Package licenses in patent pools with basic and optional patents *

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Abstract

Recently, patent pools have been often established by the patent holders in order to promote research and development (R&D) and set technological standards. Patent pools are one of the administration methods for licensing, whereby many patent holders assemble their own patents and the administrator of the patent pools offers the licenses to users. This paper investigates the patent holders' incentive to form a patent pool, the patent pool's licensing behavior, and the anticompetitive effect of a patent pool. Our model is characterized by the following two features. First, we consider different two types of patent: *basic* and *optional*. Second, we consider not only a patent pool that offers a single package license, but also a patent pool that offers multiple package licenses. The single package license includes both *basic* and *optional* patents in the patent pool. The multiple package licenses involve two licenses: one includes only *basic* patents, whereas the other includes both *basic* and *optional* patents. The results of our analysis yield some implications for a patent pool that is characterized by *the strength of complementarity* between *basic* and *optional* patents.

Keywords: patent pools, multiple package licenses, antitrust laws, bundling goods

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1 Introduction

This paper investigates the anticompetitive effect of a patent pool that offers a package license. Our analysis is characterized by the following two features. First, we consider different two types of patents: *basic* and *optional*. The *basic* technology can be used by itself, it becomes more valuable when used in combination with the *optional* technology. The *optional* technology cannot be used by itself. Second, we consider not only a patent pool that offers a single package license, but also a patent pool that offers multiple package licenses. The single package license includes both *basic* and *optional* patents in the patent pool. In the multiple package case there are two package licenses: one includes only *basic* patents, whereas the other includes both *basic* and *optional* patents.

A patent pool refers to organizations where patent holders concentrate their own patents for commercializing new innovations or for setting standards, and offer a package license that is inclusive of many patents in the pool[1] A patent pool plays an important role in solving the "tragedy of the anticommons", which is discussed in Heller and Eisenberg (1998). The well-known "tragedy of the commons" is the situation wherein a resource can be overused when it is not protected by property rights. "Tragedy of the anticommons", as Heller and Eisenberg indicated, refers to a situation wherein "excessive" property rights render the resource underused when there are multiple property rights holders. In the case of patents, excessive property rights can have the perverse effect of stifling or discouraging innovation. A patent pool is expected to be a useful means to solve this "tragedy of the anticommons" that arises, particularly in advanced technology fields. A patent pool enables firms to reduce the cost of seeking technologies and to negotiate by simplifying the license contract. Furthermore, a patent pool can avoid patent litigations and can help establish standardization committees such as MPEG-LA, DVD 6C Licensing Agency, and 3G[2].

Unfortunately, the competition authorities in many countries have a deep-rooted suspicion of patent pools, which involve cooperative activity between patent holders. There is the possibility

[1] Examples of comprehensive surveys on patent pools are Shapiro (2001) and Gilbert (2004).

[2] The standardization committees are the organizations that set international technological standards. Technological standards aim at the wide adoption of technologies in the marketplace. However, this wide adoption of technologies may bring about patent conflict between patent holders or firms. Standardization committees establish patent pools in order to avoid these conflicts. MPEG-LA, DVD 6C Licensing Agency, and 3G are examples of such standardization committees.

that a patent pool can exercise monopoly power as a major cartel[3]. Historically, patent pools have been abused since the early 1900s[4]. Priest (1977) indicated that it is possible that a patent pool is a means to disguise a cartel, formed by using a cross-license between the members in the pool. Thus, many discussions have been held between economists, legal scholars, and antitrust enforcement leagues as to whether patent pools benefit both intellectual property owners and consumers. Our concern is to determine whether patent pools are competitive or anticompetitive.

The US competition authority focuses primarily on the technical relationships between the patents included in the pool[5]. Its viewpoint is that a pool of technical substitute patents is more suspicious than a pool of technical complementary patents. In addition to this view of the US antitrust enforcement agency, Shapiro (2001) and Lerner and Tirole (2004) focused on the technical relationships between the patents included in a pool, and investigated whether patent pools have an anticompetitive effect. They concluded that a patent pool is pro-competitive when the patents are of the technical complementary type, whereas a patent pool always operates as a cartel when the patents are technical substitutes. These results are consistent with the current US and European policies (see Lerner and Tirole 2007).

Most of the literature on patent pools has sought to determine the social implications of the pool under the situation where all firms join the pool (Lerner and Tirole 2004). Recently, some works have focused on the firm's incentive problem in relation to participation in the pool (Aoki and Nagaoka 2004; Brenner 2009; Langinier 2006; Lerner and Tirole 2007). Our paper considers both the patent pool that offers only a single package license and the patent pool that offers the multiple package licenses. There are no theoretical discussions of the patent pool in the literature that offered a choice of single package and multiple package licenses. The multiple package licenses are packaged within the subsets of all the patents in the pool. In practice, it is observed that about 12% of the pools surveyed by Lerner et al. (2003) offer multiple package licenses (that is, about 88% of the pools offer the single package license). For example, MPEG-LA, which is the patent pool administrator in regard to MPEG compression technological standards, offers multiple package licenses. One enormous advantage of multiple package licenses is that they give users various choices of patents, because a single package

[3]See *Antitrust Guidelines for the Licensing of Intellectual Property.* April 1995.

