GOVERNANCE AND THE EFFICIENCY OF ECONOMIC SYSTEMS
GESY

Discussion Paper No. 342

# Standards, Innovation Incentives, and the Formation of Patent Pools

Klaus M. Schmidt*

*University of Munich

November 2010

Financial support from the Deutsche Forschungsgemeinschaft through SFB/TR 15 is gratefully acknowledged.

# Standards, Innovation Incentives, and the Formation of Patent Pools*

Klaus M. Schmidt[a)]

University of Munich, CESifo and CEPR

September 2010

This version: November 16, 2010

ABSTRACT: Technolgical standards give rise to a complements problem that affects pricing and innovation incentives of technology producers. In this paper I discuss how patent pools can be used to solve these problems and what incentives patent holders have to form a patent pool. I offer some suggestions how competition authorities can foster the formation of welfare increasing patent pools.

KEYWORDS: Patent pools, standard setting organisations, innovation, complements problem, patent thicket.

JEL CLASSIFICATION NUMBERS: L15, L24, O3.

---

*) Paper prepared for the conference "Pros and Cons of Standard Setting" organized by the Swedish Competition Authority in Stockholm, Sweden, November 12, 2010. I would like to thank Anne Layne-Farrar, Monika Schnitzer and participants at the "Pros and Cons of Standard Setting" conference for helpful comments and suggestions. Financial support by the German Excellence Initiative and the Deutsche Forschungsgemeinschaft through SFB-TR 15 is gratefully acknowledged.

a) Klaus M. Schmidt, Department of Economics, University of Munich, Ludwigstr. 28, D-80539 München, Germany, email: klaus.schmidt@LMU.de .

# 1 Introduction

Whenever high technology products of different firms interact with each other technological standards are required. These standards are based on patents that are often owned by different patent holders. Each patent holder, when setting the royalty for his patents, does not take into account that an increase of his royalty rate reduces demand for the final products and thereby reduces the profits of the other essential patent holders. This externality is the so called "complements problem" that gives rise to excessively high royalties.

A straightforward solution to the complements problem is a patent pool that jointly markets all essential patents. Even though a patent pool is a cartel that fixes an essential input price for downstream products, competition authorities acknowledge that patent pools of complementary patents can be procompetitive if they reduce royalty rates and transaction costs by allowing for "one-stop shoping". In Section 2 I review and discuss the complements problem and the role played by patent pools in more detail.

While the impact of patent pools on royalty setting is fairly well understood, much less is known about their dynamic effects. The prospect of a patent pool increases future profits and thereby presumably increases the incentives of the involved parties to invest into the technologies they contribute to the standard. However, there are two problems. First, if firms compete to get their technology included in the standard and to be a member of the patent pool there is a "business stealing effect" that may induce firms to invest too much. Second, a patent pool solves the complements problem but not the team production problem that arises when the investment of one firm benefits all other firms that belong to the pool. This induces firms to invest too little. In Section 3 I discuss how to induce firms to invest efficiently. There I show that patent pools requiring grantbacks that are formed at an early stage of the standardization process can play an important role to improve innovation incentives.

Even though patent pools can have many desirable properties firms often fail to form a pool that includes all essential patents. In many cases no pool is formed at all. Instead standard setting organizations require their members to set "reasonable and non-discriminatory" (RAND) royalties.[1] RAND commitments prevent outright refusal to license and exclusive licensing, but they impose hardly any additional constraints on royalties. As Swanson and Baumol (2005) put it: *"It is widely acknowledged that, in fact, there are no generally agreed tests to determine whether a particular license does or does not satisfy a RAND commitment."* Thus, they do not solve the complements problem. But even if a patent pool is formed, it is often the case that some holders of essential patents choose not to join it because they are better off free riding on the low royalties chosen by the firms that are in the pool. In these cases the pool mitigates the complements problem, but it does not fully solve it. In Section 4 I discuss the incentives of firms to form a patent pool. The more firms there are the larger is the problem of pool stability. I propose a new procedure for the approval of patent pools that I call "full functionality approval". This procedute makes every patent holder pivotal for the viability of the pool. If it was was adopted by competition authorities it would be much easier to form welfare increasing patent pools.

