Mergers and Sequential Innovation: Evidence from Patent Citations *

Jessica Calfee Stahl

Board of Governors of the Federal Reserve System

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Abstract

An extensive literature has investigated the effect of market structure on innovation. A persistent concern is that market structure may be endogenous to innovation. Firms may choose to merge so as to capture information spillovers or they may choose to merge so as to dampen competition in innovation. These two scenarios have very different welfare implications. This paper attempts to distinguish between the two scenarios empirically, looking at recent mergers among public companies in the United States. Using patent citation data, I find evidence that firms increase their rate of sequential innovation in the years preceding a merger, and reduce their rate of sequential innovation in the years following a merger. This suggests that mergers are motivated more by the desire to dampen competition than by the desire to capture information spillovers. I use citation-based measures of patent value to shed light on the welfare implications. The question is relevant for policy, as the FTC and DOJ frequently cite innovation as a reason for concern about a merger. JEL codes: L1, L4, O3.

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1 Introduction

An extensive literature has investigated the effect of market structure on innovation. However, a persistent concern is that market structure may be endogenous to innovation. This paper focuses on the relationship between innovation and merger decisions, acknowledging that causality may run in both directions. Firms may choose to merge so as to capture information spillovers and enhance the returns to innovation. On the other hand, firms may choose to merge so as to dampen competition in innovation. These two scenarios have very different welfare implications. This paper attempts to distinguish between the two scenarios empirically, looking at recent mergers among public companies in the United States.

Innovation is an important driver of economic growth, but there is considerable disagreement over what circumstances give firms the greatest incentive to innovate. Schumpeter (1934) and Schumpeter (1942) suggested that large firms operating in a less competitive environment might provide a better platform for innovation than small, competitive firms, due to economies of scale and a better ability to absorb the risk associated with large R&D expenditures. Since then the competition-innovation debate has been lively.

Mergers within an industry lead to larger, less competitive firms. Thus in order to better understand the connection between competition and innovation, it is useful to study the implications of mergers for innovation. Gilbert (2006) notes that out of 109 mergers that were challenged by the Department of Justice and Federal Trade Commission between 2001 and 2003, innovation was mentioned in a full 41 cases as a reason for the challenge. This is particularly striking given that many of the mergers for which innovation was not mentioned as a concern were in industries with little or no research and development. With the DOJ and FTC clearly concerned about the effect of mergers on innovation, the question has obvious policy relevance.

Innovation incentives attract attention from policy makers in part because positive externatilities associated with innovation can lead to a sub-optimal level of innovation. That is, when a firm chooses to make an R&D investment, the firm is motivated by the direct benefits that the potential innovation might reap for the firm. Yet the innovation might also provide information that inspires or enables future sequential innovations. The original innovating firm might not plan on capitalizing on this information; thus it might not include this information in its expected return. A merger might improve innovation incentives if it allows the firms involved to capture the information spillovers associated with innovation. Yet the merger might reduce innovation incentives; the firms are no longer in competition, so they no longer have an incentive to steal the profits the other firm is gaining from innovation.

However, changes in innovation activity before or after a merger do not necessarily suggest a relationship between merger and innovation decisions. Both mergers and innovation may be simultaneously driven by other factors, notably firm performance. My empirical strategy attempts to avoid this omitted variable bias by controlling for overall innovation activity and focusing on sequential innovation that takes place within merging pairs of firms. Sequential innovation refers to the process whereby innovation A is built upon by innovation B, which is in turn built upon by innovation C, and so on. I look at sequential innovation across pairs of firms in the years before and after they merge. This enables me to look at whether innovation activity influences merger decisions, and whether firms alter their innovation activity after they merge.

