Cooperative Marketing Agreements Between Competitors:

Evidence from Patent Pools

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On numerous occasions, rival firms seek to market goods together, particularly in high-technology industries. This paper empirically examines one such institution: the patent pool. The analysis highlights five findings consistent with the theoretical predictions: (a) pools involving substitute patents are unlikely to allow pool members to license patents independently, consistent with our earlier theoretical work; (b) independent licensing is more frequently allowed when the number of members in the pool grows, which may reflect the increasing challenges that reconciling users' differing technological agendas pose in large pools; (c) larger pools are more likely to have centralized control of litigation, which may reflect either the fact that the incentives for individual enforcement in large pools are smaller or that large pools are more likely to include small players with limited enforcement capabilities; (d) third party licensing is more common in larger pools, consistent with suggestions that such pools were established primarily to resolve the bargaining difficulties posed by overlapping patent holdings; and (e) during the most recent era, when an intense awareness of antitrust concerns precluded many competition-harming patent pools, more important patents were selected for pools and patents selected for pools were subsequently more intensively referenced by others.

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1. Introduction

On numerous occasions, rival firms seek to market goods together. In some cases, they seek to offer complementary products, such as when a toothpaste manufacturer offers a promotion with a toothbrush maker. Yet on other occasions, the goods are closer to substitutes, or at least somewhere in between substitutes and complements. Examples include airlines entering into code-sharing agreements, rival newspapers offering package advertising rates, and record companies allowing users to assemble customized collections of songs from multiple labels. One arena where joint marketing is particularly prevalent is in high-technology industries. Firms frequently commit to jointly make their intellectual property available, for instance through commitments to a standard-setting organization or an open source body.

These interactions have attracted relatively little scrutiny from economists. This paper seeks to address this neglect, empirically examining one knowledge-sharing institution: the patent pool. Patent pools can be defined as formal or informal organizations where for-profit firms share patent rights with each other and third parties.[1] A companion paper examines these bodies from a theoretical perspective.

Patent pools are particularly interesting for two reasons. First, the determinants of organizational structure have been a major concern in the industrial organization literature for many decades. While certain hybrids between arm's length contracting and

[1]More formally, we define these as cases where either (*a*) two or more firms combine to license patents to third parties (which we term "open" pools) or (*b*) three or more firms come together to license patents to share the patents among themselves ("closed" pools).

full integration—e.g., joint ventures—have been extensively scrutinized, patent pools represent a little studied organizational structure that may shed light on contracting challenges. The second motivation is a more practical one. The United States over the past two decades has seen an explosion of patent awards, and a dramatic increase in the volume of patent litigation between rivals. Numerous commentators have suggested that the proliferation of these awards has had socially detrimental consequences: overlapping intellectual property rights may make it difficult for inventors to commercialize new innovations. (Gallini [2002] reviews this literature.) Patent pools have been proposed by Merges [1999], Shapiro [2000], and the U.S. Patent and Trademark Office (Clark, *et al.* [2001]) as a way in which firms can address these "patent thicket" problems. Indeed, patent pools are already an economically significant institution: a recent estimate (Clarkson [2003]) suggests that sales in 2001 of devices based in whole or in part on poked patents were at least $100 billion. Were these suggestions to be adopted, their role might approach that seen in the early days of 20th century, when many (if not most) important manufacturing industries had a patent pooling arrangement.

After briefly summarizing the history of patent pools, we review the theoretical predictions concerning the structure of these pools, some of which are based on the framework in Lerner and Tirole [2002]. We then describe the construction of the sample of 63 pools established between 1895 and 2001. The analysis highlights five findings consistent with the theoretical predictions:

- First, pools involving substitute patents are unlikely to allow pool members to license patents independently, consistent with our earlier theoretical work.

- Second, independent licensing is more frequently allowed when the number of members in the pool grows, which may reflect the increasing challenges that reconciling users' differing technological agendas pose in large pools.

- Third, larger pools are more likely to have centralized control of litigation. This may reflect either the fact that the incentives for individual enforcement in large pools are smaller (*i.e.*, because free riding is more intense) or the fact that large pools are more likely to include small players with limited enforcement capabilities.

- Fourth, third party licensing is more common in larger pools, consistent with suggestions that such pools were established primarily to resolve the bargaining difficulties posed by overlapping patent holdings.

- Finally, during the most recent era, when an intense awareness of antitrust concerns precluded many competition-harming patent pools, *(a)* more important patents were selected for pools and *(b)* patents selected for pools were subsequently more intensively referenced by others.

We conclude with a clinical study of a particular patent pool, which in part corroborates the large-sample study and in part raises additional questions.

As noted above, there is a very limited amount of related literature. Priest [1977] and Shapiro [2000] represent pioneering attempts to model the rationales for patent pools. Bittlingmayer [1988] and Cassady [1959] present clinical studies of single patent pools. Gilbert [2002] provides a historical overview of these pools. Legal scholars, however, have written the bulk of the literature on these institutions: Carlson [1999] and Merges [1999] are examples.

2. A Brief History of Patent Pools[2]

The first patent pool is widely agreed to have been established by sewing machine manufacturers in 1856. By the 1890s, pooling agreements had become commonplace in the United States. Interest in patent pools stemmed in part from the desire to avoid the restrictions on anti-competitive activities that had been enacted as part of the Sherman Act of 1890. Patent pools were seen as exempt from regulatory scrutiny, a perception that was buttressed in 1902 when the U.S. Supreme Court refused to invalidate a patent pool, noting "the general rule is absolute freedom in the use or sale of patent rights under the patent laws of the United States. The very object of these laws is monopoly…."[3]

Soon thereafter, however, the tide began to shift. The Supreme Court struck down the bathtub enameling patent pool in 1912 in the *Standard Sanitary* decision. Private antitrust litigation regarding pools increased sharply thereafter. Government efforts to investigate and break up pools accelerated after well-publicized hearings on patent pools in the late 1930s. (This period also saw a more general increase in antitrust enforcement, as discussed in Ghosal and Gallo [2001].) The Supreme Court decision in the *Hartford-Empire* case, in which Justice Hugo Black pronounced "the history of this country has perhaps never witnessed a more completely successful economic tyranny over any field of industry than that accomplished by [the pool members],"[4] was widely seen as ushering in an era of regulatory intolerance for these arrangements. As a

[2]This section is based on Carlson [1999], Merges [1999], and Vaughn [1925, 1956].

[3]*E. Bement & Sons v. National Harrow Company*, 186 U.S. 70, 91 (1902).

[4]*Hartford Empire Co. v. U.S.*, 323 U.S. 386, 436-437 (1945).

consequence, the number of new patent pools formed in the United States dwindled away to almost nothing after World War II.

In recent years, however, there has been a cautious revival. In 1995, the U.S. Department of Justice and U.S. Federal Trade Commission issued its "Antitrust Guidelines for the Licensing of Intellectual Property," which explicitly noted, "cross-licensing and pooling arrangements may provide pro-competitive benefits."[5] Shortly thereafter, Justice's Antitrust Division issued a favorable review letter concerning the MPEG-2 Video patent pool. The result has been a modest resurgence of these arrangements. Numerous steps have been taken by the designers of these pools to avoid antitrust scrutiny, including in many cases the submission of the pooling agreement to the Antitrust Division for advance approval.

3. Theoretical Perspectives

In the companion work to this one (Lerner and Tirole [2002]), we present a theoretical treatment of rationales for and consequences of patent pooling agreements.[6] This section is not intended to duplicate that paper. Rather, it seeks to highlight several key insights based on that framework regarding the structure of patent pools.

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[5] http://www.usdoj.gov/atr/public/guidelines/ipguide.htm (accessed March 19, 2002).

[6] The focus of the theory paper is on normative issues relating to antitrust policy. Nonetheless, the framework leads to a number of positive insights. In this paper, we complement the earlier analysis with some additional theoretical points.

We focus here on four characteristics of the patent pools. The first of these is whether the pool allows its members to engage in *independent licensing* (*i.e.*, not as part of the pool). Lerner and Tirole [2002] show that the requirement that independent licenses be offered is a perfect screening device when—as is often the case—the antitrust authorities are poorly informed as to whether the patents in the pool are substitutes or complements. For welfare-decreasing pools (which we will refer to as "pools with substitute patents" for short[7]), the requirement that independent licenses be offered returns the outcome to what it would have been in the absence of a pool. For welfare-increasing pools ("pools with complementary patents"), the requirement that independent licensing be permitted has no impact. The theory thus predicts that in the absence of strong antitrust enforcement, patent pools should allow independent licensing precisely when it is innocuous, that is, when patents are complements. (All things being equal, we believe that firms would allow independent licensing, since it would help assuage the concerns of antitrust authorities, particularly in the most recent years.) Pools between substitutes would be likely to prohibit such licensing, due to its negative impact on pool and member profits.

We also expect that independent licensing will be more common in large pools, though the strength of our conclusions must be tempered. If a large number of patents are included in the pool, licensors are only likely to be interested in a subset of the patents. Independent licensing allows this problem to be addressed. To be sure, pools do

[7]We use this terminology, even though the change in the sign of the welfare impact does not coincide with the switch from "complements" to "substitutes" (using the definitions standard in demand theory). It is correct to say, though, that the more substitutable the patents in the pool are, the more likely it is that the pool will reduce welfare.

not need to allow independent licensing in order to let licensors select which patents meet their needs. Alternatively, they could offer "menus," or subsets of patents to license. One of the surprises we encountered in the data collection phase was how few pools (11% of the entire sample) offered menus. As the case study discussed in Section 6 highlights, transaction costs, disagreements over how to price items on the menu, and disputes over the sharing of licensing fees all served to discourage the use of menus. Such potential disagreements may make independent licensing an attractive substitute for menus.