In Section 5 I briefly discuss some policy implications of the theoretical analysis. I argue that competition authorities should not just tolerate but actively encourage and support patent pools that satisfy certain conditions. In particular they should allow for early patent pools that require grantbacks even if fairly high royalties are set. This encourages innovation and does not reduce social welfare if royalty rates can be renegotiated. I also argue that competition authorities should adopt a system of "full functionality approval" in order to solve the free rider problem in pool formation.

[1] In Europe many SSOs require royalties to be "fair" in addition.

# 2 The Complements Problem

Cournot (1838, Chapter 9) was the first to discover that if a good requires complementary inputs that are supplied by different firms each of which has market power then the suppliers exert an externality on each other that may result in excessively high prices, prices that are even higher than the monopoly price. To illustrate his point Cournot used the example of the market for brass. Brass is produced from copper and zinc in fixed proportions (about 2:1, depending on the type of brass). Suppose that these two inputs are controlled by two different monopolists. When setting his price the copper monopolist does not take into account that by increasing his price he reduces the profits of the zinc monopolist, because an increase in his price reduces the demand for brass and thereby also the demand for zinc. Similarly, an increase of the zinc price reduces the demand for copper which is not taken into account by the zinc monopolist. In equilibrium the two monopolists charge prices that are higher than the prices that an integrated monopolist (supplying both copper and zinc) would choose. This implies that if the two monopolists could form a cartel they would agree to cartel prices that are lower than current market prices and that would benefit both, the two monopolists and consumers. In fact, this problem is very similar to the double marginalization problem that arises in a chain of monopolies, where vertical integration can raise industry profits and social welfare.

## 2.1 Standard Setting and Patent Thickets

At first glance Cournot's example may seem extreme and and not very realistic, but due to recent technological developments an even more extreme situation arises frequently with high technology products that interact with each other or with complementary products. Interaction requires that all products comply with the same technological standard. For example, a cellphone can communicate with another cellphone only if both of them use the same

communication standard (such as UMTS) , a DVD can be read by different DVD players only if all comply with the same DVD standard, and so on. These technological standards use dozens or even hundreds of patents owned by many different IP holders.

Ex ante, before the standard is set, there may be several different technological solutions to a given problem and therefore several different patents competing with each other. Ex post, however, after one solution has been selected and the standard has been set, the patents required for this standard become "essential": Because large investments in the development of products based on this standard have been sunk it is impossible or prohibitively expensive to circumvent the patents used by the standard. Each holder of an essential patent is now a monopolist controlling the supply of a complementary input. The more different patent holders there are, the more severe the complements problem is. Shapiro (2001) who rediscovered the relevance of Cournot's original analysis for high technology markets calls this situation a "patent thicket".

## 2.2. Cross Licensing Agreements and Patent Pools

Natural solutions to the complements problem are cross licensing agreements and patent pools. With a cross licensing agreement two firms owning complementary patents license their patents to each other at low royalties or royalty free. Cross licensing agreements can solve the complements problem between two symmetric firms that both own complementary patents and that both use these patents for the production of some downstream good. However, they have two disadvantages. First, they cannot be used if one of the firms is a technology specialist who owns an essential patent but does not produce on the downstream market because such a firm has no use for the patent of the other patent holder. Second, when the number $N$ of essential patent holders grows the number of required cross-licensing

agreements grows to $\sum_{n=1}^{N-1} n = \frac{N(N-1)}{2}$. Thus, when many potentially asymmetric firms are involved a patent pool outperforms cross licensing agreements. Ideally, the patent pool contains all patents that are required for the standard and licenses them as a bundle. The royalty income of the pool is then distributed according to a predertimend sharing rule among the patent holders. The patent pool internalizes the complements problem and reduces transaction costs by allowing for "one stop shopping".

To be sure, a patent pool is an agreement to fix input prices, i.e. a cartel. A patent pool always has an incentive to charge a price for the bundle of patents that maximizes industry profits and implements the monopoly price on the downstream market. If the patents are substitutes, this may turn a competitive market into a monopoly and lower social welfare. However, if the patents are complements the monopoly price is lower than the sum of the royalties that the firms would charge individually. Thus, the patent pool reduces the price for the bundle of patents and raises social welfare. Furthermore, the monopoly price is socially desirable. After all, patent holders have been granted a monopoly on their patents by the government as a reward for their innovation efforts.

