Transnational Licensing in the Presence of Trade Barriers

Wen-Jung Liang[*]
Department of Industrial Economics
Tamkang University
and
Public Economics Research Center
National Taiwan University

and

Ching-Chih Tseng
Department of Industrial Economics
Tamkang University

and

Kuang-Cheng Andy Wang
Social Science Division
Center for General Education
Chang Gung University

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[*] Corresponding Author: Wen-Jung Liang, Department of Industrial Economics, Tamkang University, Tamsui, Taipei County, Taiwan 25137, ROC. Tel: 886-2-2625-1863, Fax: 886-2-2620-8731, E-mail: wjliang@mail.tku.edu.tw

Abstract

This paper develops a two-country model to take into account trade barriers in exploring the outside patentee's optimal licensing policy under Bertrand competition with a homogenous product. The focus of the paper is on the impact of the monopoly profit generated by trade costs. It shows that a fixed-fee licensing is superior to a royalty licensing for an outside patentee under Bertrand competition as trade costs relative to the innovation reduced marginal cost are higher, while the reverse occurs, otherwise. It also shows that the outside patentee would select a fixed-fee licensing non-exclusively, as trade costs relative to the innovation reduced marginal cost are higher. Moreover, the paper shows that the fixed-fee and royalty licensing are equivalent for an outside patentee, as trade costs equal zero.

1. Introduction

Patent licensing is a common practice occurred in many industries. Over the past decades, there exists a huge literature on patent licensing. Surprisingly, transnational licensing plays no role in this literature in spite of its obvious quantitative significance in international trade. Mottner and Johnson (2000) argue that transnational licensing has been a growing method of international trade by indicating that U.S. income from international licensing had an average annual increase of 12 percent in the 1990s. Nadiri (1993) also points out that transnational licensing has very much been the norm in recent years, which becomes evident from the following figures: For Japan and U.K. the total transaction of transnational licensing between 1970's to the late 1980's increased by about 400 percent, France and the U.S. about 550 percent, and West Germany over 1000 percent. Moreover, Kabiraj and Marjit (2003) argue that until 1991, many developing countries have been observed to have encouraged technology licensing, while maintaining tariffs on foreign product. Hence, transnational technology licensing in the presence of trade barriers, such as tariffs and transportation costs, is crucial and commonly existent in practical applications. Specific example includes the Royal Phillips Electronics, a Dutch company having a patent for CD-R production technology without producing CD-R in the market itself. As an outside patent holder of the CD-R product market, Phillips earns technology royalties by licensing its patent to CD-R manufacturers around the world. These licensees produce CD-R across countries and compete in the world market facing trade barriers imposed by the governments of different countries.

In licensing a cost-reducing process innovation, three types of licensing regimes, viz. the fixed-fee, royalty and auction licensing, are generally discussed in the literature. However, it should be noted that the auction licensing is seldom reported in reality. Hence, we shall not discuss this type of licensing in the paper. In terms of the patent holder's choice for a fixed-fee or a royalty licensing, the survey of firms by Rostoker (1984) shows that royalty alone is 39 percent, fixed fee alone is 13 percent, and royalty plus fixed fee is 46 percent. Moreover, Caballero-Sanz *et al.* (2005) point out the survey report published by the Association of University Technology Managers Licensing (AUTM, 2001) that about half of the licenses are exclusive, while the other half non-exclusive.[1] These figures demonstrate that in the real world, not only both fixed-fee and royalty licensing are popularly selected by the patentee, but also the patent license may be issued either exclusively or non-exclusively. Thus, it is interesting to explore for a transnational licensing under what conditions the patent holder will choose a fixed-fee or a royalty licensing with an exclusive or a non-exclusive license.

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[1] In the paper, an exclusive license can be referred to as a case where only one or part of firms get the patent license from the patent holder, while a non-exclusive license referred to as a case where all of the firms have the patent license.

Based on the above analysis, the purpose of the paper is to explore the following two issues by taking into account trade barriers with an outside patent holder, as firms engage in Bertrand competition in the commodity market with a homogenous product. Firstly, what is the outside patent holder's optimal licensing policy in terms of a fixed-fee and a royalty licensing? Secondly, whether the outside patent holder licenses the patent exclusively?

