Patents Hinder Collusion*

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Abstract

We argue that a patent system makes collusion among innovators more difficult. Our simple 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 tension between competition and patent laws almost by definition. The thinking is so widespread that most modern discussions of the boundary of competition and patent laws carefully deny such tension.[1] The apparent tension arises from the goals of the laws. Patent laws create the necessary incentives to innovative activity by granting a temporary monopoly over an innovation, thus compensating for the costs of the innovative efforts. In contrast, competition laws recognise the inefficiency of monopoly and guard consumer surplus by promoting competition. Over the past decades courts have become increasingly tolerant towards the privileges of patent holders, but the tension continues to surface in many prominent antitrust cases such as Microsoft.[2] In this study we support the modern notion of downgrading the tension. But whereas on-going debate aims at finding the proper balance between competition and patent laws, we argue that there is no tension in a deeper level. Although antitrust authorities seldom accept monopolies, they have especially hostile attitude towards cartels where firms in the same industry collude to produce as a monopoly and divide the profit. We show how the patent system makes sustaining 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,

[1] Cf., e.g., "Competition and patents are not inherently in conflict. Patent and antitrust law are actually complementary..." (Federal Trade Commission Report, 2003, p.2.)

[2] See Kortum and Lerner (1999) and Rahnasto (2003) for descriptions how the balance between competition and intellectal property laws has varied over time. Rahnasto (2003) also reviews numerous court cases centered around the issue.

the best deviation is to patent. In addition to the usual increase in instantaneous profits on the period of deviation, patenting generates a stream of future profits, since the patent by design provides protection from retaliation by the former collusion members. 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 or secret innovations are hard, if not impossible, to maintain. The second property of the patent system guarantees that even if the firms collude with patented innovations, the patent system makes deviation more attractive.

Our analysis yields straightforward policy recommendations. In industries where firms have a tendency to collude without patents, expanding the patent strength and its subject matter will yield a welfare improvement. Abolishing the prior-user rights in the patent systems would also be desirable because it would make collusion more difficult. For a similar reason, a shift from the first-to-invent rule to the first-to-file rule without prior-user rights would be desirable. As the firms can to some extent improve their ability to collude by filing joint patent applications, joint patents and research joint ventures warrant surveillance by antitrust authorities.

Although almost all studies on the patent system implicitly deal with the conflict between competition and patent laws, until recently only few have addressed it explicitly. The recent literature usually focuses on a specific question such as whether a patent pool or a collusion between first and second generation innovations should be allowed or not (see, e.g., Scotchmer and Green, 1995, Chang, 1995, Shapiro, 2001, Denicolò, 2002, and Lerner and Tirole, 2004). Carlton and Gertner (2003) take a broader view in arguing that the failure to recognise the tension between competition and patent laws can lead to errors in the adoption of traditional antitrust analysis to innovative industries. The patent-antitrust conflict has more often been explicit in the legal literature (see Rahnasto, 2003, for a survey of the literature). Traditionally patents have been regarded as a source of monopoly power, but scholars such as Dam (1994) have argued that the pricing power derived from patents has been exaggerated. Modern view considers patent and antitrust laws different means promoting the same goal, consumer welfare. Nonetheless, even under such a positive view some tension remains between the two laws and the problem is to find a proper balance between them (see, e.g., Federal Trade Commission, 2003 and Rahnasto, 2003). We tackle the patent-antitrust conflict from a slightly different angle. To the best of our knowledge we are the first to uncover the advantage of the patent system in hampering collusion.

Our model is a simplified version of Kultti, Takalo and Toikka (2003) who develop a dynamic model of innovation where agents find ideas according to an urn-ball process. A novel feature of the model is that firms can come up with similar innovations. Kultti et al. (2003) show that this feature can make patenting a dominant strategy over secrecy even if the patent protection is weak, since if a firm does not patent, someone else might do it and thereby prevent the use of the firm's innovation. In this study we continue to view innovation potentially simultaneous as it renders our argument transparent. It also seems that such simultaneous model of innovation especially characterises technology-intensive network industries where firms are typically working with the same basic technology or components (Rahnasto, 2003, and Varian, 2003). It has therefore become difficult for a single company to claim status of an inventor of a new technology.

