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To join or not to join: Examining patent pool participation and rent sharing rules ☆

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ABSTRACT

In recognition that participation in modern patent pools is voluntary, we present empirical evidence on participation rates and the factors that drive the decision to join a pool, including the profit sharing rules adopted by the pool's founders. In most participation contexts, the at-risk group is extremely difficult, if not impossible, to identify. For pools centered on technologies that result from a standard-setting process, in contrast, we are able to identify a relatively unambiguous population of patents eligible for inclusion but that have not been included in the pool. We find that vertically integrated firms, with patents and downstream operations, are more likely to join a patent pool and among those firms that do join, those with relatively symmetric patent contributions (in terms of value) to a standard appear more likely to accept numeric patent share rules for dividing royalty earnings.

1. Introduction

Until recently, the economic literature on patents pools–voluntary organizations created for the purpose of pooling a group of patents into a single licensing package–has been quite sparse. Following on the heels of the intense interest in the theories of "patent thickets" and "royalty stacking" (e.g., Shapiro, 2001, 2006), and the increased proliferation of organizations that promulgate technical standards for products and services, patent pools are emerging as an important topic for economic analysis. The newfound interest is understandable, given that patent pools are one of the more readily available tools proposed for overcoming the potentially harmful effects of overlapping or blocking patent rights (Merges, 1999; Shapiro, 2001).

Much of the economic analysis of patent pools to date has focused on their role in competition policy (Choi, 2003; Teece and Sherry, 2003; Gilbert, 2004; Lerner et al., 2007; Lerner and Tirole, 2008). As such, few of the theoretical papers have addressed the fact that joining a patent pool is voluntary (as we show below, pool participation rates in our data range from 30% to 60%). The exception is Aoki and Nagaoka (2004), which explicitly models patent pool participation. The theoretical literature has also largely assumed that pool earnings are distributed equally among members, without considering other arrangements seen in practice. Since modern patent pools tend to emerge from cooperative industry-led standard setting efforts, much of the emergent empirical literature has been focused on understanding the links between the patents and their association with standards and patent pools (Lerner et al., 2007), for example by using patent citations to measure the impact of endorsement by a standard for a patent and its holder (Rysman and Simcoe, 2008).[1]

In this paper, we extend the empirical branch of the literature by examining the determinants of joining a patent pool. We do this by exploiting our ability to identify a relatively unambiguous population of patents eligible for inclusion in a patent pool: those patents named as needing to be licensed in order to implement the standard associated with the pool, but which are not included in the pool. Unlike most participation analyses, where the group of eligible members is extremely difficult to identify outside of observed participation, we are able to use the patents declared to the standard setting organization (SSO) as potentially essential for implementing the standard to define pool eligibility; we can then isolate those eligible but not participating. We also provide some preliminary thoughts on the rules that patent pools select for dividing royalty earnings among participants. Using the theoretical literature as a starting point, we develop several hypotheses which we then test against a dataset of firms that have either joined or are eligible to join a patent pool.

We find that a number of factors appear to affect the odds of a firm joining a patent pool. In particular, firms that are vertically integrated (the firm conducts relevant research and manufactures a product

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[1] There is a legal literature with a longer history, however, which has focused primarily on patent pools as legal institutions. See, for example, Merges (1996, 1999), and Newberg (2000).

dependent on the standard) are more likely to join patent pools, which is consistent with the theoretical literature. Also consistent with theory, pools that adopt numeric proportional sharing rules-where license earnings are shared among members according to their numeric share of the total patents in the pool-tend to attract fewer joiners.[2] Examining various observable patent value measures, our findings suggest that firms with higher value patent portfolios are less likely to join a numeric proportional pool. Our findings also suggest that when patent contributions to a standard are relatively symmetric in value across firms, firms forming a pool may be more likely to accept a numeric proportional rule for dividing the royalty earnings.

The paper proceeds as follows. In Section 2 we briefly review the relevant literature and discuss how patent pools work, summarizing the participation, licensing and rent-division rules found in practice. Section 3 describes our dataset, which builds on the modern patent pools studied in Lerner et al. (2007), and presents the results of the empirical analysis on pool participation decisions. Section 4 concludes.

2. Understanding patent pools

2.1. Background

Patent pools have a long history in the US, dating back to the mid 1800 s. After an early phase of allowing a great deal of latitude for any combination of patents, antitrust authorities began to take a far more limited view of patent pools in 1912. Throughout the 1940 s more pools were disbanded than were allowed, and in the 1950 s all of the challenged patent pools were found anticompetitive (Gilbert, 2004). As a result, firms largely stopped attempting to form patent pools for a good many years. The trend finally reversed course in 1995, when the Department of Justice and the Federal Trade Commission issued new guidelines for intellectual property that recognized the pro-competitive aspects of patent pools. The guidelines triggered a new era for patent pools and today there are a number of patent pools in place, with nearly all of them emerging out of cooperative industry standard setting efforts.[3]

Within the economics literature, the most relevant study to the analysis we present here is Aoki and Nagaoka (2004), who consider a firm's incentives to join a pool. Their model assumes that licensing earnings are divided evenly among members and three types of member firms can participate—vertically integrated firms that conduct research and development (R&D) and manufacture a downstream good, firms that only perform R&D, and manufacturing-only firms. The authors find different incentives face different firm types. An R&D-only firm "always has incentive to deviate from a patent pool" because licensing royalty fees are the primary source of its profits and equal rent division does not acknowledge differences in business models. "Although the [R&D] firm would not like the royalty to be too high since it reduces demand," the authors note "it finds its profit increasing in [the royalty rate] when [the royalty rate] is small." The vertically integrated firm and the manufacturing firm, on the other hand, want royalties "to be as low as possible" in order to reduce their own production costs. Thus, the authors argue that "there should be extra distribution to research firms [within the pool] to compensate for the lack of production profits." Furthermore, Aoki and Nagaoka find that royalty rules that provide pool members with equal shares of the total earnings "cause a large scale underinvestment in R&D compared to what is collectively optimal."

2.2. Patent pool formation and governance

In practice, just as assumed in Aoki and Nagaoka, joining a patent pools is voluntary, even for firms participating in an associated SSO. For instance, hours before the establishment of the MPEG-2 pool, Lucent elected not to participate, having concluded that it would do better licensing its patents individually (Lerner and Tirole, 2008).

As might be expected, the rules defining a patent pool's operations are crafted by the founding members in the negotiations leading up to the pool (Chiao et al., 2007; Simcoe, 2008). These rules can be contentious. For example, all of the contributing members to the DVD ROM standard led by the DVD Forum discussed forming a patent pool in order to provide "one-stop shopping" for licensees.[4] When discussions over the governance rules broke down, two mutually exclusive patent pools were formed — both of which need to be licensed to manufacture products compliant with the standard.[5] In some cases, pools also have exit rules for members who have a change of heart after joining (Goldstein and Kearsey, 2004).