The study of relevant literature includes contributions by Kamien and Tauman (1986), Kamien *et al*. (1992), Muto (1993) and Poddar and Sinha (2004). Kamien and Tauman (1986) and Kamien *et al*. (1992) analyze the outside patent holder's licensing profit from the three licensing policies, viz. the fee, royalty and auction, to be equivalent in an *n*-firm model under Bertrand competition with a homogenous product. Muto (1993) employs a duopoly model with differentiated products and obtains that in a Bertrand competition, if goods are not close substitutes, the royalty is optimal for small innovations, but the fee is optimal for large innovations. Poddar and Sinha (2004) utilize a Hotelling's linear city model and show that offering a royalty licensing is the best policy for the outside patentee for both drastic and non-drastic innovations. In addition, all of the related literature point out that the outside patentee will choose to license its patent exclusively in a fixed fee licensing.[2]

[2] Kamien and Tauman (1986), Kamien *et al*. (1992), and Poddar and Sinha (2004) derive this result. Muto (1993) indicates that for the case where the products are close substitutes, the same result occurs, but does not further explore what the result will be for other cases.

The main contributions of the paper are as follows. Firstly, a fixed-fee licensing is superior to a royalty licensing for the outside patent holder under Bertrand competition as trade barriers, denoted as trade costs, relative to the innovation reduced marginal cost are higher, while the reverse occurs, otherwise. Secondly, the outside patentee would like to choose a fixed-fee licensing non-exclusively rather than exclusively, as trade costs relative to the innovation reduced marginal cost are higher, while the reverse occurs, otherwise. The intuition behind these results can be stated along these lines. The competition between firms becomes so intense that firms will choose to undercut the rival's price in each market, as they produce a homogeneous product and engage in Bertrand competition in each market with price discrimination. At equilibrium, firms will charge a limit price, which is slightly lower than its rival's marginal cost (marginal production cost plus per unit trade costs) in each market, to prevent its rival from entering the market where they have a cost advantage. Consequently, each firm becomes a local monopolist and earns a monopoly profit with a limit price in their respective local market, where it has cost advantage due to the existence of trade costs. Moreover, the bigger the trade costs are, the higher will be the monopoly rent. As a result, the outside patentee can earn higher patent profits by choosing a non-exclusive fixed-fee licensing, as trade costs relative to the innovation reduced marginal cost are higher, while the reverse occurs, otherwise.[3]

The remainder of the paper is organized as follows. Section 2 sets up a benchmark model where the patent licensing is absent. Section 3 examines the optimal amount of a lump-sum fixed-fee and optimal number of licenses for the case of a fixed-fee licensing as well as the optimal royalty rate for the case of a royalty licensing. Section 4 explores the outside patentee's optimal licensing policy. The final section concludes the paper.

2. The Benchmark Model

Consider a two-country model, *a la* Hwang and Mai (1990), in which countries, 1 and 2, are located at the opposite endpoints of the line segment with unit length, as shown in Fig. 1.[4] Along the line segment, consumers reside only in two countries 1 and 2, where market 1 and firm A are located in country 1 while market 2 and firm B in country 2.[5] The firms sell a homogeneous product with a constant marginal production cost c to the two markets. The exports of the product to the other country incur trade costs, which are composed of tariffs and transportation costs.

(Insert Figure 1 here)

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[3] Following related literature, we assume that the outside patentee can extract the whole extra profits earned by the licensees from the patent licensing.

[4] This kind of model can also be found in Liang *et al*. (2006).

[5] One can imagine British and France as these two countries, and there exists no consumer between them.

Assume that the demand function in market i takes the linear form as follows:

$$q_i = 1 - p_i, i = 1,2, \quad (1)$$

where q_i, and p_i are the quantity demand and the delivered price in market i.

