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# Patents hinder collusion

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# Patents hinder collusion \*

## Abstract

We argue that a patent institution makes collusion among innovators more difficult. Our argument is based on two properties of the patent system. First, a patent not only protects against infringement but also against retaliation by former collusion members. Second, a deviator has an equal chance with former collusion members to get a patent on new innovations. We show that if a patent system reduces spillovers, it renders collusion impossible. Moreover, it is possible to design a patent system that simultaneously increases knowledge spillovers and eliminates collusion.

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# 1 Introduction

It has been traditionally thought that there is a conflict between competition and patent laws almost by definition. The thinking is so widespread that it has become fashionable to deny such conflict.<sup>1</sup> The apparent tension arises from the goals of the laws. Patent laws aim at nurturing innovation by granting an exclusive property right over an invention. In contrast, competition laws recognize the inefficiency of exclusive rights and guard consumer welfare by promoting competition. Over the past decades courts have become increasingly tolerant towards the privileges of patent holders, but the conflict continues to surface in many prominent antitrust cases such as Microsoft.<sup>2</sup> In this study we support the notion of downgrading the conflict. But, whereas on-going debate aims at finding the proper balance between competition and patent laws, we argue that there is no conflict on a deeper level. Antitrust authorities seldom accept exclusive rights, but they are especially hostile attitude towards cartels. We demonstrate that the patent system may make collusion among innovative firms more difficult, if not impossible.

Our finding emerges from two properties of the patent system. First, when a firm holding an unpatented innovation deviates from the collusion, the best deviation is to patent. In addition to the usual increase in instantaneous profits in the period of deviation, patenting generates a stream of

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<sup>1</sup>Cf., e.g., "Competition and patents are not inherently in conflict. Patent and antitrust law are actually complementary... (Federal Trade Commission, 2003, p.2.)" and "Nor does it imply that there is an inherent conflict between intellectual property rights and the Community competition rules. (European Commission, 2004, p. C101/2)".

<sup>2</sup>See Kortum and Lerner (1999) and Rahnasto (2003) for descriptions of how the balance between competition and intellectual property laws has varied over time. Rahnasto (2003) also reviews numerous court cases centered around the issue.

future profits, since the patent, by design, provides protection against retaliation by the former collusion members. In this sense the patent system works like a leniency program in cartel cases where a cartel member can get an immunity or a significant reduction of penalties if it discloses the cartel. Second, because the deviator and other former collusion members also compete on an equal footing for patents over future innovations, the deviator can obtain positive profits in the retaliation phase. Thus, collusions where firms hold unpatented innovations are hard, if not impossible, to maintain. The second property of the patent system guarantees that the introduction of patents in an industry would make deviation more attractive, even if the firms colluded with patented innovations.

Our analysis yields straightforward policy recommendations. Expanding the patent strength and its subject matter breaks down collusions and yields a welfare improvement. Abolishing the prior-user rights in the patent systems also restricts the scope for collusive behavior. For a similar reason, a shift from the first-to-invent rule to the first-to-file rule without prior-user rights is desirable. Furthermore, because the firms may improve their ability to collude by filing joint patent applications, cross-licensing and pooling patents, such practices warrant surveillance by antitrust authorities.

Our model builds on the simultaneous model of innovation where agents find ideas according to an urn-ball process. Kultti, Takalo and Toikka (2005) show that when innovation is simultaneous, patenting can dominate over secrecy as an appropriation strategy even if the patent protection is weak: if a firm does not patent, someone else might do it and thereby exclude the firm from using the innovation. Such simultaneous model of innovation es-

pecially seems to characterize innovation-intensive network industries where standardization forces the firms to work with the same basic technology or components (Rahnasto, 2003, and Varian, Farrell and Shapiro, 2004). In this study we continue to view innovation as potentially simultaneous because it renders our argument transparent. Besides adopting the simultaneous model to the analysis of collusion, we extend it by allowing for arbitrary, potentially small, number of ideas and innovators. It turns out that the numbers of ideas and innovators have complex but nonetheless unambiguous effects on the ability to collude: supporting collusion becomes easier when the number of ideas grows or the number of potential innovators diminishes.

Although almost all studies on the patent system implicitly deal with the boundary of competition and patent laws, until recently only few have addressed it explicitly. This literature usually focuses on specific questions such as whether a collusion between first and second generation innovations should be allowed or not (e.g., Scotchmer and Green, 1995, Chang, 1995, Denicolò, 2002), or what kind of licensing deals, patent pools or settlements of patent disputes antitrust authorities should tolerate, (e.g., Shapiro, 2001, 2003, Lerner and Tirole, 2004, Maurer and Scotchmer, 2006). Carlton and Gertner (2003) take a broad view in arguing that the failure to recognize the tension between competition and patent laws can lead to errors in the adoption of traditional antitrust analysis to innovative industries where competition is dynamic.

In extensive legal literature patent and antitrust laws have often been considered different means of promoting the same goal, consumer welfare.<sup>3</sup>.

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<sup>3</sup>A part of the literature is surveyed in Rahnasto (2003). Maurer and Scotchmer (2006)

Nonetheless, even the supporters of such a positive view acknowledge that some tension remains between the two laws and point out the need to find a proper balance between them. We tackle the patent-antitrust conflict from a slightly different angle. As far as we know, we are the first to uncover the advantage of the patent system in hampering collusion.