The second characteristic of the pools we consider is whether *control of litigation is centralized.* Initially, it might be thought that it would always make sense to assign control over enforcement activities to the original patent-owners: after all, they should be better informed about their patents than anyone else. But the choice as to whether to control litigation centrally is driven by two considerations: capabilities and externalities.

On the capabilities front, the abilities of firms to detect infringements and manage patent litigation cases are likely to vary drastically. In particular, small firms without large patent portfolios are unlikely to have experienced lawyers specializing in intellectual property issues. These limited capabilities mean that centralized enforcement is advantageous. Pools with many members may be more likely to have firms without the capacity to litigate.

The choice of whether to centralize the control of litigation is also driven by the presence of externalities among the members. Each member, under decentralized enforcement, considers its own welfare, but not that of other participants. In the absence of independent licensing, each firm only receives $1/n^{th}$ of the pool's proceeds from its expenditures on enforcement. We would expect this "free-rider problem," and the consequent reduced investment in enforcement, to be most severe when there are many firms in the patent pool.

Independent licensing reduces this free-rider rider problem, as royalties on individual patents are then only partially shared. Thus, independent licensing should work against centralization. Note, though, that although this effect is clear, its strength may be limited if—as theory predicts and will be verified empirically—independent licensing is mainly present when patents are complements. Thus, the use of independent licensing will be limited, and it will only be able to partially mitigate the free-rider problem.

We should note that pool members' attitudes towards the reduced litigation resulting from decentralized control might vary. Suppose, for instance, that members are allowed to license their patents independently. If patents are substitutes (an unlikely case, as we argued above), then the under-investment in litigation leads to negative consequences for the pool. When the patents are complements, however, the absence of litigation may actually help the other pool members: the lower price that a pool member who fails to litigate his patents or his infringer charges may lead to increased demand for the other, independently licensed patents.

Pools are more likely to *grant licenses to third parties* if the latter are downstream suppliers of products not offered by the pool members or (even better) complements to the pool's products. Unfortunately, we do not observe the extent to which the pool members have a presence in the downstream product markets.

It is also difficult for us to predict whether pools consisting of patents that are substitutes or complements with each other are more likely to offer licenses to third parties. Owners of intellectual property can enter into patent pools for a number of reasons. These different motivations are likely to lead to very different choices. One rationale for entering into a patent pool is to facilitate collusion. Firms may enter into such agreements to reduce the degree of competition with their peers. In product market cartels, the pool may serve as a mechanism to extract greater profits from the downstream market. By combining patents that are substitutes and licensing them as a package, firms may be able to charge higher royalties for the usage of the technology. A more benign alternative is that firms enter into patent pools to solve the "patent thicket" problem: the presence of overlapping intellectual property holdings that make it difficult for third parties to license patent holdings and develop new technologies. Such pools, unlike the ones discussed above, have the potential to enhance social welfare.

Similarly, it is difficult for us to anticipate the impact of pool size. One conjecture is that small pools may lack the capability for downstream production, while larger pools have such a capability. Larger pools may thus be less likely to grant licenses to third parties. As we'll see once we turn to the data, however, fully 98% of the pool members have the option to make use of the patents included in the pool, so the conjectured effect is unlikely to be a strong one.[8] Alternatively, it may be possible that the motivation for forming the larger pools is that key patents are more widely distributed across firms. If the motivation for such pools is to address "patent thicket" problems, then third party licensing may be more common in these settings.

Finally, we examine the *innovation friendliness* of the pools: the extent to which features of the pool encourage or deter future innovation by the pool members. Pools encourage innovation by their members by allowing them to keep the rights to the intellectual property that they discover after the pool is formed.[9] By requiring these awards to be assigned to the patent pool, the incentive to innovate is dulled. It should be noted that however undesirable the reduced incentives to innovate are from a social perspective, this consequence may not be worrisome for pool members: firms may seek to boost their profits by "softening" their competition in the R&D market in this manner. But innovation unfriendly terms also play a more benign role. By adopting such a clause, the pool members protect themselves from hold-up problems by one of their

[8]It is not clear that that the firms exercised this option in every case; this term's prevalence may reflect the very low cost of adding such a provision to an agreement.

[9]See Lerner and Tirole [2002] for a more general analysis of the determinants of innovation friendliness.

opportunistic peers. By requiring automatic licensing, the potential problem that a pool member may make an essential discovery and then demand an extraordinary sum from the other members for access to the technology is defused.

The impact of the rate of technological progress on the decision to make a pool innovation friendly is ambiguous. If rapid technological progress characterizes an industry, the possibility of a radical innovation that would make opportunistic behavior possible is greater. This concern argues for the adoption of provisions that require the assignment of future patents, even if they reduce the incentives to innovate. At the same time, the dangers associated with the reduced incentives to innovate may be the greatest here: another firm outside the pool may be more likely to make a discovery that "leapfrogs" (obsoletes) the technology of the pool members. Thus, a faster rate of innovation in the industry increases both the costs and benefits of innovation friendliness.

The consequences of being leapfrogged are particularly severe if the main aim of the pool is to license its technology to third parties. (By way of contrast, pool members combining patents for their own use may welcome some external competition.) Hence, we would expect innovation friendliness to be positively associated with licensing to third parties, particularly when the patents included in the pool are complements.

Another set of predictions relate to the recent set of pools, almost all of which have been extensively scrutinized by the U.S. Department of Justice for possible detrimental impacts on competition. Even in the recent pools not submitted to the

Department for review, pool members—seeking to deter antitrust scrutiny—have typically hired outside experts to ascertain that the patents are truly essential (that is, complementary). It might be thought that in these pools, we would see two effects at work:

- The quality of the patents included in the pools would be higher, reflecting the screening of potential patents.
- Since in these cases, the pools are especially likely to enhance usage of the patents by third parties, the patents included in these pools should be more heavily employed by others.

We will test these suggestions using the various measures of patent quality found in the earlier literature (e.g., using patent citations as a proxy for utilization).

4. Constructing the Sample

The literature on patent pools to date—which, as noted above, has been largely confined to law reviews—focuses on the reported judicial decisions on these arrangements. While the decisions discuss aspects of the pools' structure, they do not provide sufficient details to allow a systematic analysis of the features of the pools. In order to test the theory delineated above, we needed the actual agreements governing the patent pools. This section describes the procedure we employed to construct the patent pool sample, as well as the supplemental data used in the analysis.

A. Identifying the Pools

The first question was one of definition. Our definition of patent pools in footnote 1 excludes several other types of arrangements:

- Simple cross-license arrangements between two firms, where there was no clearly stated intention of engaging in future licensing transactions.

- New operating companies that were established to manufacture products based on intellectual property of a number of firms (e.g., Radio Corporation of America).

- Firms that acquired large amounts of patents and then licensed them to other concerns (e.g., American Steel and Wire Company, American Tobacco Company, and other "patent consolidators").

- Pools that are dominated by non-profit entities (e.g., universities), where profit-maximizing considerations may not be paramount.

We then compiled a list of all identifiable patent pools. The primary sources for these identifications were Carlson [1999], Commerce Clearing House [various years], Kaysen and Turner [1959], Merges [1999], Vaughn [1925, 1956], and "War and Peace" [1942], though many other sources were used as well. In total, we identified approximately 125 patent pools, dating between 1856 and 2001. (In some cases, we were unsure based on the information that we could collect whether the arrangement satisfied our definition of a pool.)

These pools appear not to have been disclosed by firms in filings with the U.S. Securities and Exchange Commission. Instead, we obtained the pooling agreements in five ways:

- Congressional hearings during the 1930s and 1940s scrutinized a number of patent pools (especially U.S. Congress [1938-1940], U.S. House [1935], U.S. Senate [1942]). In many cases, the pooling agreements were either published in the records of the hearings or else retained as unpublished exhibits (which are preserved in the committees' files in the National Archives in Washington, D.C.)

- Many of the pools were subjects of private or federal antitrust litigation. In the course of the trials, frequently the patent pooling agreements were entered as exhibits. The dockets of these cases are preserved in the various regional depositories of the National Archives. In order to limit costs, we focused on those depositories with the greatest concentration of cases: Boston (which has records from federal district cases in the first judicial circuit), Chicago (which includes much of the sixth and seventh circuits, as well as some of the ninth circuit), Kansas City (which has records from parts of the eighth and tenth circuits, as well as older records from parts of the second and third circuit), and New York City (which has more recent records from parts of the second and third circuits).

- The Antitrust Division of U.S. Department of Justice investigated a number of patent pools, some of which were litigated against and others were not. Since the time these files were used by Hay and Kelley [1974], the records have been transferred to the National Archives' Suitland, Maryland facility. These files were located with the assistance of Johnson [1981]. As part of the investigations, the patent pooling agreements were sometimes gathered and preserved.

- The U.S. Department of Justice and the U.S. Federal Trade Commission have scrutinized a number of the recent pools. In these cases, we obtained the key documents through Freedom of Information Act requests.

- In the case of recent pools that had not been the subject of federal scrutiny, we requested the documents from the pool administrators.

