Simultaneous Model of Innovation, Secrecy, and Patent Policy

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Multiple innovators can and do come up with the same invention independently. A famous case is the telephone: two hours after Alexander Graham Bell filed a patent application for it, another application for the same invention arrived at the patent office. Many scholars, such as Ilkka Rahnasto (2003) and Hal R. Varian et al. (2004), argue that since Bell's time, simultaneous innovation has become increasingly common. We feel, and our discussions with industry practitioners confirm, that the simultaneous model of innovation characterizes especially network industries such as consumer electronics, the Internet, software, telecommunications, and payment systems, where standardization limits the possible paths for future technologies and so firms concentrate their R&D activities on the same fields. We suggest that simultaneous or independent invention has major implications for intellectual property (IP) policy.[1] In particular, the possibility of simultaneous innovation changes the patenting decision: firms tap patents for a defensive purpose, since the choice is no longer between patenting or resorting to trade secrecy, but between patenting or letting competitors patent. By exploiting the vulnerability of innovative firms to rival innovation, it is possible to design a welfare-improving patent system that induces innovators to patent rather than keep their innovations secret. Taking the simultaneous nature of innovation seriously also changes the way one should think about the relationship between IP and competition policies.

I. Secrecy and Patent Policy

Most economic literature regards patents as a device to enhance the incentive to innovate. Evidence does not seem to fully support this view. There are numerous studies suggesting that patents typically offer weaker protection than secrecy and that they stimulate information disclosure rather than investments in innovation (e.g., Wesley M. Cohen et al., 2000; Nancy T. Gallini, 2002). Such information dissemination is the essence of the disclosure or contract theory of the patent system, which maintains that society needs to grant property rights to inventors in exchange for public disclosure of their inventions. The disclosure theory has been influential in the history of the patent institution and among legal theorists. Economic analysis has, however, centered around strategic disclosure inherent in the decision to patent (see e.g., James J. Anton and Dennis A. Yao, 2004), without providing a clear conceptual framework for the theory. Vincenzo Denicolò and Luigi A. Franzoni (2003) show that disclosure theory alone suffices to rationalize patents. The same observation is also a part of Kultti et al. (2003), who isolate the circumstances in which patent policy can increase disclosure, the incentive to innovate, or both.

Our argument can be highlighted by means of a simple example. Two firms are engaged in R&D which results either in an innovation (with probability q) or a failure (with probability $1 - q$). Suppose that the innovation can be protected only by a trade secret which leaks out (e.g., due to accidental or unlawful employee communication) with probability $1 - \alpha$. When this happens, the innovation is publicly available and production is at the competitive level. If only one firm succeeds in its R&D, and there is no leakage, it earns monopoly profits, π^M. If both firms succeed and the secret does not leak out, each firm earns duopoly profits, $\pi^D < \pi^M/2$. The firms can choose their success probability

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[1] Simultaneous innovation can be independent and vice versa, but not necessarily. With some caveats, our argument applies to independent invention that is not simultaneous, but where a firm rediscovers an innovation that was made earlier by another firm.

TABLE 1—PATENTING GAME WITH EXOGENOUS INNOVATION PROBABILITY

	S	P
S	$q_1(1 - q_2)\alpha\pi^M + q_1q_2\alpha\pi^D - \frac{1}{2}Rq_1^2$	$q_1(1 - q_2)\alpha\pi^M - \frac{1}{2}Rq_1^2$
P	$q_1(1 - q_2)\alpha_p\pi^M + q_1q_2\alpha_p\pi^M - \frac{1}{2}Rq_1^2$	$q_1(1 - q_2)\alpha_p\pi^M + q_1q_2\frac{1}{2}\alpha_p\pi^M - \frac{1}{2}Rq_1^2$

TABLE 2—PATENTING GAME WITH ENDOGENOUS INNOVATION PROBABILITY

	S	P
S	$\frac{R}{2}(q^*_{SS})^2$	$\frac{R}{2}(q^*_{SP})^2$
P	$\frac{R}{2}(q^*_{PS})^2$	$\frac{R}{2}(q^*_{PP})^2$

at cost $c(q) = Rq^2/2$ where the scale factor R is assumed to be sufficiently large to yield interior solutions. When firm 1 chooses q_1 and firm 2 chooses q_2, firm 1's expected profit is $q_1(1 - q_2)\alpha\pi^M + q_1q_2\alpha\pi^D - Rq_1^2/2$.