We present our idea in a simple duopoly example in the next section and then in sections 3-4 generalise the model to allow for an arbitrary number of firms, repeated innovation, knowledge spillovers, and multimarket contact. Patent policy is introduced in section 5. We touch upon the effects of patents on the incentive to innovate and consumer surplus, and establish some welfare implications in section 6. 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 a similar innovation. The firms compete in Bertrand fashion which implies zero profits for each of them, unless the firms can sustain collusion where they equally split the monopoly profits π. To investigate the sustainability of the collusion, we evaluate the equilibrium strategy profile where each firm charges the monopoly price as long as the other firm did so in the past. If one or both firms deviate, the firms are assumed to charge the competitive price forever after. With Bertrand-competition this constitutes the optimal punishment strategy (Abreu, 1988).

Let us first consider an economy or an industry where patenting is infeasible. If the firms collude, they share the monopoly profits each earning a profit of $\pi/2$ per period. Denoting the discount factor by δ, 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 $\delta \geq \frac{1}{2}$.

We introduce patent policy in a rather crude but standard way. If a firm has a patent on an innovation, it receives a temporary monopoly over it. Let us assume that the patent is in force for T periods. After the patent expires, the innovation becomes public and the other firm can use it for free. Thus, if one of the firms patents it receives a profit of $\frac{\pi\left(1-\delta^T\right)}{1-\delta}$ and the other firm gets nothing. If both firms apply for a patent, the patent holder is selected by a lottery so that 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 $\frac{\pi}{2(1-\delta)} \geq \frac{\pi\left(1-\delta^T\right)}{1-\delta}$ or if $\delta^T \geq \frac{1}{2}$. Thus, if the patent is in force for at least two periods, the patent system makes it more difficult to sustain collusion. The reason is simple: the patent not only gives a temporary monopoly over the innovation, but it also provides temporary protection 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. We will next model such innovation process explicitly. We also generalise the above example by allowing for repeated innovation, knowledge spillovers, multimarket contact, and an arbitrary number of 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 δ. 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, e.g., Wolinsky, 1988, and Lu and McAfee, 1996). 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 $Bin\left(A, \frac{1}{I}\right)$. In other words, an agent always finds an idea but there may or may not 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

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

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

We assume that an innovator can keep a certain proportion α of the innovation secret. This means that proportion $1-\alpha$ of it becomes public; this is the spillover effect that can be controlled by the patent policy. We model this so that with probability α a new innovation stays private and with probability $1-\alpha$ secrecy leaks out. When the secrecy leaks out, the innovation becomes public so that anyone can use it. As a result, production is at the competitive level. The innovations become obsolete with probability $1-\lambda$. It is assumed that the probabilities remain the same each period; one could as well think that whether innovations remain profitable or not is determined only once. We focus on a steady state equilibrium where the stock of innovations remains the same from period to period.

The timing of events within a period is the following: First the agents find ideas, then the new innovations become either public or remain private, 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. We would also like to point out that the possibility of simultaneous innovation is not the 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 π when the monopoly price is charged. The monopoly naturally emerges if only one innovator finds an idea that can be maintained in secrecy. 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 their profits to zero. If the innovators collude and charge the monopoly price, they share the monopoly profit equally.

4 Collusion without Patent Policy

We want to determine when collusion can be sustained in an economy without patents. The analysis follows the standard repeated-game treatment of collusion. 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 deviates, the innovators are assumed to play the stage-game equilibrium strategy charging the competitive price forever after.

Without loss of generality we focus on an innovator who has no previous innovations. Deviating from collusion in case the deviator makes an innovation yields a one period monopoly profit but zero after that. 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.

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

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

where $\Omega(k)$ is the probability that exactly k other innovators find the same idea, as defined by (1), and where

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

is the innovator's expected utility when she has one innovation with k other colluding innovators. By stationarity, these utilities do not depend on time. The way δ, the common discount factor, enters into (2) shows that the value function is evaluated in the very beginning of a period.