In all, we were able to collect the documentation on 63 patent pools.[10] We then identified and coded the key characteristics of the agreements. We focused on the initial agreement establishing the pool, rather than the many amendments that frequently characterize these agreements.

Given the lack of a systematized database of patent pools, it is difficult to assess the comprehensiveness of our sample. At the same time, it is reassuring that the distribution of the 63 pools, summarized in Table 1 and 2, reflects the patterns discussed in Section 2. We believe it is likely that the sample underrepresents the very oldest pools: the federal government was far less active in antitrust enforcement during this

[10]We have not identified any non-U.S. government sources for patent pool agreements (though our sample does include some agreements exclusively between firms outside the United States). Antitrust authorities outside the U.S. historically do not appear to have systematically reviewed or litigated patent pooling arrangements until recent years.

period, and many of district court files from this period are lost or unusable. In addition, it may be that pools involving German firms are disproportionately represented, since ties between German and American firms were a particular focus of the Bone Committee's hearings in 1942.

B. Supplemental Information

We next collected a variety of information on each of these pools. One important variable in our analysis was patenting activity in the industry of the patent pool in the five years prior to the establishment of the pool. To undertake this analysis, we first determined which patent subclasses using today's classification scheme the patent pool covered. (The patent classification scheme is periodically updated as new technologies emerge.) These subclasses were identified in two ways. First, we examined the U.S. Patent and Trademark Office's (USPTO) *Manual of Classification* (available at http://www.uspto.gov/go/classification/uspcindex/indextouspc.htm), which details the U.S. patent classification scheme. Second, we determined the patents that were included in the pool from the pooling agreements. These were determined from the agreements themselves and USPTO indexes. We ascertained the subclasses into which the patents are assigned today using the database available at http://patft.uspto.gov/netahtml/search-adv.html. We then determined how many patents were assigned to these subclasses (whether included in the pool or not) in the years before the establishment of the pool using the latter database. We also computed two alternative measures: the overall growth in patenting by pool members and the patenting by members in the subclass covered by the patent pool. A detailed index to U.S. patent awards by firm is available in electronic format only after the early 1970s. To identify patenting by firms for the older pools, we used the USPTO's annual *Index of Patents Issued by the Commissioner of Patents* and its predecessor publications.

We also collected several other measures, which we used in supplemental regressions not reported in the paper:

- *The revenues of pool members in the five years prior to the establishment of the pool*. For recent pools, we employed the data in Compustat and WorldScope databases. For older pools, we relied on information in the *Moody's Industrial Manuals*, which list both U.S. and major foreign firms, and various non-U.S. national corporate directories. In some cases, we were able to determine from the publication another measure of financial performance (e.g., the firm's operating profits or net income), but not the firm's revenues. In these cases, we used the median ratio between this measure and the revenues for other firms in the industry during the same year (also determined from the *Moody's* manual) to impute the revenue. We were not able to determine any financial information, however, for approximately one-third of the firms.

- *The median book-to-market ratio for firms in the industry of the patent pool in the year prior to the establishment of the pool*. This ratio, which is frequently used as a proxy for growth prospects, was determined for recent pools using the Compustat and the Center for Research in Securities Prices (CRSP) databases. For the pools established prior to the 1970s, we employed market value data from the CRSP database and the book value data collected from *Moody's* manuals by Davis, Fama, and French [2000]. Because valuation levels shift dramatically over this period, we adjust the median industry book-to-market ratio by subtracting from it the median ratio for all firms in that year.[11]

[11]This data set only extends as far back as 1926, so we do not have this measure for earlier patent pools.

C. Additional Data for the Most Recent Pools

As noted above, we intensively study five patent pools[12] formed in 1995 and after. We elected to focus on recent pools for two reasons. First, as noted above, there was a strong rationale for believing that these pools would be consistently innovation and efficiency enhancing, as opposed to those from earlier periods, where considerable diversity characterized the population of pools.[13] Second, the U.S. patents in these pools could be analyzed using the National Bureau of Economic Research (NBER) Patent Citations Data File constructed by Hall, Jaffe, and Trajtenberg [2001]. (Detailed information about U.S. patents awarded before the 1970s are not available in any electronic database.)

Upon identifying the pooled patents, we proceeded to form two sets of matching patents:

- The first of these matching sets included the patents awarded to the same firms that were most proximate to the pooled patent. (We defined the most proximate patent as the one with the closest award number.)[14]

- The second of these matching patents was the most proximate patents awarded to the same type of assignee as the pooled patents and within the same USPTO

[12]The pools whose patents were analyzed included the two DVD, MPEG-2, 1394, and DVB-T associations. Though we had the pooling agreements for two additional recent patent pools, the Bluetooth and 3G organizations, these documents did not include data on which patents had been assigned to these pools. Thus, we could not use these two pools in the patent analysis.

[13]While antitrust officials are unlikely to always know whether the patents in the pools are substitutes or complements, the use of external reviewers to determine essential patents and (as we argue in Lerner and Tirole [2002]) the presence of independent licensing requirements help insure that these recent pools are innovation and efficiency enhancing.

[14]We were not able to assign a matching patent based on this criterion for one pooled patent because the assignee did not own any patents other than the patents included in the pool.

> technology class. We relied upon the assignee type field in the NBER patent database to determine whether each patent was assigned to a government, non-government organization (mostly corporations), or an individual, and whether the patent was assigned to a U.S. or non-U.S. entity.

When the matching patent coincided with a patent that was included in a pool or with a patent that was already selected as a matching patent, then the next most proximate patent was selected as the matching patent. In cases where the matching patent for a given pooled patent based on the same-firm criteria was the same as the matching patent based on the same-class criteria, we found a new same-class match for the patent, choosing the second most proximate award.

In the majority of cases, the award date of the matching patents was the same as the award date of the pooled patent. The mean of the absolute number of days between the pooled patent and the matched patent based on the same-firm criteria was 37.3 days and the median was 0.0. The mean absolute number of days between the pooled patent and the matched patent based on the same-class criteria was 2.5 days and the median was 0.0.

5. Analysis

We proceed in two parts. First, using the patent pools established before 1995, we examine the determinants of the characteristics of these agreements. We then focus on the most recent pools, and exploit our more detailed data on these organizations.

A. Analyses of Pool Characteristics

Our first approach is to examine the univariate relationships. Table 3 presents an initial tabulation of the four dependent variables we will examine, as well as the three independent variables discussed above.

While such an analysis can only scratch the surface—we do not consider the relationships between the dependent variables or the interaction effects discussed above—a few patterns stand out. First, a secular trend appears to be at work. Independent licensing provisions are more common in later pools, while the centralized control over litigation has become less so. Second, pool size appears to matter. Larger pools are associated with a greater probability of independent licensing, consistent with theoretical suggestions above.

We then seek to estimate a formal model. Following the discussion in Section 3 above, we hypothesize the following relationships:

$$indivlic = a + b \times firmcount + c \times substitute + \varepsilon_1$$

$$litigcentral = d + e \times firmcount + f \times firmcount \times licto3rd \times (1\text{-}indivlic) + g \times indivlic + h \times substitute \times indivlic + \varepsilon_2$$

$$licto3rd = i + j \times firmcount + k \times substitute + \varepsilon_3$$

$$innovfr = l + m \times licto3rd + n \times (1\text{-}substitute) \times licto3rd + o \times growth + \varepsilon_4$$

These equations had three sets of variables, which we will discuss in turn.

There were four limited dependent variables. *Indivlic*, *licto3rd*, and *innovfr* take on value one if the pool allows independent licensing by pool members, allows licensing to third parties, and does not require pool members to automatically assign discoveries to the pool. *Litigcentral* takes on the value of one if litigation is controlled by each firm acting on its own; three if the pool is in control of the litigation with no provision for opt-out; and two in the intermediate cases. Simultaneous estimation is necessary because some limited dependent variables appear on the right-hand side of the equations.

The exogenous independent variables included the count of the number of parties in the pool (*firmcount*) and the growth of patenting in the industry segment of the pool in the five years prior to the pool's formation (*growth*). Because we believe that there will be substantial non-linearities with firm size (e.g., the coordination challenges may be very different in a pool with two members and one with six members, but not differ appreciably between ones with ten and thirty members), we winsorize the firm count variable. *Firmcount* is top-coded at six. In robustness checks discussed below, we use alternative measures for the count of the firm members and for growth.

The variable *substitute* takes on the value one if the patents in the pool are pure substitutes, zero if they are entirely complements, or else takes on an intermediate value in this range. Because we do not observe the degree of substitutability, we estimate this as a latent variable, using the following fifth equation:

$$substitute = p + q\times y45bef + r\times royaltyfreemem\times(1\text{-}licto3rd) + s\times notgilbertcase + \varepsilon_5$$

The independent variables are measures that we expect will be associated with the degree of substitutability or complementarity of the patents in the pool. *Y45bef* indicates pools formed before the *Hartford-Empire* decision of 1945; *royaltyfreemem* denotes pools where the members used the patents in the pool on a royalty free basis; and *notgilbertcase* denotes pools other than those identified by Gilbert [2002] as ones where the courts identified the pool as anti-competitive in intent. Only the rationale for the second item probably needs discussion. We hypothesized that in cases where pool members were free to use patents on a royalty free basis and the pool did not license them to third parties, it was less likely that the decision to establish the pool was driven by anticompetitive motivations (and the patents were less likely to be substitutes).