I use patent counts to control for innovation activity, and patent citations to trace paths of sequential innovation within and across firms. I undertake a comprehensive match of recent mergers in the US to the patent database; patent data are from the NBER (Hall et al 2001) and merger data are from the Securities Data Company (SDC). I observe every patent's citations to other patents, which the patent office is responsible for listing. For each pair of merging firms, I define an internal citation as any citation from one firm to itself or to its merging partner. The goal is to look at the number of internal citations made by pairs of firms before and after they merge, controlling for total patent and citation counts. I use the fixed-effects Poisson model (Hausman et al., 1984), allowing for unobserved heterogeneity across firms and mergers.

I find that, across a variety of industries, internal citations increase in the years leading up to a merger, then decline in the years following a merger. The pre-merger increase suggests that innovation activity does indeed affect merger decisions; firms may choose to merge partly because they find themselves increasingly building upon one another's innovations. However, the post-merger decline suggests that mergers are motivated more by the desire to dampen competition than by the desire to capture information spillovers.

This result would seem to have negative welfare implications. However, it is possible that pre-merger patenting is excessive due to competition, and the dampening of competition allows the firms to divert resources away from patenting and towards more productive uses. If this is the case, then the post-merger reduction in internal citations could have positive welfare implications. In ongoing work, I am using citation-based measures of patent originality, generality and similarity in order to test whether post-merger patents are more valuable than pre-merger patents.

2 Related Literature

Quite a few papers have looked at the relationship between innovation and, alternatively, competition, market structure or firm size. Gilbert (2006) gives an excellent review of this literature. Most of these studies have used some measure of R&D expenditures as the outcome variable, though a few have looked at patent counts. Culbertson and Mueller (1985) and Lunn (1986) find weak evidence of a positive correlation between innovation and both firm size and market concentration. A major advantage of patent data is that we can use citation data to trace the evolution of innovative activity. My focus on sequential innovation, and on the trade-off between the internalization of information spillovers versus the dampening of competition, exploits this feature of the patent data.

Belenzon (2006) develops a model that shows that the more firms are able to internalize the information spillovers associated with innovation, the greater will be their incentive to innovate. He treats the internalization of spillovers as exogenous, and looks at how this affects the R&D and market value of the firm. In this paper I consider the possibility that mergers affect the internalization of spillovers and therefore affect innovation incentives. But while mergers may enable firms to internalize spillovers associated with innovation, they may also dampen competition in the innovation market. This paper estimates the net effect of mergers on sequential innovation in recent history, acknowledging that innovation incentives may themselves affect merger decisions.

3 Data

Merger data are from the Securities Data Company (SDC). They include every merger between publicly held companies in the United States from 1980 to the present. The patent data are from the NBER patent database (Hall et al., 2001). The link between the two datasets is the CUSIP number assigned to publicly issued securities by Standard & Poor's Compustat. SDC lists a CUSIP number for each firm in the merger dataset. Patent assignees have been matched to a CUSIP number through a name standardization program.[1] Citation and assignee data are available for patents that were granted from 1976 to the present. In estimation, I use the patent's application date rather than the grant date; this is presumably closer to the date when the actual innovation took place. It typically takes one to three years for a patent to be granted once the application reaches the patent office. Thus the application dates span from 1974 to 2005. Merger data are cut off after 2003 to allow us to observe two years of patent activity after the merger takes place. I am able to identify 864 mergers in which both firms involved have at least one patent.[2] These mergers involve 562 firms; some firms are involved in multiple mergers.

When patent A cites patent B, I take this as evidence that patent A in some way built upon patent B's innovation. I want to find out whether,

[1]This is a very involved process. For example, IBM patents might be assigned to "IBM," "I.B.M.," "Intl Business Machines," "International Business Machines," etc. A match of patent assignees was originally done to the 1999 universe of companies. The NBER Patent Dataset Project has nearly completed a match to the current universe of companies (due mainly to work by Bronwyn Hall, Iain Cockburn, Megan MacGarvie and Jim Bessen). It is the latter match that I use.