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 private. The innovator's profit share depends on the number of the other innovators who find the same idea: with probability $\left(1-\frac{1}{I}\right)^{A-1}$ the innovator makes the innovation alone and can reap the monopoly profits π alone, with probability $\binom{A-1}{k}\left(\frac{1}{I}\right)^{k}\left(1-\frac{1}{I}\right)^{A-1-k}$ k other innovators find the idea and each innovator makes profits $\pi/(k+1)$. Then with probability λ the new innovation remains useful. In such a case 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

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

be the expected profit share from collusion. Then, inserting (3) and (4) into

(2) and using (3) again, (2) can after somewhat tedious algebra be simplified to

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

Equation (5) shows that the model behaves nicely. The return on collusive innovation is the larger, the larger is the monopoly profit (π), the higher is the discount factor (δ), the smaller is the spillover rate $(1-\alpha)$, the smaller is the obsolescence rate $(1-\lambda)$, and the larger is the expected profit share from collusion (σ).

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, π, during the period of deviation but receives zero forever after that, except when she manages to find an innovation alone. By the one-stage deviation principle, it suffices to consider the case where the deviator decides to deviate in a certain period and not after that. Further, it turns out to be useful to consider the case where the deviator only deviates when she finds the innovation with some fixed number n of other agents.

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

$$\begin{aligned} \widetilde{V} &= (1-\alpha)\,\delta V + \alpha \sum_{k=0}^{A-1} \Omega\,(k) \left[\frac{\pi}{k+1} + \lambda\delta U_k + (1-\lambda)\,\delta V\right] \\ &\quad + \alpha\Omega\,(n) \left[\pi + \delta V^D - \frac{\pi}{n+1} - \lambda\delta U_n - (1-\lambda)\,\delta V\right] \end{aligned} \tag{6}$$

where $\widetilde{V}$ 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 utility when 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 as 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

$$V^D = \alpha\Omega\left(0\right)\left(\pi + \lambda\delta V_1^D + (1-\lambda)\delta V^D\right) + \left(1 - \alpha\Omega\left(0\right)\right)\delta V^D. \tag{7}$$

As the punishment renders the market where the deviation occurred competitive, the deviator has no profitable innovations unless she manages to find a new idea alone. Therefore in (7)

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

captures the expected utility of an agent who has deviated and who possesses a monopoly to exactly one invention. In (7) the first term on the right-hand side is the expected utility from making a new innovation alone. With probability $\Omega\left(0\right) = \left(1-\frac{1}{I}\right)^{A-1}$ there are no other innovators. With probability α the new innovation remains private, and the deviator receives monopoly profits. With probability λ 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 $\sum_{k=1}^{A-1}\Omega(k) = 1 - \Omega(0) = 1 - \left(1 - \frac{1}{I}\right)^{A-1}$, the deviator will be punished, eliminating the profits from her new innovation.

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

$$V^D = \frac{\alpha\left(1 - \frac{1}{I}\right)^{A-1}\pi}{(1-\delta)(1-\delta\alpha\lambda)}. \tag{9}$$

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

$$\widetilde{V} = V + \alpha\Omega(n)\left[\pi - \frac{\pi}{(n+1)(1-\delta\alpha\lambda)} - \delta\left(V - V^D\right)\right]. \tag{10}$$

The first two terms in the brackets in (10) 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. The third term 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 $A > 1$.