The five equations are estimated simultaneously following the approaches delineated in the discrete choice literature. Heckman [1978] discusses the issues of identification and estimation in this setting. Schmidt [1981] provides the necessary and sufficient conditions for simultaneous equations with limited dependent variables to be internally consistent.

More specifically, each limited dependent variable, y, is associated with a latent variable, y^*, that follows a normal distribution:

$$\text{Prob}(y = i) = \text{Prob}(z_{i-1} < y^* < z_i)$$

The set of parameters includes $\{a,\ldots, o, q,\ldots, r\}$ and the threshold parameters $\{z_i\}$. The scaling constant p is used to enforce the constraint that the latent variable *substitute* falls between 0 and 1. As a result, p is not a well-identified parameter to be estimated in the analysis. The estimates are obtained by numerically maximizing the log likelihood function. The standard errors of the estimates are calculated from the inverse of the

Fisher information matrix. The numerical second derivative of the log likelihood function is used as in Hamilton [1994].

The intensive reviews of the draft patent pool agreements by U.S. Department of Justice officials in 1995 and thereafter may have resulted in fundamentally different dynamics behind these agreements. Reflecting this concern, our analysis is restricted to pools established prior to 1995.

The results from this analysis are presented in Table 4. The following results stood out from the analyses:

- Pools involving substitute patents are unlikely to allow pool a member to license patents independently, consistent with our earlier theoretical work.
- Independent licensing is more frequently allowed when the number of members in the pool grows, which may reflect the increasing challenges associated with reconciling users' differing technological agendas in large pools.
- Larger pools are more likely to have centralized control of litigation. As noted above, this may reflect either the fact that the incentives for individual enforcement in large pools are smaller (*i.e.*, because free riding is more intense) or the fact that large pools are more likely to include small players with limited enforcement capability. The former hypothesis had suggested that the interaction between the count of firms in the pool and the absence of independent licensing would have particular explanatory power, but this coefficient proves to be insignificant and of the opposite sign.
- Suggestive, though statistically insignificant, results emerge from the relationship between the centralized control of litigation and independent licensing. As predicted above, independent licensing is associated with a lower probability of centralized control of litigation.
- We had few unambiguous predictions regarding the determinants of patents being licensed to third parties. We find that third party licensing is more common in larger pools, which is consistent with suggestions that such pools were established primarily to resolve the bargaining difficulties posed by overlapping patent holdings.

- Again, the analysis of innovation friendliness produces suggestive, if statistically insignificant results. Innovation friendly terms are associated with pools where there is licensing to third parties, particularly of complementary patents.

- The estimated latent variable regressions generate one statistically significant result consistent with our priors: pools identified by Gilbert [2002] as particularly problematic are more likely to contain substitutes. The greater probability of pools formed prior to 1945 having substitute patents, while statistically insignificant, is also consistent with our priors.

While our ability to examine the robustness of the results was limited by the small sample size and the modest number of details on the pool members that we were able to ascertain, in unreported regressions we undertook a variety of supplemental analyses. We employ alternative dependent and independent variables (for instance, coding *litigcentral* as a binary measure like the others and no longer winsorizing *firmcount*). We substitute the alternative variables measuring growth (growth in pool members' sales and patenting) for growth in overall industry patenting. The results delineated above continue to come through, though the significance of the *firmcount* measure is frequently lower when the full measure is used, due to the heavy influence of a few very large pools.

Another set of robustness checks examined the possibility of selection biases. As acknowledged above, our sample was not a random one: the pools included in the analysis were disproportionately likely to have been litigated. These pools might reasonably be thought to have characteristics (e.g., anti-competitive provisions) not shared by the others. To address this concern, we examined the subset of historical pools that were identified through means other than litigation records: those revealed in the course of congressional hearings. The criteria used to select pools for scrutiny by

Congress were quite different: for instance, a number of hearings systematically examined all active pools in certain industries (e.g., dyestuffs, petroleum, and precious metals) or involving firms of a given nation (Germany).

We repeated the above analyses, using this sub-sample. Because of the smaller sample size, we did not estimate the full set of equations, but rather single equations or sets of two equations. The magnitude of the effects continued to be similar, though the statistical significance was more modest in some cases (reflecting the smaller sample size).

A third concern related to the presence of omitted variable biases. We were worried that our results could stem from the fact that variables such as *firmcount* might be correlated with important omitted measures, such as the degree to which the members of the pool dominated the upstream or downstream product markets. While we could not thoroughly address this concern, we did explore the robustness of the results to specifications with additional independent variables. These results were generally consistent, though significance levels did vary.

B. Analysis of Pool Performance

We then examined the relative importance of the patents that were included in the recent pools, as well as the effects of selection into these pools on the usage of these patents. We focus our analysis on the most recent period when, as noted above, patent pools were subject to extensive antitrust scrutiny. Consistent with theoretical suggestions above, pools appear to have higher-quality patents and the inclusion in the pool seemed to trigger more utilization.

Table 5 provides a look at the differences between pooled patents and their counterparts. In Panel A, we focus upon a measure of the importance: patent citations received. A patent that receives more citations is generally viewed as being more important than a patent with fewer citations (see, for instance, Jaffe and Trajtenberg [2002]). We divided the number of citations to each patent into two components: the citations received before the pool was formed and those received afterwards.

In order to count the number of citations a patent received before and after the pool was formed, we used the NBER Patent Citation Data File. We were able to identify all of the patents that cited patents in our sample through the end of 1999. Once we identified these patents, we used the grant date of each citing patent to determine if it was awarded before or after the formation of a given pool. For the matching patents, we similarly examined the number of citations prior to and after the formation of the pool in which the corresponding pooled patent was included.

The number of citations received before the pool was formed served as a measure of the importance of a patent that can reasonably be assumed to be unaffected by its inclusion in a pool. The number of citations received after the pool was formed reflects factors such as the intrinsic significance of the patent, the increased attention received due to its inclusion in the pool, and potentially the decreased concerns about blocking patent issues that arise in follow-on innovations. In Panel A of Table 5, we compare the average annual number of citations before and after the pools' formation. Tests of the equality of means and medians reveal that the number of citations received before and after pool formation are both significantly higher for pooled patents relative to the matching patents. These results suggest that the patents included in the pools were relatively more important.

Figure 1 and 2 provide a graphical look at the number of citations received by year. In the first graph, we present the annual citation rate relative to the year of the award: e.g., we depict the citations per patent in the sample in the year after the award. Consistently, those patents that are included in the pools are more intensively cited. In the second, the citations are presented relative to the year of pool formation. The figure reveals that while patents in the pool are more intensively cited than their peers, the difference is confined to the years immediately before the pools' formation and the years subsequent to the pools' establishment.

In Panel B and Panel C of Table 5, we look at differences in "originality" and "generality" respectively between patents included in pools and the matching sets. We use the measures of originality and generality employed by Jaffe and Trajtenberg [2002], where generality/originality is defined as one minus the sum of the squared percentage of citations received/made from each patent class. Originality is a proxy for the innovativeness of patents because patents citing patents from a more diverse set of classes can be thought of as linking innovations from a broader set of domains. Panel B indicates that the originality of the pooled patents is not significantly different from the originality of the matching sets.

Generality is also related to the economic value of a patent. Patents cited by patents from a wider set of classes tend to be more valuable because they form the basis for follow-on innovations in a larger set of fields. Panel C reveals that the generality of the pooled patents is significantly higher than the generality of the matching patents. This suggests that either the patents being included in pools have the potential to be leveraged in a wider variety of domains or the effect of being included in the pools results in their broader utilization.

In Panel D, we utilize the number of claims made by a patent as a proxy for the scope of a patent. Patents that make more claims tend to be broader and therefore more valuable. For both matching sets in Panel D, the Wilcoxon median test yields a smaller p-value than the t-test. This difference can be attributed to the skewness in the distribution of the number of claims made by patents. The results of the Wilcoxon median test are probably more relevant because of the weaker distributional assumptions made by this test.[15] Employing the set of matching patents by class and by firm, the Wilcoxon median test indicates that the number of claims made by pooled patents is significantly higher than non-pooled patents at the 10% level of significance. Restricting the set of matching patents to matches by firm yields similar results.

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[15]The Wilcoxon median test simply assumes that the two sets come from populations with the same distribution without imposing restrictions on what this shape may be.

We then seek to perform similar analyses of the characteristics of pooled patents in a multivariate framework. We employed the same sets of matching patents as above to construct our sample. The dependent variables we used in these analyses are the same measures of patent characteristics as used above: citations received, originality, generality, and claims made.

In Table 6, we explore the importance of patents as measured by citations received. We use as the dependent variable the number of citations received in each year after the award. As in the univariate analysis, we employed this strategy to address the concern that once a patent is included in a pool, it will receive more citations due its exposure and its availability on established licensing terms. We employ several specifications, in the style of Furman and Stern [2002]. First, we simply estimated ordinary least squares regressions, with dummy variables controlling for the year of the patent award, the vintage of the patent (that is, the number of years between the award and the observation), and each matched set of patents (the pooled patent and the two matching ones). The patents in the pool are more frequently cited in general, but particularly after the establishment of the pool.