[4]See Gilbert (2004) for historical perspectives on the antitrust treatment of patent pools.

[5]The US Department of Justice focused on the technical relationship between the pools in three business review letters regarding an MPEG patent pool and two DVD patent pools. See Shapiro (2001) for details.

license inclusive of all the patents in the pool could be tie-in sale. The recent guidelines of the European Commission encourage patent pools to offer the multiple package licenses as a useful way to provide users with a broader choice [6].

In this paper, we investigate the patent holders' incentive to form a pool, the patent pool's licensing behavior, and the anticompetitive effect of a pool. In particular, we focus on the patent pool that offers multiple package licenses. When does a patent pool offer the multiple package licenses and when does it not do so? When does the patent pool have an anticompetitive effect? Should the competition authorities, such as the European Commission, encourage patent pools to offer the multiple package licenses? We find that the technical complementarity between the patented technologies in a pool plays a critical role in answering the above questions.

The paper is organized as follows. Section 2 defines patented technologies and the users' gross surplus for using patent in our models. Section 3 characterizes the licensing fees in the case where the patent pool licenses monopolistically. Section 4 characterizes the licensing fees in the case where patent holders license individually. Section 5 analyzes the anticompetitive effect of a patent pool, using the outcomes of Sections 3 and 4, and then investigates patent holder's incentives to form a patent pool. Finally, Section 6 discusses the results derived from the analysis conducted in the paper.

2 Basic set-up

We suppose that there are two patents, A and B. Patent A relates to *basic* technology, whereas patent B involves *optional* technology, which is valuable only when used in combination with the *basic* technology. Although the *basic* technology can be used by itself, it becomes more valuable when used in combination with the *optional* technology. The *optional* technology cannot be used by itself. Each patent is owned by a patent holder, A and B. Following Shapiro (2001) and Lerner and Tirole (2004), we distinguish between patent holders and users. Patent holders do not have the ability to commercialize the patented technology on their own. The patent holder obtains the licensing fee from patent users, and the users obtain a surplus using the patents.

Users make their products by using patents, which is represented by $U(m, \theta)$. $m \in \{0, 1, 2\}$ denotes the number of patents employed by the user to make a product, and θ represents

[6] See the Guidelines on the application of Article 81 of the EC Treaty to technology transfer agreements (2004/C 101/02).

the heterogeneity between users. Note that the users buy license A first because it is *basic*. Therefore, $m = 1$ implies that the user uses only patent A and $m = 2$ implies that the user uses both patents A and B. For simplicity, we assume that users are distributed uniformly on the interval [0, 1].

Our model specifies the user's gross surplus function as the following quadratic form:

$$U(m, \theta) = \theta m + sm^2, (m = 0, 1, 2) \tag{1}$$

where $s > -1/3$. The levels of gross surplus for each number of patents are $U(0, \theta) = 0$, $U(1, \theta) = \theta + s$, and $U(2, \theta) = 2\theta + 4s$. We find that a user with a high θ obtains a high level of gross surplus for any number of patents used. The heterogeneity of the gross surplus between users is also assumed by Lerner and Tirole (2004). They explained heterogeneity in terms of (a) the fixed cost for the user to adopt the patent, (b) the user's opportunity costs of choosing the patent, and (c) the benefits that the user derives from the patent.

The initial differences in the gross surplus are $\triangle U(1, \theta) = \theta + s$ and $\triangle U(2, \theta) = \theta + 3s$. The difference, $\triangle U(1, \theta)$, implies the user's willingness to pay for patent A when the user does not access any patent, and $\triangle U(2, \theta)$ is the user's willingness to pay for patent B when the user already has access to patent A. Note that the willingness to pay for an additional patent depends on θ, and the user with a high θ obtains a high additional surplus[7]. Lerner and Tirole (2004) assumed that the willingness to pay for an additional patent is the same between users. Under this assumption, a patent pool solely offers single package licenses because all users demand the same number of patents. In practice, however, 12% of the patent pools in the Lerner et al. (2003) sample offered multiple package licenses. To explain the observed offering of multiple package licenses by 12% of the patent pools, we must allow for differences in the willingness to pay for an additional patent between users. In reality, because of the variations in the ability or knowledge of each user, it is no wonder that there are differences in their benefits from using an additional patent.