Note that abstaining from a patent pool is not synonymous with patent holdup, which is generally defined as the exploitation of a patent's "essentiality" for implementing a standard by seeking compensation that exceeds the patent's marginal contribution to the standard (Shapiro, 2001). Legitimate reasons for not participating in a patent pool might include: minimal contributions to the standard and no intention of actively seeking licensing fees for the relevant patents or existing cross licenses with most or all other relevant patent holders. Non-holdup strategic reasons might include a desire to avoid close patent review by a third party that could expose weak patents or an ongoing research plan for which future break-throughs are expected.

Because modern patent pools are largely spawned by standard setting efforts, most are comprised of complementary patents. That is, the patents cover distinct elements of a technology and need to be used together to implement the standard. Within an SSO, multiple substitute (patented) technologies may be proposed during a standard's definition, although typically one option is chosen for official inclusion in the standard and that option is then eligible for inclusion in the pool.[6] Even though the firms contributing complementary patents to the standard may be rivals, offering competing products in a downstream market, the patents they contribute to the standard and, if they choose to join, to the patent pool, are generally not substitutes. As a result, all of the patents in the pool are deemed necessary–typically through independent review according to member-defined criteria[7]–for implementing the product or service specified by the standard, and thus all need to be licensed.[8] Using an independent expert for review recognizes the difficulty of determining genuine essentiality, which involves a technical and

[2] This effect is quite difficult to measure, since the sharing and joining rule are endogenous for all founding members. We can only measure the effect of the sharing rule on participation among firms who join already established patent pools, for whom the sharing rule is exogenous.

[3] There are instances of patent pools in the pharmaceutical sector as well. Glaxo SmithKline, for instance, announced that it would create a patent pool to promote research in tropical diseases.

[4] Weiss, Paul. Letter to Joel Klein Regarding Request for Business Review letter of Patents for DVD Technology. October 9, 1998, at 10.

[5] Merges (1999) provides a discussion of the DVD Forum members' unsuccessful attempt to form a single patent pool for the DVD standard.

[6] This is not always the case, however, when SSO members have difficulty agreeing on a single option. For example, the 3G mobile telecommunications standard includes two distinct technologies for the air interface portion of a cellular call (from the phone to the base station). Technical Specification 25 of the 3G standard, which defines the air interface, includes both frequency division duplex (FDD) and time division duplex (TDD). See http://www.3gpp.org/specs/numbering.htm.

[7] A patent can be deemed legally essential for a standard if the standard cannot be implemented without infringing that patent, if it is "necessarily infringed" or if "there is no realistic alternative"; this is the rule chosen by the DVD-2 patent pool. Alternatively, commercial essentiality maintains that a standard cannot be implemented in a manner palatable to consumers without the patent, even though the standard might function properly without it; the DVD-1 patent pool takes this more encompassing approach.

[8] There is, in fact, a cottage industry devoted to in-depth patent review for essentiality determination. The results of these reviews are not made public, so we cannot determine the exclusion rate. We are unaware of any litigation over essentiality determinations, although industry sources indicate that, not surprisingly, these are hotly contested among patent pool members.

legal assessment of a patent's claims against the chosen definition of essentiality. It also acknowledges the contentious nature of such reviews. Once submitted patents have been vetted, the pool provides a way to consolidate the essential complementary rights, enabling more widespread licensing and use of the standard.

After deciding to form a patent pool and establishing the basis for patent inclusion, the next decision facing founding pool members regards licensing terms. Consistent with Lerner and Tirole (2008) theoretical predictions for complementary patent pools, most modern pool agreements allow for independent licensing by pool members outside of the pool. Thus licenses for any of the patents within a pool can be negotiated independently with the patent owner.[9] While independent licenses are typically priced in bilateral negotiations, the license fee the pool charges for the full package of patents is collectively set by pool members. Most choose a royalty structure, where licensees pay the pool administrator either a percentage of the licensee's net sales of the licensed product or a flat fee per unit sold.

While Aoki and Nagaoka assume an equal distribution of profits across all members, equal sharing rules are not seen in practice. Instead, we find three distinct sharing rules in the active pools we study: royalty-free licensing and thus no royalties to divide; numeric proportional rules, where members receive a share of the aggregate earnings based on the number of patents they contribute to the pool; and value proportional rules, where members with more valuable contributions receive a larger share of the earnings. The most common rule is the numeric proportional one:six of the nine pools we analyze below have agreed to such a rule.[10] All but one of these six patent pools is administered by MPEG LA—an independent licensing administrator that grew out of the MPEG-2 patent pool efforts. The prevalence of such numeric rules is somewhat surprising, since it is well understood that simple patent counts do not reflect the value of underlying technical contributions (Lanjouw et al., 1998). Simple rules are, however, far easier to administer.

The MPEG-2 agreement offers a typical numeric rule. It states that royalty payments will be divided according to the formula $^{P}/_{N} \cdot M$, where P is the number of pool patents the party holds in a country, N is the total number of essential patents in that country belonging to the pool (as determined by expert review), and M is the total royalties collected in that country. Each country is therefore treated distinctly, with rents divided according to patent ownership within that country.

Other pools have established more complex rules where the division of earnings depends on certain indicators of the value of the patents contributed. Two of the pools we analyze fall under this category.[11] Instead of devising a formula, the members of the pools negotiated collectively to determine what each contributor receives. For example, public documents indicate that one of the DVD pools' royalty sharing plans is a function of the age of the patents, how often they are infringed, and whether they pertain to optional or mandatory features of the standard.[12]

Only one of the nine modern patent pools we examine has agreed to royalty-free licensing. With a few specific exemptions–such as for patents that involve third parties–the Bluetooth pool offers its package of patents free of charge. The pool includes any patents pertaining to protocols, data formats, and electrical signaling characteristics owned or controlled by pool members.

All pools must agree on how to deal with follow-on patents. Pools often establish "grant back" policies, whereby future patented inventions relevant to the pool's technology must be offered to the pool at no fee. MPEG-2, for instance, has such a policy.[13] Pools must also address the issue of how rent division changes when new patents are added to the pool. For pools with numeric proportional rules members have incentives to increase their patent portfolios in an attempt to increase their shares. The MPEG-2 pool agreement addresses this issue by stipulating that if new patents are added to the pool, licensing royalties for existing patents will not change during the term of license. This maintains some stability in royalty shares over time, with all adjustments made at the time of license renewal, but does not eliminate the perverse incentive to patent aggressively. The pool for 1394 FireWire technology has a different rule: all newly added patents to the pool are automatically licensed without additional charge. This structure locks in the royalty rate division over time, but without a significant increase in demand resulting from the new patent's inclusion in the pool, this policy reduces participants' incentives to make additional contributions. The DVD pool agreement specifies that if new firms enter the pool, existing royalties will remain unchanged unless the new member's contributions are absolutely critical.

