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Patent hold-up and royalty stacking: the case of multiple downstream firms

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Abstract

The objective of this paper is twofold. First, we study the patent hold-up problem in game-theoretic framework. We show that in subgame perfect equilibrium of the patent hold-up game the innovating manufacturer exerts reduced effort to develop the new product and the patent holder obtains the entire value of product innovation. Second, we show that royalty stacking, which is believed to magnify the patent hold-up, may cause less severe problems than the ones predicted by Lemley and Shapiro [11] when competition on the downstream product market is introduced.

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Keywords: patent hold-up; royalty stacking; downstream competition

1. Introduction

The problem of hold-up by patent owners grew to be the central public policy issue in intellectual property law [10; 17]. Among different arguments against patents (for discussion see e.g. [1; 9]) the patent hold-up seems to have gained the most attention in recent years [3]. Partly it is due to the fact that inventions subject to patent protection lost their uniform character [14].

The patent system has to deal with inventions made up of many different components produced by different firms and industries (e.g. pharmaceuticals, biotechnology, information technology sector). According to Boldrin and Levine [1] this technological interrelatedness puts future inventions to an enormous hold-up problem, i.e. with many

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licenses to be purchased by the innovating firm, each patent holder, in raising the price of "his" component, imposes an externality on other patent holders and so charges a higher than efficient patent royalty. Knowing the latter the innovating manufacturers reduce the efforts to develop new products. For Boldrin and Levine [1] this is the main dynamic general equilibrium failure of today's patent system.

The patent hold-up problem is more severe in the presence of royalty stacking, i.e. when multiple patents read on a single product [11]. Lemley and Shapiro [11] analyzed the implications of royalty stacking in situations where the constraint on the royalty rate charged by each patent holder arises from the reduction in output that results from higher running royalties. The purpose of the paper is to extend the framework offered by Lemley and Shapiro [11] to the case of multiple downstream firms. Our model focuses on the effects of royalty stacking in an oligopolistic industry when there are many patent holders for the features used in the final product.

The article is organized as follows. First, for the clarity of further discussion, the patent hold-up problem is presented as an extensive-form game. Next, the phenomenon of royalty stacking is characterized on the basis of relevant literature. In the central part of the paper a model of royalty stacking in the case of multiple downstream firms is considered. A brief summary and concluding remarks are in the last section.

2. Patent hold-up problem in game-theoretic framework

Consider the following three-stage game between innovating manufacturer (IM) and patent holder (PH). Innovating manufacturer can exert small effort in research and development (e_S) or large effort (e_L) in order to develop the new product. π stands for extra firm's profits accruing from innovation in small and large effort case respectively ($\pi_S < \pi_L$). Assume that the efforts can be measured by the value of firm R&D spendings. Assume further that the new product consists of at least one component (or product feature) that is subject to royalty demand on the part of patent holder. Patent holder charges royalty rate of $x \in [0, \pi]$. Innovating manufacturer can either accept (Y) the demand of patent holder or reject (N) it and suspend the innovation project in its current form (some redesign work can be done in future). The payoffs are given in the figure 1.

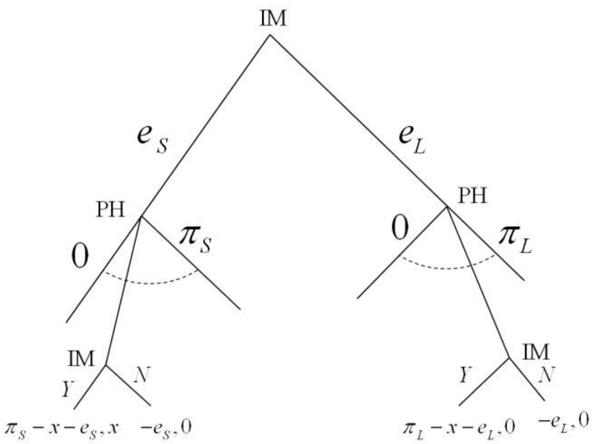

Figure 1. Patent hold-up problem – extensive-form game.
Source: on the basis of [19].

Observe that there is an infinite number of subgames following a demand by patent holder (uniquely identified by royalty demand, x). In all subgames with $x < \pi$, innovating manufacturer best action is to accept the royalty demand. In the subgame following the history $x = \pi$, innovating manufacturer is indifferent between accepting and rejecting the royalty demand. In a subgame perfect equilibrium innovating manufacturer either accepts all royalty demands on the part of patent holder or accepts all demands of $x < \pi$ and rejects the demand of $x = \pi$. Look that if innovating manufacturer accepts all royalty demands, then patent holder's optimal demand is of $x = \pi$. If IM rejects the demand of $x = \pi$ and accepts all other demands, there is no optimal demand for PH. This means that the discussed game has a unique subgame perfect equilibrium in which IM accepts all royalty demands. So, in the subgame following small effort in research and development, PH demands π_S and IM accepts it. In the subgame following large effort in research and development, PH demands π_L and IM accepts it. In both cases IM achieves strictly negative payoffs. Given the above subgame perfect equilibrium strategies, IM's best action at the initial node is to exert small R&D effort.