The second difference in the gross surplus is $\triangle^2 U(2, \theta) = 2s$. The value of s represents *the strength of complementarity* between *basic* and *optional* patents. When an *optional* patent

[7]This specification satisfies the discrete form of what we refer to as the Spence? Mirrlees single-crossing condition in the Contract Theory literature; see, for example, Salanie (2002) and Bolton and Dewatripont (2005). The condition is known for separating different types of agents by offering larger allocations to higher types and making them pay for the privilege.

significantly enhances the usefulness of a *basic* patent, the value of s cannot be negative (*the strength of complementarity is strong*). Then, the gross surplus function is convex for the number of patents. The user's additional gross surplus for an *optional* patent is larger than that for a *basic* patent: $\triangle U(1,\theta) \leq \triangle U(2,\theta)$. An example is the combination of a PC and MS Office, containing MS Word and Excel, etc. The PC is the *basic* patent and MS Office is the *optional* patent. If we use MS Office installed on a PC, we would have a significantly larger additional gross surplus.

When an *optional* patent does not significantly enhance the usefulness of the *basic* patent, then the value of s could be negative (*the strength of complementarity is weak*). Then, the gross surplus function is strictly concave for the number of patents. In this case, $\triangle U(1,\theta) > \triangle U(2,\theta)$ is satisfied. We can consider a PC and typing software as an example. Typing software is an application software program for teaching touch typing. However, installing typing software, which is *optional*, would not result in a significantly large additional gross surplus.

3 Patent pool pricing

3.1 Users' decisions and the demand for package licenses

In this section, we characterize the equilibrium for the case where patents A and B are monopolistically licensed only by the patent pool formed by patent holders A and B. The patent pool could offer users two package licenses, A and AB. In package A, the pool licenses patent A for users for a licensing fee, p_A. In package AB, the pool licenses patents A and B for users for the licensing fee, p_{AB}; the package AB is a bundled good. If a user wants only the *basic* patent, he or she can buy package A, whereas if a user wants both the *basic* and the *optional* patent, he or she can buy the package AB. In addition, we assume that a pool must pay very low costs for offering a package license. The pool does not offer the package that no users buy.

Given the licensing fees, p_A and p_{AB}, the users choose the number of patents m to maximize their net surplus. When packages A and AB are offered by the patent pool, the type θ user chooses which package to buy in the following manner:

- The user does not buy any packages (the user chooses $m = 0$) if $\theta + s - p_A < 0$.
- The user buys package A (the user chooses $m = 1$) if $\theta + s - p_A \geq 0$ and $\theta + 3s < p_B$, where $p_B \equiv p_{AB} - p_A$.

- The user buys package AB (the user chooses $m = 2$) if $\theta + 3s \geq p_B$.

As the surpluses differ across different users, the number of patents chosen by each user also differs across users. Now, we define $\theta_A \equiv p_A - s$, $\theta_B \equiv p_B - 3s$. The type θ_A user is indifferent between buying package A and not buying any package. The type θ_B user is indifferent between buying package A and package AB. Each user behaves as follows:

- The users on interval $[0, \theta_A]$ where $\theta_A \equiv p_A - s$ do not buy any packages.
- The users on interval $[\theta_A, \theta_B]$ where $\theta_B \equiv p_B - 3s$ buy package A.
- The users on interval $[\theta_B, 1]$ buy package AB.

Lemma 1. *When given licensing fees satisfy the inequality $p_B - p_A > 2s$, there are users who buy package A.*

Proof. When $\theta_A < \theta_B$, there are users who buy package A. From the definition of θ_A and θ_B, we can find that $\theta_A < \theta_B \Leftrightarrow p_B - p_A > 2s$. ■

When licensing fees satisfy the inequality $p_B - p_A > 2s$, there are both users who buy package A and users who buy package AB ($\theta_A < \theta_B$). Then, the demand for the package A is:

$$D_A = \theta_B - \theta_A. \tag{2}$$

The demand for the package AB is:

$$D_{AB} = 1 - \theta_B. \tag{3}$$

When licensing fees do not satisfy the inequality $p_B - p_A > 2s$, then no user buys package A ($D_A = 0$). The type θ user decides whether to buy the package AB in the following manner:

- The user does not buy any packages (the user chooses $m = 0$) if $2\theta + 4s < p_{AB}$.
- The user buys package AB (the user chooses $m = 2$) if $2\theta + 4s \geq p_{AB}$.

Then, defining $\theta_C \equiv (p_{AB}/2) - 2s$, the demand for the package AB is:

$$D_{AB} = 1 - \theta_C. \tag{4}$$

3.2 Patent pool equilibrium

For simplicity, we ignore the costs paid by the pool members (the patent holders) for developing their own patents. Given the demand function for each package license, the patent pool's profit is $\Pi_{pool} = p_A D_A + p_{AB} D_{AB} = p_A(D_A + D_{AB}) + p_B D_{AB}$. Note that $D_A + D_{AB}$ is the demand for patent A. The patent pool determines p_A and p_B to maximize its profit.