## 2.3 Vertically integrated and Non-integrated Patent Holders

Some patent holders are technology specialists who are active only on the upstream market for technology, while others are vertically integrated and also manufacture products that are sold downstream to final consumers. It is sometimes argued that in the absence of a pool vertically integreated firms will charge lower royalties because they are more concerned about the downstream market. Kim (2004) and Schmidt (2008) show that this need not be the case. To the contrary, vertically integrated firms have an incentive to increase royalties in order to raise their rival's costs.

However, with a patent pool there is a conflict of interest between vertically integrated and non-integrated firms when it comes to the determination of royalties charged by the pool. Vertically integrated firms make part of their profits downstream. They have an incentive to lower royalties in order to shift profits downstream at the expense of non-integrated patent holders who make all their profits upstream. Thus, it may be difficult to agree to a patent pool if patent holders are asymmetric.

## 2.4 Distinguishing Patents that are Complements from Patents that are Substitutes

The papers considered so far assume that all patents are perfect complements. Indeed, the recent doctrine of competition authorities is that only essential patents be included in a patent pool.[2] When all patents are perfect complements a patent pool unambiguously increases social welfare, and it unambiguously decreases social welfare when all patents are perfect substitutes. However, it is often unclear whether patents complement each other or compete with each other. Lerner and Tirole (2004) have shown that whether patents are complements or substitutes is endogenous and depends in general on the licensing fees charged for them. Thus, it may be difficult for competition authorities to determine whether a patent should be allowed in a pool or not.

However, Lerner and Tirole also point out a simple screening mechanism to distinguish welfare-increasing patent pools from pools that lower welfare. They show that welfare-decreasing pools are unstable if independent licensing by pool members outside the pool is possible, while welfare-increasing pools are unaffected. If patents are substitutes patent owners can compete outside the pool and thereby undermine the cartel. If patents are complements this option is unattractive and not harmful to the pool. It may even be beneficial if the patents can be used for other applications. Thus, requiring patent pools to grant

[2] The Department of Justice and the Federal Trade Commission have softened this stance in their joint report on antitrust and IP issued April 2007 (http://www.ftc.gov/opa/2007/04/ireport.shtm ). Now they acknolwedge that including substitute patents need not be anti-competitive. Patent pools will be reviewed according to the rule of reason in the future. See also Layne-Farrar and Lerner (2008, p. 8).

permission to independent licensing is a simple safeguard against welfare-decreasing pools. In fact, in an empirical study of 63 patent pools formed in the US between 1895 and 2001 Lerner, Strojwas and Tirole (2007) find that patent pools are indeed more likely to have independent licensing when patents are complements.

# 3. Patent Pools and the Innovation Incentives

While the complements problem and the beneficial effects of patent pools on pricing are well understood by now, the literature has largely ignored the question of which effect a patent pool has on the incentives of the involved firms to develop new and improve existing technologies. Two types of innovations have to be distinguished. *Ex ante* innovations are innovations that are made before a standard is formed. Firms compete to get their technologies into the standard. *Ex post* innovations are innovations that can be made after the basic technologies for the standard have been selected. A firm contributing to the standard can then invest to further improve its technology.

A patent pool increases the profits made by the firms that own IP rights that are essential to the standard. Thus, the anticipation of a patent pool always increases the incentives to invest. However, in the case of *ex ante* innovations firms may invest too much, while they always invest too little in case of *ex post* innovations.

## 3.1 *Ex ante* Innovations

Dequiedt and Versaevel (2006) consider a dynamic model with $N$ symmetric firms each of which invests continuously over time. Innovations are modeled by a Poisson process. A patent pool is formed if $K < N$ independent innovations have been made. The value of an innovation is larger when it is included in the pool. Thus, there is a patent race where each firm tries to be among the first $K$ innovators. The prospect of the pool increases investment

incentives. Moreover, the investment pattern is upward sloping over time until the pool is formed. Note, however, that the private value of being in the pool is larger than the social value. Thus, there is a "business stealing effect" and firms may have an incentive to invest too much.