If the innovation can be protected by a patent, the firms can choose whether to file for a patent (P) or employ secrecy (S). This decision has to be made before learning whether the competitor has succeeded or not. If both firms are successful and file for the patent, each firm obtains it and the associated profit with probability ½. To facilitate the comparison of patent protection and secrecy, we encapsulate patent policy in a single dimension, the strength of the patent. It is defined by the probability α_p that a patent holder can exclude the competitor from using the innovation. With probability $1 - \alpha_p$, the innovation becomes public, e.g., the patent is found invalid or it can be infringed so that production is at the competitive level. This definition of the patent strength looks on patents as uncertain property rights (see Mark A. Lemley and Carl Shapiro, 2005).

We can summarize the symmetric patenting game in the matrix (Table 1), which displays the row player's payoff.

It is straightforward to solve the equilibrium levels of q_1 and q_2 in a symmetric equilibrium. Let q^*_{ij}, $i, j \in \{S, P\}$, denote the equilibrium success probability when i is the row player's choice and j is the column player's choice. At the (interior) equilibrium values the matrix becomes Table 2 where $q^*_{SS} = \alpha\pi^M/[\alpha(\pi^M - \pi^D) + R]$, $q^*_{SP} = \alpha\pi^M(R - \alpha_p\pi^M)/R^2$, $q^*_{PS} = \alpha_p\pi^M/R$, and $q^*_{PP} = \alpha_p\pi^M/(\frac{1}{2}\alpha_p\pi^M + R)$.

It is clear that we need to compare only the equilibrium success probabilities (Table 2). It can then be easily confirmed that when $\alpha_p = \alpha$, patenting is a strictly dominant strategy and, given $\pi^D < \pi^M/2$, the firms also invest more in innovation than without the patent system. By continuity, there exists $\bar{\alpha} < \alpha$ such that, for all patent strengths in $[\bar{\alpha}, \alpha]$, patenting is a strictly dominant strategy and the firms invest more, even though the patent offers weaker protection than secrecy. Note that we impose no specific demand structure or form of the duopolistic competition. For example, the argument could accommodate a standard, decreasing, inverse-demand function and Cournot or Bertrand competition.

The example conveys our main message: an effective patent policy can afford less protection than secrecy, indicating that the reward and disclosure functions of the patent system are not necessarily mutually exclusive. A more complete model of simultaneous innovation and IP policy should, however, include at least three additional properties. First, there should be a large, potentially infinite, number of innovators and innovations. Second, one should clarify how more than one innovator can discover the same innovation. Finally, one should distinguish actual innovations from unknown ideas as Suzanne Scotchmer (2004) forcefully argues.

In Kultti et al. (2003), we account for these properties. This helps to understand whether, and how, secrecy constrains patent policy when innovation is simultaneous. It is clear that if patent protection is very weak, firms waive patent rights and keep their innovations secret. This gives some lower-bound $\underline{\alpha}$ for implementable patent policy. Analogously, if patent protection is sufficiently strong, all firms prefer patenting. This defines $\bar{\alpha}$ above for which the patent policy works in the textbook manner: firms embrace patents and stronger protection increases the incentive to innovate. If the level of patent protection is in $[\underline{\alpha}, \bar{\alpha}]$, some firms patent and some resort to secrecy. In this interval, changes in the patent strength have no impact on the incentive to innovate, but only on information diffusion and the propensity to patent.

We can also determine the socially optimal IP policy. Society is generally better off with patents than without them and, although weak patent protection can be effective, it is not necessarily optimal. The optimal patent can offer stronger or weaker protection than secrecy, but that depends on other considerations, such as the innovative potential of the economy and the rate of obsolescence.

II. Competition Policy and Patents

The simultaneous model of innovation also provides a fresh angle on the debate about the subtle relationship between IP and competition policies. In other work (Kultti et al., 2004), we show that when innovation is simultaneous, patents can limit the scope for collusion in innovative industries.

Our argument can again be illuminated by a simple example, which in this case consists of a standard infinitely repeated version of Bertrand duopoly. There are two firms that have come up with the same innovation. Since the firms compete in the Bertrand fashion, they earn zero profits unless they can sustain collusion where they equally split the monopoly profits π^M. To investigate the sustainability of collusion, we evaluate the equilibrium strategy profile where each firm charges the monopoly price, as long as both firms did so in the past. If one or both firms deviate, the firms are assumed to charge the competitive price thereafter.

