimates increase for both the 1-week and 4-week premiums to 11.5% and 16.2%. Taken together, these findings suggest that acquirers expend more capital on targets during IP merger waves, either because their value is higher, or because of stronger competition in the acquisition market during IP merger waves.

5.2 Firm Characteristics Around Deals

The final set of analyses seeks to understand firm-level characteristics around merger deals. As a firm's portfolio of patents is approaching expiration, it might be experiencing declining profitability and depleting its cash reserves, while cutting expenses to mitigate the effect of the

approaching expirations. We continue to focus on deals occurring in waves and study differential effects for IP merger waves. For each variable of interest, we use the difference between the current value and the preceding year's value. By using first-differences, we remove unobserved firm heterogeneity, similar to including a firm fixed effect.

Table 9 examines pre-merger characteristics for firms just prior to announcing a merger. Column 1 reports that acquirer profit margins decline by 13.4%, which is statistically significant at the 1% level and economically large compared to the sample mean of -5.1%. Column 2 finds that acquirers are reducing costs by 1% relative to their assets. This is a 45.5% decrease relative to the sample average. Profitability is also declining at acquiring firms by 5.6% (Column 3) and cash reserves are being depleted by 4% compared to the previous year (Column 4). Both effects are highly statistically significant and economically meaningful. Lastly, Column 5 reports that investment opportunities, as measured by an acquirer's market-to-book ratio, drops by 1.0 during an IP merger wave. This is a decline of nearly 50% compared to the sample mean of market-to-book. Overall, we find that acquirers are experiencing deteriorating financial conditions and seek to stave off the upcoming expiration of patents.

Lastly, we examine how acquiring firms perform after completing a merger. Table 9 highlights that, on average, acquirers' performance is deteriorating. Given that these deals are completed at higher premiums and are met with lower announcement returns, this evidence is consistent with the conclusion that acquisitions in IP merger waves are an attempt to externally replace the expiring IP, as the examples in the introduction illustrate.

Table 10 studies the post-deal performance and investment opportunities of acquiring firms after completing mergers. Column 1 reports the difference between return on assets (ROA) one year following a deal relative to the current year. We find that profitability drops by 8.5% for

those deals occurring in patent expiration waves relative to deals in merger waves and outside of patent waves. Column 2 expands the window for ROA in the following two years, and finds that profitability declines by 2.6%. Both estimates of post-deal profitability are statistically significant and economically large. Columns 3 and 4 examine the following investment opportunities for acquirers, as proxied by the market-to-book ratio. We find that this measure drops by 0.4 and 0.5 in the one year and two years after a merger, respectively.

Overall, this poor performance suggests that the market's assessment at merger announcement, reflected in the CAR, was correct. Further, combined with the pre-merger performance, these results suggest that the acquisition was made in an unsuccessful attempt to stem the deteriorating performance. Nevertheless, the counterfactual is inherently unobservable, so it is possible that the acquiring firm's performance would have been even worse absent the acquisition.

6. Conclusion

This paper studies the role of innovative activity in the clustering of merger activity, often called merger waves. We find evidence that waves of patent expirations can set off industry merger waves. The deals in IP merger waves notably differ from those occurring in other merger waves. We report that these deals tend to have lower announcement returns and higher target premiums, and are followed by declines in the performance and investment opportunities for acquirers. Further, we find that acquirers in IP merger waves experience declining profit margins, profitability and cash holdings, as they simultaneously cut costs to mitigate the impact of the approaching patent expirations. Taken together, we offer novel evidence on the role of patenting activity, and in particular their expirations, as a determinant of mergers and their clustering within an industry.