Due to the discrete nature of the number of citations received, we also ran a set of regressions using a negative binomial specification. We again employed a dummy variable for each group of patents, and also estimated the equation with a distinct dummy variable for each patent. Once again, patents included in pools were more frequently cited in general, and especially after their inclusion in a pool (an effect that was particularly strong in the latter specification).[16]

We employed only one observation for each patent in the regressions analyzing originality, generality, and the number of claims reported in Table 7. As control variables, we employed dummy variables for the year in which a patent was granted, the pool in which the patent was included (the pool of the corresponding pooled patent in the case of matching patents), and the category of the patent as defined in the NBER patent database.[17] The results are also consistent with the univariate comparisons in Table 5. Across the specifications, generality is highly significant while originality is not. These regressions suggest that pooled patents tend to have a broader range of applications but do not integrate a broader set of innovations. The last regression reveals that the number of claims made by pooled patents is not significantly greater than the number of claims made by non-pooled patents.

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[16]We repeat the regression analyses, adding a dummy variable for patents that would be added to a pool in the next one-to-three years. This term is also positive and significant across the regressions. Even after we control for the greater propensity to cite both patents that are already in pools and those that are soon to be added to pools, however, the coefficient on the variable denoting patents that are included in pools is consistently positive and significant. In other words, the tendency to cite pooled patents more frequently is not confined to the periods immediately before and after they are included in a pool.

[17]These categories are Chemical (excluding drugs), Computers and Communications, Drugs and Medical, Electrical and Electronics, Mechanical, and Other.

6. Field Research

To gain a richer understanding of the forces shaping patent pooling agreements, we supplemented our theoretical and large-sample research with a case study of the MPEG-2 patent pool.[18] MPEG-2 is a digital video compression standard used in products including DVD and high definition television. The standard was developed by the International Organization for Standardisation (ISO) under the leadership of Leonardo Chiariglione, along with scientists and engineers from many universities and corporations. The standard setting effort began in the July 1990 and the final MPEG-2 standard was approved in November 1994. During the completion of the standard setting process, intellectual property issues became a paramount concern. While all participants in the standard setting process signed a letter of assurance of fair, reasonable, and nondiscriminatory (RAND) licensing, concerns lingered due to the large number of patents required to implement the standard. Even if each individual patentholder licensed their patents on reasonable terms, Chiariglione and other participants were concerned that the sum of all such licenses might not be reasonable.[19]

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[18]This section is based on interviews with current and former employees from five different organizations that participated in or negotiated with the pool. In addition, we spoke with Leonardo Chiariglione, Vice President, Multimedia at Telecom Italia Lab, the research center of Telecom Italia. Finally, we spoke with a representative from MPEG LA, the corporate entity formed to administrate the pool.

[19]It should be noted that considerable ambiguity surrounds the definition of what constitutes RAND licensing. A number of standard-setting bodies we talked to were unable to provide a precise definition of what constituted a reasonable royalty. For instance, one group indicated that they used 5% as an upper bound, but did not distinguish between cases where the rate applied to the individual component and the entire system.

The MPEG Intellectual Property Rights Working Group was thus formed in 1993 to develop a unified approach to MPEG-2 licensing. As the standard materialized, this task was led by CableLabs, an R&D consortium for the cable industry formed in the late 1980s when there was little compatibility among cable systems in the U.S. CableLabs was an active participant in the MPEG-2 standard setting process with the goal of making sure that the resulting standard was consistent with their needs. Baryn Futa, executive vice president and COO of CableLabs, gained the trust of participants by chairing the MPEG intellectual property working group. Solutions other than a patent pool were considered, such as a trade association that would function as a clearinghouse. But patent holders wanted to ensure that their intellectual property would be aggressively marketed and thus rejected such an association. As a result, CableLabs and other licensors injected $3 million to found a corporation, MPEG LA, which handled licensing MPEG-2 patents.

Forming the MPEG-2 patent pool and convincing companies to join the pool was complicated due to the different incentives among pool members. These heterogeneous incentives, as well as antitrust considerations, shaped the critical features of the pool.

The most debated issue was the licensing rate that MPEG LA would charge licensees. The primary motive for certain companies was not to maximize licensing revenues, but rather to accelerate the adoption of the standard. For instance, while Sony is both a licensor and licensee of MPEG-2 patents, Sony focuses on maximizing sales of its electronics products and pursues patents as a "defensive mechanism" to protect its intellectually property.

By way of contrast, other organizations such as Lucent and Columbia University wanted to maximize the licensing revenues they received from their MPEG-2 patents. Columbia was particularly motivated to see the pool succeed due to its fears that if a pool were not formed, then MPEG-2 patents would largely be shared via royalty-free cross-licensing agreements. Since the university did not stand to gain by being offered a license to another firm's technology, in the absence of a pool Columbia would be put in the unenviable position of demanding license payments in an environment where no other cash payments were being made for MPEG-2 licenses. Thus, Columbia's ability to demand a relatively high royalty rate was balanced by its need to ensure that a patent pool emerged.

On the other hand, Lucent's bargaining position with the MPEG-2 pool was quite different. Lucent had a large internal licensing department with sufficient resources to conduct its own MPEG-2 licensing activities. Moreover, Lucent believed that two of its patents were most critical to the MPEG standard. Lucent felt that the licensing rate established by MPEG LA was lower than it could have been and decided not to join the pool.[20] Lucent estimated that the higher royalty rates it would be able to charge by not joining the pool would more than offset the decreased fraction of the MPEG-2 market that would license its technology if it pursued its own licensing activities.[21]

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[20]Lucent was also constrained by licensing policies that were established as part of a 1956 consent decree settling federal antitrust litigation against Western Electric.

[21]So far, this has not been the case, as MPEG-2 licensees generally have been willing to pay Lucent no more than the per-patent rate charged by MPEG LA for licenses under Lucent's MPEG-2 patents. The failure of Lucent to reap attractive returns from its "hold

The final licensing rate set by the pool was $4 per decoder for each MPEG-2 system. This "one size fits all" strategy led to problems in some markets. In some cases, licensees already had licenses to some of the MPEG-2 patents based on broad licensing agreements they had with MPEG LA member firms. In such cases, the licensees have demanded that the rates they are charged be reduced. MPEG LA has handled such situations by telling these firms to negotiate concessions with the individual firms involved in the previous licensing agreements rather than altering the standard MPEG LA licensing terms. A bigger problem has occurred in using the same terms for firms in different industries. Computer companies have been reluctant to pay these rates, due to the computer industry norm of not paying royalties and due to the number of features embodied in computers that do not relate to MPEG-2. This led seven MPEG LA pool members to initiate infringement litigation against Compaq and Dell.

Additional clauses in the MPEG LA license agreement were designed to make MPEG-2 licensees comfortable in adopting the technology. The MPEG LA license grants licenses under the future MPEG-2 essential patents of pool members at no additional charge. This provision was viewed as a way to allay the fears of potential licensees that they would be subject to a hold-up problem if and when new MPEG-2 patents surfaced. The MPEG LA license also commits to not raising the royalty rate unless extreme

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out" strategy may appear initially puzzling. The seller of a complementary good should be able to charge more when other firms cut their prices. Industry observers, however, argued that substantial uncertainty surrounded the determination of the proper royalty rate for patents. MPEG LA's decision to set a low rate may have been seen as a signal of the patents' value, leading to a reduced willingness to license Lucent's complementary patents at a high rate.

conditions arise. This clause is also intended to make potential licensees comfortable with committing to use MPEG-2 in their products without the worry of being charged excessively high licensing rates in the future.[22]

The commitment not to raise royalty rates, however, also impacts the ability of the pool to attract new licensors. When a new licensor enters the pool, as any essential MPEG-2 patent holder may do, each existing licensor is diluted: the formula used by the pool for royalty distribution calls for each licensor to receive a pro rata share of the licensing revenues (based on the number of essential patents it owns) while the rate charged to licensees remains constant. This formula was seen as the only feasible formula to avoid controversies regarding assigning value to each individual patent.

The influence of antitrust concerns necessitated that (*a*) licensors would not be precluded from offering licenses under their individual patents, (*b*) pool membership would be open to any firm with essential MPEG-2 patents, and (*c*) only "essential" patents (as determined by outside counsel) would be included. In other respects, however, the pool was somewhat user unfriendly. For instance, licensees were required to grant back the patents on any innovations that are essential to MPEG-2. One possible rationale was that while pool members made important concessions to the Department of Justice, in other areas they felt free to even the balance.

[22]In point of fact, the royalty rate has subsequently been lowered to $2.50, even as the number of patent families covered by the pool has expanded from 25 to 118.

7. Conclusions

This paper empirically examines the structure and impact of patent pools. These complex organizations have been little studied, despite their inherent interest on both theoretical and practical grounds. We suggest that the changing features of these arrangements over time and across different circumstances—as well as the performance of recent pools—are in many respects consistent with theory.

At the same time, the final section, which examined a particular pool in detail, has highlighted some issues that we did not address here. For instance, the importance of insuring equitable treatment across pool members and the apparent signaling role that the terms of the MPEG license played are not issues addressed in our theoretical framework. These questions would certainly deserve further exploration.

Another set of unexplored issues relate to the generality of the patterns seen here. As noted in the first paragraph of this paper, joint marketing arrangements are seen in many industries, and many of these arrangements are similar to those posed here.[23] Exploring the nature of and rationales for these arrangements appears to be a promising area for future researchers.

[23]The mapping is, of course, not exact. For instance, in airline code-sharing arrangements, an analogy to "innovation friendliness" is the extent to which the agreement encourages the introduction of new routes. An analogy to "centralized control of litigation" is the degree to which decisions over key assets are jointly managed.