Collusion can be sustained as an equilibrium when $V \geq \widetilde{V}$ or, equivalently, by using (10), when

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

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

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

The temptation to deviate is the greatest when $n = A - 1$ since then the agent's share of the monopoly profits is the least. Determining the condition for maintaining collusion in this case gives a conservative lower bound on the discount factor, above which collusion is possible in all markets. Expression (12) becomes

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

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

By totally differentiating (13) with respect to δ, α, λ, A, and I we establish the following finding:

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 α and λ in the model are essentially similar to the effect of δ. The more likely it is that the innovations become public or obsolete, the more likely is the exogenous break-down of collusion, and the higher is the "effective" discount factor. The number of innovators (A) has two opposite effects. On the one hand, the smaller is the average profit to a collusion member, the larger is the incentive to deviate. On the other hand, the more innovators there are, the smaller is the probability of finding an idea alone, which reduces the profit opportunities in the punishment phase. Proposition 1 shows that the first effect dominates. Had we evaluated the sustainability of collusion for some $n < A - 1$, the effect of A would be more ambiguous, as (12) suggests. As to the effect of I, it is reminiscent of the result by Bernheim and Whinston (1990) that maintains that multimarket contact facilitates collusion, because the deviator can be punished in several markets.

5 Collusion with Patent Policy

Patent policy involves many dimensions such as patent length, strength and height whose effects have been extensively studied in the literature. As our main objective is to evaluate whether patent policy can be used to make collusive behaviour more difficult, we introduce the patent policy in a rather general way by viewing patent as a probabilistic property right. We assume that the patent strength is $\alpha_p \in (0, 1]$, which is the probability that the patent cannot be infringed. With the complementary probability, 1-α_p, the patent is found invalid or it can be infringed by others, driving the profits from the innovation to zero. In our model such a 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 easier one, which is also 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 assume that collusion combines monopoly pricing with refraining from patenting. This assumption makes our argument transparent. It may sound strong, but our results would be qualitatively similar if we allowed for joint patenting. We also maintain the purpose of patent law of awarding only one patent on the same innovation. Hence potential antitrust problems stemming from mutually blocking patents cannot arise in our model. In conclusion we discuss in more detail about the possibility to collude on patented innovations.

As a result of the assumption, 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 considerably, since the best deviation is to patent and to get the monopoly protected by the patent. As the patent policy is typically imperfect ($\alpha_p < 1$), the deviator takes a risk between getting a monopoly 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. When all the innovations are patented each innovation can be held by one agent who gets monopoly revenue from it. If multiple agents make the same innovation, the patent holder is randomly selected among them and the others receive nothing.

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

$$\begin{aligned} \widetilde{V}_p &= (1-\alpha)\,\delta V + \alpha \sum_{k=0}^{A-1} \Omega\,(k) \left[\frac{\pi}{k+1} + \lambda \delta U_k + (1-\lambda)\,\delta V \right] \\ & +\alpha \Omega\,(n) \left[\pi + \delta(1-\lambda) V_p^D + \delta \lambda V_{p1}^D - \delta \lambda U_n - \delta(1-\lambda) V - \frac{\pi}{n+1} \right] \end{aligned} \tag{14}$$

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 monopoly profits in the market where she has 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:

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

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

$$V_p^D = (1-\alpha_p)\delta V_p^D + \alpha_p \sum_{k=0}^{A-1} \frac{\Omega\,(k)}{k+1} \left[\pi + \lambda \delta V_{p1}^D + (1-\lambda)\,\delta V_p^D + k \delta V_p^D \right] \tag{16}$$

The second term on the right-hand side of (16) comes from the possibility that the deviator can obtain a new patent. She gets a 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. Solving for V_p^D yields

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

Comparing (5) to (17) suggests that from the innovators' point of view collusion and patenting are practically equivalent. Indeed, it makes a little difference for 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 using (2), (3), and (15), (14) can be rewritten as

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

From (10) and (18) we see how the incentive to deviate is larger under the patent system than without with. As in (10), the two first 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 market where the deviation occurs but also in the other markets in subsequent periods. Because the collusion can be sustained only if the term in the brackets in (18) is negative, we can easily 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 $V \geq \widetilde{V}_p$ that can be rewritten after the substitution of (5) and (17) into (18) as

$$\frac{n}{n+1}\left(1-\delta\alpha\lambda\right)+\left(\alpha_p-\alpha\right)\frac{\delta\lambda}{(n+1)}+\left(\alpha_p-\alpha\right)\frac{\delta\sigma}{1-\delta}\leq 0 \tag{19}$$

The left-hand side of (19) is increasing in α_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 original 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 the deviation occurs. Even if we restrict the attention to this single market, the protection conferred by the patent makes collusive behaviour more difficult, as in the example of Section 2. But when the situation 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 can even get higher payoffs in the punishment phase than under collusion, if the patent system reduces the spillovers. Thus a strong patent protection eliminates possibilities for an efficient punishment and maintaining collusion becomes impossible.