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Table 1
Summary Statistics

This table reports summary statistics for patent and merger waves, and their determinants. Panel A summarizes patent expiration and merger wave variables, and Panel B describes acquirer characteristics. Patent expiration waves are based on the term expiration of a patent, accounting for patent term adjustments and removing patents that expire based of maintenance fees. Patent maintenance fee waves are based on patents expiring because of a failure to pay its dues. Combined patent waves include both patents expiring based on term expirations and from lapses in maintenance fees. Patent and merger wave activity occurs between 1980 and 2009, and the related wave variable is an indicator equaling one if a wave occurs in a particular year. Industries are based on the Fama-French 49-industry classification. Each measure of patent waves is lagged by one year. *Patent expiration wave*, *Patent maintenance fee wave*, *Combined patent wave*, and *Merger wave* are determined using the methodology of Harford (2005). *Market-to-Book* is the median industry ratio by year, *Returns* is the median return in an industry for the three previous years, *SD(Returns)* in the standard deviation of this return, *Rate Spread* is Moody's Seasoned Baa Corporate Bond Yield relative to the yield on the 10-Year Treasury Constant Maturity, *Economic Shock Index* is the first principal component of the seven shock variables in Harford (2005) and *Tight Capital* is an indicator variable equaling one when the *Rate Spread* is above its median value. *Cumulative abnormal returns* (CAR) are constructed by subtracting the expected return based on a market model from the realized return. CARs are estimated using an event window of one day before the announcement of a merger until three days after the event, and from one day before the announcement to five days after the event. *1-day Premium* is the deal's offer price relative to the target's stock price 1-day before the announcement (in percentage points). *1-week Premium* and *4-week Premium* are defined similarly, and relative to the stock price one week and four weeks before the announcement, respectively. Acquirer characteristics are defined in Tables 9 and 10.

Panel A: Patent Expiration and Merger Waves

	Number of observations	Mean	Median	Standard deviation
Merger wave	1,470	0.052	0.000	0.223
Patent expiration wave	1,470	0.076	0.000	0.264
Patent maintenance fee wave	1,470	0.076	0.000	0.264
Combined patent wave	1,470	0.079	0.000	0.270
Market-to-Book	1,470	1.711	1.565	0.824
Returns	1,470	0.281	0.234	0.484
SD(Returns)	1,470	0.211	0.182	0.139
Rate Spread	1,470	2.234	2.074	0.630
Economic Shock Index	1,470	0.296	-0.076	1.479
Economic Shock Index X Tight Capital	1,470	0.198	0.000	1.166

Table 1 (continued)
Panel B: Acquirer Characteristics

	Number of observations	Mean	Median	Standard deviation
CAR[-1,3]	2,942	0.009	0.004	0.103
CAR[-1,5]	2,942	0.007	0.002	0.119
1-day Premium	547	32.980	27.78	31.029
1-week Premium	547	39.496	33.160	35.537
4-week Premium	542	46.986	38.095	41.083
ΔProfit Margins(t-1,t)	2,843	-0.051	-0.006	0.379
ΔSG&A(t-1,t)	2,237	-0.022	-0.006	0.095
ΔROA(t-1,t)	2,845	-0.024	-0.006	0.126
ΔCash(t-1,t)	2,840	-0.043	-0.011	0.119
ΔMarket-to-book(t-1,t)	2,832	-0.381	-0.072	1.559
ΔROA(t,t+1)	2,623	-0.045	-0.003	0.185
ΔROA(t,t+2)	2,369	-0.052	-0.006	0.202
ΔMarket-to-book(t,t+1)	2,609	-0.362	-0.095	1.173
ΔMarket-to-book(t,t+2)	2,355	-0.530	-0.167	1.488

Table 2

Patent Expiration and Merger Waves

This table lists patent and merger wave activity from 1980 to 2009. Patent expiration waves are based on the term expiration of a patent, accounting for patent term adjustments and removing patents that expire based on maintenance fees. *Patent expiration waves* and *Merger waves* are determined using the methodology of Harford (2005).

Decade	Patent Expiration Waves	Merger Waves	Total
1980-1989	42	21	63
1990-1999	34	36	70
2000-2009	35	20	55
Total	111	77	

Table 3

Do Innovation Cycles Waves Predict Merger Waves? Univariate Evidence

This table examines whether innovation cycles are related to merger waves. *Patent expiration wave* is based on the term expiration of a patent, accounting for patent term adjustments and removing patent that expire based of maintenance fees. *Patent maintenance fee wave* is based on patents expiring because of a failure to pay its dues. *Combined patent wave* includes both patents expiring based on term expirations and from lapses in maintenance fees. Patent and merger wave activity occurs between 1980 and 2009, and the related wave variable is an indicator equaling one if a wave occurs in a particular year. Waves are based on the Fama-French 49-industry classification. Each measure of patent waves is lagged by one year. *Patent expiration wave*, *Patent maintenance fee wave*, *Combined patent wave*, and *Merger wave* are determined using the methodology of Harford (2005). All models are logit specifications and include an intercept term. The coefficients reported are the average marginal effects. Robust standard errors are reported in parentheses. ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