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Table 1: The sample of patent pools. The table presents information on the 63 pools analyzed in the paper, including the year in which the pool was formed, the Standard Industrial Classification (SIC) that most closely describes the pool's subject matter, the number of members initially included in the pool, the nationalities of the entities initially in the pool, and the manner in which the pool agreement(s) were located.

Pool Subject Matter	*Year of Formation*	*Closest SIC Code*	*Initial Pool Membership*	*Nations Represented*	*Source of Contract*
Pneumatic Straw Stackers	1895	3523	3	U.S.	NAR
Duplicating Machines	1912	3579	2	U.S.	NAR
Automobiles	1915	3711	146	U.S.	USC
Railroad Couplers	1916	3743	6	U.S.	NAR
Aircraft	1917	3721	8	U.S.	USC
Braking Systems	1924	3714	2	U.S.	NAR
Plate Glass	1924	3211	4	U.S.	NAR
Sand-Spun Pipe	1924	3321	7	U.S.	NADC
Dyestuffs	1925	2865	11	Ger.; U.S.	USC
Magnesium	1927	3339	2	U.S.	USC
Metal Dies	1928	3544	2	Ger.; U.S.	USC
Cast Iron Pipe	1929	3321	4	U.S.	NADC
Coated Abrasives	1929	3291	9	U.S.	NAR
Petroleum Refining-JASCO	1929	2911	4	Ger.; U.S.	USC
Petroleum Refining-Hydro Patents	1930	2911	4	Ger.; U.S.	USC
Water Conditioning Apparatus	1930	3589	3	Ger.; U.K.; U.S.	NAR
Grinding Hobs	1931	3545	3	U.S.	NAR
Magnesium Alloys	1931	3339	2	Ger.; U.S.	USC
Rail Joint Bars	1931	3312	3	U.S.	NAR
Railroad Springs	1932	3493	3	U.S.	NAR
Hydraulic Oil Pumps	1933	3561	3	U.S.	NADC
Machine Tools	1933	3541	4	U.S.	NAR
Petroleum Refining-Gray Processes Co.	1933	2911	5	U.S.	USC
Petroleum Refining-JUIK Group	1933	2911	5	U.S.	USC
Phillips Screws	1933	3452	2	U.S.	NAR
Television/Radio Apparatus-Australia	1933	3651	2	Australia	NAR
Beryllium	1934	3339	3	Ger.; U.S.	USC
Electrical Equipment	1934	3600	3	Ger.; U.S.	NAR
Lecithin	1934	2070	5	Den.; Ger.; U.S.	NAR
Petroleum Refining-Fractional Distillation	1934	2911	5	U.S.	USC
Polymeric Acrylic Acid	1934	2821	2	Ger.; U.S.	USC
Variable Condensers	1934	3629	3	U.S.	NAR
Acrylic Acid For Laminated Glass (Plexigum)	1935	3229	2	U.S.	NAR
Dyestuffs	1935	2865	5	Switz.; U.S.	USC
Petroleum Refining-Gas Polymerization	1935	2911	5	U.S.	USC

General Chemical	1936	2800	3	Can.; U.K.; U.S.	USC
Male Hormones	1937	2833	4	Ger.; Switz.; U.S.	NAR
Wrinkle Finishes	1937	3582	2	U.S.	NAR
Dropout Cutouts	1938	3643	2	U.S.	NAR
Inductive Heat Treatment	1938	3547	2	U.S.	NAR
Opthalmic Frames	1938	3851	2	U.S.	NAR
Petroleum Refining-Hydrocarbon	1938	2911	5	Ger.; U.S.	USC
Pour Depressants	1938	2911	3	U.S.	NAR
Slip Covers	1938	2221	3	U.S.	NADC
Petroleum Refining-Alkylation	1939	2911	4	U.K.; U.S.	USC
Dyestuffs	1940	2865	3	U.K.; U.S.	USC
Television Equipment	1942	3651	3	U.S.	NAR
Television/Radio Apparatus-Canada	1943	3651	4	Can.; U.S.	NAR
Alginate (Dental) Impression Powder	1947	3843	3	U.S.	NADC
Plastic Artificial Eyes	1948	3842	2	U.S.	NAR
Television/Radio Apparatus-Great Britain	1948	3651	5	Neth.; U.K.	NAR
Tractor Cabs	1948	3537	3	U.S.	NAR
Daylight Fluorescent Pigments	1949	2816	4	U.S.	NADC
Glass Fibers	1956	3229	3	Jap.; U.S.	NAR
Sewing Machines	1956	3639	3	It.; Swed.; U.S.	NAR
Laser Eye Surgery	1992	3845	2	U.S.	FTCFOIA
MPEG-2 Digital Video	1997	3652	8	Jap.; Neth.; U.S.	DOJFOIA
DVD-ROM, DVD-Video	1998	3652	3	Jap.; Neth.	DOJFOIA
Wireless Personal Area Networking-Bluetooth	1998	3663	9	Fin.; Jap.; Swed.; U.S.	POOL
1394 Digital Data Transfer Interface	1999	3577	6	Japan; Neth.; U.S.	POOL
DVB-T - Digital Broadcasting	1999	3663	4	Fr.; Jap.; Neth.	POOL
DVD-ROM, DVD-Video	1999	3652	6	Jap.; U.S.	DOJFOIA
3G-Mobile Communications	2001	3663	19	Fin.; Fr.; Ger.; It.; Jap.; Neth.; S.K.	POOL

Notes: Standard Industrial Codes ending with one or more zeros indicate that the pool covered multiple subclasses within a given classification.

National abbreviations: Can. = Canada; Den. = Denmark ; Fin. = Finland; Fr. = France; Ger.= Germany; It. = Italy; Jap. = Japan; Neth. = The Netherlands ; S.K. = South Korea; Swed. = Sweden; Switz. = Switzerland; U.K. = United Kingdom ; U.S. = United States.

Source abbreviations: DOJFOIA = U.S. Department of Justice Freedom of Information Act request; FTCFOIA = U.S. Federal Trade Commission Freedom of Information Act request; NADC = U.S. Department of Justice files in the National Archives (Suitland, Maryland); NAR=District court docket files in the regional facilities of the National Archives (Boston; Chicago; Kansas City; and New York City); POOL = provided directly by patent pool administrator; USC = published hearings or unpublished files of the U.S. congressional investigations.

Table 2: Summary of characteristics of patent pools. The table presents summary information on a variety of features of the sample of 63 patent pools. Medians and standard deviations are not reported for dummy variables.

	Mean	*Median*	*Standard Deviation*	*Minimum*	*Maximum*
Year signed	1942	1934	24	1895	2001
Number of initial members in pool	4.54	3	4.85	2	36
Number of nations initially represented in pool	1.67	1	1.03	1	7
Must patents be transferred to the pool?	0.25			0	1
Are future patents automatically assigned to the pool?	0.73			0	1
Must know-how also be transferred to other pool members?	0.35			0	1
Do pool members use the patents in the pool?	0.98			0	1
Do all pool members have relevant patents?	0.75			0	1
Are cash transfers required as part of joining pool?	0.13			0	1
Can pool members use all patents on a royalty-free basis?	0.24			0	1
Are licensing proceeds split equally between pool members?	0.23			0	1
Are patents licensed to third parties?	0.67			0	1
Can other parties join the pool?	0.19			0	1
Can individual pool members license the patents?	0.44			0	1
Are patents licensed to third parties on "most favored nation" basis? [a]	0.52			0	1
Must third party licensees "grant back" patents on future discoveries? [a]	0.52			0	1
Do third party licensees face menu of license types? [a]	0.14			0	1
Is the royalty rate charged third parties fixed in the pool agreement? [a]	0.33			0	1
Is the per unit rate charged third parties fixed in the pool agreement? [a]	0.45			0	1

[a]Only computed for those pools where third party licenses are offered.

Table 3: The prevalence of terms of patent pools. The table presents four critical terms that that affect the workings of patent pools: the stipulations that pool members can offer licenses independent of those offered by the pool, that the control of the litigation process is centralized, that licenses are granted to third parties, and that pool members need not assign to the pool all future related patents. In each case, the characteristics of the pools are presented for pools that did or did not have this requirement. The characteristics examined are whether the agreement is signed before 1945, whether the agreement is signed in 1995 or after, the count of firms originally in the patent pool, and the growth of patenting in the industry segment of the pool in the five years prior to the formation of the pool. In each case, the first line presents the mean of each measure and the t-test of the null hypothesis that these two populations are identical; and the second line, the median and the associated Wilcoxon test. (For the univariate values, a Pearson χ^2-statistic is presented.) Asterisks denote cases where the differences are statistically significant. The final row presents the mean frequency of the term in the sample.

	Test Reported	*Pool members can make own licenses*		*Centralized control of patent litigation?*		*Licenses granted to third parties?*		*Pool members need not transfer patents to pool?*	
		Yes	No	Yes	No	Yes	No	Yes	No
Agreement before 1945?	χ^2-test	64%	**86%	85%	**58%	69%	*90%	72%	88%
Agreement after 1994?	χ^2-test	25%	***0%	6%	*21%	14%	5%	15%	0%
Count of pool	t-test	5.8	*3.6	4.6	4.6	3.9	5.9	4.8	4.1
members	Wilcoxon	4	*3	3	3	3	3	3	4
Five-year growth,	t-test	67%	51%	54%	66%	57%	60%	67%	33%
pool industry patenting	Wilcoxon	52%	26%	30%	36%	26%	64%	48%	15%
Mean for sample		*44%*		*25%*		*66%*		*75%*	

* Statistically significant at 10% confidence level.
** Statistically significant at 5% confidence level.
*** Statistically significant at 1% confidence level.