2.3. Patent pool participation hypotheses

The issue of whether or not to join a patent pool is likely a straightforward matter of maximizing firm profits. As Aoki and Nagaoka (2004) point out, firms with different business models will view patent pools through very different lenses. We might expect, then, to find that pool participation rates are higher among vertically integrated firms. These firms benefit from patent pools in two ways. First, pro-competitive pools of complementary patents generally lower the aggregate license fee that manufacturers face, in addition to lowering the transaction costs of obtaining licenses. Vertically integrated firms manufacture products embodying the standard and so they benefit from pools through lower costs in cross-licensing the necessary patents. Second, vertically integrated firms benefit from the royalties they earn through the pool as patent holders. While they could license these patents outside of a pool, perhaps for a higher per-patent fee, the pool can provide more widespread licensing, which coupled with the cross-licensing benefits, could tilt a vertically integrated firm's decision toward joining.

Research-and-development oriented firms, however, earn revenues only through licensing payments. If they can earn higher royalties outside of the pool, it could be in their best interest not to join. Extending this line of thought, we might expect that firms with especially valuable contributions to a standard (say, in terms of crucial components for the standard) would opt out of the patent pool since they are more likely to be able to negotiate higher royalties for their patents undiluted by other less-valuable contributions. This line of reasoning leads to our first hypothesis:

H1. Business models affect participation

- **a.** Vertically integrated firms are relatively more likely join a patent pool.
- **b.** Firms focused primarily on research and technology development (a licensing business model) are less likely to join a patent pool.

Case study evidence suggests that the sharing rule adopted by a pool also can have an impact on firms' willingness to join (Lerner and Tirole, 2008). Value proportional rules are easy to understand since they fit neatly into traditional economic thinking. The literature establishes that the distribution of patent value is highly skewed, with some patents worth a considerable amount (either commercially or in terms of generating follow-on research) while others are worth next to nothing (e.g., Scherer et al., 1959; Pakes, 1986; Scherer and Harhoff, 2000). Even among complementary patents declared "essential" for implementing a

[9] This arrangement can be interpreted as mixed bundling, where a package is offered along with its individual components. Arrangements of this sort help patent pools pass antitrust scrutiny (Lerner and Tirole, 2008).

[10] 1394, AVC, DVB-T, MPEG-2, MPEG-4, and WCDMA.

[11] The two DVD pools.

[12] Klein, Joel, Assistant Attorney General. Department of Justice, Antitrust Division. Business Letter of Review for the DVD-2 Patent Pool. Fax to Carey R. Ramos. June 10, 1999, available at www.usdoj.gov/atr/public/busreview/2485.htm.

[13] In fact, nearly all of the pools we study have grant back policies, where pool members have agreed to automatically license any future patents relevant to the pool on reasonable and non-discriminatory terms. Bluetooth is the exceptions. Bluetooth's royalty-free licensing likely explains its lack of a grant back policy.

standard, the value of a given patent's contribution can vary substantially depending on the component involved and the availability of alternative technologies (Layne-Farrar et al., 2007). Higher value patents should therefore earn higher royalty payments. We expect, then, that firms following an R&D model will be more inclined to join pools that opt for value-based sharing rules, and more inclined to push for value proportional rules when joining a pool at the founding stage.

Numeric proportional rules, on the other hand, appear to be justified on transaction cost grounds, since they are likely to be relatively easy to administer. The pool administrator must simply collect the royalties from licensees and distribute them to members according to a precise formula. In contrast, the DVD-1 pool agreement, which relies on a value-based rule, notes that members' independent auditors may audit the pool books and records once a year to ensure they receive their agreed upon royalties.[14] Clearly, this kind of oversight can get costly.

We would expect that royalty-free rules also appeal to fewer firms, although this arrangement can be justifiable for strategic reasons. For instance, companies may wish to promote a technology if widespread use of that technology enhances one of the firm's key products or services or is otherwise complementary to the firm's business model. A number of firms are well-known for this kind of strategy. For example, IBM has invested large sums (over $1 billion) in Linux open-source software[15] as a means of unifying the operating systems on its various computers to increase hardware sales (Campbell-Kelly and Garcia-Swartz, 2009). Likewise, Google offers a host of services to consumers free of charge in order to drive revenue-generating ad traffic.[16] Thus, the firms joining the Bluetooth pool might have chosen to do so to spur sales of their other, related products.

The differences in business models and revenue strategies suggest our second hypothesis:

H2. Rent sharing rules affect pool participation

- **a.** Royalty-free rules will result in lower rates of participation than either other rent sharing rule.
- **b.** Numeric proportional rules will appeal more to vertically integrated firms than R&D oriented firms.
- **c.** Numeric proportional rules will result in lower rates of participation than value-based rules.

The hypotheses listed under H2 are difficult to test empirically because the sharing rule is decided at the same time founding firms are finalizing their pool participation choice (sharing is endogenous). For firms deciding to join an already existing pool, however, the rent sharing rules can be taken as exogenous. We discuss this problem below in the empirical analysis.

Given that essential patents will tend to vary in their values, we might expect differences across patent portfolios among SSO members to affect pool participation. For example, when potential pool participants view the value of their contributions to a standard as roughly equivalent to other members' or when differences in raw patent counts are indicative of differences in the relative value contributed, then numeric proportional rules should roughly coincide with value rules. That should make firms more willing to adopt numeric proportional rules. In this special case, firms with symmetric contributions that elect to join a patent pool need not forego equity and efficiency in the name of lower transaction costs, so numeric proportionality is more attractive. This leads us to our third and final hypothesis.

H3. Patent contributions affect participation

- **a.** Firms with relatively symmetric patent offerings to a standard are more likely to join a patent pool.
- **b.** Firms with relatively symmetric patent offerings are more likely to agree to numeric proportional sharing rules.

3. Empirical analysis

In this section, we describe the data that we employ for the empirical tests of our hypotheses. After describing the data collection efforts, we present some descriptive statistics and then provide the regression results.