Our study also relates to the extensive economics literature on tacit collusion, summarized by Ivaldi, Jullien, Seabright, Rey and Tirole (2003). Following Fershtman and Muller (1986), we focus on a semicollusive industry where firms can only collude in pricing and behave non-cooperatively in their innovation and patenting decisions. Collusion in other dimensions beyond pricing requires more coordination and is more laborious to implement. The semicollusion assumption is also shared by Fershtman and Pakes (2000) who show how investments affect collusion possibilities and vice versa. In our model, dynamic competition over future innovations has an important impact on the ability to sustain collusion both with and without patents. Because innovation is repeated, deviators can obtain positive profits despite the optimal retaliation. The profit opportunities in the retaliation phase are generally improved by the introduction of patents. This property of the patent system is strenuous to eliminate by manipulating the patent system in an anticompetitive manner. That is, although the innovating firms could raise the cost of retaliation in the market where deviation occurs, e.g., by means of joint patenting or cross-licensing, it would be much harder to do so in future, unknown markets.

We present a simple duopoly example in the next section. The example 

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provide a nice overview of the main issues.

shows the first part of our argument, which applies to one innovation stage in isolation. To allow the feedback from dynamic innovation to collusion possibilities, we generalize the model in sections 3-4. Besides dynamic innovation, this richer environment incorporates an arbitrary number of ideas and firms, knowledge spillovers, multimarket contact and the possibility of innovations to become obsolete. Patent policy is introduced in section 5. In section 6 we touch upon the effects of patents on the incentive to innovate and consumer surplus, and discuss some welfare implications. We also discuss about robustness of our findings and possible extensions of the model. We conclude with presenting some testable hypothesis in section 7.

## 2 An Example

Before going to the full model, we illuminate our basic argument in a standard infinitely repeated version of the Bertrand duopoly. There are two firms that have come up with the same innovation. The firms compete in Bertrand fashion which implies zero profits for each of them, unless the firms can sustain tacit collusion where they share monopoly profits  $\pi$  on the equilibrium path. If either of them deviates, they reverse to stage game Nash equilibrium thereafter. With Bertrand-competition this constitutes the optimal punishment strategy (Abreu, 1988).

Let us first consider an industry where patenting is infeasible. If the firms collude, they equally split the monopoly profits each earning a profit of  $\pi/2$  per period. Denoting the discount factor by  $\delta$ , the discounted sum of profits from collusion is given by  $\frac{\pi}{2(1-\delta)}$ . By deviating from collusion a firm can

reap the monopoly profits in the period of deviation. As the profits in the punishment stage are zero, the collusion can be sustained if  $\frac{\pi}{2(1-\delta)} \geq \pi$  or if  $\delta \geq \frac{1}{2}$ .

In this example we introduce patent policy in a textbook manner: If a firm obtains a patent on an innovation, it receives a temporary monopoly over it, say, for  $T$  periods. After the patent expires, the innovation is in public domain and the other firm can use it for free. Thus, if one of the firms patents, it receives a profit of  $\frac{\pi(1-\delta^T)}{1-\delta}$  and the other firm gets nothing. If they apply for a patent, both firms have an equal probability of  $1/2$  of receiving the patent and the associated profits.

Patent policy does not affect payoffs from collusion but it crucially affects the payoffs in the case of a deviation. As the patent also provides temporary protection, the best deviation is to patent the innovation. Now the collusion can be sustained if  $\frac{\pi}{2(1-\delta)} \geq \frac{\pi(1-\delta^T)}{1-\delta}$  or if  $\delta^T \geq \frac{1}{2}$ . Thus, if the patent is in force longer than one period, the patent system makes it more difficult to sustain collusion. The reason is simple: the patent not only provides temporary protection against infringement but also against the punishment by the former collusion partner. Moreover, patenting is a strictly dominant strategy when  $\delta^T < \frac{1}{2}$ .

An assumption underlying our argument above is that the duopolists can make similar innovations and keep them secret. In the next section we model such innovation process explicitly. We also allow for repeated innovation, knowledge spillovers, multimarket contact, and an arbitrary number of ideas and firms.

### 3 The Model

The economy is of an infinite horizon and proceeds in discrete time. There are  $A$  agents who innovate and each of whom has the same discount factor  $\delta$ . There are also  $I$  ideas or potential innovations, and the agents contact them randomly. Following O'Donoghue, Scotchmer and Thisse (1998) we distinguish ideas from innovations: only ideas that are found constitute innovations. This innovation process is just the urn-ball model familiar from the literature on random matching (see Butters, 1977, for the seminal work). Because the number of agents is  $A$  and the number of ideas  $I$ , the number of agents that find a particular idea is binomially distributed according to  $Bin(A, \frac{1}{I})$ . In other words, an agent always finds an idea but there may be other agents who find the same idea. From the point of view of any single agent, the probability that there are exactly  $k$  other agents who find the same idea is given by

$$- (k) \equiv \binom{A-1}{k} \left(\frac{1}{I}\right)^k \left(1 - \frac{1}{I}\right)^{A-1-k}. \quad (1)$$

Until section 6 we view the conflict between antitrust and patent laws from the antitrust perspective. So for the moment we abstract from the issues related to the incentives to innovate and patent policy by assuming that innovation is costless.