Table 4: Regression analysis of the determinants of patent pool structure. The table presents a generalized method of moments estimation of a system of equations. The sample consists of 56 patent pools formed between 1895 and 1994. The dependent variables are as follows: qualitative variables denoting whether the pool allowed independent licenses, whether the control of litigation was centralized, whether patents were licensed by the pool to third parties, and whether the terms of the pool were innovation friendly, and a latent variable measuring whether the patents in the pool were substitutes (constrained to fall between zero and one, with one denoting cases where they were substitutes). The independent variables include the count of firms originally in the patent pool (top-coded as 6), the growth of patenting in the industry segment of the pool in the five years prior to the formation of the pool, dummy variables denoting pools formed before 1945, where members use the patents on a royalty-free basis, and not among those identified by Gilbert [2002] as displaying anti-competitive behavior, and various dependent variables. Standard errors reported in brackets.

	Dependent Variable:									
	Are Independent Licenses Allowed?		Is Control of Litigation Centralized?		Are Patent Licensed To Third Parties?		Is Pool Innovation Friendly?		Are Patents Substitutes?	
Count of firms in pool	0.29	**[0.14]	0.25	*[0.14]	0.33	**[0.14]				
Are patents substitutes?	-1.48	*[0.77]			-0.25	[0.89]				
Count of firms * Third party licensing * No independent licensing			-0.13	[0.14]						
Independent licensing			-1.20	[0.93]						
Substitutes * Independent licensing			0.36	[0.98]						
Patents licensed to 3rd parties?							0.13	[0.40]		
Complements * 3rd party licensing							0.41	[1.34]		
Growth of patenting in the industry							0.27	[0.28]		
Pool formed before 1945?									0.18	[0.26]
Members use royalty-free and don't license to others?									0.16	[0.10]
Not problematic case (Gilbert [2002])									-0.66	*[0.38]
Constant	0.06	[0.73]	0.14	[0.58]	-0.17	[0.80]	0.80	**[0.40]	0.66	[a]
Log likelihood	-171.05									
Number of observations	51									

*=Significant at the 10% level; **=significant at the 5% level; ***=significant at the 1% level.

[a]Standard error is not meaningful for constant in latent variables estimation.

Table 5: Comparison of patents included in recent pools with matching patents. The sample consists of 174 patents that were included in five patent pools formed in 1995 and after along with 347 matching patents. The patents are compared according to several measures of technological and economic significance that Hall, Jaffe, and Trajtenberg [2001] refer to as patent importance, originality, generality, and scope. The first four columns present means of the various measures [medians in brackets] for the set of patents that were included in pools and for two sets of matching patents. The first of these sets labeled "Matching Patents by Firm and Class" contains two matching patents for each pooled patent. The first of these matching patents was chosen as the most proximate patent awarded to the same firm. The second of these matching patents was chosen as the most proximate patent awarded within the same main USPTO technology class and to the same type of assignee. The matching set used in the third and fourth column consists of the two sub-sets of matching patents. p-values from t-tests and Wilcoxon tests of the null hypotheses that the two samples have the same means and medians are presented in the fifth and sixth columns respectively.

		Panel A: Importance				
	Pooled Patents	*Matching Patents by Firm and Class*	*Matching Patents by Firm*	*Matching Patents by Class*	*p-Value from t-Test*	*p-Value from Wilcoxon Median Test*
Citations/year received before pool formation	1.6 [0.9]	0.8 [0.4]			0.000	0.000
Citations/year received before pool formation	1.6 [0.9]		0.8 [0.3]		0.000	0.000
Citations/year received before pool formation	1.6 [0.9]			0.7 [0.4]	0.000	0.000
Citations/year received after pool formation	2.5 [0.9]	1.3 [0.3]			0.001	0.000
Citations/year received after pool formation	2.5 [0.9]		1.3 [0.3]		0.016	0.000
Citations/year received after pool formation	2.5 [0.9]			1.3 [0.3]	0.007	0.001
		Panel B: Originality				
	Pooled Patents	*Matching Patents by Firm and Class*	*Matching Patents by Firm*	*Matching Patents by Class*	*p-Value from t-Test*	*p-Value from Wilcoxon Median Test*
Originality measure	0.38 [0.44]	0.38 [0.44]			0.863	0.711
Originality measure	0.38 [0.44]		0.37 [0.44]		0.809	0.619
Originality measure	0.38 [0.44]			0.38 [0.44]	0.953	0.884
		Panel C: Generality				
	Pooled Patents	*Matching Patents by Firm and Class*	*Matching Patents by Firm*	*Matching Patents by Class*	*p-Value from t-Test*	*p-Value from Wilcoxon Median Test*
Generality measure	0.42 [0.48]	0.33 [0.40]			0.005	0.004
Generality measure	0.42 [0.48]		0.34 [0.44]		0.023	0.019
Generality measure	0.42 [0.48]			0.33 [0.38]	0.012	0.010
		Panel D: Scope				
	Pooled Patents	*Matching Patents by Firm and Class*	*Matching Patents by Firm*	*Matching Patents by Class*	*p-Value from t-Test*	*p-Value from Wilcoxon Median Test*
Number of claims made	16.1 [13]	15.2 [11]			0.525	0.058
Number of claims made	16.1 [13]		14.2 [10]		0.171	0.057
Number of claims made	16.1 [13]			16.1 [12]	0.984	0.170

Table 6: Regression analysis of citations to patents included in recent patent pools. The sample consists of 174 patents that were included in five patent pools formed in 1995 and after along with 347 matching patents that were selected based on grant date and belonging to the same USPTO patent class and being assigned to the same firm as the pooled patents. The dependent variables consist of the number of patent citations in each year, whether before or after the award. In Panel A, the sample includes the pooled patents, as well as the full set of 347 matching patents that were chosen based on assignee and class. Panel B includes the pooled patents as well as the matching set of patents selected based on assignee. Panel C includes the pooled patents as well as the matching set of patents selected based on patent class. Independent variables include a dummy variable indicating whether the patent was included in a pool, whether the observation was after the formation of the pool, the year the patent was awarded, the years since the award of the patent, and either the patent grouping (including the patent and its matches) or the individual patent. (Only the first two dummies are reported.) In each panel, the first regression employs an ordinary least squares (OLS) specification, the second two, a negative binomial specification. Standard errors are reported in brackets.

Panel A: Matched Sample includes Matches by Firm and Matches by Class						
			Specification:			
	OLS		*Negative Binomial*		*Negative Binomial*	
Was patent included in pool?	0.86	***[0.11]	0.71	***[0.06]		
Patent in pool and after pool formed?	1.19	***[0.18]	0.19	** [0.09]	0.25	***[0.07]
Dummies for award year and vintage?	Yes		Yes		Yes	
Dummies for patent groupings?	Yes		Yes		No	
Dummies for individual patents?	No		No		Yes	
p-Value	0.000		0.000		0.000	
R^2	0.35					
Number of observations	3,020		3,020		3,020	
Panel B: Matched Sample includes Matches by Firm Only						
			Specification:			
	OLS		*Negative Binomial*		*Negative Binomial*	
Was patent included in pool?	0.91	***[0.13]	0.83	***[0.07]		
Patent in pool and after pool formed?	1.11	***[0.21]	0.15	[0.10]	0.27	***[0.08]
Dummies for award year and vintage?	Yes		Yes		Yes	
Dummies for patent groupings?	Yes		Yes		No	
Dummies for individual patents?	No		No		Yes	
p-Value	0.000		0.000		0.000	
R^2	0.40					
Number of observations	2,014		2,014		2,014	
Panel C: Matched Sample includes Matches by Class Only						
			Specification:			
	OLS		*Negative Binomial*		*Negative Binomial*	
Was patent included in pool?	0.83	***[0.13]	0.64	***[0.07]		
Patent in pool and after pool formed?	1.14	***[0.21]	0.16	*[0.10]	0.14	*[0.08]
Dummies for award year and vintage?	Yes		Yes		Yes	
Dummies for patent groupings?	Yes		Yes		No	
Dummies for individual patents?	No		No		Yes	
p-Value	0.000		0.000		0.000	
R^2	0.38					
Number of observations	2,009		2,009		2,009	

* Statistically significant at 10% confidence level.
** Statistically significant at 5% confidence level.
*** Statistically significant at 1% confidence level.

Table 7: Ordinary least squares regression analysis of patent significance for patents included in recent patent pools. The sample consists of 174 patents that were included in five patent pools formed in 1995 and after along with 347 matching patents that were selected based on grant date and belonging to the same USPTO patent class and being assigned to the same firm as the pooled patents. The dependent variables consist of several measures of technological and economic value which Hall, Jaffe, and Trajtenberg [2001] refer to as patent originality, generality, and scope. In Panel A, the sample includes the pooled patents, as well as the full set of 347 matching patents that were chosen based on assignee and class. Panel B includes the pooled patents as well as the matching set of patents selected based on assignee. Panel C includes the pooled patents as well as the matching set of patents selected based on patent class. Independent variables include a dummy variable indicating whether the patent was included in a pool, as well as dummy variables (not reported) that control for the year the patent was awarded, the pool to which the patent belongs (in the case of matching patents, this is the pool of the corresponding patent that was included in a pool), and the patent category as defined by Hall, Jaffe, and Trajtenberg [2001]. All regressions employ an ordinary least squares specification. Standard errors are reported in brackets.