Note that the Bertrand game with a homogeneous product has the property "winner-takes-all". That is, the firm with a lower marginal cost (marginal production cost plus trade costs), will undercut the rival's price and takes the whole market. Since firm A is located in market 1, it can use its location advantage to force out its rival from the market. Similarly, firm B has an edge over firm A in market 2 and will use this advantage to price firm A out of the market. It follows that the winner's price in its advantageous market would be slightly lower than its rival's marginal cost, i.e., a limit price.[6] Without loss of generality, the winners' equilibrium prices are set equal to the limit prices of markets 1 and 2, which can be derivable as the following equality holds:

$$p_1^{AN} = p_2^{BN} = t + c, \quad (2)$$

where the superscript "N" denotes the variables associated with the case where patent licensing is absent; and t is trade costs.

It is worth noting that any price exceeding the monopoly price, $[(1 + c)/2]$, would lead to a lower profit and would never be charged by firms. Hence, Bertrand

[6] See Liang *et al*. (2006).

competition can not operate in situations where the trade costs are higher than [(1 − c)/2]. For the purpose of simplifying the analysis, we will discuss only the case where Bertrand competition operates (hereafter the Bertrand competition operating assumption, i.e., $t \leq [(1-c)/2]$), throughout the rest of the paper.

The profit of firms A and B can be derived jointly from equations (1) and (2) as,

$$\pi_1^{AN} = \pi_2^{BN} = t(1-t-c), \text{ for } t \leq [(1-c)/2]. \tag{3}$$

3. The Innovation Licensing Model with An Outside Patent Holder

Assume that there is an outside patent holder, who is located beyond the two countries, having a patent of a cost-reducing innovation. Assume further that this innovation can reduce both firms' marginal cost by the same amount ε, where $0 < \varepsilon < c$.

Following the definition of Arrow (1962), an innovation is drastic, if the licensee can drive its rival out of the market and meanwhile charge a monopoly price in a fixed-fee licensing. For a fixed-fee licensing, the licensee's marginal production cost will be reduced to $c - \varepsilon$. It follows that this case occurs, as trade costs t relative to the innovation reduced marginal cost ε are so small that $t \leq \varepsilon$ - (1 -

c) in the paper.[7] In what follows, we use Figure 2 to illustrate the areas for the drastic and non-drastic innovations measured by the combinations of (t, ε), in which the horizontal axis denotes the amount ε and the vertical axis represents the trade costs t. Note that the Bertrand competition operating assumption, $t \le [(1 - c)/2]$, is assumed to be valid throughout the paper. Thus, this case can be measured by the area C in Figure 2, where $C \equiv \{(t,\varepsilon) \mid t \le \varepsilon - (1-c), t \le (1-c)/2\}$. On the other hand, a non-drastic innovation consists of two cases. The first case is that the licensee can drive its rival out of the markets but is unable to charge monopoly prices, referred to as *the non-drastic innovation with global monopoly* in the paper. This case arises as t relative to ε lies in the medium range such that the licensee captures the entire demands for both markets with limit prices, resulting in restrictions $t \le \varepsilon$ and $t \ge [\varepsilon - (1 - c)]$.[8] Thus, this case can be measured by the sum of the areas B^n and B^e in Figure 2, where $B^n \cup B^e \equiv \{(t,\varepsilon) \mid t \le \varepsilon, t \ge \varepsilon - (1-c), t \le (1-c)/2\}$. The second case is that the licensee is unable to drive its rival out of the market, referred to as *the non-drastic innovation with local monopoly* in the paper. This case emerges as t relative to ε is so high that each firm can only serve as a local monopolist in the

7 Firm A's monopoly price for market 2, $p_2^{AM} = (1 + t + c - \varepsilon)/2$, has to be no greater than firm B's marginal production cost c to ensure that firm A can charge monopoly prices, providing a restriction, $t \le [\varepsilon - (1 - c)]$.

8 The situation that firm A's marginal cost in market 2 must be no greater than that of firm B, i.e., $t + c - \varepsilon \le c$, to force firm B out of the market provides a restriction $t \le \varepsilon$. In addition, the non-drastic innovation requires a restriction $t \ge [\varepsilon - (1 - c)]$.

advantageous market, resulting in a restriction, $t \geq \varepsilon$, to the trade costs.[9] Thus, this case can be measured by the area A in Figure 2, where $A \equiv \{(t,\varepsilon) \mid t \geq \varepsilon, t \leq (1-c)/2\}$.