We assume that an innovator can keep the innovation secret with probability  $\alpha$ . With probability  $1 - \alpha$  the secret leaks out and the innovation becomes public; this is the spillover effect. If the innovation becomes public, there is free entry to its utilization, which drives production to the competi-

tive level. To make steady state analysis viable we assume that innovations become obsolete with probability  $1 - \lambda$ . Probabilities  $\alpha$  and  $\lambda$  remain the same each period; one could as well think that they realized only once. We focus on a steady state equilibrium where the stock of innovations is the same from one period to another.

The timing of events within a period is the following: First the agents find ideas, then the new innovations become either public or remain proprietary, then the agents consume and profits accrue to those who possess innovations, and finally the innovations (both new and old) either become obsolete or remain economically viable. Changing the timing of events does not affect our findings. Nor is the possibility of simultaneous innovation a feature that drives the results. The model would work in a similar way if the agents could find the same innovation that was made earlier by some other agent but this would be harder to analyze.

We postulate that to each innovation corresponds a demand function that generates a monopoly profit  $\pi$  when the monopoly price is charged. We can also think that  $\pi$  reflects the value of innovations: the larger is the market generated by an innovation, the larger is  $\pi$ . The monopoly naturally emerges if only one innovator finds an idea and can keep it secret. When many innovators come up with an idea we assume that competition is of Bertrand-type so that the innovators charge the competitive price, driving the profits to zero. If the innovators collude and charge the monopoly price, they share the profit equally.

Collusion in our model can only take place in pricing. Collusive behavior in additional dimensions, e.g., in the search of ideas and patenting, requires

more extensive coordination and is hence more demanding to obtain. In section 6.2 we discuss the sensitivity of our results with respect to this semi-collusion assumption. The analysis of collusive pricing follows the standard repeated-game treatment. We evaluate a trigger strategy profile where each innovator charges the monopoly price as long as all other innovators did so in the past. If one or more players deviate, the innovators reverse to the stage-game equilibrium strategy charging the competitive price forever after.

## 4 Collusion without Patent Policy

We want to determine when collusion can be sustained in an industry where patent protection is unavailable. Without loss of generality we focus on an innovator who has no previous innovations. Deviating from collusion yields a one period monopoly profit but zero after that.<sup>4</sup>

Evaluated in the beginning of a period, the expected life-time utility of an innovator who has no innovations and who colludes whenever she comes up with an innovation is determined by

$$V = (1 - \alpha) \delta V + \alpha \sum_{k=0}^{A-1} \pi(k) \left[ \frac{\pi}{k+1} + \lambda \delta U(k) + (1 - \lambda) \delta V \right], \quad (2)$$

where  $\pi(k)$  is the probability that exactly  $k$  other innovators find the same

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<sup>4</sup>If the innovator had  $n$  other innovations he would, of course, deviate from collusion in all markets simultaneously and the immediate profit would be roughly  $n$ -fold compared to the case of an innovator with no innovations. The future loss would also be approximately be  $n$ -fold. Although this is not quite accurate since the profitability of deviation depends on the number of colluding partners, it is evident that considering an innovator with  $n$  previous innovations would complicate the analysis without adding insights.

idea, as defined by (1), and where

$$U(k) = V + \frac{\alpha\pi}{(k+1)(1-\alpha\lambda\delta)} \quad (3)$$

is the innovator's expected utility when she has one innovation with  $k$  other colluding innovators.

The first term on the right-hand side of (2) comes from the possibility that the new innovation immediately becomes public. This occurs with probability  $1 - \alpha$ , and then the innovator gets  $V$  next period. The second term is composed of the expected profits when the new innovation stays proprietary. The innovator's profit share depends on the number of the other innovators who find the same idea: with probability  $\binom{A-1}{k}$ ,  $k \in \{0, 1, 2, \dots\}$  other innovators find the idea and each innovator makes profits  $\pi/(k+1)$ . Note that when  $k$  is zero, there is no collusion, because the innovator is the sole producer in the market. With probability  $\lambda$  the new innovation remains useful, and the innovator's utility in the subsequent period is given by (3). With probability  $1 - \lambda$  the new innovation becomes obsolete and the innovator's utility is again  $V$ .

Let

$$\sigma \equiv \sum_{k=0}^{A-1} \binom{A-1}{k} \frac{1}{k+1} = \frac{I \left[ 1 - \left(1 - \frac{1}{I}\right)^A \right]}{A} \quad (4)$$

be the expected profit share from collusion, which is decreasing in the number of innovators ( $A$ ) and increasing in the number of ideas ( $I$ ). Then, after

inserting (3) and (4) into (2) and using (3) again, (2) can be simplified to

$$V = \frac{\sigma\alpha\pi}{(1-\delta)(1-\alpha\lambda\delta)}. \quad (5)$$

Equation (5) shows that the model behaves nicely. The return on collusive innovation is inversely related to the spillover rate  $(1-\alpha)$  and the obsolescence rate  $(1-\lambda)$ , but directly related to the size of the market generated by the innovation  $(\pi)$ , the discount factor  $(\delta)$  and the expected profit share from collusion  $(\sigma)$  (which in turn is a decreasing function of  $A$  and an increasing function of  $I$  by (4)).