3.1. The data

We base our study on nine modern patent pools, all of which grew out of standard setting efforts.[17] In particular, we study the operating practices of the following patent pools:

- *1394*, a pool that aggregates patents comprising the 1394 (FireWire) standard for digital audio and video interfaces, developed by the Institute for Electrical and Electronics Engineers (IEEE). Almost all modern digital camcorders have included a FireWire connection since 1995 and many computers intended for home or professional audio/video use have built-in FireWire ports.
- *3G Partnership Project (WCDMA FDD)*, a pool created as part of the 3G Patent Platform Arrangement, provides access to a subset of the patents needed for the 3G wireless standard.[18]
- *AVC*, a pool based on the Advanced Video Coding (AVC) standard developed jointly by MPEG and the International Telecommunications Union (ITU) Video Coding Experts Group (VCEG), a combination known as the Joint Video Team. AVC is a standard for a digital video codec (a device or software module that enables video compression or decompression) which is noted for achieving very high data compression.
- *Bluetooth*, a pool that emerged from the IEEE Bluetooth standard for wireless personal area networking, which provides a way to connect and exchange information between devices like PDAs, mobile phones, laptops, etc. via a secure, globally unlicensed short range radio frequency.
- *DVB-T*, a pool based on the European Telecommunication Standards Institute (ETSI) standard for Digital Video Broadcasting-Terrestrial.
- *DVD-1*, a pool with three founding members contributing to DVD Forum's Digital Video Disc (Video and Read Only Memory (ROM)) standards.
- *DVD-2*, another pool comprised of members of DVD Forum that contributed to the DVD-Video and -ROM standards. These companies formed DVD 6C LA, a consortium licensing agency representing the six founding members. There is no overlap in membership between DVD-1 and DVD-2, although both pools cover the same standards.
- *MPEG-2*, a pool that formed out of MPEG's digital video standard setting efforts and in cooperation with the ITU.
- *MPEG-4*, another patent pool based on an MPEG standard, in cooperation with the International Organization for Standardization (ISO), this time for audio visual compression.

We construct a dataset that describes each of the nine patent pools listed above. The standard setting organization associated with the pool provides an observable and well-defined universe of potential patent pool members that enables analysis of pool participation. While most SSOs do not require members to conduct exhaustive IPR searches, most do have disclosure rules (Lemley, 2002; Rysman and

[14] See Klein, Joel, Assistant Attorney General. Department of Justice, Antitrust Division. Business Letter of Review for the DVD-1 Patent Pool. Fax to Garrard R. Beeney. December 16, 1998, available at www.usdoj.gov/atr/public/busreview/2121.htm.

[15] "Linux is an operating system for which the source code is available free without restrictions on use or requiring royalties." See http://www-1.ibm.com/linux/va_4066.shtml.

[16] See http://www.google.com/intl/en/corporate/business.html.

[17] Our intent is to cover all modern pools that are (or were in the recent past) actively licensing a group of patents. Any pool not currently in operation is excluded from our analysis.

[18] Note that the 3G Patent Platform Arrangement calls for the creation of 5 separate pools. Only the W-CDMA pool was actively licensing patent at the time of our analysis. More recently, Sisvel has created a patent pool for CDMA-2000 and activity has begun to establish a pool for 4G Long Term Evolution (LTE).

Simcoe, 2008). Moreover, the FTC has established a reputation for intolerance concerning firms that fail to disclose relevant IPRs who then expect to collect royalties from those implementing the standard.[19] As a result, the members disclosing patents to SSOs should capture fairly well the group of relevant patent holders within an SSO eligible for pool membership.

For every firm that contributes a patent to a standard, and is thus potentially eligible to join the related pool as a licensor, we collect company information on the products and services the firm provides and whether it manufactures any products relying on the standard from which the pool formed.[20] We define vertically integrated firms as those that contribute patents to a standard and also manufacture a product based on that standard. To make this determination, we searched each company's website and 10-k from the year the pool was formed for key words related to the standard. Universities are *not* considered vertically integrated as they do not manufacture products. Thus the non-vertically-integrated list includes entities that do not manufacture any products, such as universities, research labs, and R&D oriented firms, plus firms that do not manufacture products clearly based on the standard. (See Table A-3 for details.)

We also add patent data for each company. Each of the patent pool licensing agencies lists the patents included in the pool, with the exception of Bluetooth given its royalty-free status. For each patent listed as included in the pool, our data includes the USPTO patent number, title, primary class (using the U.S. patent classification scheme), the number of claims made, prior art listed, and non-self forward citations received (through December 2005). For Bluetooth we estimated a patent list by identifying all patents containing the keyword "Bluetooth" in the description or specification that were assigned to members known to contribute patents to Bluetooth. We then filtered the resulting list by comparing the class distribution to that of the patents disclosed to the Bluetooth standard. A pool patent had to be within one of the classes listed in the patents declared to the standard and each class had to also contain at least two patents. The most recent patent disclosed to the standard was granted in 2003, so to maintain consistency, we used this year as our cut-off date for all Bluetooth pool patents.

To identify all eligible patents, we used patents declared as essential to the related standard.[21] We counted all members making a patent declaration to the standard or the patent pool. In other words, some members included patents directly in the pool without first disclosing them to the standard. As these were obviously eligible for both the SSO and the pool, we included them.

This identification strategy worked for all patent pools with the exception of the two pools associated with DVD Forum, which did not require its members to disclose specific patents to the standards body. To identify the eligible patents for the DVD standards, we located patents containing the key words "DVD-Video" or "DVD-ROM", within the appropriate U.S. technology classes, and assigned to DVD Forum members. We narrowed our list to patents granted before 2004, as the DVD pools contain patents granted in 2003 or earlier.

[19] See for example, *In the Matter of* Rambus Incorporated, FTC Docket No. 9302, or *In the Matter of* Dell Computer Corporation, 121 F.T.C. 616.

[20] This is done via Internet searches for each company. Note that a handful of patents are listed within a particular patent pool but were not first disclosed to the associated standard.

[21] Because some standard setting organizations require only blanket intellectual property right disclosures, we are only able to analyze a portion of the patents relevant for a standard. We pull those patents that are explicitly listed for a standard and compare those to the broader list of patents held by participating firms, matching on keywords and class. The patents disclosed to the DVB SSO, for example, are estimated to cover 84% of the standard—more than any other standard we examined. The lowest coverage was the Bluetooth standard, where it appears that only 9% of the patents in the standard were actually disclosed to the SSO. Of course, some firms holding relevant patents fail to disclose them formally to the SSO, particularly when a royalty-free license agreement is in place.

3.2. Descriptive statistics

Table 1 compares participation in a standard with participation in the related pool. These figures provide us with a sense of the pool's participation rate along with its coverage of the patents needed to implement the standard. The third column of Table 1 presents the total number of firms eligible to join the pool (standard members that contributed patents to the standard).[22] The next column reports the number of firms that elected to join the pool.[23] The third column presents the percentage participation rate. As these three columns illustrate, patent pools do not often provide full coverage of a standard (or more generally, a technology). That most pools contain roughly one-third of the eligible firms reinforces the voluntary nature of pool participation. Moreover, several of the pools are comprised of relatively few companies. The DVB-T pool, for instance, has only 4 members from among the ten firms that had patents relevant to the standard.