[2]As far as I know, this is the first paper to undertake a comprehensive match of all recent mergers in the United States to the patent database.

when two firms merge, they begin to build upon one another's innovations more than previously. Looking at a particular merger between firm i and firm j, the question then becomes: do firm i's (j's) patents cite firm j's (i's) patents more frequently after the merger than they did before the merger? However, the target in the merger often (but not always) ceases to exist after the merger, so that we are often left with only firm i or j in the patent database. In order to deal with this, I identify all citations made by either firm involved in a merger as either "internal" or not. An internal citation is a citation made to either firm i or j. That is, the following are internal cites: i cites i, j cites j, i cites j and j cites i. The following are non-internal: i cites someone other than i or j, j cites someone other than i or j. The question then becomes: Do internal cites made by firms i and j increase after the merger, controlling for non-internal cites made by firms i and j? Note that I cannot distinguish between the effect on the acquirer and the effect on the target.

4 Estimation

An observation is at the level of a merging pair of firms in a year. For each merger-year observation, it is either pre-merger or post-merger. I look at how the rate of internal citations varies in the pre-merger versus post-merger years.

The construction of the dataset is made more complicated by the fact that some firms are involved in multiple mergers. Suppose that firm i acquires firm j in 1980 (call this merger 1), and then this merged firm acquires firm k in 1990 (call this merger 2). If we ignored the fact that these two mergers were related, then for merger 1, we would test whether the following sum increases after 1980:

$$(i \to j) + (j \to i) + (i \to i) + (j \to j)$$

where $i \to j$ refers to i citing j, and so on. And for merger 2, we would test whether the following sum increases after 1990:

$$(i \to k) + (k \to i) + (i \to i) + (k \to k)$$

However, if we acknowledge that these are sequential mergers, then two corrections must be made. One, a jump in self-citations by firm i after 1990 is probably a result of merger 2, yet this might be incorrectly attributed to merger 1 as well. To deal with this, I cut off observations for each merger at the point when the merged firm is involved in another merger. In this example, observations for merger 1 would span from 1976 through 1989 rather than through 2004. Secondly, internal citations for merger 2 do not include only the above sum, but also $i \to j$, $j \to i$, $k \to j$, $j \to k$, and $j \to j$. Thus when we have a sequence of mergers involving the same firm(s), we have to broaden our definition of an internal citation for all but the first merger. In this example, the test for merger 2 would be whether the following sum increases after 1990:

$$(i \to k)+(k \to i)+(i \to j)+(j \to i)+(j \to k)+(k \to j)+(i \to i)+(j \to j)+(k \to k)$$

For firms involved in more than two mergers, the sum becomes even longer, but the logic is straightforward. In the dataset, the maximum number of mergers in which a single firm is involved is 17.

As mentioned, the data are annual. The dependent variable in estimation is the annual number of internal citations as discussed above. Control variables are the number of patents applied for by the merging pair of firms, the number of citations (internal and non-internal) made by those patents, the number of citations received by the merging pair of firms, as well as firm (or pair-of-firm) and year dummies. Therefore results are not driven by an overall increase in citations made by the firms, an overall increase in citations received by the firms, a time trend or any persistent unobserved heterogeneity across firms.

I begin by presenting Ordinary Least Squares results. However, the dependent variable is a count variable. Thus linear regression is not ideal because it can lead to negative predicted values. Complications arise, however, because inclusion of a large number of dummy variables (fixed effects) in a non-linear count model leads to biased coefficients. Hausman et al (1984) develop a fixed-effects Poisson model which attempts to get around this problem. Essentially, the model predicts not the number of internal citations for each merger in each year, but instead the number of internal citations for each merger-year *as a fraction of the sum of that merger's internal citations over all years*. See Hausman et al. (1984) for further explanation. I present results from both OLS and the fixed-effects Poisson.