We next calculate the expected life-time utility of an innovator who decides to deviate from collusion. Because the innovators are using trigger strategies, the deviating innovator earns maximum profit,  $\pi$ , during the period of deviation but receives zero thereafter, except when she manages to find an innovation alone. We apply the one-stage deviation principle, and consider the deviation only when the deviator finds the innovation with some fixed number  $n$  of other agents.

The expected life-time utility of a deviating innovator is then given by

$$\begin{aligned} \tilde{V} = & (1-\alpha)\delta V + \alpha \sum_{k=0}^{A-1} \binom{A-1}{k} \left[ \frac{\pi}{k+1} + \lambda\delta U(k) + (1-\lambda)\delta V \right] \\ & + \alpha \binom{A-1}{n} \left[ \pi + \delta V^D - \frac{\pi}{n+1} - \lambda\delta U(n) - (1-\lambda)\delta V \right] \end{aligned} \quad (6)$$

where  $\tilde{V}$  and  $V^D$  denote the utilities of the deviating innovator and of an innovator who deviated in the previous period. The first term on the right-hand side of (6) captures the possibility that the innovation immediately

becomes public in which case the deviation decision is inconsequential. The second term is the expected utility from collusion if the innovation does not become public. Here also the case of  $n$  other agents is included, but since in this case the innovator deviates, it is subtracted in the third term that reflects the payoff from deviation. There the first term in the square brackets is the immediate utility from deviation and the second is the expected utility after deviation.

The utility of the innovator who deviated in the previous period is given by

$$V^D = \alpha - (0) (\pi + \lambda \delta V_1^D + (1 - \lambda) \delta V^D) + (1 - \alpha - (0)) \delta V^D. \quad (7)$$

Since the punishment renders the market where the deviation occurred competitive, the deviator's only chance to get positive profits is to find a new idea alone. Therefore in (7)

$$V_1^D = V^D + \frac{\alpha \pi}{1 - \alpha \lambda \delta} \quad (8)$$

gives the expected utility of an agent who has deviated and who is the sole innovator exactly in one market. In (7) the first term on the right-hand side is the expected utility from making a new innovation alone. With probability  $1 - (0) = (1 - \frac{1}{I})^{A-1}$  there are no other innovators. With probability  $\alpha$  the new innovation remains secret, and the deviator receives monopoly profits. With probability  $\lambda$  the innovation remains useful, and the deviator's utility in the subsequent period is given by (8). With probability  $1 - \lambda$  the new innovation becomes obsolete and the deviator is again without profitable innovations. The second term is the expected utility when either someone else

finds the same idea or when the new innovation immediately becomes public. If someone else finds the same idea, which occurs with probability  $\sum_{k=1}^{A-1} \binom{A-1}{k} = 1 - \binom{A-1}{0} = 1 - \left(1 - \frac{1}{I}\right)^{A-1}$ , the deviator will be punished, eliminating the profits from her new innovation.

Substituting (8) for  $V_1^D$  in (7) and simplifying yields

$$V^D = \frac{\alpha \binom{A-1}{0} \pi}{(1 - \delta)(1 - \alpha \lambda \delta)}. \quad (9)$$

Then, after using (2) and involved algebra, the utility of the deviating innovator (6) can be rewritten as

$$\tilde{V} = V + \alpha \binom{A-1}{n} \left[ \pi - \frac{\pi}{(n+1)(1 - \alpha \lambda \delta)} - \delta (V - V^D) \right]. \quad (10)$$

Collusion can be sustained as an equilibrium when  $V \geq \tilde{V}$  or, equivalently, when the term in the brackets in (10) is negative, i.e., when

$$\pi - \frac{\pi}{(n+1)(1 - \alpha \lambda \delta)} - \delta (V - V^D) \leq 0. \quad (11)$$

The first two terms on the left-hand side capture the gain from the deviation in the market where the deviation occurs, i.e., the difference between the monopoly profits from the period of deviation and the forgone profit stream from collusion. These are the usual tradeoffs that affect the sustainability of collusion. In our model, however, there is a third term that reflects the expected loss from the deviation in other markets in subsequent periods. In contrast to many other repeated-game treatments of collusion, the deviating

innovator can obtain positive profits in the punishment phase. Nevertheless, comparing (5) and (9) shows that the punishment is real in the sense that  $V > V^D$  for  $A > 1$ .

Inserting (5) and (9) into (11) gives

$$1 - \frac{1}{(n+1)(1-\delta\alpha\lambda)} - \frac{\delta\alpha\left(1-\frac{1}{I}\right)^{A-1}(I+A-1)}{(1-\delta)(1-\delta\alpha\lambda)A} \leq 0. \quad (12)$$

The temptation to deviate is the greatest when  $n = A - 1$ , since then an innovator's share of the collusive profits is the least. This case then gives a conservative lower bound on the discount factor above which collusion is possible in all markets. Letting  $n = A - 1$  in (12) we obtain

$$\delta\alpha \left[ \lambda A + \frac{\left(1-\frac{1}{I}\right)^{A-1}(I+A-1)}{1-\delta} \right] \geq A - 1. \quad (13)$$

Condition (13) confirms the usual findings concerning the sustainability of collusion. On the one hand, it is evident that when  $\delta$  approaches zero, collusion cannot be sustained. On the other hand, when  $\delta$  approaches unity the left-hand side becomes greater than the right-hand side. Because the left-hand side is an increasing function of  $\delta$ , there exist a threshold for the discount factor,  $\bar{\delta}$ , such that for all  $\delta \geq \bar{\delta}$  collusion can be sustained.