(Insert Figure 2 here)

The game employed in this context is a four-stage game. In the first stage, the outside patentee chooses a fixed-fee or a royalty licensing contract to maximize its profit. In the second stage, the outside patentee announces how many licenses to be issued and charges a fixed-fee under a fixed-fee licensing or a royalty rate under a royalty licensing to maximize its profit. The third stage marks the decision of the firm of whether to purchase a license or not; and in the final stage, firms engage in Bertrand price competition with a discriminatory pricing in the markets.

3.1. Fixed-Fee Licensing

In this subsection, we examine the outside patentee's optimal amount of a lump-sum fixed-fee and optimal number of licenses, as it chooses a fixed-fee licensing.

3.1.1 The Case of the Non-Drastic Innovation with Local Monopoly

Assume that the outside patentee licenses the patent to firm A only. Recall that this case is measured by the area A in Figure 2. The sub-game perfect Nash equilibrium can be solved by backward induction beginning with the final stage.

[9] Since firms A's marginal cost must be no less than that of firm B in market 2, i.e., $t + c - \varepsilon \geq c$, we can then derive this restriction.

In the final stage, the licensee's and non-licensee's limit prices can be derived as:

$$p_{1L}^{AFe} = t + c, \text{ for } (t,\ \mathring{a}) \in A, \tag{4.1}$$

$$p_{2L}^{BFe} = t + c - \varepsilon, \text{ for } (t,\ \mathring{a}) \in A, \tag{4.2}$$

where the superscript "*F*" and "*e*" denote variables associated with the case of a fixed-fee licensing and that of an exclusive licensing, respectively; and the subscript "*L*" denotes variables associated with the case of a non-drastic innovation with local monopoly.

We can calculate from (1) and (4) to obtain the licensee's and non-licensee's profit as follows:

$$\pi_{1L}^{AFe} - F_L^e = (t + \varepsilon)(1 - t - c) - F_L^e, \text{ for } (t,\ \mathring{a}) \in A, \tag{5.1}$$

$$\pi_{2L}^{BFe} = (t - \varepsilon)(1 - t - c + \varepsilon), \text{ for } (t,\ \mathring{a}) \in A, \tag{5.2}$$

where F_L^e is the lump-sum fixed fee.

In the third stage, the licensee's maximum willingness to pay for the license is the difference between the licensed and unlicensed profit, $F_L^e = \pi_{1L}^{AFe} - \pi_1^{AN}$ or equivalently $F_L^e = \varepsilon(1 - t - c)$.

In the second stage, since the outside patentee can extract the whole licensee's benefit from licensing, its profit can be derived as:

$$\Omega_L^{Fe} = F_L^e = \varepsilon(1 - t - c), \text{ for } (t, \varepsilon) \in A, \tag{6}$$

where $\Omega_L{}^{Fe}$ denotes the outside patentee's profit level.

Next, assume that the outside patentee issues the license non-exclusively. Following the same procedure, we derive:

$$p_{1L}{}^{AFn} = p_{2L}^{BFn} = t + c - \varepsilon, \text{ for } (t, å) \in A, \tag{7}$$

$$\Omega_L^{Fn} = 2F_L^n = 2\varepsilon(1 - t - c + \varepsilon), \text{for } (t, å) \in A, \tag{8}$$

where the superscript "*n*" denotes variables associated with the case of a non-exclusive licensing.

Subtracting (6) from (8), we have:

$$\Omega_L^{Fn} - \Omega_L^{Fe} = 2\varepsilon(1 - t - c + \varepsilon) - \varepsilon(1 - t - c) > 0, \text{for } (t, å) \in A. \tag{9}$$

Eq. (9) shows that the outside patentee would like to license its patent non-exclusively in a non-drastic innovation with local monopoly. Thus, we can establish:

Proposition 1. *Assume that firms engage in Bertrand competition. The outside patent holder would like to license the patent non-exclusively in a fixed-fee licensing, as trade costs relative to the innovation reduced marginal cost are so high that the innovation is non-drastic with local monopoly.*

3.1.2 The Case of the Non-Drastic Innovation with Global Monopoly

Assume that the outside patentee licenses the patent to firm A only. Recall that this case is measured by the sum of the areas B^n and B^e in Figure 2.