Dependent variable	Merger Wave	Merger Wave	Merger Wave
Model	(1)	(2)	(3)
Lagged Patent Expiration Wave	0.044***		
	(0.017)		
Lagged Patent Maintenance Fee Wave		0.011	
		(0.020)	
Lagged Combined Patent Wave			0.016
			(0.019)
Observations	1,470	1,470	1,470
Pseudo-R2	0.010	0.000	0.001

Table 4

Multivariate Evidence

This table studies whether innovation cycles are related to merger waves, and incorporates common determinants of merger activity. *Patent expiration wave* is based on the term expiration of a patent, accounting for patent term adjustments and removing patents that expire based of maintenance fees. *Patent maintenance fee wave* is based on patents expiring because of a failure to pay its dues. *Combined patent wave* includes both patents expiring based on term expirations and from lapses in maintenance fees. Patent and merger wave activity occurs between 1980 and 2009, and the related wave variable is an indicator equaling one if a wave occurs in a particular year. Industries are based on the Fama-French 49-industry classification. Each measure of patent waves is lagged by one year. *Patent expiration wave*, *Patent maintenance fee wave*, *Combined patent wave*, and *Merger wave* are determined using the methodology of Harford (2005). *Market-to-Book* is the median industry ratio by year, *Returns* is the median return in an industry for the three previous years, *SD(Returns)* in the standard deviation of this return, *Rate Spread* is Moody's Seasoned Baa Corporate Bond Yield relative to the yield on the 10-Year Treasury Constant Maturity, *Economic Shock Index* is the first principal component of the seven shock variables in Harford (2005) and *Tight Capital* is an indicator variable equaling one when the *Rate Spread* is above its median value. All models are logit specifications and include an intercept term. The coefficients reported are the average marginal effects for the wave variables. Robust standard errors are reported in parentheses. ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

Dependent variable	Merger Wave	Merger Wave	Merger Wave
Model	(1)	(2)	(3)
Lagged Patent Expiration Wave	0.046***		
	(0.016)		
Lagged Patent Maintenance Fee Wave		0.003	
		(0.021)	
Lagged Combined Patent Wave			0.014
			(0.019)
Market-to-Book	0.008	0.008	0.008
	(0.005)	(0.005)	(0.005)
Returns	0.002	-0.000	0.000
	(0.011)	(0.011)	(0.011)
SD(Returns)	-0.006	-0.009	-0.008
	(0.037)	(0.038)	(0.038)
Rate Spread	-0.037***	-0.036**	-0.036***
	(0.014)	(0.014)	(0.014)
Economic Shock Index	0.001	0.001	0.001
	(0.004)	(0.005)	(0.005)
Economic Shock Index X Tight Capital	0.003	0.004	0.004
	(0.006)	(0.007)	(0.006)
Observations	1,470	1,470	1,470
Pseudo-R2	0.034	0.023	0.023

Table 5

Wave Timing

This table examines the timing of innovation cycles and its relation to merger waves. *Patent expiration wave* is based on the term expiration of a patent, accounting for patent term adjustments and removing patents that expire based of maintenance fees. Patent and merger wave activity occurs between 1980 and 2009, and the related wave variable is an indicator equaling one if a wave occurs in a particular year. Industries are based on the Fama-French 49-industry classification. *Patent expiration wave* is lagged by one year, two years, three years and four years. *Patent expiration wave* and *Merger wave* are determined using the methodology of Harford (2005). The controls are the determinants of merger waves in Table 4. All models are logit specifications and include an intercept term. The coefficients reported are the average marginal effects. Robust standard errors are reported in parentheses. ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