By totally differentiating (13) with respect to  $\delta$ ,  $\alpha$ ,  $\lambda$ ,  $A$ , and  $I$  we obtain:

**Proposition 1** *The threshold level of the discount factor that makes collusion possible in all markets is increasing in the level of knowledge spillovers, the obsolescence rate and in the number of innovators. It is decreasing in the number of ideas.*

The effects of  $\alpha$  and  $\lambda$  are similar to the effect of  $\delta$ : these three parameters constitute the ‘effective’ discount factor. When spillover or obsolescence rates are high, colluding innovators realize that their profits from the innovation do not necessarily last long, which makes deviation more attractive. Hence, sustaining collusion should be difficult in innovative industries with appropriability problems.<sup>5</sup> The effects of the numbers of innovators ( $A$ ) and ideas ( $I$ ) are more diverse. It is pragmatic to distinguish between the effects in the ‘deviation market’ (the two first terms on the left-hand side of (11)) from the effects in all ‘future markets’ (the third term in (11)). As usually, collusion is more difficult with more competitors in the deviation market, since both the short-run gains from deviation are larger and the long-run benefits from collusion smaller. The long-run effect of  $A$  applies to the future markets, too. However, there is also a counterbalancing effect in the future markets, because the larger the number of innovators, the smaller the probability of innovating alone. This dilutes the profit opportunities in the punishment phase, raising the cost of retaliation. Proposition 1 shows that the effects enhancing the incentive to cheat dominate. The number of ideas has no impact on the deviation market, but it has two opposite effects on the cost of retaliation in the future markets. As the number of ideas grows, it becomes easier to find one alone in the punishment phase. But the profit share from collusion is increasing in  $I$  (see (4)), which makes the punishment harsher. The net effect is an increased cost of retaliation.

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<sup>5</sup>Ivaldi et al. (2003), too, predict that collusion is more difficult in innovative industries but do not discuss appropriability.

## 5 Collusion with Patent Policy

Patent policy involves many dimensions such as patent length, breadth, strength and height whose effects have been extensively studied. Because our main objective is to show that patent policy intrinsically makes collusive behavior more difficult, we introduce patents in a simple but general way: following Ayres and Klemperer (1999), we view patents as probabilistic property rights. We assume that the patent strength, denoted by  $\alpha_p \in (0, 1]$ , determines the probability that a patent holder can exclude rivals from using the patented invention. With probability  $1 - \alpha_p$  the patent is found invalid or it can be infringed by others, driving the profits from the invention to zero. In our model the patent strength is a perfect substitute to the patent length, measured by the number of periods a patent is in force, in the sense that whatever policies can be achieved by using one variable can also be achieved by the other. We choose to work with the strength, which is in practice more relevant variable than the length; for instance, vast majority of patents is voluntarily cancelled before the statutory term has passed, and a substantial proportion of litigated patents is found invalid. We also maintain the purpose of patent law of awarding only one patent on the same invention. Hence potential antitrust problems stemming from mutually blocking patents cannot arise in our model. In section 6.2, we discuss in more detail the possibility to collude on patented innovations.

The expected life-time utility in collusion is the same as before, i.e., it is given by (5). The utility of a deviating agent differs, however, since the best deviation is to patent and to get the protection against retaliation provided

by the patent.<sup>6</sup> Since the patent protection is typically imperfect ( $\alpha_p < 1$ ), the deviator encounters a tradeoff between getting protection and allowing the innovation to become public. Moreover, the worst punishment by other innovators is to begin patenting. In other words, before the deviation the industry is in collusion where no patents are employed but the deviation triggers patenting. If multiple agents make the same innovation, the patent holder is randomly selected among them and the others receive nothing. When all the innovations are patented, there is only one producer in each market.

Let us denote the innovator's payoff if she decides to deviate and patent when she finds an innovation with  $n$  other innovators by

$$\begin{aligned} \tilde{V}_p = & (1 - \alpha) \delta V + \alpha \sum_{k=0}^{A-1} \binom{A-1}{k} \left[ \frac{\pi}{k+1} + \lambda \delta U(k) + (1 - \lambda) \delta V \right] \\ & + \alpha \binom{A-1}{n} \left[ \pi + (1 - \lambda) \delta V_p^D + \lambda \delta V_{p1}^D - \frac{\pi}{n+1} - \lambda \delta U(n) - (1 - \lambda) \delta V \right] \end{aligned} \quad (14)$$

where  $V_p^D$  denotes the deviator's expected utility when her patent becomes obsolete and  $V_{p1}^D$  when it remains useful. The interpretation of (14) is similar to that of (6). The main difference is that the expected utility after deviation is split into two terms,  $\delta(1 - \lambda)V_p^D$  and  $V_{p1}^D$ . The split is due to the protection conferred by the patent against punishment. Provided that the patent remains useful, the deviator can enjoy profits in the market where she has