5 Results

The dataset consists of the patent citation activity of 864 merging pairs of firms over a period of 32 years, from 1974 to 2005. Descriptive statistics are presented in Table 1. On average, these pairs of firms apply for 51 patents per year which make an average of 466 citations, receive an average of 403 citations per year and make an average of 0.24 internal citations per year. However, the data are highly skewed; the medians are much less than the means for these variables.

OLS results with year and firm fixed effects are shown in Table 2. The coefficient on the post-merger dummy is positive and statistically significant, but the magnitude is small. On average, firms cite one another 0.11 more times per year after merging. However, results vary by industry; refer to Table 3.

Estimation of the fixed-effects Poisson model leads to a different result altogether. Results are shown in Table 4. The coefficient on the post-merger dummy is negative and statistically significant, and of a greater magnitude than for OLS. On average, firms cite one another 40% less annually after merging. Fixed effects are for merging pairs of firms rather than for firms (which is more stringent). Since the fixed-effects Poisson model is predicting each merger's allocation of internal citations across the years, the merging pair of firms must have at least one internal citation in the sample period in order to be included in estimation. Only 238 of the 864 mergers made at least one internal citation in the sample period.

The sample period includes many years preceding and following most mergers. Therefore, it is not very informative to simply know the average number of internal citations in the years before the merger relative to the average number of internal citations in years after the merger. It would be interesting to see how the internal citations are allocated across years. Figure 1 reveals this. On the x-axis is the number of years since the merger took place. At zero, it is the year of the merger; at -5, it is five years before the merger; at +5, it is five years after the merger.

It appears that internal citations tend to increase in the years leading up to the merger, and begin to fall in the years following the merger. Looking at the plot, it is easy to imagine that the number of internal citations averaged across all years after the merger might be either greater or less than the number of internal citations averaged across all years before the merger, depending on the method of estimation. The year-to-year pattern is more revealing. The increase in internal citations in the years leading up the merger suggests an innovation race; the fall in internal citations in the years following the merger suggests a reduction in competition.

Interestingly, the picture is fairly similar across industries. Figure 2 is for the chemical industry, Figure 3 is the electronic equipment industry (not including computer equipment), Figure 4 is for the industrial/computer equipment industry and Figure 5 is for the (mostly medical) instruments industry.

6 Conclusion

I find that across a variety of industries, internal citations increase in the years leading up to a merger, then decline in the years following a merger. The pre-merger increase suggests that firms choose to merge partly because they find themselves increasingly building upon one anothers innovations. The post-merger decline suggests that mergers are motivated more by the desire to dampen competition than by the desire to capture information spillovers. It is possible, however, that pre-merger patenting is excessive due to competition. In ongong work, I am using citation-based measures of patent originality, generality and similarity to determine whether post-merger patents actually add more value on average than do pre-merger patents. If this is the case, then a post-merger reduction in cross-citations could actually have positive welfare implications.

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Table 1: Descriptive Statistics

Variable (Annual)	**Mean**	**Median**	**SD**
Internal Citations	0.24	0	2
Patents	51	3	190
Citations Made	466	23	1943
Citations Received	403	10	1770

Table 2: OLS Results

Post-Merger Dummy	0.11* (0.03)
Patents	0.001* (0.0002)
Citations Made	-0.00004 (0.00002)
Citations Received	-0.0001* (0.00001)
N	24,948
Number of Mergers	864
Number of Firms	562
Number of Years	32
Adjusted R^2	0.42
* Statistically Significant at 1%	

Table 3: OLS Results by Industry

Industry	Coefficient on Post-Merger Dummy
Chemicals (137 Mergers)	0.41* (0.27)
Electrical Equipment (141 Mergers)	0.04 (0.07)
Industrial & Computer Equipment (128 Mergers)	-0.13* (0.09)
Instruments, esp. Medical (125 Mergers)	0.13 (0.06)*
Transportation Equipment (61 Mergers)	-0.22* (0.09)
Paper Industry (21 Mergers)	-0.11 (0.12)