Columns six through eight of Table 1 focus on patent coverage. These columns report, in order, the total count of specific patents declared to the standard, the number of patents offered by the related pool, and the percentage of standard patents that count reflects. Patent coverage is never 100%. In many cases the patents included in the pool represent a small fraction of the total patents declared to the related standard. This is driven by two distinct factors. First, joining the pool is voluntary and many standard participants refuse to join, leaving all of their patents outside of the pool. Second, for those firms that do join, their patents are subject to an independent review for essentiality, and not all patents declared as essential to a standard are actually found to be so. The last column of the table gives the age of the pool, meant to capture the state of the pool's technology. Older pools may no longer attract members simply because the covered technology has been supplanted.

Table 2 breaks the data down according to business model. The third column reports the percentage of pool members that participate in downstream manufacturing (vertically integrated, as defined above) while the fourth column reports the percentage of non-pool members that do so. The fifth column reports test statistics on the difference. These statistics demonstrate that the pools are largely comprised of vertically integrated firms that manufacture a product directly dependent on the standard (consistent with hypothesis H1). The bottom panel of the table reports these same statistics for all pools combined by rent sharing rule.

Table 3 offers measures of value for the patents in our dataset. To accurately measure patent value, individual patent must be examined in detail from a legal and technical perspective. Given the difficulty of that assessment, the literature has proposed several proxies for patent value that are objective and easily observable. The list of generally accepted proxies include citations made to a patent after granting (non-self forward cites), the "generality" of the patent (i.e., the extent to which follow-on patents cover a broad range of technology fields and applications), patent "originality" (i.e., the breadth of technology fields the patent draws from its prior art), and the number of claims made within a patent (see e.g., Trajtenberg, 1990; Harhoff et al., 1999; Jaffe and Lerner, 2001; Trajtenberg et al., 1997; but see also Gambardella et al., 2008 for some cautions regarding citations).

The first three of these value proxies are presented in Table 3. We calculate average annual citations per patent for pool members and non-pool members. The "Test" column presents t-test results comparing pool and non-pool averages. The second set of columns present annual generality measures. The final set of columns present the originality results. Since this last measure is not dependent on time (prior art is fixed), we calculate overall average originality per patent for pool and non-pool members. The bottom panel of the Table combines pools by rent

[22] Note that this figure will not necessarily match the total number of standard members, as not all members declare patents.

[23] This figure does not necessarily match the total number of pool members, as firms not contributing patents to a standard can join a related pool as licensees.

Table 1
Patent pool participation.

Pool	Pool profit sharing rule	All firms eligible for pool	Total # of firms joining pool	Firm participation rate	Total patents declared to standard†	Total patents in pool	Pool coverage rate	Pool age[a]
1394	Proportional	17	9	53%	80	60	75%	8
AVC	Proportional	45	14	31%	55	37	67%	2
Bluetooth	Royalty-free	25	8	32%	141	116	82%	10
DVB-T	Proportional	10	4	40%	29	5	17%	3
DVD-1	Value-based	12	4	33%	289	81	28%	9
DVD-2	Value-based	12	7	58%	289	195	67%	8
MPEG-2	Proportional	59	19	32%	142	98	69%	10
MPEG-4	Proportional	71	24	34%	106	94	89%	9
WCDMA	Proportional	34[b]	10	29%	348	36	10%	3

Notes: †specific patent declarations only, including those offered through the pool but not officially declared to the standard.
[a] This is year of analysis (2007) minus year of inception.
[b] There are 30 firms that have patents declared to the standard plus 3 that are in the pool but have no patents declared to the pool and 1 (Sharp) which has patents in the pool but not declared to ETSI.

sharing rule. Note that patents not included in proportional pools tend to have higher annual citations than the patents included in the pool.

3.3. Testing the hypotheses

To test the three hypotheses described above, we estimate logistic regressions where the dependent variable is equal to one if a firm chose to join a pool for which it was eligible (i.e., for which it had patents in a related standard) and zero otherwise.[24] An individual record therefore represents a firm-pool combination. In other words, for each patent pool we have a single record for every firm that declared at least one U.S. patent to the associated standard and is therefore eligible to join the pool.[25] If a firm is eligible for more than one pool, it will have multiple records. All of the firm-pool records are then stacked into a single dataset. We have a total of 170 firm-pool records in the dataset. Because the number of firms is insufficient to run separate regressions for each pool, we address the hypotheses pertaining to sharing rules through independent variables in the participation regressions.

Table 4 reports our results. The baseline regression includes the following variables. The dummy variable for whether the firm is vertically integrated is meant to test H1. The share of eligible members who are founders, which is equals zero if the firm is among the founders and equals the number of founders divided by the number of firms that could have been founders otherwise, is meant to test whether the rent dissipation concerns affect the participation decision (Dequiedt and Versaeval, 2006). The average number of claims per patent for the firm's patents declared to the standard is a patent quality control.[26] The number of patents the firm has declared to the standard captures the firm's active participation in the development of the standard. The average age of the firm's patents measures the firm's interest in licensing revenues (older patents have a shorter remaining statutory life). The age in years of the pool (2007 minus the year of pool creation) is a control for technologies that may have been supplanted in the marketplace. And finally, dummy variables for the technology area of the standard (the omitted technology category is audio-visual) are meant to capture differences in practice across industries.

As predicted in H1, vertically integrated firms are more likely to join patent pools. This coefficient is highly statistically significant (and stable across all models). The share of eligible members that are founders is negative and significant, implying that the larger the number of firms organizing a patent pool, the less likely other firms will find it beneficial to join later on. Average claims per patent are positive and significant, indicating that the higher the number of claims in a portfolio the more likely a firm is to join a pool, although this result disappears when a control for sharing rule is introduced (next column). The number of patents in the standard is not statistically significant, nor is average patent age, the latter of which is somewhat surprising. The coefficient on pool age is, not surprisingly, negative and significant, suggesting that the older a pool is the less likely firms are to join it. This could reflect the pool technology becoming dated and therefore less relevant over time. Both of the included technology dummies are statistically significant, with networking pools attracting more members and telecom pools attracting fewer members than audio-visual pools.

The model in the next column adds variables exploring the impact of the sharing rule. In particular, we add a dummy variable indicating whether the pool has a numeric sharing rule, which is interacted with a dummy variable for the firm *not* being a founding member. The interaction coefficient is therefore estimated by those firms for whom the numeric proportionality rule can be taken as given. The interaction is meant to address the endogeneity problem mentioned earlier. If, as appears to be the case, sharing rules do not change over time, then the sharing rule decision is endogenous for founding members only, and not for firms joining after the decision has been made. Estimating the impact of the rule for non-founding members therefore should measure the effect of the given rule on a firm's decision to join a pool. The estimated coefficient on the interaction term is negative, implying that firms are less likely to join an

Table 2
Percent of firms vertically integrated, Pool vs. non-pool.