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<sup>6</sup>Note that the optimal deviation, even without patents, takes place immediately after innovators come up with the same invention. With patents it would also be harder to deviate in subsequent periods for legal reasons. For example, in the US the inventor who has practiced the invention more than a year is in principle barred from patenting the innovation. In Europe the right to a patent once the invention is practiced is lost even faster.

deviated also in the subsequent period. As in the case of no patent policy (8),  $V_{p1}^D$  can be expressed as a function of  $V_p^D$ :

$$V_{p1}^D = V_p^D + \frac{\alpha_p \pi}{1 - \delta \alpha_p \lambda}. \quad (15)$$

The deviator's expected utility in the case where her patent becomes obsolete is given by

$$V_p^D = (1 - \alpha_p) \delta V_p^D + \alpha_p \sum_{k=0}^{A-1} \frac{\binom{k}{k+1}}{k+1} [\pi + \lambda \delta V_{p1}^D + (1 - \lambda) \delta V_p^D + k \delta V_p^D] \quad (16)$$

The second term on the right-hand side of (16) comes from the possibility of obtaining a new patent. The deviator gets a new patent with probability one if she innovates alone, with probability  $\frac{1}{2}$  if there is another innovator, with probability  $\frac{1}{3}$  if there are two other innovators and so on. Inserting (15) into (16) and solving for  $V_p^D$  yields

$$V_p^D = \frac{\sigma \alpha_p \pi}{(1 - \delta)(1 - \delta \alpha_p \lambda)}. \quad (17)$$

Comparing (5) to (17) shows that from the innovators' point of view collusion and patenting are practically equivalent. Indeed, it makes little difference to a risk-neutral innovator whether she gets a share of  $\frac{1}{k+1}$  of monopoly profits for sure, or whether she gets the full monopoly profits with probability  $\frac{1}{k+1}$ .

By (2), (3), and (15), (14) can be rewritten as

$$\tilde{V}_p = V + \alpha_p (n) \left[ \frac{\pi}{1 - \delta \alpha_p \lambda} - \frac{\pi}{(n+1)(1 - \delta \alpha \lambda)} - \delta (V - V_p^D) \right]. \quad (18)$$

As in (10), collusion can be sustained only if the term in the brackets is negative. The terms in the brackets in (10) and (18) suggest that the incentive to deviate is larger under the patent system than without with. As earlier, the first two terms in the brackets show the gain from the deviation in the market where the deviation takes place. Without patents the deviator can derive profits only from the period of the deviation. In contrast, under the patent system she is protected against punishment and receives payoffs from the subsequent periods, unless the innovation becomes public. The last term in (18) shows that not only the patent protects against punishment in the deviation market but also in the other markets in subsequent periods. It is easy to establish the following finding:

**Proposition 2** *If the patent system reduces spillovers ( $\alpha_p \geq \alpha$ ), collusion is impossible in the patent system.*

**Proof.** Collusion can be sustained only if  $V \geq \tilde{V}_p$ , which can be rewritten after the substitution of (5) and (17) into (18) as

$$\frac{n}{n+1} (1 - \delta\alpha\lambda) + (\alpha_p - \alpha) \frac{\delta\lambda}{(n+1)} + (\alpha_p - \alpha) \frac{\delta\sigma}{1-\delta} \leq 0. \quad (19)$$

The left-hand side of (19) is increasing in  $\alpha_p$ . Evaluating it at  $\alpha_p = \alpha$  shows that it is zero when  $n = 0$  and it is strictly positive for  $n \geq 1$ . ■

The explanation for the finding is straightforward. If the patent system fulfills its primary purpose and enhances the property rights over the innovation, it simultaneously protects against the punishment by the former collusion members. The first two terms in (19) capture the benefits from the

deviation in the market where it occurs. Even if we restrict the attention to this single market, the protection afforded by the patent hinders collusive behavior, as in the example of Section 2. But when the innovation is repeated the protection against the punishment expands beyond the market where the deviation originally occurred, because all innovators have an equal chance of getting a patent over new innovations. The last term in (19) suggests that the deviator even gets higher payoffs in the future markets in the punishment phase than under collusion, if the patent system reduces the spillovers. Thus a strong patent protection eliminates possibilities for an efficient retaliation both in the deviation market and in future markets, and collusion becomes impossible.

Because collusion makes sense only if  $n \geq 1$ , we can strengthen the above result. As in the previous section, let us evaluate (19) at  $n = A - 1$  when the incentive to cheat is the highest. Let us denote the threshold level of patent strength that makes (19) hold as an equality by  $\hat{\alpha}_p$ , i.e., if  $\alpha_p \geq \hat{\alpha}_p$ , collusion is impossible under the patent system.

**Proposition 3** *For  $\alpha_p \in [\hat{\alpha}_p, \alpha]$  the patent system both increases the spillovers and makes collusion impossible.*

**Proof.** We need to prove that  $\hat{\alpha}_p < \alpha$ . Evaluating (19) at  $n = A - 1$  and solving for  $\alpha_p$  such that it holds as an equality shows that  $\hat{\alpha}_p$  is given by

$$\hat{\alpha}_p = \alpha - \frac{(1 - \delta)(A - 1)(1 - \delta\alpha\lambda)}{\delta[\lambda(1 - \delta) + \sigma A]},$$

which is clearly strictly smaller than  $\alpha$ . ■

This is quite remarkable a result. Even if the patent system provides weaker protection than secrecy, it can make collusion impossible. Moreover, (19) suggests that for some  $\alpha_p < \hat{\alpha}_p$  collusion remains possible but, by continuity, it is more difficult to sustain it under the patent system than without it.