Gilbert and Katz (2009) ask how the overinvestment problem can be solved. They also consider a patent race model. There are $K$ innovations required for a new standard to work, but only two firms competing to make these innovations. The innovations are perfect complements. If each firm makes at least one innovation then both firms are required for the standard. If one firm makes all K innovations then this firm is a monopolist and sets up the standard alone. Thus, on the one hand, each firm has an incentive to underinvest because there is a free-rider problem. A discovery made by firm 1 also benefits firm 2 if both of them are required for the standard. On the other hand, a firm has an incentive to make all discoveries itself in order to prevent the other firm from participating in the standard. If the latter "business stealing" effect is sufficiently strong, firms invest too much. Gilbert and Katz (2009) characterize the optimal sharing rule that induces both firms to invest efficiently. The optimal rule is linear in the number of patents owned by each firm. In order to induce firms to invest efficiently the optimal sharing rule has to be complemented by a tax (or subsidy) imposed by the government that reduces the profits of the patent pool and thereby investment incentives. Unfortunately, the optimal tax depends on the parameters of the model and is therefore difficult to implement in practice.

## 3.2 Ex post Innovations

Another interesting and important case is the ex post situation where the standard has been formed and the major technologies have been chosen already, but before the standard is commercially implemented additional innovations that improve the standard can be made.

Layne-Farrar (2009, p.4) considers ex post innovation and patenting in the 3G mobile telecom standard. She reports that *"at the time the technology for the UMTS mobile telecoms standard was selected, the document specifying a crucial component was only 30 pages long, but by the time the standard was ready for commercial implementation the page count had increased to over 13,000."* This suggests that ex post innovation is indeed important.[3]

The analysis of this case is straightforward. Consider a situation where $N$ firms each contributed a basic technology to the standard. Suppose that $M$ of these firms, $M \leq N$, can now make an investment that improves the quality of their technology. Higher quality may result in lower production costs for downstream producers or in higher valuations of consumers. Without a pooling agreement firms impose two externalities on each other. First, because of the complements problem royalties will be set too high. This reduces demand for the final product and thereby reduces the incentive to invest for each firm. Second, investing in quality increases the demand for the final good and thereby the demand for the complementary patents. This gives rise to a team production problem. Each firm benefits from the investment of the other firm: When choosing its investment level a firm does not take into account the positive external effect of its investment on the profits of other patent holders. Thus, again, this induces firms to invest too little.

Suppose now that firms know at the time of their investment decisions that a patent pool will be formed licensing all essential patents as a bundle. Because the royalties charged by the pool are lower than the sum of the royalties firms would charge individually, the total quantity sold downstream and total profits increase which increases each firm's investment incentives. The patent pool solves the complements problem given the investments that have been undertaken, but it does not solve the team production problem. It is still the case that

[3] It is sometimes argued that ex post patenting is opportunistic and aimed at shifting rents and getting a larger share of the standard's royalty revenues. However, Layne-Farrar (2009) rejects the hypothesis that all ex post patenting is opportunistic and only directed at shifting rents. Instead, on the basis of reasonable empirical measures she finds that many ex post patents are valuable and reflect genuine innovations.

each firm has to share the fruits of its investment with all other essential patent holders. Thus, investments are lower than if all firms were fully integrated.

Is it possible to solve the team production problem and to induce efficient ex post innovations, i.e. innovations that a fully integrated firm would have chosen? The problem is that the royalty rate is endogenously determined by the investments. If the royalty could be set exogenously it would be easy to induce efficient investments. The marginal benefit of the investment is the marginal increase of downstream production due to the higher quality of the standard times $r_i$, the royalty rate collected by firm i. If $r_i$ is set such that the marginal benefit of investment equals marginal cost of investment at the efficient investment level, the firm will invest efficiently.

This can be implemented by giving the patent pool the option to buy out the patent holders who invested. Suppose that $M < N$, i.e. there are some pool members who do not invest. When the standard is set all essential patent holders form a patent pool that contains the relevant patents on which the standard is based. Furthermore, all contributing parties commit to include all future patents that are required by the standard to the patent pool, i.e., so called "grantbacks" are imposed.[4] The patent pool fixes optimal linear royalties $r_i$ that induce each investing party $i$ to invest efficiently. The problem is that ex post these royalties are likely to be inefficient, so firms have an incentive to renegotiate them. Suppose the patent pool has the option to make a take-it-or-leave-it offer to buy out those members that had to invest. They are offered a fixed fee equal to the royalty income they would have received in the absence of renegotion. This leaves their investment incentives unaffected. Then the pool chooses the optimal royalty rate that maximizes industry profits.