Table 4: Fixed-Effects Poisson Results

Post-Merger Dummy	-0.40* (0.03)
Patents	0.006* (0.0004)
Citations Made	-0.0004* (0.00005)
Citations Received	-0.0003* (0.00004)
N	6,943
Number of Mergers	238
Number of Years	32
Wald Chi^2	1849
* Statistically Significant at 1%	

Figure 1: Predicted Internal Citations as a Function of Years Since Merger

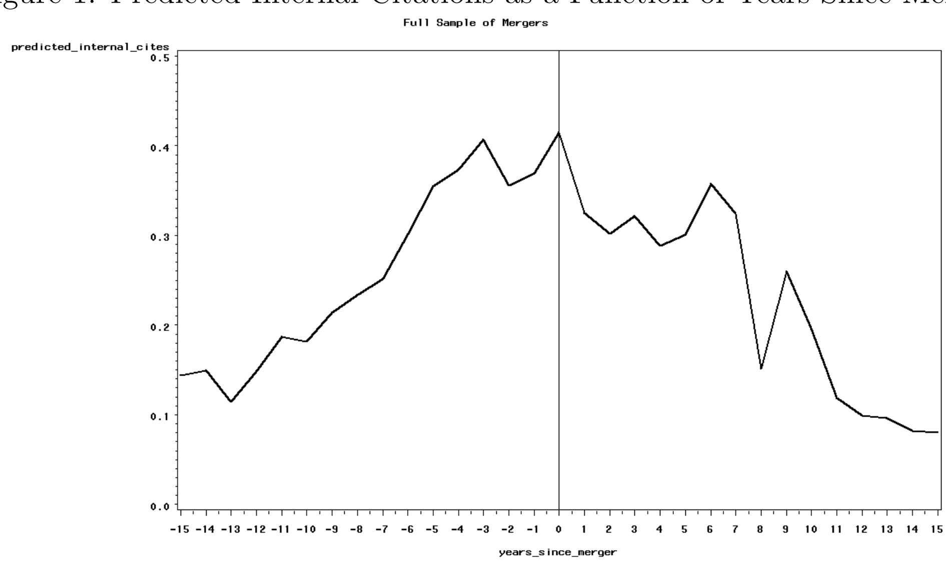