## 6 Discussion

### 6.1 Welfare

So far we have taken the viewpoint of antitrust authorities and focused on the tension between competition and patent laws that prevails in the market after the innovation is made. The viewpoint abstracts from the effects of patents on the incentive to innovate and consumer surplus, which are the key issues in the literature on the patent policy. However, as shown by Fershtman and Pakes (2000), they should be equally important considerations for competition policy, since whether an industry can or cannot sustain collusion also affects the incentives to innovate, which in turn affects consumer surplus and welfare in a dynamic context. Although the prior research has uncovered several complex effects of patents, the standard Nordhausian trade-off provides a reasonable benchmark for welfare discussion.

Let us assume that the incentive to innovate is increasing and post-innovation consumer surplus decreasing in  $\alpha_p$  and  $\alpha$ . We focus on an industry where innovators collude without the patent system, which requires large enough  $\delta$  to make collusion feasible.<sup>7</sup> Consider the effects of introduc-

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<sup>7</sup>If the innovators do not collude without patents, the situation will reduce to the

ing the patent system into the industry. Assume first that the patent system does not affect the spillover rate, i.e.,  $\alpha_p = \alpha$ . By Proposition 2, collusive behavior is no longer feasible in the industry. But otherwise introducing patents changes little: both under the patent system and collusion, the markets are monopolized unless the underlying innovations become public. Because there is no difference in the spillover rate, the consumer surplus is identical in both cases. Similarly, the incentives to innovate are identical, because risk-neutral innovators do not care whether they get an equal share of monopoly profits for sure or the full monopoly profits with an equal probability. We can therefore conclude that introducing patents into a collusive industry breaks down collusion but leaves welfare unchanged, if it leaves the spillover rate unchanged.

Assume then that policy-makers control the patent strength in the patent system. At this juncture welfare discussion easily becomes convoluted because there can be too little or too much innovation in the competitive market equilibrium, not to mention collusive environment. If the collusive industry supports too little innovation, the policy-makers could enhance the incentive to innovate by imposing a strong patent protection ( $\alpha_p > \alpha$ ). This would eliminate collusive behavior (Proposition 2), nonetheless reduce post-innovation consumer surplus but increase the incentive to innovate. The increase in innovative activity should create more new markets and foster aggregate consumer surplus and welfare in a dynamic context. If there is too much innovation under collusion, patent protection can be made weak

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analysis of patent policy. We refer to our complementary work (Kultti, Takalo, and Toikka, 2005) for a characterization of optimal patent policy in a similar model of simultaneous innovation without possibility to collude.

( $\alpha_p < \alpha$ ) to weaken the incentive to innovate, spread information and expand post-innovation consumer surplus. From Proposition 3 we know that for  $\alpha_p \in [\hat{\alpha}_p, \alpha]$  such a patent policy would also break down collusion and for some  $\alpha_p < \hat{\alpha}_p$ , it would make collusion more difficult.

In our case, however, it is immaterial whether boosting the incentive to innovate or disseminating information is desirable from the welfare point of view. Propositions 2-3 suggest that either goal can be achieved by introducing patents practically without concerns about collusion. Hence, we can summarize the welfare discussion in the following result:

**Remark 1** *A welfare improvement can always be obtained by introducing a patent system into a collusive industry*

As to the optimal patent policy, it can be generally implemented without making collusion easier. There is a theoretical possibility that the optimal policy is so weak, i.e., the optimally set  $\alpha_p$  approaches to zero, that it facilitates collusion. But in practice such a policy is hardly feasible, because the innovators will resort to secrecy if the patent protection is very weak (Kultti, Takalo, and Toikka, 2005).

## 6.2 Robustness and Future Work

Our main point to show that the patent system involves properties that can break collusion. As we show, the result can be generalized to an arbitrary number of innovators and ideas, spillovers, and the possibility of innovations to become obsolete. There are, however, many important issues that lie outside the limited scope of this paper. Following the literature on semicollusion

(Fershtman and Muller, 1986), we assume that innovators can only collude in pricing, the reason being that collusive behavior in other dimensions, e.g., in the search of ideas and patenting, requires coordination in a higher level. In our model, collusion in innovation would mean that many agents contact the same idea. In practice this could be achieved, e.g., by establishing a research joint venture. In this case it would be natural to assume the research joint venture partners can also coordinate their patenting decision and apply for a joint patent once they come up with an idea.<sup>8</sup> Drawing on Martin (1996) we can speculate that such joint patenting facilitates collusion, compared with the situation where no *joint* patents are allowed, because it expands possibilities to retaliate in the market where deviation occurs. However, the introduction of *patents* even with joint patenting possibility into an industry where patenting was previously impossible would still increase the incentives to deviate from collusion in so far at least one independent innovator remains outside the joint patenting venture. In any case, if the venture partners could not make an irreversible commitment to the joint venture, joint patenting would have no impact on the punishment possibilities in other markets in subsequent periods. Hence, while the issue of joint patenting certainly warrants more attention, especially by antitrust authorities, we think that it would not change our main result that introducing patents limits the scope for collusion.