Pool	Profit sharing rule	% Vertically Integrated		Test statistic (p-value)††
		Pool members	Non-pool members†	
1394	Proportional	89%	0%	4.44 (0.035)*
AVC	Proportional	93%	33%	6.02 (0.014)*
Bluetooth	Royalty-free	63%	0%	4.29 (0.038)*
DVB-T	Proportional	75%	25%	2.00 (0.157)
DVD-1	Value-based	100%	100%	0.55 (0.460)
DVD-2	Value-based	86%	100%	0.78 (0.377)
MPEG-2	Proportional	89%	25%	16.47 (<0.001)**
MPEG-4	Proportional	79%	40%	3.18 (0.075)
WCDMA	Proportional	57%	35%	0.86 (0.354)
Combined pools	Proportional	83%	32%	36.63 (<0.001)**
	Royalty-free	63%	0%	4.29 (0.038)*
	Value-based	91%	92%	0.02 (0.902)
	Overall	82%	41%	31.66 (<0.001)**

N = 170.
Notes: †we examine any firm that made a patent IP declaration to the standard.
††Chi-squared test result for statistical difference between pool and non-pool percentages, probabilities reported.
Significance at the 0.05 level and better marked with * and 0.01 and better marked with **.

[24] We employ a robust cluster estimator, with observations clustered by firm. See the Appendix for summary statistics describing the regression dataset.
[25] Firms that made blanket declarations to the standard (whose patent portfolio in the standard is therefore not known) are not considered in the regression analysis.
[26] We explored other patent value measures in unreported results, but claims were the most stable.

Table 3
Patent value measures, comparing pool patents to non-pool patents, controlling for patent age.

		Average annual citations			Average generality[a]			Average originality		
Standard	Sharing rule	Pool	Non	Tests	Pool	Non	Tests	Pool	Non	Tests
1394	Proportional	1.04	1.97	2.86**	0.45	0.58	1.59	0.39	0.14	−2.71**
AVC	Proportional	0.78	1.40	2.11*	0.44	0.55	1.31	0.42	0.47	0.68
Bluetooth	Royalty-free	0.49	0.51	0.08	0.28	0.27	−0.14	0.37	0.29	−1.14
DVB-T	Proportional	1.73	1.55	−0.21	0.60	0.36	−1.85	0.35	0.20	−1.06
DVD-1	Value-based	1.02	0.85	−0.96	0.25	0.27	0.56	0.20	0.40	4.80**
DVD-2	Value-based	0.90	0.89	−0.01	0.27	0.26	−0.31	0.43	0.22	−4.70**
MPEG-2	Proportional	1.64	1.94	0.83	0.51	0.52	0.18	0.35	0.41	1.07
MPEG-4	Proportional	0.65	0.97	1.00	0.35	0.50	1.45	0.40	0.32	−0.93
WCDMA	Proportional	0.98	1.31	0.74	0.30	0.28	−0.06	0.45	0.34	−2.19*
Combined pools	Proportional	1.08	1.41	2.19*	0.43	0.38	−2.18*	0.39	0.33	−2.56*
	Royalty-free	0.49	0.51	0.08	0.28	0.27	−0.14	0.37	0.29	−1.14
	Value-based	0.93	0.86	−0.61	0.26	0.27	0.17	0.37	0.37	−0.07
	Overall	0.93	1.16	2.55*	0.35	0.33	−0.67	0.38	0.34	−2.04*

N = 868.
Notes: The statistics presented above compare patents included in a pool to patents not included. Yearly citations per patent within each pool, average per patent reported. Generality is also an average per patent over years by pool. The generality formula, following Trajtenberg et al. (1997), is $G_i = \left[1 - \sum_j^{n_i} S_{ij}^2\right]$ where S_{ij} is the share of citations received by patent i, in patent class j, out of n_i patent classes. Originality is based on prior art, and therefore does not change over time. We report average originality within each pool. The originality formula is the same as generality, except S_{ij} is the share of citations made by patent i in patent class j, out of n_i patent classes. The analysis excludes reissued patents and patents issued after 2004. We test whether non-pool patents have statistically higher measures than pool patents using two-tailed t-tests. Test statistics are reported, with statistical significance at the 0.05 level or better marked with * and significance at the 0.01 level or better marked with **.
[a] We use only non-self cites. Furthermore, patents that have zero non-self forward cites are dropped as it is in not possible to calculate generality for such patents. This resulted in a sample size of 868 patents.

established pool that employs a numeric proportional rule. Unfortunately, since only two of the pools in our data have adopted value-based sharing rules and only one pool adopted a royalty-free licensing rule, we were unable to explicitly test these other sharing rules.

The third specification presented considers the impact of patent symmetry. As a measure of portfolio symmetry, we add a ratio of the firm's average number of claims per patent divided by the standard's average number of claims per patent (the standard less that firm).[27] The portfolio symmetry variable is positive and significant, as predicted. Thus, when a firm's patent value as measured by the number of claims is similar to that of the standard as a whole, the firm is more likely to join the associated pool.

The last regression model presented in Table 4 includes only those firms that did not join the pool at the time of its formation. As mentioned above, such firms take as given the revenue sharing rule within a pool. As with the other specifications, we find that vertical integration and symmetry are positive and significant in explaining late participation, while the ratio of founders to all eligible firms is negative and significant, supporting the rent dissipation theory.

4. Conclusions

We have focused on extending the empirical literature on patent pools. In light of the voluntary nature of patent pools, and the finding that as many as one half to two-thirds of the eligible firms chooses not to join a patent pool, the main focus here has been on the determinants of joining. Using the theoretical literature as a starting point, we developed several hypotheses which we then tested using a dataset of firms that have either joined or are eligible to join a patent pool. Because modern patent pools have largely emerged from standard setting efforts, we were able to identify the population of firms eligible to join a pool but that chose to not join. With this reasonably complete at-risk population, we were then able to identify factors that affect a firm's decision to join or not join a pool.

We identify a number of factors that appear to affect the odds of joining a pool. The most prominent among the variables that increase the probability of joining are the vertical integration (whether the firm manufactures a product dependent on the standard) and the symmetry between the quality of a firm's patent portfolio and the standards' overall patent contributions. Among those factors that reduce a firm's likelihood of joining a pool are larger founding member groups and numeric proportional sharing rules.

The three hypotheses we developed are largely supported by the empirical analysis. The strongest support was for H1, which predicted vertically integrated firms are more likely to join a pool. The evidence is

Table 4
Logistic regression results, dependent variable is pool participation.