Dependent variable	Merger Wave	Merger Wave
Model	(1)	(2)
Lagged 1-year Patent Term Wave	0.042**	0.045***
	(0.017)	(0.017)
Lagged 2-year Patent Term Wave	-0.006	-0.005
	(0.022)	(0.022)
Lagged 3-year Patent Term Wave	-0.028	-0.025
	(0.026)	(0.026)
Lagged 4-year Patent Term Wave	0.002	0.008
	(0.020)	(0.020)
Observations	1,470	1,470
Controls	No	Yes
Pseudo-R2	0.0122	0.036

Table 6

Patent Waves Heterogeneity

This table studies heterogeneity in patent waves. Panel A examines variation in patenting intensity, and Panel B explores the importance of macroeconomic conditions in facilitating patent expiration waves. *Patent expiration wave* is based on the term expiration of a patent, accounting for patent term adjustments and removing patents that expire based of maintenance fees. Patent and merger wave activity occurs between 1980 and 2009, and the related wave variable is an indicator equaling one if a wave occurs in a particular year. Industries are based on the Fama-French 49-industry classification. Each measure of patent waves is lagged by one year. High patenting intensity is based on industries with the top quantile of patenting activity, and low patenting intensity is defined as the remain *Patent expiration wave*, *Patent maintenance fee wave*, *Combined patent wave*, and *Merger wave* are determined using the methodology of Harford (2005). *Market-to-Book* is the median industry ratio by year, *Returns* is the median return in an industry for the three previous years, *SD(Returns)* in the standard deviation of this return, *Rate Spread* is Moody's Seasoned Baa Corporate Bond Yield relative to the yield on the 10-Year Treasury Constant Maturity, *Economic Shock Index* is the first principal component of the seven shock variables in Harford (2005) and *Tight Capital* is an indicator variable equaling one when the *Rate Spread* is above its median value. All models are logit specifications and include an intercept term. The coefficients reported are the average marginal effects for the wave variables. Robust standard errors are reported in parentheses. ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

Panel A: Patenting Intensity

Dependent variable	Merger Wave	Merger Wave	Merger Wave	Merger Wave
Patent Intensity	High Patenting	Low Patenting	High Patenting	Low Patenting
Model	(1)	(2)	(3)	(4)
Lagged Patent Expiration Wave	0.060*	0.036*	0.061*	0.039**
	(0.035)	(0.019)	(0.033)	(0.019)
Market-to-Book			0.043*	0.001
			(0.024)	(0.007)
Returns			-0.020	0.004
			(0.035)	(0.012)
SD(Returns)			0.018	-0.030
			(0.081)	(0.050)
Rate Spread			-0.039	-0.035**
			(0.029)	(0.016)
Economic Shock Index			-0.011	0.002
			(0.010)	(0.007)
Economic Shock Index			0.007	0.001
X Tight Capital			(0.010)	(0.011)
Observations	360	1,110	360	1,110
Pseudo-R2	0.014	0.007	0.056	0.029

Table 6 (continued)
Panel B: Macroeconomic Conditions

Dependent Variable		
Model	(1)	(2)
Lagged Patent Expiration Wave	0.092***	0.089***
	(0.020)	(0.019)
Lagged Patent Expiration Wave	-0.115***	-0.110***
X Tight Capital	(0.040)	(0.039)
Market-to-Book		0.005
		(0.005)
Returns		0.004
		(0.011)
SD(Returns)		-0.013
		(0.037)
Rate Spread		-0.032**
		(0.013)
Economic Shock Index		0.001
		(0.004)
Economic Shock Index		0.005
X Tight Capital		(0.006)
Observations	1,470	1,470
R-squared	0.036	0.054

Table 7
Announcement Returns

This table examines announcement returns for deals occurring during merger waves from 1980 to 2009 for acquirers and targets. *Patent expiration wave* is based on the term expiration of a patent, accounting for patent term adjustments and removing patents that expire based of maintenance fees. *Patent expiration wave* and *Merger wave* are determined on the methodology of Harford (2005). *Cumulative abnormal returns* (CAR) are constructed by summing abnormal returns, which are formed by subtracting the expected return based on a market model from the realized return, in the event window. CARs are estimated using an event window of one day before the announcement of a merger until three days after the event, and from one day before the announcement to five days after the event. ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