For simplicity, we ignore the costs paid by the pool members (the patent holders) for developing their own patents. Under the demand function of each package license, the patent pool's profit is $\Pi_{pool} = p_A D_A + p_{AB} D_{AB} = p_A(D_A + D_{AB}) + p_B D_{AB}$. Note that $D_A + D_{AB}$ is the demand for patent A. The patent pool decides p_A and p_B to maximize the profit. From *lemma 1* and the definition of demand (2), (3) and (4), the profit is rewritten as the follows.

$$\Pi_{pool} = \begin{cases} p_A(1-\theta_A) + p_B(1-\theta_B), & if\ p_B - p_A > 2s\ (\theta_A < \theta_B). \\ p_{AB}(1-\theta_C), & if\ otherwise. \end{cases}$$

The equilibrium licensing fees are given by the solution of above profit maximization problem. Now we consider the case where patent pool offers both package A and AB. The optimal licensing fees are the solution of the following profit maximization problem.

$$\max_{p_A, p_B} p_A(1-\theta_A) + p_B(1-\theta_B),$$

where $p_B - p_A > 2s$. The interior solution should satisfy the following equations.

$$\frac{\partial \Pi_{pool}}{\partial p_A} = (1 - p_A + s) - p_A = 0 \tag{5}$$

$$\frac{\partial \Pi_{pool}}{\partial p_A} = (1 - p_A + s) - p_A = 0 \tag{6}$$

Since the second order condition is warranted, the licensing fees which satisfy (5) and (6) are $p_A^* = (1+s)/2$, $p_B^* = (1+3s)/2$. Checking these licensing fees satisfy the inequality $p_B - p_A > 2s$, we find that the optimal solution is $p_A^* = (1+s)/2$ and $p_B^* = (1+3s)/2$ (that is $p_{AB}^* = p_A^* + p_B^* = 1 + 2s$) if s is negative value.

The equation (5) and (6) is rewritten as the following forms:

$$\psi_A(p_A) \equiv \frac{p_A}{1-p_A+s} = 1 \quad (7)$$

$$\psi_A(p_A) \equiv \frac{p_B}{1-p_B+3s} = 1 \quad (8)$$

where $\psi_A(p_A)$ and $\psi_B(p_B)$ are the price elasticity of the demand for patent A, and of the demand for patent B, respectively. Both $\psi_A(p_A)$ and $\psi_B(p_B)$ are increasing for each licensing fee. The licensing fees are determined in such that $\psi_A(p_A)$ and $\psi_B(p_B)$ are equal to one. When $\psi_A(p_A)$ is located above $\psi_B(p_B)$ as Fig. 1, there are users who buy the package A ($\theta_A < \theta_B$). In the case where s is negative value, patent B is not really attractive for users compared with patent A. Then the price elasticity of demand for patent B is smaller than that of demand for patent A; $\psi_B(p_B) > \psi_A(p_A)$. Similarly to the mechanism of price discrimination, p_A is higher than p_B; $p_B - p_A < 2s$.

[Insert Fig. 1]

If s is not negative value, then the patent pool does not offer the package A. The patent pool's problem is

$$\max_{p_{AB}} p_{AB}(1-\theta_C),$$

The optimal licensing fee satisfies

$$\frac{\Pi_{AB}}{p_{AB}} = (1 - \frac{1}{2}p_{AB} + 2s) - \frac{1}{2}p_{AB} = 0 \quad (9)$$

Since the second order condition is warranted, the licensing fees which satisfy (9) is $p^*_{AB} = 1 + 2s$. Then we get the following proposition.

Proposition 1. Patent pool pricing
(1) Multiple package licenses: *When s is negative value, the patent pool offers two package licenses A and AB, the licensing fees are $p^*_A = (1+s)/2$, $p^*_{AB} = 1+2s$ ($p^*_B = (1+3s)/2$).*
(2) Single package license: *When s is not negative value, the patent pool offers only single package AB, and the licensing fee is $p^*_{AB} = 1+2s$.*

Proposition 1 shows that patent pool pricing is characterized by the value of s. When *the strength of complementarity* between A and B *is weak* ($s < 0$), both the package license A, inclusive of only *basic*, and the package license AB, inclusive of *basic* and *optional*, are offered by the patent pool. Each package licensing fee is $p_A^* = (1+s)/2$ and $p_{AB}^* = 1+2s$. In this case, there are both users who buy the package license A and who buy the package license AB. The patent pool is willing to offer the multiple package licenses by offering not only the package license AB but also the package license A in order to maximize his/her own profit. On the other hand, when *the strength of complementarity is strong* ($s \geq 0$), Only the package license AB, inclusive of basic and optional, is offered by the patent pool. The package licensing fees is $p_{AB}^* = 1+2s$. In this case, there are users who buy only the package license AB, if they buy the license. Since *the strength of complementarity is strong*, there are not the users who use only patent A. This case corresponds to the patent pool pricing in Shapiro (2001) and the demand margins bind in Lerner and Tirole (2004).