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

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

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

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

which is clearly strictly smaller than α. ■

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 $\alpha_p < \widehat{\alpha}_p$ collusion becomes possible but, by continuity, it is more difficult to sustain it under the patent system than without it.

6 Welfare Discussion

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 questions in the literature on the patent policy. Although the literature has uncovered several complex effects of patents, the standard Nordhaus trade-off provides a reasonable benchmark for welfare discussion. Let us thus assume that the incentive to innovate is increasing and consumer surplus decreasing in α_p and α.

We assume large enough δ to make collusion feasible and focus on an industry where innovators collude without the patent system. [3] Let us consider the effects of introducing the patent system into the industry. Assume first that the patent system does not affect the spillover rate, i.e., $\alpha_p = \alpha$. Both under the patent system and collusion, the innovations are monopolised unless they 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 leaves welfare unchanged, if it leaves the spillover rate unchanged.

Let us then allow policy-makers to control the spillover rate in the patent system. At this juncture welfare discussion easily becomes convoluted because, as known, there can be too little or too much innovation in the market equilibrium. If the market supports too little innovation, the policy-makers could enhance the incentive to innovate by imposing a strong patent protection ($\alpha_p > \alpha$). If the market produces too much innovation, patent protection

[3] If the innovators do not collude without patents, the situation will reduce to the analysis of patent policy. We refer to our earlier work (Kultti, Takalo, and Toikka, 2003) for a characterization of optimal patent policy in a similar model of simultaneous innovation without possibility to collude.

can be made weak ($\alpha_p < \alpha$) to spread information and expand consumer surplus. In our case, however, it is immaterial whether boosting the incentive to innovate or disseminating information is desirable. Propositions 2-3 suggest that either goal can be achieved by introducing patents practically without concerns about the collusion. Hence, we can summarise welfare discussion in the following result:

Proposition 4 *A welfare improvement can 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 α_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, 2003).

7 Conclusion

The traditional view regards the patent system as a necessary evil that is needed to create the incentives to innovation by awarding a temporary monopoly over an innovation. Recently many have argued that it is an unnecessary evil. Our argument can be interpreted that perhaps there was no evil in the first place. We show that the patent system makes collusive behaviour 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 the patent system 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 members in the market where deviation takes place. Second, both deviators and former collusion members have an equal chance of getting a patent on new innovations in other markets, which also limits the possibilities to retaliate against deviations.

Our analysis yields a number of testable implications. The first is that collusion should be less frequent in innovative industries where spillovers are high and innovations become obsolete. 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 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. The other system, which is no longer used outside the US, is based on the first-to-invent rule, which tends to make deviation from collusion 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 make deviation from collusion more costly.

Even if the testable prediction concerning the first-to-file vs. the first-to-invent rule is moot, some antitrust implication 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 whether the patent policy can be used to prevent collusive behaviour. Our invariably affirmative answer is based on a number of strong assumptions that should be relaxed in future research. For example, we assume that under the patent system the firms collude by keeping their innovation unpatented. In reality, firms can apply for joint patents and form research joint ventures or other joint organisations that take care of patenting. Drawing on Martin (1996) we can speculate that such opportunities for joint patenting facilitate collusion, because they expand possibilities to retaliate in the market where deviation occurs. Similarly, patenting might raise antitrust concerns if innovators colluded on patented innovations by cross-licencing their patents across the markets. Especially if the innovators managed to build patent portfolios of equal sizes, they could establish a symmetric multimarket contact that is conducive to collusion. Nonetheless, patents continue to protect deviators against third parties and, in the competition for future markets, our analysis would remain unchanged, suggesting that the patent system hinders collusion even if collusion through joint patenting or cross-licensing is possible.

