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Innovative Applications of O.R.

Optimal patent policy in the presence of vertical separation☆

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ABSTRACT

We examine a license contract in vertically separated markets, in which an inventor and a manufacturer bargain over royalties. The hold-up problem is found to be bilateral in that not only the licensor but also the licensee can delay the introduction of new technology. Given the probabilistic validity of patents and penalty upon infringement as patent instruments, we derive the optimal policies as a mix of them; not only can they always maximize the total amount of wealth but also they allocate the wealth according to each firm's contribution to the introduction of new technology. From the perspective of patent reform, our model supports the entire market value rule on the ground that it can always yield the first-best result. We also show that there is scope for self-correction in the market; even without the government's intervention, firms can adjust their bargaining power to improve social welfare to a certain extent.

1. Introduction

Innovation is one of the most important factors that drive market growth. To stimulate it, enough compensation should be granted to those who contribute to the introduction of new technology, typically in the form of patent rights. However, few different parties are required to innovate and diffuse knowledge into society; some might be able to develop new technologies, and yet not be capable of making products based on it, while others might be specialized in manufacturing without the ability to invent for themselves. A license contract bridges the gap between such parties, and the government's policy on patent protection directly affects not only its terms but also its *timing*. Thus, meticulous care is needed to design patent policies; otherwise, the introduction of new technology might be delayed significantly by *either* party. However, little attention has been paid to the dynamic perspective of vertical separation and the direction of the hold-up problem.

In this study, we examine a license contract problem in vertically separated markets in which an innovator and a manufacturer bargain over royalties. In particular, we investigate the problem based on the real options framework, which enables us to capture the dynamic perspective of the license contract. The government's policy on patent protection is directly linked to license bargaining; firms decide not only the terms but also the timing of the license contract taking the patent policies into account. We introduce two channels of patent policies: probabilistic validity of patents and penalty upon infringement, and analyze how they affect the timing of innovation, the amount of surplus, and its distribution in the market.

First, our model clarifies the bilateral hold-up problem inherent in the license contract of vertically separated markets. Namely, the introduction of new technology can be delayed significantly not only by the inventor but also by the licensee. Most previous studies have focused on the hold-up induced by the inventor, but our model captures the hold-up problem in both directions by incorporating the firms' investment timing decision. With this argument, we elucidate why strong patents can harm the patentee's interests. Given strong protection, the patentee can raise royalties by exercising more leverage over the bargaining. This makes the manufacturer less willing to make products, thereby delaying the license contract. The patentee generates revenue from the contract, and the delay cuts off those revenues. Schankerman and Scotchmer (2001) and Shapiro (2010) addressed the bilateral hold-up problem, but they focused on the amount of investment reduced by the hold-up. We elucidate the novel aspects of the problem, that is, how much the development of new technology is delayed by the bilateral hold-up problem.

In spite of the inherent problem, we derive the optimal policy as a mix of two patent instruments that can maximize social

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welfare by resolving the bilateral hold-up effectively. The optimal policy aligns both parties' incentives to invest, and eventually makes the firms invest as if they were vertically integrated. The policy is optimal in that not only is the total amount of wealth in society maximized but also the wealth is allocated to the firms in accordance with their contribution to the introduction of new technology. This feature coincides with the direction of desirable patent reform suggested by Shapiro (2008). It is shown that we can always have the first-best result by adopting the optimal policy since the two patent instruments can always complement one another when one of them is infeasible.

We also discuss the implications of our model on the direction of patent reform in virtue of the general framework that embraces different types of damages regimes and a full range of probabilistic validity. The model clarifies why an ironclad patent, a policy that always guarantees the validity of granted patents, is not optimal; it might not be able to yield the first-best result, even when we fully utilize another channel of the policies, penalty upon infringement. From the perspective of the damages regime, the model shows that reasonable royalties, that is, the royalties that would have been negotiated initially in the presence of patents with a certain validity, might not be enough to compensate a nonproducing patentee. Yet, the entire market value rule, which attributes the whole surplus to the patentee when applied to the reasonable royalties, is found to be optimal because it can always achieve the first-best result. This finding supports the direction of patent reform currently under discussion in the U.S. Congress.

Last, we show that in spite of the inherent inefficiency in vertically separated markets, there is still scope for improvement in social welfare even without the intervention of the government. If we suppose that firms can adjust their bargaining power, it is possible that the firm chooses to lower its bargaining power for the sake of its own interests. If one of the firms wants to make the investment much earlier than the other party would like, the former is willing to reduce its share from the license contract to incentivize the latter as long as the benefits from the earlier investment dominate the losses from the decrease in the firm's bargaining power. This counter-intuitive result arises from the fact that firms need each other to put the investment into practice, and thus, the expected profits of one firm depend on the counterparty's willingness to invest, which is in line with the argument from Schankerman and Scotchmer (2001).