The patent pool offers only the package AB which is similar to the tie-in sale and is not willing to offer multiple package licenses in order to maximize his/her own profit. In order to avoid the tie-in sale, EU committee encourages patent pools to offer multiple package licenses. But our result is that none of users buy package licenses when is negative. Therefore, the recommendation of the competition authority makes no senses in the case $s \geq 0$ under our model.

4 Individual pricing

4.1 Demand for each patent

In this section, we consider the case where a patent pool is not established. Patent holder A and B individually licenses the users to his/her own patent. If a user wants to use patent A (patent B), the user must access to patent holder A (patent holder B). If a user wants to use both patent, then the user must access with both the patent holders.

Given the licensing fee p_i $(i = A, B)$, the users decide whether or not to choose each patent to maximize their net surplus. In the same manner of section 3, we describe the users behavior as the follows. When given licensing fees satisfy the inequality $p_B - p_A > 2s$,

- The users on interval $[0,\ \theta_A]$ where $\theta_A \equiv p_A - s$ do not buy any packages.
- The users on interval $[\theta_A,\ \theta_B]$ where $\theta_B \equiv p_B - 3s$ buy the package A.

- The users on interval $[\theta_B,\, 1]$ buy both license A and B.

When given licensing fees satisfy the inequality $p_B - p_A \leq 2s$,

- The users on interval $[0,\, \theta_C]$ where $\theta_C \equiv (p_{AB}/2) - 2s$ do not buy any packages.
- The users on interval $[\theta_C,\, 1]$ buy both license A and B.

Given the licensing fee p_i $(i = A, B)$, the users decide whether or not to choose each patent to maximize their net surplus. The demands for patent A and B are

$$d_A = \begin{cases} 1 - \theta_A & if\ p_B - p_A > 2s \\ 1 - \theta_C & if\ p_B - p_A \leq 2s \end{cases} \tag{10}$$

$$d_B = \begin{cases} 1 - \theta_B & if\ p_B - p_A > 2s \\ 1 - \theta_C & if\ p_B - p_A \leq 2s \end{cases} \tag{11}$$

Under each demand of patent, the profits of patent holder A and B are $\pi_A = p_A d_A$ and $\pi_B = p_B d_B$, respectively.

4.2 Individual pricing equilibrium

The patent holders decide their licensing fees to maximizing their own profit, as a given other licensing fee. Individual pricing equilibrium is characterized by the follows:

Proposition 2. Individual pricing
(1) When s is negative value, Nash equilibrium licensing fees are $p_A^{**} = (1+s)/2$, $p_B^{**} = (1+3s)/2$.
(2) When s is not negative value, Nash equilibrium licensing fees are $p_A^{**} = p_B^{**} = 2(1+2s)/3$.

Proof. If the equilibrium licensing fees p_A^{**} and p_B^{**} satisfy the inequality $p_B^{**} - p_A^{**} > 2s$, the patent holder A and B are faced on the demands of their patents $1-\theta_A$ and $1-\theta_B$, respectively. Then the licensing fee of patent A is $p_A^{**} = (1+s)/2$, which maximizes the profit of patent holder A, for any licensing fee of patent B, as far as $p_B - p_A > 2s$ is satisfied. The licensing fee of patent B is $p_B^{**} = (1+3s)/2$, which maximizes the profit of patent holder B, for any licensing fee of patent A, as far as $p_B - p_A > 2s$ is satisfied. Substituting $p_A^{**} = (1+s)/2$ and $p_B^{**} = (1+3s)/2$ is equilibrium licensing fees when $s < 0$.

Next, if the equilibrium licensing fees p_A^{**} and p_B^{**} satisfy the inequality $p_B^{**} - p_A^{**} \leq 2s$, the patent holder A and B are faced on the same demands $1 - \theta_C$. The licensing fees of patent A and B must maximize each profit of patent holders for each licensing fee. Then optimal response of patent holder A is $p_A^{**} = -(1/2)p_B^{**} + 1 + 2s$, and the optimal response of patent holder B is $p_B^{**} = -(1/2)p_A^{**} + 1 + 2s$. Therefore Nash equilibrium is $p_A^{**} = p_B^{**} = (2+4s)/3$. Substituting the licensing fees into the inequality $p_B^{**} - p_A^{**} \leq 2s$, we can find $p_A^{**} = p_B^{**} = (2+4s)/3$ is equilibrium licensing fees when $s \geq 0$.

