Patent pool as a method to avoid "the tragedy of anti-commons"

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Abstract

In this paper, we investigate the future externality of the anti-commons and the effect of patent pool on the avoidance of the anti-commons using the standard oligopolistic model, in which the strategic interactions among patent users are considered. We establish the following main results. (1) If the demand function is not relatively convex, the future external effect of the anti-commons occurs, and then patent pool is effective to solve the anti-commons. (2) Patent pool can always improve social welfare. (3) Under elastic demand function, each patent holder has incentive to participate in the patent pool.

Keywords : The tragedy of anti-commons, Current externality, Future externality, Patent licensing, Patent pool.

JEL classification numbers : D43, D62, L13, O34

1. Introduction

This paper aims to examine whether patent pool is beneficial for patent holders, and whether it is effective from the welfare viewpoint under the circumstance that any firms cannot produce a good without holding numerous patented technologies. This circumstance is called as "the tragedy of anti-commons." Heller (1998) and Heller and Eisenberg (1998) defined it as the situation that an over assignment of property rights for a privately owned resource brings about under utilization of the resource from the welfare viewpoint. Anti-commons on the patent licensing occurs in several R&D intensive industries. According to Heller and Eisenberg (1998), for instance, whereas biomedical discoveries can be freely available for "down stream" biomedical firms in America before an implementation of pro-patent policies, the purchase of numerous patented biomedical discoveries is necessary for down stream firms to use these discoveries after the implementation.

According to Buchanan and Yoon (2000) and Schulz, Parisi, and Depoorter (2001), the above example of anti-commons called patent fragmentation cause the two kinds of externalities : One externality called *current externality* can be described as the increase in the patent royalty invoked by "prisoner's dilemma" of the patent holder's pricing, which means that each patent holder set its royalty level given all other patent holder's pricing level. Another externality called *future externality* means that the decreases in the patent users invoked by higher level of royalties than the level of what the current externality could be internalized.

From the standpoint of externality, Buchanan and Yoon (2000) tackled this problem using simple duopolistic model, and showed the relationship between the tragedy of commons and that of anti-commons. Parisi, Schulz and Depoorter (2000) analyzed the above relationship, and classified the four categories about commons and anti-commons. Schulz, Parisi and Depoorter (2001) tried to construct the general model of anti-commons. These literatures, however, have two problems : (1) they did not explicitly point out the policy implication to relax "anti-commons." (2) They did not deal with the behavior of the resource users explicitly.

Shapiro (2001) tried to present the answers for the former problem. He suggested that patent pool and package licenses are effective methods to solve patent fragmentation. In addition, Shapiro (2001) showed that each patent holder has an incentive to form patent pool to internalize the current externality by using an oligopolistic patent holders' pricing model extended Buchanan and Yoon (2000)'s one, in which each patent user's is assumed to be a perfectly competitive firm. Alternatively, cartel formation by each patent holder causes the price reduction of patent and the increase in the received patent royalties, and accordingly is beneficial for patentees. However, Shapiro (2001) did not examine future externality explicitly, because each patent user's strategic behavior is not considered in his model.

In this paper, we extend Shapiro (2001)'s model to what considers patent user's strategic behavior. We consider the future externality of the anti-commons, and examine the validity of Shapiro (2001)'s result. In addition, we analyze whether patent pool improves social welfare. We establish the following results : (1) the future external effect of the anti-commons does not always occur. (2) Patent pool does not always increase patent royalty, while it always improves social welfare. (3) Whether this externality occur depends on the curvature conditions of demand function of a good produced by using patented technologies, whilst whether patent pool is beneficial for each patent owner depends on price elasticity of demand as well as the elasticity of royalty with respect to the number of patent pool members.

The paper is organized as follows. In section 2, we present a theoretical model that strategic behavior of each patent user is explicitly considered, and derive preliminary results from the model. In section 3, we show the main results. Concluding remarks are given in section 4.