For similar reasons, we can also ignore the possibility of cross-licensing

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<sup>8</sup>Of course we could also think of joint patent applications being feasible without research joint ventures. In this case the firms would need to coordinate their patenting after they come up an idea independently. This kind of coordination seems to be particularly complex to implement and, hence, joint patenting without coordination of innovative activities seems to be very unlikely.

patents across markets. Like joint-patenting, cross-licensing in itself could obviously raise antitrust concerns: Eswaran (1994) shows that cross-licensing provides a means to establish a multimarket contact and from Bernheim and Whinston (1990) we know the conditions where such a multimarket contact is conducive to collusion. Nonetheless, we have two reasons to believe that our main results would survive in the environment where the multimarket contact via cross-licensing facilitated collusion. First, patents continue to protect deviators against parties outside cross-licensing schemes. Second, unless binding ex-ante licensing deals over undeveloped innovations are possible, our analysis would remain unchanged in the competition for future markets.

We also assume high enough patent quality so that only one patent can be awarded in case of multiple independent discoveries of the same idea. Although this is a plausible point of departure, it is clearly restrictive: there are often multiple patents associated with a single innovation in many industries. Related research (Shapiro, 2001, Lerner and Tirole, 2004) suggests that antitrust problems could arise from patent pools where firms collude by holding partially overlapping or blocking patents. As in the case of joint patenting and cross-licensing, patent pools or mutually blocking patents would expand retaliation possibilities in the deviation market, because a deviator can be taken to court over patent infringement. If innovation is repeated, the prediction is more ambiguous, since the deviator can get non-blocking patents in future innovation periods. Overall, it is still likely that allowing for patent pools or blocking patents would leave our main results intact. Worth noting is, however, that the analysis of patent pools would be somewhat awkward in

our model. To investigate the antitrust problems arising from patent pools would require more careful modelling of repeated innovation with overlapping ideas and endogenous patent quality, where patents on the same idea can sometimes be partial complements and sometimes partial substitutes.

In assessing the reliability of observations here, however, a caveat should be kept in mind. Joint venture, cross-licensing and patent pool agreements sometimes include clauses that, e.g., require partners to "grant back" their new invention to the pool or to the other partners. Such clauses might be anticompetitive because they could increase retaliation possibilities beyond the market where deviation originally took place.

## 7 Conclusion

The traditional view regards the patent system as a necessary evil that is needed to create the incentives to innovation by awarding an exclusive property right over an innovation. Recently many have argued that it is an unnecessary evil. Our argument can be interpreted that perhaps there is no evil in the first place. We show that the patent system makes collusive behavior more difficult and often impossible. Moreover, collusion can be impossible even if the patent system provides weak protection and, thereby, promotes information disclosure. It then follows that if innovative firms collude whenever they can, social welfare is in general higher with a properly designed patent policy than without it.

The findings are based on the two properties of the patent system. First, patents almost by definition protect against retaliation by former collusion

partners in the market where deviation takes place. Second, in innovative industries where competition is dynamic, both deviators and other former collusion partners have an equal chance of getting a patent on new innovations in future markets, which also reduces the cost of retaliation.

Our analysis yields a number of testable implications. The first is that collusion should be less frequent in innovative industries where spillovers are high or innovations become obsolete rapidly. The second is that collusion should be less frequent in industries where patents provide strong protection or where propensity to patent is high. As a result, quiet patenting activity in an innovative industry where patenting is feasible should be looked suspiciously from the antitrust point of view. The third hypothesis is subtler: in principle, collusion should be less frequent in the first-to-file patent system. In the US, where the patent system is based on the first-to-invent rule, deviation from collusion should be more costly. The problem with the hypothesis is twofold. First, the first-to-invent rule sometimes allows patenting by a later innovator if the first innovator has relied on secrecy. Second, in, e.g., Europe and Japan the effect of the first-to-file is counterbalanced by the prior-user rights. Like the first-to-invent rule, prior-user rights raise the cost of retaliation in the market where deviation occurs.

Even if the testable prediction concerning the first-to-file vs. the first-to-invent rule is moot, some competition policy implications are clear. As in Denicolò and Franzoni (2004), our analysis suggests that removing prior-user rights could improve welfare since it should hamper collusion. Similarly, the exception to the first-to-invent rule is justified: allowing a later innovator patent when the first innovator has kept the innovation secret should

make collusion more difficult. A bolder interpretation of our results supports stronger patents and the expansion of patent subject matter in the sense that they reduce the scope for collusion.

We believe that our analysis provides a useful first pass on the question of whether the patent policy can be designed to prevent collusive behavior. Our invariably affirmative answer is based on a number of strong assumptions that should be relaxed in future research. Prior research (e.g., Eswaran, 1994, Martin, 1996, Shapiro, 2001, 2003, and Lerner and Tirole, 2004) has identified a number of means such as cross-licensing, patent pools, patent settlements and research joint ventures that enable firms to use the patent system in an anticompetitive manner. While such means can certainly facilitate collusion in a world with patents and hence deserve closer scrutiny by researchers and antitrust authorities alike, they do not seem to change our proposition that antitrust authorities are better-off in a world with patents than without them. Nor are the incentives to innovate relevant for our main result. Indeed, that we find patents involving beneficial competition policy properties without recourse to the incentives to innovate is noteworthy.

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