■

Similar to proposition 1, proposition 2 shows that individual pricing is characterized by the value of s. When *the strength of complementarity is weak* ($s < 0$), patent holder A of the *basic* offers the equilibrium licensing fee $p_A^{**} = (1+s)/2$ and patent holder B of the *optional* offers the equilibrium licensing fee $p_B^{**} = (1+3s)/2$. In the case, there are the users who buy only *basic* and who buy both *basic* and *optional*. Since *the strength of complementarity is weak* ($s < 0$), the demand for patent A is independent of the demand for patent B. Then each patent holder sets his/her licensing fee, regardless of the strategic interaction between patent holders. The licensing fee of *basic* patent is set higher than that of *optional*, because price elasticity of demand for patent holder A is lower than that of demand for patent holder B. As the result, when s is negative value, these licensing fee is asymmetric; $p_A^{**} > p_B^{**}$.

When *the strength of complementarity is strong* ($s \geq 0$), each patent holder A and B offers the equilibrium licensing fee $p_A^{**} = p_B^{**} = (2+4s)/3$. In the case, the users decide whether they buy two licenses from patent holder A and patent holder B, since *the strength of complementarity is strong* . Since the users who buy any license buy both paten A and B, the demand for the patents depends on the sum of licensing fees $(p_A + p_B)$. Therefore each patent holder must set his/her licensing fee under the strategic interaction between patent holders. The concern of the users who buy both patent A and B is only the sum of licensing fees. Then patent holder A does not have technical advantage as the patent holder of *basic* patent, and these licensing fee is symmetric ; $p_A^{**} = p_B^{**}$. This case corresponds to the Cournot-Shapiro argument in Shapiro (2001) and *Demand margin bind* in Lerner and Tirole (2004).

5 Welfare analysis

In section 3 and 4, we characterize the licensing fees in the equilibrium under a patent pool and in the absence of a patent pool. Comparing the welfare of patent pool pricing with that of individual pricing, we analyze whether or not a patent pool enhances social welfare.

We define the social welfare as the sum of users' net surplus and patent holders' profit. Since users' payment for the patent is equal to the profit of patent holder A and B, the social welfare is equal to the gross surplus of users. If there are the users who buy only patent A, then the social welfare (that is the sum of users' net surplus) is

$$\int_{\theta_A}^{\theta_B} (\theta + s)d\theta + \int_{\theta_B}^{1} (2\theta + 4s)d\theta \tag{12}$$

where $\theta_A \equiv p_A - s$ and $\theta_B \equiv p_B - 3s$. Therefore the social welfare depends on the licensing fee of patent A and B (or licensing fees of patent packages), p_A and p_B [8].

If there are not the users who buy only patent A, then the social welfare is

$$\int_{\theta_C}^{1} (2\theta + 4s)d\theta \tag{13}$$

where $\theta_C \equiv (p_A + p_B/2) - 2s$. The social welfare depends on the sum of licensing fees (or licensing fee of the package AB), $p_A + p_B$.

Proposition 3. *A patent pool does not affect the welfare when s is negative value, but enhances welfare when s is not negative value.*

Proof. Now, we consider the case where the value of s is negative. From proposition 1-(1) and proposition 2-(1), we know that the licensing fees in patent pool pricing are same as in the individual pricing ($p_A^* = p_A^{**}$). Then we can find that a patent pool does not affect the welfare (12) when s is negative value.

[8] Our model does not define R&D cost of patent holders. As the result, the social welfare is same as the sum of all users' gross surplus, and the social welfare does not include the social cost for R&D. Once information goods such as technical information are developed, the additional cost for licensing information goods is zero (R&D cost is lump cost). The social welfare is all users' gross surplus minus R&D lump cost. But this does not influence our results.

Next we consider the case where the value of s is not negative. When s is not negative, lower the sum of the licensing fees $p_A + p_B$, higher the social welfare (13). From proposition 1-(2), the licensing fee is $p^*_{AB} = p^*_A + p^*_B = 1 + 2s$ in the patent pool pricing. And the licensing fee is $p^{**}_A + p^{**}_B = 4(1 + 2s)/3$ n the individual pricing, from proposition 2-(2). Then we can find that a patent pool enhances social welfare when is not negative value.

■

Next we investigate whether the patent holder A and B have the incentive to form a patent pool. As the standard assumption of the corporate merger theory, we assume that the patent holders A and B form a patent pool if the patent pool's profit is larger than the sum of the profit of the patent holders A and B ($\Pi_{pool} > \pi_A + \pi_B$) [9], with the profit of patent pool, Π_{pool}, we can get the following proposition.