The subgame perfect equilibrium of the whole patent hold-up game is as follows: PH's strategy is (π_S, π_L) and IM's strategy is (e_S, Y, Y). The outcome of the game is that small R&D effort is exerted by the innovating firm and the patent holder obtains the entire value of product innovation.

3. Royalty stacking and the severity of patent hold-up problem

Yang [20] remarks that royalty stacking is one of the most pressing concerns facing patent litigation that a reasonable royalties calculation seeks to address. The patent hold-up problem is more severe in the presence of royalty stacking, i.e. when multiple patents read on a single product [11]. Royalty stacking is occurring when a product sold to end users incorporates many separate patented inputs, and the holder of the patent to one such input charges a high royalty from the product manufacturer without regard to the effect of this royalty on the total amount of royalties that the manufacturer must pay to all holders of patented inputs [18]. According to Geradin and Rato [4] royalty fees that have to be paid to all patent holders may add up to a very large amount, sometimes so large that it is no longer economically justified for the manufacturer to make a good. Jones et al. [8] estimate that royalty stacking occurs when various licenses combine to impose on manufacturer aggregate royalty obligations of 6%-20% (or greater).

Geradin and Rato [4] discuss four conditions that have to be met in fully-fledged royalty stacking case. First, innovation has to be sequential and cumulative, so that the interrelated patents can stack up. Second, there have to be many patented inputs for a given product. Third, patents have to be held by numerous and distinct holders. Finally, licensees cannot have patents that may be traded with licensors, because possible cross-licensing may significantly reduce the probability of royalty stacking.

Godt [7] explains how royalty stacking can effectively limit knowledge transfers from science (universities and research institutes) to industry. Accumulated negotiated royalties by researchers in the subsequent research process can exhaust the profit margins for the commercial developer of the invention. In such a case technology transfer from science to industry will not happen.

It is worth noticing that the potential for royalty stacking is particularly high within industrial standard setting efforts [6; 15; 16]. The risk of royalty stacking arises in this case from the fact that downstream firms face multiple upstream gatekeepers, each of whom must grant a license to their essential patents, before the downstream firms can effectively commercialize the standard. The risk of royalty stacking is exceptionally high in high-tech industries where standards are set by cooperative efforts of firms [5].

The negative effects of royalty stacking can be increased by the introduction of the "entire market value rule" to legal system. The "entire market value rule" allows a patentee whose patent covered only a component of or improvement to an infringing article to recover damages based on the entire value of that article, provided that the patentee could show that sales of the article were properly attributable to the patented invention alone [13]. The producer of a good constructed from many patented components may infringe multiple patents and as a consequence be required to pay for multiple licenses. Since patent damage rules allow for the overcompensation of patentees, the infringer may as a result pay overlapping royalties [13].

Lemley and Shapiro [11] discussed the effects of royalty stacking in the industries where a single downstream firm uses patents owned by many patentees. They found that the output of the downstream firm falls as the number of patent holders rises, and it approaches zero as the number of patentees becomes large. In this framework, the combined royalties reach the point where the downstream firm's threat to shut down comes into play.

Elhauge [2] in his analytical framework discovered that the severity of patent hold-up problem is reduced if there is competition on the downstream product market or upstream market for inventions (see also [12]). In this paper we follow the first research direction indicated by Elhauge [2] by extending the framework offered by Lemley and Shapiro [11] to the case of multiple downstream firms.

4. The model of royalty stacking

We consider an industry composed of the upstream and the downstream firms. There are N identical upstream firms, each of whom holds a patent on features required to manufacture the final product supplied by the downstream firms.

There are K identical downstream firms, each of whom manufactures the final product offered on the market. The total demand faced by the downstream firms is given by

$$q = a + v - p, \tag{1}$$

where q is the quantity of the final product demanded at price p, a is a constant parameter measuring the value of the product that does not contain any of the patented features, and v is a variable that captures the increase in the product value due to the inclusion of the patented features in the final design.

Each downstream firm faces a constant unit cost of manufacturing c. In addition to the cost of manufacturing, each firm is obliged to cover patent royalties in order to supply the product with the patented features.

The competition among the downstream firms is assumed to be of Cournot type, i.e., the firms choose their outputs simultaneously and independently. The output of firm j is denoted by q_j, thus

$$q = \sum_{i=1}^{K} q_i . \tag{2}$$

Each upstream firm i owns a patent on a feature that adds value v_i to the final product. Following Lemley and Shapiro [11], the patented features are assumed to be technically independent, so that the inclusion of all of them in the final design raises the value of the product by

$$v = \sum_{i=1}^{N} v_i . \tag{3}$$

Also, for simplicity, it has been assumed that the downstream firms decided to include all N patented features in the final product.