There is a growing body of literature on a licensing problem in vertically separated markets. Katz and Shapiro (1986) and Kamien and Tauman (1986) found licensing based on a fixed-fee more efficient than that with royalties, whereas Bousquet, Cremer, Ivaldi, and Wolkowicz (1998) and Martín and Saracho (2010) showed that ad valorem royalties dominate fixed-fee and per-unit royalties in general. Crama, Reyck, and Degraeve (2008) even incorporated milestone payment, emphasizing the effects of having a three-part tariff under incomplete information, and Crama, Reyck, and Degraeve (2013) extended the model to the case of multiple R&D stages. These studies, however, did not pay enough attention to the dynamics perspective of the contract. Our model fills this gap in the literature by incorporating the investment timing decision into the model. This enables us to elucidate how the hold-up problem can be created by both the patentee and the licensor, and to derive the optimal patent policies that can effectively resolve the problem.

The inefficiency in a license contract of vertically separated markets is natural, and many studies have attributed it to information asymmetry (e.g., Anton & Yao, 1994; Bessen & Maskin, 2009; Allain, Henry, & Kyle, 2016). We, however, paid attention to the dynamic aspects of the results of vertical separation, and found that a lack of commitment yields the inefficiency even in the absence of information asymmetry. We show that firms cannot commit their investment timing. Ganglmair, Froeb, and Werden (2012) showed that ex ante commitment can resolve the hold-up problem by the innovator, but they presumed an exogenously given discrete timeline. In contrast, we endogenize the timing of licensing in a continuous-time dynamic framework and show that the commitment is infeasible for the hold-up in both directions.

A vast literature is dedicated to the optimal design of patent policy. The traditional literature has focused on classic instruments such as patent length and breadth.[1] In recent years, however, great attention has been given to other facets of patent policies, those associated with patent litigation. For instance, a growing body of papers regards the probabilistic validity of patents as a patent strength (e.g., Anton & Yao, 2006; Farrell & Shapiro, 2008; Choi, 2009; Henry & Turner, 2010; Shapiro, 2010). As noted by Lemley and Shapiro (2005), patent rights are inherently probabilistic, leaving the patent holders in the shadow of litigation. In fact, U.S. patent law (35 U.S. Code §282) stipulates that a patent shall be presumed valid and that the burden of establishing invalidity of a patent or any claim thereof shall rest on the party asserting such invalidity. This novel perspective was said to have emerged in the economics literature since Gallini (2002). Not only has it drawn much attention from theoretical researchers since then, but also many examples of empirical evidence have supported this point of view (e.g., Allison & Lemley, 1998, Moore, 2000).

The effects of damages and injunctions on the incentive to innovate have been a prominent subject of discussion in patent policies as well. Schankerman and Scotchmer (2001) investigated the impact of damages rules in vertically related markets in which a nonproducing patentee has an ironclad patent, and found that the unjust enrichment rule is superior to the lost profits rule. In contrast, Choi (2009) took probabilistic patents and a producing patentee into account and showed that the lost profits rule provides more protection to patent holders than the unjust enrichment rule. As pointed out by Lemley (2009), however, many patent owners lose their entitlement to the lost profits rule due to the difficulties of proof. The author noted that reasonable royalties usually do not provide enough compensation to patent holders but the application of the entire market value rule to reasonable royalties is likely to overcompensate the patentee. Henry and Turner (2010) analyzed price competition between a patentee and an imitator under different types of patent damages regimes, and Shapiro (2010) demonstrated the role of injunctions and the reasonable royalty rule upon royalty negotiations in vertically related markets with probabilistic patents.

These novel issues, however, have mostly been analyzed in static models, and fewer studies have attempted to examine them from the perspective of dynamics. In contrast, we elucidate the timing decision, which allows us to evaluate the value of R&D investment in a more comprehensive way. Meanwhile, to our best knowledge, there is no study that takes both patent instruments (i.e., the probabilistic validity of patents and damages upon infringement) into account and investigates their interaction. In this model, we effectively integrate both as patent policies and investigate their impacts on R&D dynamics. More specifically, patent policies are described as a pair of the two patent instruments[2] and the timing of R&D investment and license contract in vertically separated markets is endogenously determined.

[1] See Nordhaus (1969), Scherer (1972), Gilbert and Shapiro (1990), Klemperer (1990), Denicolò (1996).

[2] Chu and Furukawa (2011) also considered a mix of patent instruments in their R&D-based economic growth model: the patent breadth and the profit division rule as patent instruments. In contrast to their work, which regarded the division of profits as an exogenously given patent policy, we endogenize the division of profits as a solution of Nash bargaining between the firms.

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