Related research (Shapiro, 2001, Lerner and Tirole, 2004) also suggests that antitrust problems could arise from patent pools where firms collude by holding partially overlapping and blocking patents. In the context of one-shot innovation, pooling patents would probably expand retaliation possibilities, because deviators can be taken to court for patent infringement. If innovation is repeated, the prediction is more ambiguous, since the deviators can get non-blocking patents in future innovation periods. It is, however, little awkward to discuss patent pools in the context of our model, because we assume high enough patent quality so that only one patent can be awarded among multiple innovations of the same idea. To investigate the antitrust problems arising from patent pools in this environment 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.

References

[1] Abreu, D. (1988). "On the Theory of Infinitely Repeated Games with Discounting", *Econometrica*, 56, 383-396

[2] Bernheim, B. D. and M. D. Whinston (1990) "Multimarket Contact and Collusive Behavior", *RAND Journal of Economics*, 21, 1-26.

[3] Carlton, D. and R. Gertner (2003) "Intellectual Property, Antitrust, and Strategic Behavior", in A. Jaffe, J. Lerner, and S. Stern (eds) *Innovation*

Policy and the Economy, vol. 3, Cambridge, MA: MIT Press. .

[4] Chang, H. (1995) "Patent Scope, Antitrust Policy, and Cumulative Innovation", *RAND Journal of Economics*, 26, 34-57.

[5] Dam, K. (1994) "The Economic Underpinnings of Patent Law", *Journal of Legal Studies*, 247-271.

[6] Denicolò, V. (2002) "Sequential Innovation and the Patent-Antitrust Conflict", *Oxford Economic Papers*, 54, 649-668.

[7] Denicolò, V. and L. A. Franzoni (2004) "Patents, Secrets, and the First-Inventor Defense", *Journal of Economics and Management Strategy,* 13. 517-538.

[8] Federal Trade Commission (2003) "Report on How to Promote Innovation Through Balancing Competition with Patent Law and Policy", http://www.ftc.gov/opa/2003/10/cpreport.htm.

[9] Green, J. and S. Scotchmer (1995) "On the Division of Profit in Sequential Innovation", *RAND Journal of Economics*, 26, 20-33.

[10] Kortum, S., and J. Lerner (1999) "What is Behind the Recent Surge in Patenting?", *Research Policy*, 28, 1-22

[11] Kultti, K., T. Takalo and J. Toikka (2003) "Secrecy versus Patenting", University of Helsinki Department of Economics Discussion Papers No. 547.

[12] Lerner, J. and J. Tirole (2004) "Efficient Patent Pools", *American Economic Review*, 94, 691-711.

[13] Lu, X. and R. P. McAfee (1996) "The Evolutionary Stability of Auctions over Bargaining", *Games and Economic Behavior*, 15, 228-254.

[14] Martin, S. (1996) "R&D Joint Ventures and Tacit Product Market Collusion", *European Journal of Political Economy*, 11, 733-741.

[15] O'Donoghue, T., S. Scotchmer and J.-F. Thisse (1998) "Patent Breadth, Patent Life, and the Pace of Technological Improvement", *Journal of Economics and Management Strategy*, 7, 1-32.

[16] Shapiro, C. (2001) "Navigating the Patent Thicket: Cross Licenses, Patent Pools, and Standard Setting", in A. Jaffe, J. Lerner, and S. Stern (eds.), *Innovation Policy and the Economy*, vol. 1, 119-150, Cambridge, MA: MIT Press.

[17] Rahnasto, I. (2003) "*Intellectual Property Rights, External Effects, and Antitrust*", Oxford: Oxford University Press.

[18] Varian, H. (2003) "Economics of Information Technology", Manuscript, http://www.sims.berkeley.edu/~hal/Papers/mattioli/mattioli.html.

[19] Wolinsky, A. (1988) "Dynamic Markets with Competitive Bidding", *Review of Economic Studies*, 55, 71-84.