IP protections, trade secrets and patents, are probabilistic property rights as in the previous example, but here the probabilities are realized at the end of each period. Let us first consider an industry where patenting is infeasible. A firm can keep its innovation secret with probability α; otherwise, trade secrets leak out and the innovation becomes public. If the firms collude, they share the monopoly profit, each earning $\pi^M/2$ per period. Denoting the discount factor by δ, the discounted sum of profits from collusion is given by $\pi^M/2(1 - \alpha\delta)$. By deviating from collusion, a firm can reap the monopoly profit in the period of deviation. Because the profits in the punishment stage are zero, collusion can be sustained if $\pi^M/2(1 - \alpha\delta) \geq \pi^M$ or if $\delta \geq 1/2\alpha$.

If either firm has a patent on the innovation, it can exclude the competitor from using the innovation with probability α_p. With probability $1 - \alpha_p$, the innovation becomes public. Thus, if one of the firms applies for a patent, it receives a profit of $\pi^M/(1 - \alpha_p\delta)$ and the other firm gets nothing. If both firms apply for a patent, they have an equal chance of receiving it.

Patent policy does not affect payoffs from collusion, but it crucially affects the incentive to deviate. Since a patent not only gives a property right over the innovation, but also protection against retaliation by the former collusion partner, the best deviation is to seek the patent. As patent protection provides positive expected profits in the punishment phase, collusion can now be sustained only if $\pi^M/2(1 - \alpha\delta) \geq \pi^M/(1 - \alpha_p\delta)$ or if $\delta \geq 1/(2\alpha - \alpha_p)$. Thus, the threshold level of the discount factor is strictly larger with patents than without them, implying that even a weak patent system reduces the firms' ability to collude.

Our intention here is to provide another example of why IP policies should be reconsidered in the light of the simultaneous nature of innovation. The example is admittedly rough and abstracts from many important features of simultaneous innovation and the patent system that have bearings on competition policy. For instance, firms may collude over a patented innovation by applying for a joint patent. It has also been frequently suggested that cross-licensing and patent pools may facilitate collusion. Such practices can clearly eliminate the protection against retaliation in the above example. The practices require the ability to coordinate actions beyond pricing, however.

Moreover, in a truly dynamic context, deviators and former collusion members would compete on equal footing for patents over future innovations, and so deviators could obtain positive profits in the retaliation phase in spite of previous joint patenting or cross-licensing. This property of the patent system guarantees that even if firms colluded with patented innovations, the patent system would render deviation more attractive. Finally, the example does not take into account the incentive to innovate, and it may well be that collusion fosters more innovation than a weak patent system. But this possibility does not jeopardize our point that if innovation is simultaneous, the patent system is likely to prevent collusion.

III. Conclusion

Simultaneous innovation is frequent in practice, perhaps increasingly so. In such an environment, patents can have previously overlooked virtues. Traditionally the patent system is regarded as a necessary evil that is needed to create the incentive to innovate by awarding property rights over innovations. Recently, many have argued that it is an unnecessary evil. Our argument implies that there need be no evil in the first place. If innovation is simultaneous or independent, we can always design a weak patent system where innovators patent their discoveries rather than keep them secret. Such a patent system can stimulate both information dissemination and innovative activity. It can also hinder collusive behavior, since patents, by definition, afford deviating innovators leverage in the punishment phase. Although some private agreements concerning patents, such as cross-licensing and joint patenting, may be conducive for collusion, it is at most those agreements that should raise antitrust concerns, not the patent system in itself.

In our view, society is better off with a weak patent system than without it. But our results support the critics of strong patent protection who argue that the strengthening of patent rights over the past decades has resulted in an increase in patenting without a corresponding increase in innovative activity (see, e.g., James Bessen and Robert M. Hunt, 2004; Adam B. Jaffe and Josh Lerner, 2004). If patent protection is enhanced when some innovators resort to secrecy and some patent, it can only induce more innovators to patent without affecting their R&D expenditures. It is also hard to reconcile strong patent protection with information diffusion.

Finally, to the extent that firms discover the same innovations independently, our findings contribute to the intensively debated question of whether independent invention should be a defense to infringement in patent law (see, e.g., Stephen M. Maurer and Scotchmer, 2002; Kultti and Takalo, 2003; Denicolò and Franzoni, 2004; Shapiro, 2005). It is precisely the absence of the independent-invention defense that makes the patent system so powerful in disseminating information and hampering collusive tendencies. Our arguments, hence, emphasize the advantages of a "pure," first-to-file system against the U.S.-style first-to-invent system and against the European-style first-to-file system, where prior-user rights dilute the incentive to patent under the threat of independent innovation.

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