It is important that the renegotiation offer is made by a party that does not invest to induce the other parties to invest efficiently. But even if all parties have to invest the

[4] Grantbacks are a regular feature of many patent pools with complementary patents. See Lerner et al. (2007).

mechanism of forming an early patent pool with high royalties that are renegotiated downwards after investments have been sunk can increase investments and welfare as compared to a situation where no early pool can be formed.

# 4. Voluntary Participation in a Patent Pool

Patent pools for complementary patents have very desirable properties, but in many cases they are not formed or do not include all essential patents. The problem is that firms have to join a patent pool voluntarily, and they often choose not to do so. Sometimes firms participate in the standard setting process to make sure that their technology is included in the standard, but then refuse to join the patent pool. For example, shortly before the establishment of the MPEG-2 pool, Lucent chose not to participate because it concluded to be better off licensing outside the pool than being a pool member.[5] Sometimes a patent pool break up and several mutually exclusive patent pools are formed. For example, there were ten firms involved in the standard setting efforts for digital versatile discs (DVDs). However, after the standard was set these firms split up into two mutually exclusive patent pools. Even though industry experts agree that this is inefficient, firms have been unable to agree to one large pool.[6] A munfacturing firm has to license both patent pools in order to be compliant with the standard.

## 4.1 Free-Riding on the Pool

The reason for the failure to form an all inclusive patent pool is again a free rider problem. It would be profit maximizing for the group of all essential patent holders to form a patent pool and charge the full integration royalty rate for the bundle of all essential patents, but for any

[5] See Layne-Farrar and Lerner (2008, p. 7).
[6] See Merges (1999, p. 36-37) for a discussion of why two separate pools formed.

individual patent holder it is even better not to join but to free-ride on the low royalty set for the other patents in the pool by charging a higher royalty rate himself.

Aoki and Nagaoka (2004) consider a firm's incentives to join a patent pool. They show that if there are three or more symmetric patent holders that do not produce on the downstream market, then not joining the pool is always profitable as a unilateral conduct (i.e., as long as the other parties still form a pool). Furthermore, if there are different types of firms, some vertically integrated (i.e. owning essential patents but also manufacturing output) and some "R&D only" firms (i.e. owning essential patents but not producing downstream), then there is a conflict of interest. As discussed in Section 2.3 already, vertically integrated firms want royalties to be low in order to shift profits to the downstream market, while "R&D only" firms want royalties to be higher because they make all their profits upstream. Thus, vertically integrated firms have stronger incentives to join a patent pool than non integrated firms.

## 4.2 Patent-Pool Participation under Different Sharing Rules

Layne-Farrar and Lerner (2008) present empirical evidence on the factors affecting the decision to join a patent pool. They find that vertically integrated firms are indeed more likely to join a pool. They also look at how different sharing rules affect the incentives to join. They show that pools adopting numeric proportional sharing rules (royalties are shared in proportion to the number of patents submitted to the pool) tend to attract fewer joiners because simple patent counting does not reflect the value of the patents. Furthermore, firms with more valuable patent portfolios (as measured by citations) alre less likely to join a pool that uses a numeric proportional sharing rule.

Layne-Farrar, Llobet and Padilla (2010) theoretically evaluate another sharing rule that has been proposed as a means of avoiding patent hold up. The "incremental value rule" rewards each firm equal to the value that their patented technology contributes to the standard

on an *ex ante* basis (compared to the next best alternative). This rule has many attractive properties, but the authors show that it fails to induce firms to join a patent pool whenever this is efficient. The larger the number of essential patent holders, the lower is the probability that a pool will be formed.

## 4.3 Patent Pool Stability

Aoki and Nagaoka (2004) consider the incentives of an individual patent holder to join a pool, assuming that the pool will be formed in any case. However, this is not necessarily the case. If firm 1 does not participate in the pool it may be optimal for the remaining $N-1$ firms not to join a pool either. This stabilizes the "grand pool" (that includes all esential patents): If firm 1 anticipates that its refusal to join the pool will induce all firms to break off as well and to set their royalties non-cooperatively, then firm 1 is better off joining the pool. Aoki and Nagaoka (2005) analyze this problem as a coalition formation problem using the tools of cooperative game theory. They show that if the number of essential patent holders grows it becomes more and more difficult to sustain pool stability.