The patent holders compete by simultaneous and independent setting of royalties for their intellectual property rights. The royalty rate of an upstream firm i is denoted by r_i. Thus, the total royalty rate paid by each downstream firm per unit of production is

$$r \equiv \sum_{i=1}^{N} r_i . \tag{4}$$

The profit of a downstream firm j is given by

$$\pi_j = (a + \sum_{i=1}^{N} v_i - \sum_{j=1}^{K} q_i - c - \sum_{i=1}^{N} r_i)\, q_j . \tag{5}$$

Solving for a symmetric Nash equilibrium of the Cournot-competition game of the downstream firms, we obtain the optimal output level of each downstream firm as a function of royalty rates set by the upstream firms to be

$$q_j = \frac{a + \sum_{i=1}^{N} v_i - c - \sum_{i=1}^{N} r_i}{K+1}, \tag{6}$$

and the total market output for the given values of the royalty rates:

$$q = K\, q_j = K \frac{a + \sum_{i=1}^{N} v_i - c - \sum_{i=1}^{N} r_i}{K+1} . \tag{7}$$

Thus, from (1), the price of the final product is given by

$$p = \frac{a + \sum_{i=1}^{N} v_i + K\left(c + \sum_{i=1}^{N} r_i\right)}{K+1}. \tag{8}$$

Now, consider the upstream firms' problem. The profit of an upstream firm *i* can be calculated as

$$r_i\, q = r_i\, K \frac{a + \sum_{i=1}^{N} v_i - c - \sum_{i=1}^{N} r_i}{K+1}. \tag{9}$$

Solving for a symmetric Nash equilibrium of the simultaneous-move royalty-setting game, we obtain the optimal level of the royalty rate charged by each upstream firm as

$$r_i^* = \frac{a + \sum_{i=1}^{N} v_i - c}{N+1}, \tag{10}$$

and the equilibrium royalty rate paid by each downstream firm per unit of output is calculated as

$$r^* = N\, r_i^* = N \frac{a + \sum_{i=1}^{N} v_i - c}{N+1}. \tag{11}$$

Thus, from (6), the equilibrium supply of each downstream firm equals to

$$q_j^* = \frac{a + \sum_{i=1}^{N} v_i - c}{(K+1)(N+1)}, \tag{12}$$

the equilibrium total market output amounts to

$$q^* = K\, q_j^* = K \frac{a + \sum_{i=1}^{N} v_i - c}{(K+1)(N+1)}, \tag{13}$$

and the equilibrium price of the final product is given by

$$p^* = a + \sum_{i=1}^{N} v_i - K \frac{a + \sum_{i=1}^{N} v_i - c}{(K+1)(N+1)}. \tag{14}$$

The equilibrium profit of each downstream firm equals to

$$\pi_j^* = \frac{\left(a + \sum_{i=1}^{N} v_i - c\right)^2}{(K+1)^2 (N+1)^2}. \tag{15}$$

When K=1, we have the case of a monopolist manufacturer who includes the patented features in the design of the final product. If the patent owners set the prices independently and simultaneously, this case is identical to the one discussed by Lemley and Shapiro [11], where the total output resulting from (13) equals to

$$q^* = \frac{a + \sum_{i=1}^{N} v_i - c}{2(N+1)} \; . \tag{16}$$

Clearly, with an increasing number of patent holders, the total market output declines, and approaches zero for large N.

However, when the final product is not manufactured by a monopolist, the total output is greater than the one predicted by (16). Actually, it follows from (13), that with a growing number of manufacturers, the overall quantity supplied increases, and for large K, the total output approaches

$$q^* = \frac{a + \sum_{i=1}^{N} v_i - c}{(N+1)} \; , \tag{17}$$

which is twice as large as the output of the monopolist, given by (16). Thus, when the downstream market structure is oligopolistic, the royalty stacking may cause less severe problems than the ones predicted by Lemley and Shapiro [11] in the case of a monopolist manufacturer.

5. Conclusion

This paper focused on two interrelated economic phenomena (patent hold-up and royalty stacking) that are in the center of current policy discussions on major patent reforms. Arguments referring to patent hold-up and royalty stacking may support the belief that the patent system in its current form allows patent holders to effectively hamper the commercialization of complex technologies as well as limit the output of the downstream firms responsible for delivery of the product to the end customers. In this paper, in analytical framework proposed by Lemley and Shapiro [11], we showed that the severity of royalty stacking problem is significantly reduced by introduction of competition on the downstream market. Thus, when the downstream market structure is oligopolistic, the royalty stacking may cause less severe problems than the ones predicted by Lemley and Shapiro [11] in the case of a monopolist manufacturer.

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