2. The model and the preliminary analysis

Each patent owner holds a single patent that is essential for the production of a final good. None of them is assumed to produce it. The number of patent holder is m. Patent royalties consist of a running royalty and a fixed fee. Each patent user (firm) has to pay $C(m)$ as total running royalty per output and $F(m)$ as total fixed fees to m patent holders. Following Buchanan and Yoon (2000)'s result, we assume that both total running royalties per output and total fixed fees are increasing function of the number of patent holders. For simplicity, any production cost is assumed to be null. Each firm's profit is defined as

$$\pi_i = p(Q)q_i - C(m)q_i - F(m), \tag{1}$$

where $p=p(Q)$ is the inverse demand function of the final good, Q is total output q_i and is each firm's output. Each firm engages in Cournot competition. We assume that monopolist can enjoy positive profit. Assuming symmetric equilibrium, the long-run free-entry equilibrium has to satisfy the first order condition and the zero-profit conditions, which are given by

$$p(Q) + p'(Q)q - C(m) = 0, \tag{2}$$

$$p(Q)q - C(m)q - F(m) = 0. \tag{3}$$

From (2), each firm's total output is regarded as a function of the number of entrants n, which is denoted by

$$Q = Q(n). \tag{4}$$

Substituting (4) into (1) yields $\pi = \pi(n)$. We consider the following entry-exit dynamics $\dot{\pi} = \sigma\pi(n)$,
where σ is positive parameter. The free-entry equilibrium is locally stable and unique, if $\pi(n)$ is a decreasing function of the number of entrants n, *i. e.*,

$$\pi'(n) = \frac{p'(Q)Q}{n}\left[(n-1)Q'(n) + \frac{1}{n^2}\right] < 0, \tag{5}$$

where

$$Q'(n) = -\frac{p(Q)}{p''(Q)Q + (n+1)p'(Q)}.$$

Equation (5) implies that $\pi(n)$ is a decreasing function of n if the demand function is not too convex. Thus, we establish

Lemma 1 : Unless the demand function is too convex, then the long-run free entry equilibrium is stable and unique.

Following Schulz, Parisi, and Depoorter (2001), we define the anti-commons as follows :

Definition : The anti-commons consist of current and future externalities. The current externality means that the increase in the number of patent holders raises total royalty payments of each patent user. The future externality means that the increase in the number of patent holders decreases the number of entrants at the long-run equilibrium.

Note that the current externality is assumed in the model.

In order to examine the effect of the increase in patent holder m on the total output and the number of entrant, we obtain

$$\begin{bmatrix} p''Q+(n+1)p' & p-C \\ p'Q+p-C & -F \end{bmatrix}\begin{bmatrix} dQ \\ dq \end{bmatrix}+\begin{bmatrix} -nC' \\ -C'Q+nF' \end{bmatrix}dm \tag{6}$$

by differentiating (2) and (3) totally. Substituting (2) and (3) into the first term on the LHS of (6) and rearranging terms, the determinant of the first term is given by

$$\Delta=\begin{bmatrix} p''Q+(n+1)p' & p-C \\ p'Q+p-C & -F \end{bmatrix}=-(p-C)Q(p''q+2p'). \tag{7}$$

The sign of (7) is positive, because the second order condition is valid, i.e.,
$p''(Q)q+2p'(Q)<0.$ (8)
From (6) and (7), using Cramer's formula, we obtain

$$\frac{dQ}{dm}=-\frac{nC'F+(p-C)(C'Q+nF')}{\Delta}, \tag{9}$$

$$\frac{dh}{dm}=-\frac{[p''Q+(n+1)p']nF'+(p''Q+2p')C'Q}{\Delta}. \tag{10}$$

Whereas the sign of the RHS of (9) is clearly negative, the sign of the RHS is negative (positive) if $p''Q+2p'\leq 0\,(p''Q+(n+1)p'\geq 0)$ from (5). Therefore, we establish

Lemma 2 : (i) The increase in the patent fragmentation reduces total output. (ii) If demand function is not relatively convex, then the increase in the patent fragmentation reduces the number of patent users. Otherwise, then it enhances the number of patent users.

Furthermore, we define the social welfare W as a sum of consumer surpluses, total profits, and total patent royalties. Since patent royalties are offset, it can be expressed as

$$W(Q)=\left[\int_0^Q p(s)ds-p(Q)Q\right]+p(Q)Q \tag{11}$$

irrespective of whether the patent pool exists or not. The first term on the LHS of (11) is consumer surpluses, and the second one is total revenue. Equation (11) implies that the level of welfare is an increasing function of total output at any equilibria. Therefore, we get

Lemma 3 : The increase in the total output improves social welfare.

3. The main results

In the case of patent licensing about complement technologies, the future externality of the anti-commons can be regarded as a circumstance where the increase in the patent fragmentation decreases the number of patent users from Definition. From Lemmas 1 and 2 (ii), we can derive the following results:

Proposition 1 : If the demand function is not relatively convex, then the future external effect of the tragedy of anti-commons prevails. Otherwise, then it does not prevail.