	Baseline	Sharing rules	Symmetry	Non-founders[b]
Constant	3.90*	−0.04	4.05**	2.08
	(1.60)	(1.01)	(1.58)	(2.37)
Vertical integration	2.92**	2.07**	2.99**	2.96**
	(0.65)	(0.46)	(0.66)	(0.76)
Ratio founders/all firms	−17.01**		−17.44**	−13.45**
	(3.01)		(3.08)	(4.97)
Average # claims	0.05*	0.03		
	(0.02)	(0.02)		
# of patents in standard	−0.01	−0.03	−0.01	
	(0.02)	(0.02)	(0.02)	
Average patent age	−0.01	0.05	−0.01	−0.02
	(0.06)	(0.05)	(0.06)	(0.06)
Pool age	−0.38**	−0.12	−0.41**	−0.33*
	(0.14)	(0.08)	(0.14)	(0.15)
Networking	3.47**	1.10	3.65**	3.16**
	(1.10)	(0.66)	(1.14)	(1.19)
Telecom	−4.00**	−1.52*	−3.68**	−3.70**
	(1.07)	(0.71)	(1.03)	(1.17)
Numeric[a]		−1.61**		
		(0.48)		
Portfolio symmetry*			0.95**	1.02**
			(0.36)	(0.39)
Pseudo R^2	0.5790	0.2947	0.5859	0.3421

N = 170.
Notes: The table presents logistic regression results, where the dependent variable is a dummy that takes on the value of one if a patent is included in a particular pool for which it is eligible and zero otherwise. Statistical significance at the 0.05 level or better marked with * and significance at the 0.01 level or better marked with **.
*Symmetry is defined by the ratio of a firm's average number of patent claims divided by the average number of patent claims for the standard as a whole.
[a] The numeric proportionality rule dummy variable is interacted with a dummy variable for non-founding members. The numeric rule coefficient is therefore estimated among firms for whom the sharing rule is likely exogenous. As a result, we omit the ratio founders/all firms.
[b] Firms joining the pool at its time of creation are excluded. This reduces the number of observations to 101.

[27] We tried a similar ratio with citation measures (not reported), but the coefficient was not statistically significant.

Appendix A-1. Dataset details

Variable	Number of observations	% of total
Pool members	96	44
Non-pool members	74	56
Vertically integrated firms	109	64
Audio–visual	117	69
Networking	22	13
Telecom	31	18
Numeric proportionality rule	134	79
Value-based	24	14
Royalty-free	12	7

A-2. Regression variables

Variable	Mean	Median	Min	Max	S.D.
Ratio founders/all firms	0.16	0.15	0	0.58	0.15
Average # claims	20.44	18.72	2	78	12.09
# of patents in standard	8.65	3	1	66	13.67
Average patent age	9.72	8.75	3	25*	4.34
Pool age	7.09	9	2	10	3.16
Portfolio symmetry	1.20	0.74	0	14.22	1.61

Notes: The number of observations is 170 firm-pool combinations for each variable. *Expired patents will exceed the 20 year limit.

A-3. Classification of firms as vertically integrated, by standard

Standard	Entity name	Vertically integrated	Standard	Entity name	Vertically integrated
1394	APPLE COMPUTER, INC.	Y	MPEG-2	HITACHI, LTD	Y
1394	CANON KABUSHIKI KAISHA	Y	MPEG-2	INTEL CORPORATION	N
1394	HITACHI, LTD	Y	MPEG-2	INTERNATIONAL BUSINESS MACHINES CORPORATION	N
1394	INMOS LIMITED	N	MPEG-2	JVC	Y
1394	LG ELECTRONICS INC.	Y	MPEG-2	LG ELECTRONICS INC.	Y
1394	MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.	Y	MPEG-2	LUCENT TECHNOLOGIES INC.	N
1394	SEMICONDUCTOR ENERGY LABORATORY CO., LTD.	N	MPEG-2	MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.	Y
1394	SONY CORPORATION	Y	MPEG-2	MITSUBISHI DENKI KABUSHIKI KAISHA	Y
1394	TOSHIBA CORPORATION	Y	MPEG-2	NEC CORPORATION	Y
1394	U.S. PHILIPS CORPORATION	Y	MPEG-2	NIHON TOKUSHU NOYAKU SEIZO K.K.	Y
AVC	COLUMBIA UNIVERSITY	N	MPEG-2	NORTHERN TELECOM LIMITED	N
AVC	DIVA SYSTEMS CORPORATION	Y	MPEG-2	PMC-SIERRA LTD.	N
AVC	FASTVDO LLC	N	MPEG-2	QUALCOMM, INC.	N
AVC	FUJITSU LIMITED	Y	MPEG-2	RACAL DATA COMMUNICATIONS INC.	N
AVC	INTERNATIONAL BUSINESS MACHINES CORPORATION	N	MPEG-2	RCA	Y
AVC	JVC	Y	MPEG-2	ROBERT BOSCH GMBH	N
AVC	LG ELECTRONICS INC.	Y	MPEG-2	SAMSUNG ELECTRONICS CO., LTD.	Y
AVC	MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.	Y	MPEG-2	SCIENTIFIC-ATLANTA, INC.	Y
AVC	MICROSOFT CORPORATION	Y	MPEG-2	SIEMENS AKTIENGESELLSCHAFT	Y
AVC	MITSUBISHI DENKI KABUSHIKI KAISHA	Y	MPEG-2	SONY CORPORATION	Y
AVC	SAMSUNG ELECTRONICS CO., LTD.	Y	MPEG-2	STC PLC	N
AVC	SIEMENS AKTIENGESELLSCHAFT	Y	MPEG-2	TEKTRONIX INC.	Y
AVC	SONY CORPORATION	Y	MPEG-2	THOMSON	Y
AVC	THOMSON	Y	MPEG-2	TOSHIBA CORPORATION	Y
AVC	TOSHIBA CORPORATION	Y	MPEG-2	U.S. PHILIPS CORPORATION	Y
AVC	U.S. PHILIPS CORPORATION	Y	MPEG-4	APPLE COMPUTER, INC.	Y
AVC	UB VIDEO INC.	Y	MPEG-4	AT&T CORP.	N
BLUETOOTH	AGERE SYSTEMS INC.	N	MPEG-4	CANON KABUSHIKI KAISHA	Y
BLUETOOTH	CERTICOM CORPORATION	N	MPEG-4	COMPETITIVE TECHNOLOGIES OF PA, INC.	N
BLUETOOTH	ERICSSON, INC.	Y	MPEG-4	DIVA SYSTEMS CORPORATION	Y
BLUETOOTH	GOLDEN BRIDGE TECHNOLOGY, INC.	N	MPEG-4	ETAT FRANCAIS, MINISTRE DES POSTES, DES TELECOMMUNICATIONS ET DE L'ESPACE	N
BLUETOOTH	INTEL CORPORATION	N	MPEG-4	FASTVDO LLC	N
BLUETOOTH	INTERNATIONAL BUSINESS MACHINES CORPORATION	N	MPEG-4	FRANCE TELECOM	N
BLUETOOTH	MICROSOFT CORPORATION	Y	MPEG-4	FUJITSU LIMITED	Y
BLUETOOTH	MOTOROLA, INC.	Y	MPEG-4	GENERAL ELECTRIC COMPANY	Y
BLUETOOTH	NOKIA	Y	MPEG-4	GENERAL INSTRUMENT CORPORATION	Y
BLUETOOTH	NTRU CRYPTOSYSTEMS, INC.	N	MPEG-4	HITACHI, LTD	Y