Proposition 4. *When s is negative value, $\Pi_{pool} = \pi_A + \pi_B$ is satisfied. Then the patent holder A and B does not have the incentive to form a patent pool. When s is not negative value, $\Pi_{pool} > \pi_A + \pi_B$ is satisfied. Then the patent holder A and B have the incentive to form a patent pool.*

Proof. Firstly we consider the case where s is negative value. We already know the licensing fees in patent pool pricing are same as in the individual pricing ($p^*_A = p^{**}_A$ and $p^*_B = p^{**}_B$. The profit of the patent pool is same as the sum of profit of patent holders A and B.

$$\Pi_{pool} = \pi_A + \pi_B = \frac{(1+s)^2 + (1+3s)^2}{4}$$

Then the patent holder A and B does not have the incentive to form a patent pool.

Next we consider the case where s is not negative value. From the proposition 1-(2), we get the patent pool profit is $\Pi_{pool} = (1 + 2s)^2/2$. On the other hand, the profits of patent holders A and B are $\pi_A = \pi_B = 2(1 + 2s)^2/9$, from the proposition 2-(2). Then we can find that $\Pi_{pool} > \pi_A + \pi_B$ is satisfied. When s is not negative, the patent holders A and B have the incentive to form a patent pool.

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[9] We do not focus on the process of patent pool formation and the stability of pools, as Brenner (2005) and some other studies have undertaken. In our paper, the patent holders have the incentive to form a patent pool if the profit of the pool is larger than the sum of the patent holders' profits, since the equilibrium in the pool case is equal to the corporative solution of the patent holders (the pool maximizes their joined profits).

Proposition 3 and 4 show that the effect of a patent pool on the welfare and the patent holders' incentive to form a pool are characterized by the value of s. When *the strength of complementarity is weak* ($s < 0$), a patent pool does not affect the welfare and patent holders do not have the incentive to form a patent pool. From proposition 2, we find that each patent holder sets his/her licensing fee without influencing each other in ex-post, when s is negative. The patent pool pricing is equal to the individual pricing: $p_A^* = p_A^{**}$, $p_{AB}^* = p_A^{**} + p_B^{**}$, Then the patent pool does not affect the welfare. Further, the patent holders do not have the incentive to form patent pool, since the corporative pricing does not change their own profit.

On the other hand, a patent pool enhances the welfare and patent holders have the incentive to form a patent pool when *the strength of complementarity is strong* ($s \geq 0$). From proposition 2, we find that each patent holder sets his/her higher licensing fee in order to get his/her more profits. As the result, the licensing fee of the patent pool is lower than the sum of licensing fees of individual patent holders: $p_{AB}^* < p_A^* + p_B^*$. Then the patent pool enhances the welfare. Further the patent holders have the incentive to form a pool, since the corporative pricing by forming a pool can reduces the licensing fees to the levels which maximize both profit of patent holders.

6 Conclusion

This paper investigates the anti-competitive effect of the patent pool which offers the package license. The most important work of the paper is to consider *the strength of complementarity* between *basic* and *optional* patents. We find that *the strength of complementarity* characterizes the licensing behavior of the patent pool, the social welfare, and the patent holders' incentive to form the patent pool. Our main results are as follows.

(1) If *the strength of complementarity* between *basic* and *optional* is weak, the patent holders do not have the incentive to form the patent pool; otherwise, there is other patent holders' incentive beyond our model. If the patent pool is formed for any reasons, both the package license inclusive of only *basic* , and the package license inclusive of *basic* and *optional* are offered by the patent pool (multiple package licenses). Then the form of the patent pool does not change the licensing fee which user pay to patent holders. As result, the patent pool does not affect the welfare.

(2) If *the strength of complementarity* between *basic* and *optional* is strong, the patent holders

have the incentive to form the patent pool. Only the package license inclusive of *basic* and *optional* is offered by the patent pool (single package license). Then the form of the patent pool reduces the licensing fee which users pay to patent holders. As the result, the patent pool enhances the welfare.

These results lead to four suggestions. First, we suggest that actually-observed many patent pools could include only strong complementary patents. It is observed that about 88% of the patent pools, surveyed by Lerner et al. (2003), offers the single package license. From our model, it is when *the strength of complementarity is strong* that the single package license is offered by the patent pool. Therefore, we can guess that actually-observed many patent pools include only strong complementary patents.

Second, we suggest the reason why actually-observed many patent pools include only strong complementary patents. Our model explains that the patent holders have strong incentive to form a patent pool, if *the strength of complementarity is strong*, conversely the patent holders do not have the incentive to form a patent pool, if *the strength of complementarity is weak*. Furthermore, the antitrust guidelines require the patent pools only to include "*essential patents*" which implies strong complementary among the patents.