The intuition behind Proposition 1 can be explained as follows : the increase in the patent fragmentation causes two effects on the entry of each patent user. The one effect is that the decrease in each incumbent output through the increase in the total running royalty per output facilitates entry, because the decrease in each incumbent output enhances price level. The degree of price increase depends on the curvature condition of demand function. If the demand function is not relatively convex, then the degree is not strong; otherwise, then it is strong. The other effect is that the increase in the total fixed fee relaxes entry. Since the increase in convexity of demand function enhances the former effect, the former (the latter) dominate the latter (the former) when the demand function is (not) relatively convex.

Next consider patent pooling system. According to Buchanan and Yoon (2000) and Shapiro (2001), the introduction of the patent pool enables for patentees to internalize the current externality of royalty pricing, and accordingly decreases the total royalty level each firm faces to. In our model, it implies the level of total running royalties per output and that of fixed fees each firm has to pay to all patent holders are $C(1)$ and $F(1)$ respectively, because an entire group of patents is licensed in a package under patent pooling system. In other words, there would be a single patent holder under patent pooling system.

From Lemmas 1, 2 (i), and 3, we establish

Proposition 2 : (i) Patent pool can always improve welfare. (ii) If the demand function is not relatively convex, then patent pool is effective to solve the anti-commons; otherwise, then it deteriorates this externality.

Proposition 2 suggests that patent pool is a desirable system from the welfare viewpoint, even if it cannot disappear anti-commons.

In order to adopt patent pooling system, it must be beneficial for each patent holder. The sum of total running royalties and total fixed fees $R(m)$ is given by

$$R(m)=C(m)Q(m)+n(m)F(m). \tag{12}$$

Considering (2), (3), (9), and (10), and differentiating (12) with respect to m yields

$$R'(m)=\frac{np(2c'q+F')[1-(1/\epsilon)]}{p''q+2p'}, \tag{13}$$

where $\epsilon=-(p/p'Q)$ is the price elasticity of demand. If the price elasticity of demand is (not) less than one, then $R'(m)$ is positive (negative), because of (8). Since the level of royalty received by each patent holder $r(m)$ is $R(m)/m$, differentiating (13) with respect to m

yields

$$r'(m)=\frac{R(m)}{m^2}\left[\frac{R'(m)m}{R(m)}-1\right]. \tag{14}$$

From (13) and (14), therefore, we establish

Proposition 3 : (i) Suppose that the price elasticity of demand is not less than one. Patent pool can maximize royalty received by each patent holder. (ii) Suppose that the price elasticity of demand is less than one. If the elasticity of the royalty received by each patent holder with respect to the number of members is (not) smaller than one, then patent pool can (not) maximize royalty received by each patent holder.

Proposition 3 implies that each patent holder has incentive to form patent pool if the demand function is elastic, while he or she does not always have it if demand function is inelastic.

From Propositions 2 and 3, we present the following four cases according as curvature condition of demand function and the degree of price elasticity. (1) Demand function is elastic and is not relatively convex. (2) Demand function is elastic and relatively convex. (3) Demand function is inelastic and is not relatively convex. (4) Demand function is inelastic and is relatively convex. Each patent holder participates in patent pool voluntarily, and patent pool is effective for the avoidance of anti-commons in the case (1), while each of them certainly has incentive to form patent pool, but patent pool is not effective to solve the future avoidance in the case (2). Whereas each patent owner does not have incentive to form patent pool, which can solve the anti-commons problem in the case (3), patent pool does not form, and is not effective in the case (4).

We derive the following policy implication from the above results. In the case (2), government has to intervene not to form patent pool from the standpoint of avoidance of the future external effect, while government intervention is not needed from the welfare viewpoint. Government should help patent holders to form patent pool to solve the anti-commons problem in the case (3). In the case (4), government intervention is needed from the welfare viewpoint.

4. Concluding Remarks

In this papere, we investigate the future externality of the anti-commons and the effectiveness of patent pool on the avoidance of the anti-commonse. We establish the following main results. (1) If the demand function is not relatively convex, the future external effect of the anti-commons occurs, and then patent pool is effective to solve the anti-commons. (2) Patent pool can always improve social welfare. (3) Under elastic demand function, each patent holder has incentive to participate in the patent pool.

The above results suggest that government intervention is needed when each patent owner does not form patent pool voluntarily, and that government have to be concerned about the shape of demand function.

We inpose to simplify current external effect of the anti-commons. As a future research we will construct the more general dynamic model, in which strategic interaction among patent holders as well as users are explicitly considered, in order to examine the validity of the above results.

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