	Acquirer		Target	
Dependent Variable	CAR	CAR	CAR	CAR
Model	(1)	(2)	(3)	(4)
Patent Expiration Wave	-0.006	-0.011**	0.066***	0.065***
	(0.005)	(0.005)	(0.018)	(0.018)
Constant	0.010***	0.009***	0.174***	0.170***
	(0.002)	(0.002)	(0.008)	(0.008)
Observations	2,914	2,914	1,311	1,311
Event window	[-1,3]	[-1,5]	[-1,3]	[-1,5]
R-squared	0.001	0.002	0.011	0.010

Table 8

Deal Premiums

This table explores the relation between deal premiums paid by acquirers and patent expirations waves. The sample includes deals occurring in merger waves from 1980 to 2009. *Patent expiration wave* is based on the term expiration of a patent, accounting for patent term adjustments and removing patents that expire based of maintenance fees. *Patent expiration wave* and *Merger wave* are determined on the methodology of Harford (2005). *1-day Premium* is the deal's offer price relative to the target's stock price 1-day before the announcement (in percentage points). *1-week Premium* and *4-week Premium* are defined similarly, and relative to the stock price one week and four weeks before the announcement, respectively. ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

Dependent variable	1-day Premium	1-week Premium	4-week Premium
Model	(1)	(2)	(3)
Patent Expiration Wave	8.176**	11.508***	16.234***
	(3.199)	(3.653)	(4.209)
Constant	31.230***	37.028***	43.384***
	(1.492)	(1.703)	(1.973)
Observations	547	547	542
R-squared	0.012	0.018	0.027

Table 9
Pre-Merger Acquirer Characteristics

This table studies an acquirer's characteristics prior to a merger in a patent expiration wave. The sample includes deals occurring in merger waves from 1980 to 2009. *Patent expiration wave* is based on the term expiration of a patent, accounting for patent term adjustments and removing patents that expire based of maintenance fees. *Patent expiration wave* and *Merger wave* are determined on the methodology of Harford (2005). *ΔProfit Margins* is the difference in net income relative to assets from year t-1 to t, *ΔSG&A* is the difference in selling, general and administrative expenses relative to assets from year t-1 to t, *ΔROA* is the difference in profitability from year t-1 to t, *ΔCash* is the difference in cash and short-term investments relative to assets from year t-1 to t, and *ΔMarket-to-book* is the difference in the market value of equity and book value of debt relative to the book value of the firm from year t-1 to t. All variables are winsorized at the 1% level in each tail. ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

Dependent Variable	ΔProfit Margins	ΔSG&A	ΔROA	ΔCash	ΔMarket-to-book
Model	(1)	(2)	(3)	(4)	(5)
Patent Expiration Wave	-0.134***	-0.010***	-0.056***	-0.040***	-1.015***
	(0.017)	(0.004)	(0.006)	(0.005)	(0.069)
Observations	2,822	2,832	2,827	2,827	2,832
R-squared	0.021	0.003	0.034	0.019	0.071

Table 10

Long-term Operating Performance and Investment Opportunities

This table examines the long-term operating performance and investment opportunities of an acquirer in a patent expiration wave. The sample includes deals occurring in merger waves from 1980 to 2009. *Patent expiration wave* is based on the term expiration of a patent, accounting for patent term adjustments and removing patents that expire based of maintenance fees. *Patent expiration wave* and *Merger wave* are determined on the methodology of Harford (2005). *ΔROA(t,t+1)* is the difference in profitability from year t to t+1, *ΔROA(t,t+2)* is the difference in profitability from year t to t+2, *ΔMarket-to-book(t,t+1)* is the difference in the market value of equity and book value of debt relative to the book value of the firm from year t to t+1, and *ΔMarket-to-book(t,t+2)* is the difference in the market-to-book ratio from year t to t+2. All variables are winsorized at the 1% level in each tail. ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

Dependent Variable	ΔROA(t,t+1)	ΔROA(t,t+2)	ΔMarket-to-book(t,t+1)	ΔMarket-to-book(t,t+2)
Model	(1)	(2)	(3)	(4)
Patent Expiration	-0.085***	-0.026***	-0.435***	-0.458***
Wave	(0.009)	(0.010)	(0.056)	(0.074)
Observations	2,623	2,369	2,609	2,355
R-squared	0.034	0.003	0.023	0.016