To illustrate this point consider a simple example: There is a perfectly competitive downstream market with a linear demand function $Q = A - b \cdot p$, where $Q$ is the total quantity sold, A,b >0 are parameters, and $p$ is the market price. In competitive equilibrium the market price is equal to the perceived marginal cost of the downstream firms, so $p = c + \sum_{i=1}^{N} r_i$, where $c$ is the marginal cost of downstream production and $r_i$ is the royalty charged by patent holder $i$, $i \in \{1,...,N\}$. Consider the following three situations.

- *Non Integration:* If all $N$ firms choose their royalties non-cooperatively there is a unique symmetric Nash equilibrium in which each firm sets $r_i^{NI} = \frac{A-bc}{b(N+1)}$ and makes profit $\Pi_i^{NI} = \frac{(A-bc)^2}{b(N+1)^2}$ .

- *Full Integration:* If a grand patent pool forms each patent holder charges $r^{FI} = \frac{A-bc}{2Nb}$ and makes profit $\Pi_i^{FI} = \frac{(A-bc)^2}{4Nb}$.

- *Partial Integration:* If $N-1$ firms form a patent pool while firm 1 sets its royalty rate non-cooperatively, then there is a unique symmetric Nash equilibrium in which firm 1 chooses $r_1^{PI} = \frac{A-bc}{3b}$ and the pool chooses for each of its members $r_i^{PI} = \frac{A-bc}{3b(N-1)}$, $i \in \{2,...,N\}$. In this case $\Pi_1^{PI} = \frac{(A-bc)^2}{9b}$ and $\Pi_i^{PI} = \frac{(A-bc)^2}{9b(N-1)}$ .

Note first that $\Pi_i^{FI} > \Pi_i^{NI}$, i.e. all firms are better off with the grand patent pool than with non integration. Note also that $\Pi_1^{PI} > \Pi_1^{FI}$ , i.e. firm 1 is better off not joining the pool if all other firms form a pool of size $N-1$. This is the free-rider problem. Thus, the crucial question is whether it is profitable for the remaining $N-1$ firms to form a pool of their own. If $N<5$ it is easy to check that $\Pi_i^{PI} < \Pi_i^{NI}$, so they will not form a pool. This stabilizes the grand pool. Each firm anticipates that if it does not join the grand pool then no pool will be formed, so each firm has an incentive to join. In $N=5$ the remaining 4 firms are just indifferent whether to form a pool on their own or not. If $N>5$ we have $\Pi_i^{PI} > \Pi_i^{NI}$, so the remaining $N-1$ firms will always form a pool which induces firm 1 not to join the grand pool.[7]

[7] Unfortunately, the analysis of Aoki and Nagaoka (2005) is incomplete. They do not consider the possibility that if N grows larger, it becomes more attractive for (N-1) firms to form a pool on their own, but this pool may also become unstable: firm 2 may choose not join any pool if it expects the remaining (N-2) firms to form a pool. This in turn could induce firm 1 not to

## 4.3 With a Little Help from the Competition Authority

The free rider problem could be solved if each firm was pivotal: If it does not join the grand pool then no pool will be formed and all patent holders will choose their royalties non-cooperatively. However, the previous example shows that this threat is not credible for large $N$, because even if some essential patent holders do not join the grand pool it is still optimal for the others to form a smaller pool without them.

This problem can be solved if the competition authorities adopt the following procedure for getting a patent pool approved. I will call this procedure "Full Functionality Approval":

- The full functionality of the standard has to be described, i.e. what can be achieved by the standard without access to any additional patents.
- The maximum total royalty for the bundle of all patents has to be specified.
- Each patent holder keeps the right to license his patents independently outside the pool.
- Grantbacks are imposed, i.e. each patent holder commits to include all future patents in the pool that are essential to the standard.

The patent authority approves the patent pool under the condition that no additional patents are required to achieve the described functionality. Thus, it is the responsibility of the patent pool to include all relevant patents. If a licensee proves to the competition authorities that full functionality cannot be achieved legally with the patents included in the pool or that he has to pay higher royalties in order to achieve legal full functionality, then this licensee can use the patents of the pool for free. If the competition authority learns (this way or another) that

---

leave the grand pool in the first place. In the linear example given above this does not cause a problem. With N>5 the grand pool will never form. However, this problem has not been ruled out in general.

additional patents are required to achieve full functionality, then the approval of the patent pool is null and void and each member has to charge his royalties non-cooperatively.