Third, it is less important on our model that the competition authorities, such as the European Commission etc, encourage patent pools to offer the multiple package licenses. The licensing behavior of patent pools is determined by the profit maximization of the patent pools. If multiple package licenses increase the profit of a patent pool, the patent pool is willing to offer the multiple package licenses. Otherwise, the patent pool does not offer the multiple package licenses as long as the competition authorities enforce the patent pool to offer the multiple package licenses. Even if the competition authorities enforce the patent pool which offers the single package license to offer the multiple package licenses, any users dose not buy the package license which include only basic as long as the licensing fee of the single package license change.

Finally, we suggest the criterion for pro-competitive patent pools. The antitrust guidelines indicate that the patent pools should not include patents except "*essential patents*" which implies strong complementary among patents. On our model, *the strength of complementarity* characterizes the anti-competitive effect of a patent pool on the social welfare. We find that the patent pool is pro-competitive when *the strength of complementarity is strong*. This corresponds to the case where the patent pool includes complementary patents in Shapiro (2001) and the demand margins bind in Lerner and Tirole (2004). Further, the theoretical criterion is consistent to the antitrust guidelines which require the patent pools to include only "*essential patents*".

On the other hand, the patent pool is neither pro-competitive nor anti-competitive when *the strength of complementarity is weak.* Lerner and Tirole (2004) concludes that a patent pool is anti-competitive when the patent pool includes only *substitutes* which can replace other patents, that is to say *similar patents.* Our paper finds that a patent pool does not affect the social welfare if the patent pool includes only patents which are weak complementary between the patents. Therefore weak complementary patents need not be included in patent pools, since there is not social benefit. Furthermore other factors outside our model might give negative effect to the social welfare. We conclude that the antitrust guidelines which require the patent pools only to include "*essential patents*" are appropriate for competition policy.

In this paper, we find that patent holders do not have the incentive to form the patent pool which offers the multiple package licenses voluntarily. But some patent pools which offer multiple package licenses are observed actually. That is the problem which remains to be solved in our paper.

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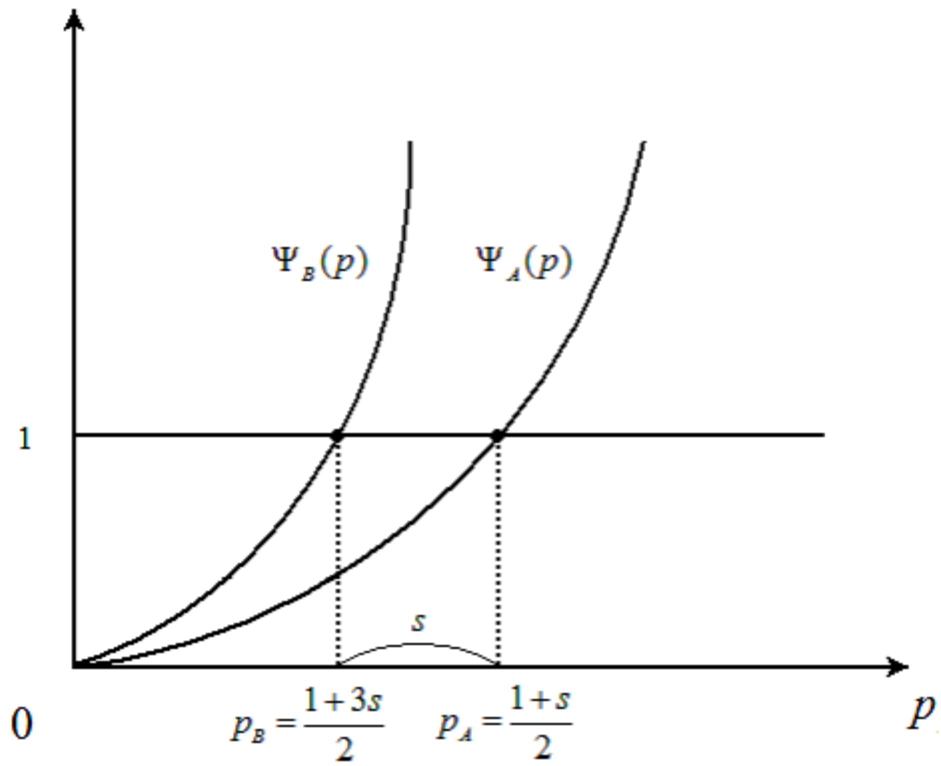

Figure 1: $\psi_A(p)$ and $\psi_B(p)$ (the case where the value of s is negative) The value of and are the price elasticity of demand for patent A, and of the demand for patent B. The figure shows that the price elasticity of demand for patent A is larger than that of the demand for patent B for any same, when is negative value.