Panel A: Matched Sample includes Matches by Firm and Matches by Class						
	Dependent Variable:					
	Originality		*Generality*		*Claims*	
Was patent included in pool?	0.008	[0.024]	0.082	***[0.027]	0.853	[1.424]
p-Value	0.002		0.000		0.438	
R^2	0.096		0.187		0.048	
Number of observations	518		433		505	
Panel B: Matched Sample includes Matches by Firm Only						
	Dependent Variable:					
	Originality		*Generality*		*Claims*	
Was patent included in pool?	0.013	[0.028]	0.074	**[0.033]	1.891	[1.363]
p-Value	0.007		0.000		0.216	
R^2	0.129		0.212		0.086	
Number of observations	345		287		336	
Panel C: Matched Sample includes Matches by Class Only						
	Dependent Variable:					
	Originality		*Generality*		*Claims*	
Was patent included in pool?	0.005	[0.028]	0.089	**[0.031]	-0.066	[1.757]
p-Value	0.003		0.000		0.672	
R^2	0.124		0.199		0.053	
Number of observations	347		300		337	

* Statistically significant at 10% confidence level.
** Statistically significant at 5% confidence level.
*** Statistically significant at 1% confidence level.

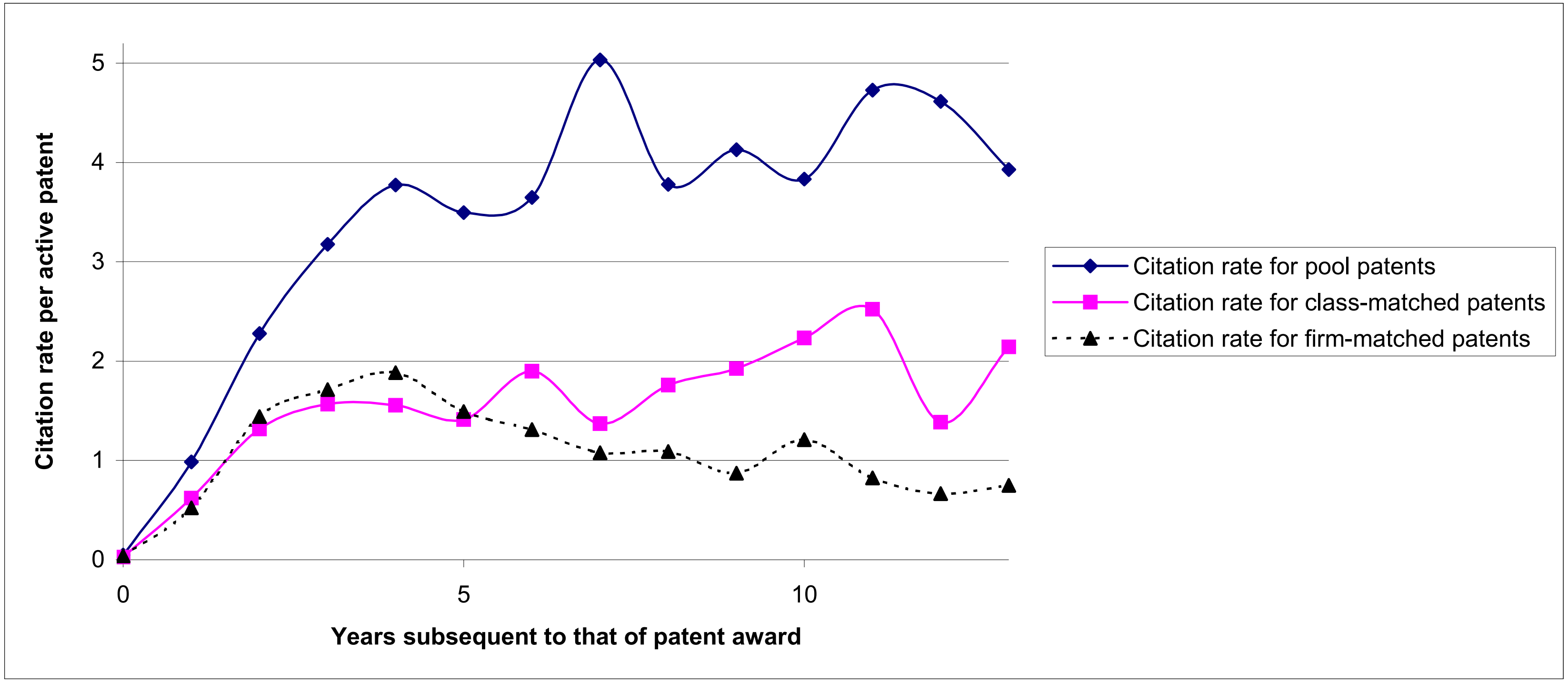

Figure 1: Citation rate for pool and matching patents relative to award date. The sample consists of 174 patents that were included in five patent pools formed in 1995 and after along with 347 matching patents that were selected based on grant date and belonging to the same USPTO patent class and being assigned to the same firm as the pooled patents. The figure presents the mean number of citations per patent for each year after the award (the calendar year of the patent award is designated as year 0, and so forth). Because there are few seasoned patents in the sample, the final observation includes awards from year 13 and afterwards.

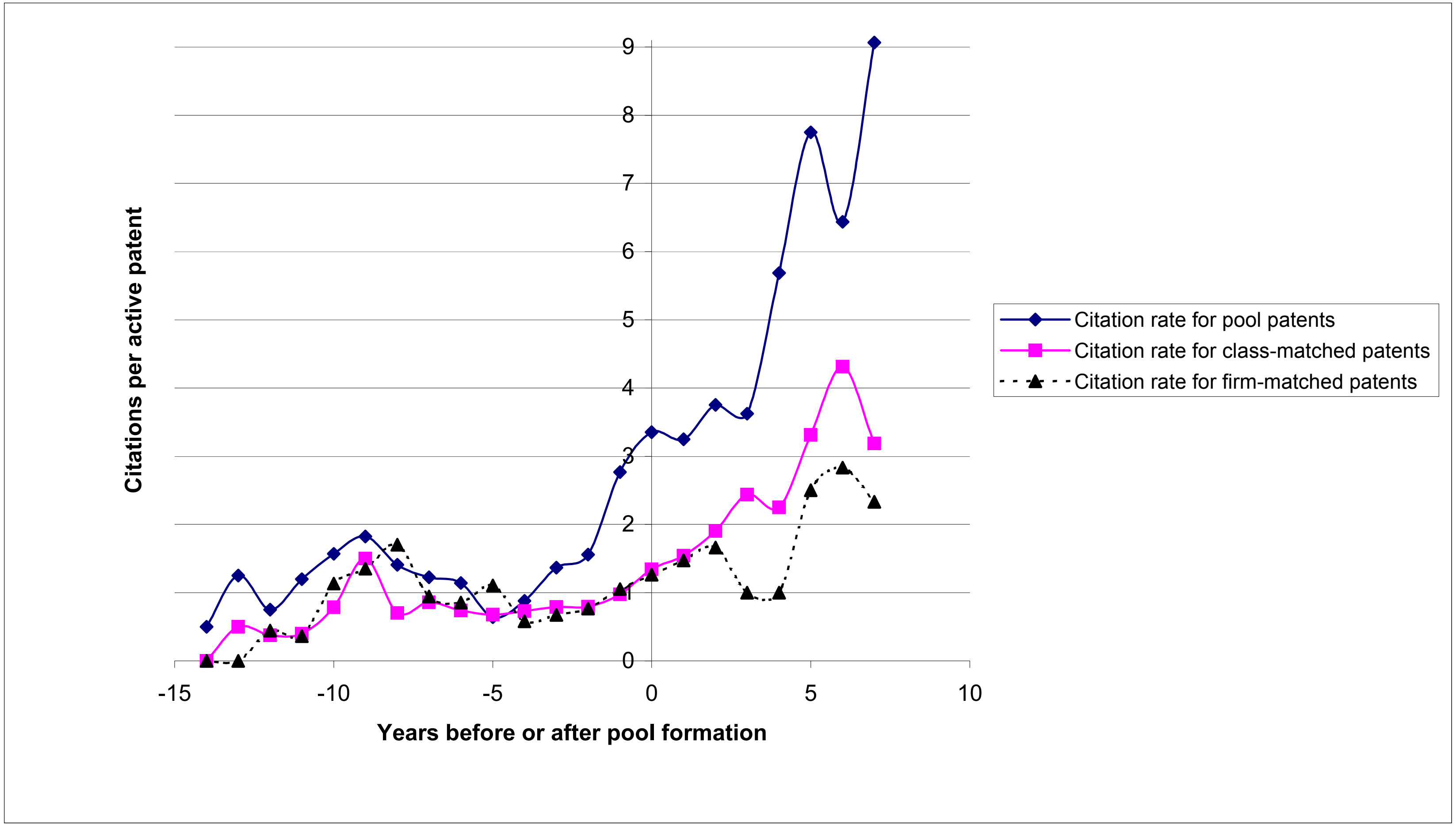

Figure 2: Citation rate for pool and matching patents relative to pool formation date. The sample consists of 174 patents that were included in five patent pools formed in 1995 and after along with 347 matching patents that were selected based on grant date and belonging to the same USPTO patent class and being assigned to the same firm as the pooled patents. The figure presents the mean number of citations per patent for each year before and after the formation of the pool (the calendar year of the pool's formation is designated as year 0, and so forth).