Suppose that the competition authority adopts "Full Functionality Approval". Consider a standard that requires *N* essential patents to be fully functional. If a patent pool adopts a sharing rule that gives each essential patent holder at least as much as he would have received if all patent holders set their royalties independently, then all patent holders will join the patent pool. Because the patent pool is efficient such a sharing rule always exists.

Full Functionality Approval makes every essential patent holder pivotal. If he does not join the pool, full functionality cannot legally be achieved without infringing on his patent, so a pool will not be approved, or approval will be withdrawn as soon as he complains that the standard infringes on his patent rights. Thus, any patent holder not joining the pool causes all other patent holders to set their royalty rates non-cooperatively. The patent pool gives each patent holder at least as much as he would have gotten if royalties were set non-cooperatively, so it is optimal for each patent holder to join. Because the pool is more efficient than non-cooperative royalty setting it is always possible to share the royalties of the pool such that each patent holder is better off.

Note that licensees play an important role for this mechanism to work. If there is an essential patent holder outside the pool charging additional royalties, the pool has an incentive not to raise this issue with the competition authorities if it is afraid that the pool will be dissolved. However, a licensee has a strong incentive to report this to the competition authorities because he is rewarded with a free license for all patents in the pool. The free license does not expropriate pool members because they voluntarily agreed to join the pool under the conditions of Full Functionality Approval.

This mechanism has the additional advantage of deterring so called "patent trolls", i.e. firms secretly holding patents that are essential for the standard. A patent troll waits until the

standard has been set and large investments have been sunk. Then he steps out, sues the other patent holders for infringing on his patent and uses an injunction to hold them up.[8] With Full Functionality Approval this strategy is self-defeating. If a patent troll sues the other patent holders the pool is automatically dissolved. Thus, negotiations about a new pool have to start from scratch. All patent holders are again symmetric and there is no benefit to the patent troll from hiding his patent. The members of the old patent pool will offer to add his patent to the other N patents in a new pool and to give the patent troll a share of 1/(N+1) of the pool royalties. Because in this situation all patent holders are symmetric the patent troll cannot expect to extract a higher share of the pool revenues. This is what he would have gotten in the first place had he participated in the forming of the old pool. Thus, being a patent troll does not pay off.

# 5 Policy Implications

Because a patent pool is an agreement to fix input prices, it can and has been used to form a cartel and to suppress competition on markets that would otherwise be competitive. This is the reason why patent pools have been considered illegal per se by the US antitrust authorities until the mid 1990s.[9] Competition authorities have come to treat patent pools for complementary patents more favorably in recent years. For example, in the *Antitrust Guidelines for the Licensing of Intellectual Property Rights* (1995, p. 28), jointly issued by the US Department of Justice and the Federal Trade Commission, it is acknowledged that patent pools "provide procompetitive benefits by integrating complementary technologies, reducing transaction costs, clearing blocking positions, and avoiding costly infringement lititation"[10]. However, the agencies also point out that "pooling arrangements can have

[8] See Lemley and Shapiro (2007) and Layne-Farrar and Schmidt (2010) for a more detailed discussion of "patent trolls".
[9] See Gilbert (2004) for a historical review of the role of patent pools in the U.S. economy.
[10] US Department of Justice and Federal Trade Commission (1995), "Antitrust Guidelines for the Licensing of Intellectual Property", April 6, 1995, available at http://www.justice.gov/atr/public/guidelines/0558.pdf .

anticompetitive effects", and that when "pooling arrangements are mechanisms to accomplish naked price fixing or market devision, they are subject to challenge under the per se rule." This is an important reason why standard setting organizations often carefully avoid talking about royalties and why patent pools, if they are formed at all, are often formed rather late in the standardization process.

The preceeding sections have shown that patent pools can play an important role in lowering royalties, reducing transaction costs, disseminating new technologies, and fostering innovation incentives. However, due to the free rider problem in pool formation, the larger the number of essential patent holders the more difficult it is to establish a pool that comprises all essential patents. Thus, we are probably seeing less and smaller patent pools than would be socially optimal.