(continued on next page)

Appendix A-3 (*continued*)

Standard	Entity name	Vertically integrated	Standard	Entity name	Vertically integrated
BLUETOOTH	TOSHIBA CORPORATION	Y	MPEG-4	HYUNDAI CURITEL, INC.	Y
BLUETOOTH	XTREMESPECTRUM, INC.	N	MPEG-4	INTERAND CORPORATION	N
DVB-T	CIBA-GEIGY CORPORATION	N	MPEG-4	JVC	Y
DVB-T	DOLBY LABORATORIES INC.	N	MPEG-4	LG ELECTRONICS INC.	Y
DVB-T	FRANCE TELECOM	N	MPEG-4	MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.	Y
DVB-T	GTE LABORATORIES, INC.	N	MPEG-4	MICROSOFT CORPORATION	Y
DVB-T	JVC	Y	MPEG-4	MITSUBISHI DENKI KABUSHIKI KAISHA	Y
DVB-T	MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.	Y	MPEG-4	RCA	Y
DVB-T	NOKIA	Y	MPEG-4	REALNETWORKS, INC.	N
DVB-T	U.S. PHILIPS CORPORATION	Y	MPEG-4	SAMSUNG ELECTRONICS CO., LTD.	Y
DVD-1	HITACHI, LTD	Y	MPEG-4	SHARP KABUSHIKI KAISHA (SHARP CORPORATION)	Y
DVD-1	JVC	Y	MPEG-4	SIEMENS AKTIENGESELLSCHAFT	Y
DVD-1	LG ELECTRONICS INC.	Y	MPEG-4	SONY CORPORATION	Y
DVD-1	MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.	Y	MPEG-4	TELEDIREKTORATETS FORSKNINGSAVDELING	N
DVD-1	MITSUBISHI DENKI KABUSHIKI KAISHA	Y	MPEG-4	THOMSON	Y
DVD-1	PIONEER CORPORATION	Y	MPEG-4	TOSHIBA CORPORATION	Y
DVD-1	SANYO ELECTRIC CO., LTD.	Y	MPEG-4	U.S. PHILIPS CORPORATION	Y
DVD-1	SONY CORPORATION	Y	WCDMA	ALCATEL	Y
DVD-1	THOMSON	Y	WCDMA	ASUSTEK COMPUTER INC.	Y
DVD-1	TIME WARNER ENTERTAINMENT CO., L.P.	Y	WCDMA	BROADCOM CORPORATION	N
DVD-1	TOSHIBA CORPORATION	N	WCDMA	CSELT - CENTRO STUDI E LABORATORI TELECOMUNICAZIONI S.P.A.	N
DVD-1	U.S. PHILIPS CORPORATION	Y	WCDMA	D.S.P.C. TECHNOLOGIES LTD.	N
DVD-2	HITACHI, LTD	Y	WCDMA	ELECTRONICS AND TELECOMMUNICATIONS RESEARCH INSTITUTE	N
DVD-2	JVC	Y	WCDMA	ERICSSON, INC.	Y
DVD-2	LG ELECTRONICS INC.	Y	WCDMA	EVOLIUM S.A.S.	N
DVD-2	MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.	Y	WCDMA	FRANCE TELECOM	Y
DVD-2	MITSUBISHI DENKI KABUSHIKI KAISHA	Y	WCDMA	FUJITSU LIMITED	N
DVD-2	PIONEER CORPORATION	Y	WCDMA	HUGHES ELECTRONICS CORP.	N
DVD-2	SANYO ELECTRIC CO., LTD.	Y	WCDMA	INDUSTRIAL TECHNOLOGY RESEARCH INSTITUTE, TAIWAN	N
DVD-2	SONY CORPORATION	Y	WCDMA	IPWIRELESS, INC.	N
DVD-2	THOMSON	Y	WCDMA	MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.	Y
DVD-2	TIME WARNER ENTERTAINMENT CO., L.P.	Y	WCDMA	MITSUBISHI DENKI KABUSHIKI KAISHA	N
DVD-2	TOSHIBA CORPORATION	N	WCDMA	NEC CORPORATION	N
DVD-2	U.S. PHILIPS CORPORATION	Y	WCDMA	NOKIA	Y
MPEG-2	ALCATEL	Y	WCDMA	NORAND CORPORATION	N
MPEG-2	AT&T CORP.	N	WCDMA	NORTEL NETWORKS LIMITED	N
MPEG-2	AUDIO CODES LTD.	N	WCDMA	NTT DOCOMO, INC.	Y
MPEG-2	BELGIAN STATE	N	WCDMA	PACIFIC COMMUNICATION SCIENCE, INC.	N
MPEG-2	CANON KABUSHIKI KAISHA	Y	WCDMA	PRECISION TRACKING, INC.	N
MPEG-2	COLUMBIA UNIVERSITY	N	WCDMA	QUALCOMM, INC.	N
MPEG-2	COMPRESSION LABS, INC.	N	WCDMA	RESEARCH IN MOTION LIMITED	Y
MPEG-2	DUBNER COMPUTER SYSTEMS, INC.	N	WCDMA	SAMSUNG ELECTRONICS CO., LTD.	Y
MPEG-2	ECI TELECOM LTD.	N	WCDMA	SHARP	Y
MPEG-2	FRANCE TELECOM	N	WCDMA	SIEMENS AKTIENGESELLSCHAFT	Y
MPEG-2	FUJITSU LIMITED	Y	WCDMA	SKYWORKS SOLUTIONS, INC.	N
MPEG-2	GENERAL ELECTRIC COMPANY	Y	WCDMA	TEXAS INSTRUMENTS, INCORPORATED	N
MPEG-2	GENERAL INSTRUMENT CORPORATION	Y	WCDMA	TOSHIBA CORPORATION	Y
MPEG-2	GRASS VALLEY GROUP, INC.	Y	WCDMA	U.S. PHILIPS CORPORATION	Y

weakest for the predictions relating to patent pool sharing rules (H2), due to data and interpretative constraints. Deeper analysis of sharing rules is the logical next step, but this will require more and better data.

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