Figure 2: Predicted Internal Citations as a Function of Years Since Merger

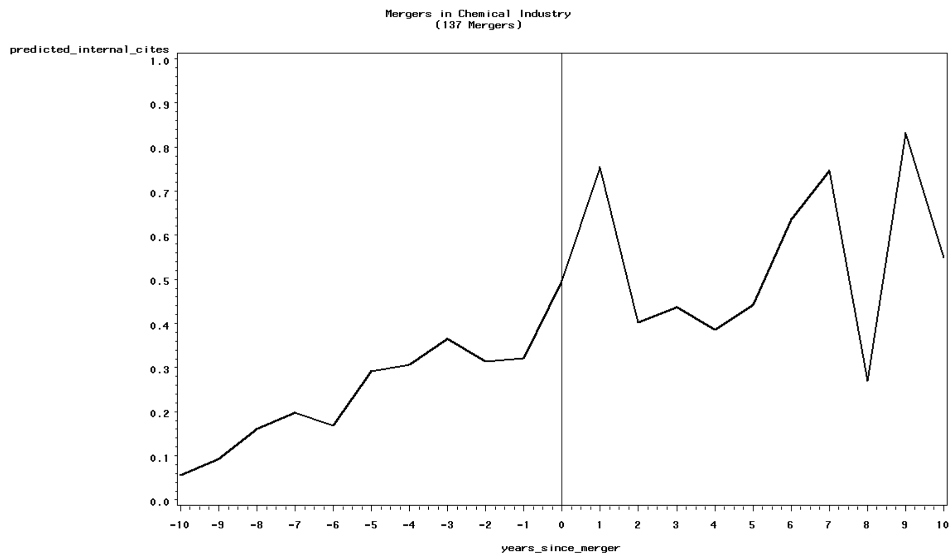

Figure 3: Predicted Internal Citations as a Function of Years Since Merger

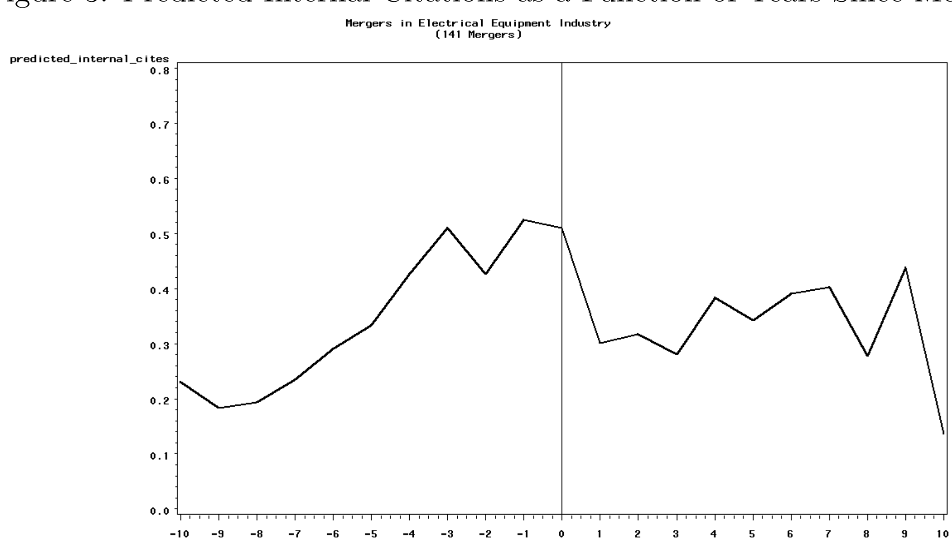

Figure 4: Predicted Internal Citations as a Function of Years Since Merger

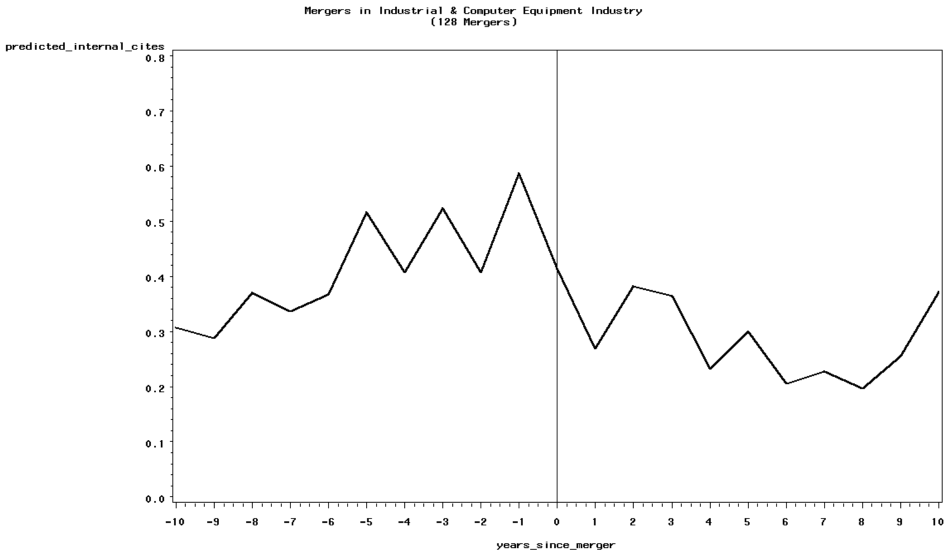

Figure 5: Predicted Internal Citations as a Function of Years Since Merger