Competition authorities should not only tolerate patent pools but actively encourage them, provided that pools allow for independent licensing outside the pool and require grantbacks. These safeguard are necessary to make sure that the pool is not used to suppress competition between patents that are substitutes and that follow-up innovations cannot be used to block the pool. With these safeguards in place there is little risk that patent pools are anti-competitive.

Patent pools are not just a means to solve the complements problem, they can also be used to mitigate the free rider problem in innovation incentives. However, this requires that pools are formed at an early stage of the standardization process. The combination of high royalties and grantback provisions can give powerful investment incentives, in particular when these royalties are renegotiated after investments are made. Thus, competition should be more lenient towards early pools, even if they set royalties that seem higher than socially optimal.

A second suggestion is to adopt a system of “full functionality approval”. Because each patent holder wants to free-ride on the low royalties set by the other patent holders who stay in the pool, many pools do not form or do not include all essential patents. “Full functionality approval” can help to solve this problem by making every patent holder pivotal. Each patent holder knows that without his cooperation a pool cannot be sustained and everybody will charge royalties non-cooperativly. This increases the incentives to disclose all relevant patents and to join the pool.

**References**


Aoki, Reiko and Sadao Nagaoka. 2004. "The Consortium Standard and Patent Pools." Hitotsubashi University, mimeo.

Aoki, Reiko and Sadao Nagaoka. 2005. "Coalition Formation for a Consortium Standard through a Standard Body and a Patent Pool - Theory and Evidence from MPEG2, DVD and 3G." Hitotsubashi University, mimeo.

Cournot, Augustin. 1838, 1897. "Researches into the Mathematical Principles of the Theory of Wealth."New York: MacMillan.

Dequiedt, Vianney and Bruno Versaevel. 2006. "Patent Pools and the Dynamic Incentives to R&D." CNRS, mimeo.

Gilbert, Richard J. 2004. "Anti-Trust for Patent Pools: A Century of Policy Evolution." *Stanford Technology Law Review,* Vol. 3.

Gilbert, Richard J and Michael L Katz. 2009. "Efficient Division of Profits from Complementary Innovations." University of California at Berkeley, mimeo.

Kim, Sung H. 2004. "Vertical Structure and Patent Pools." *Review of Industrial Organization,* Vol. 25, 231–250.

Layne-Farrar, Anne. 2009. "Innovative or Indefensible? An Empirical Assesment of Patenting Within Standard Setting." LECG, mimeo.

Layne-Farrar, Anne and Josh Lerner. 2008. "To Join or Not to Join: Examining Patent Pool Participation and Rent Sharing Rules." Harvard University, mimeo.

Layne-Farrar, Anne; Llobet, Gerard and Jorge Padilla. 2010. "Payments and Participation: The Incentives to Join Cooperative Standard Setting Efforts." LECG, mimeo.

Layne-Farrar, Anne and Klaus M Schmidt. 2011. "Licensing Complementary Patents: "Patent Trolls," Market Structure, and Excessive Royalties." *Berkeley Technology Law Review,* Vol. 25, 1123–1145.

Lemley, Mark A and Carl Shapiro. 2007. "Patent Hold-up and Royalty Stacking." *Texas Law Review,* Vol. 85, 1991–2049.

Lerner, Josh; Strojwas, Marcin and Jean Tirole. 2007. "The design of patent pools: the determinants of licensing rules." *RAND Journal of Economics (Blackwell),* Vol. 38, 610–625.

Lerner, Josh and Jean Tirole. 2004. "Efficient Patent Pools." *American Economic Review,* Vol. 94, 691–711.

Merges, Robert P. 1999. "Institutions for Intellectual Property Transactions: The Case of Patent Pools." University of California at Berkeley, mimeo.

Schmidt, Klaus M. 2008. "Complementary Patents and Market Structure, CEPR Discussion Paper Series, 7005.

Shapiro, Carl. 2001. "Navigating the Patent Thicket. Cross Licenses, Patent Pools, and Standard Setting." In: Jaffe, A.; Lerner, J.; Stern S. (Hg.): *Innovation Policy and the Economy,* Vol. 1. Cambridge, Mass.: MIT Press .

Swanson, Daniel G and William J Baumol. 2005. "Reasonable and Nondiscriminatory (RAND) Royalties, Standards Selections, and Control of Market Power." *Antitrust Law Journal,* Vol. 73, 1–58.