Although firm A can capture the whole demands for both markets, it has to charge limit prices equaling marginal production cost, plus firm B's trade costs, in each market to prevent firm B from entering the markets. Thus, we can obtain:

$$p_{1G}^{AFe} = t + c, \text{ for } (t, å) \in B^n \cup B^e, \tag{10.1}$$

$$p_{2G}^{AFe} = c, \text{ for } (t, å) \in B^n \cup B^e, \tag{10.2}$$

$$\Omega_G^{Fe} = \varepsilon(1 - t - c) + (\varepsilon - t)(1 - c), \text{ for } (t, å) \in B^n \cup B^e, \tag{11}$$

where the subscript "*G*" denotes variables associated with the case of a non-drastic innovation with global monopoly.

Next, assume that the outside patentee issues the license non-exclusively. Note that if the firm does not have the patent license under the case of a non-exclusive licensing, it will be driven out of the market and earn zero profit.[10] Hence, each firm's maximum willingness to pay for the license equals the licensed profit minus the unlicensed profit, which equals zero in this case. We can thus derive the outside patentee's profit as follows:

$$\Omega_G^{Fn} = 2F_G^n = 2t(1 - t - c + \varepsilon), \text{ for } (t, \varepsilon) \in B^n \cup B^e. \tag{12}$$

We are now in a position to examine the optimal number of licenses. This can

[10] This result emerges because the rival has a license in this case. Thus, firm with no license must be driven out of the market.

be done by comparing the patented profit of an exclusive fixed-fee licensing with that of a non-exclusive fixed-fee licensing by subtracting (11) from (12) as follows:

$$\Omega_G^{Fn} - \Omega_G^{Fe} = \{t[2(1-c-t+\varepsilon)+(1-c+\varepsilon)] - 2\varepsilon(1-c)\}$$

$$> 0, \text{for } (t,\varepsilon) \in B^n, \quad (13.1)$$

$$< 0, \text{for } (t,\varepsilon) \in B^e, \quad (13.2)$$

where $t_1 = [3(1-c+\varepsilon) - \sqrt{9(1-c)^2 + 2\varepsilon(1-c) + 9\varepsilon^2}\,]/4$ in Figure 2.

Eq. (13) indicates that the optimal number of licenses for a fixed-fee licensing can be of either exclusive or non-exclusive depending on the magnitude of trade costs. It is non-exclusive if trade costs are relatively higher measured by the area B^n in Figure 2 where $B^n \equiv \{(t,\varepsilon) \mid (1-c)/2 \geq t \geq t_1, \varepsilon \geq t \geq \varepsilon - (1-c)\}$, while exclusive if trade costs are relatively lower measured by the area B^e where $B^e \equiv \{(t,\varepsilon) \mid t_1 \geq t \geq \varepsilon - (1-c)\}$. Therefore, we can establish the following Proposition:

Proposition 2. *Assume that firms engage in Bertrand competition and that trade costs relative to the innovation reduced marginal cost lie in the medium range such that the innovation is non-drastic with global monopoly. The outside patent holder would like to license the patent non-exclusively in a fixed-fee licensing as trade costs are relatively higher, whereas exclusively, when it is relatively lower.*

Note that the result derived in Propositions 1 and 2 is significantly different from that derived in Kamien and Tauman (1986), Kamien *et al*. (1992), Muto (1993) and Poddar and Sinha (2004), in which the outside patentee always licenses the patent exclusively in a fixed-fee licensing under Bertrand competition.[11] This difference arises because this paper put forth the ideology that, the bigger the trade costs are, the higher will be the limit price and hence the monopoly profit in each market. As a result, the outside patentee would like to license the patent non-exclusively to capture the total monopoly profits, as trade costs are relatively higher. On the contrary, the total monopoly profits are so low that the outside patentee turns to license the patent exclusively, as trade costs are relatively lower. However, there exist no trade barriers in the related literature. Hence, no monopoly profit generated from trade barriers occurs in those papers such that the outside patentee always licenses the patent exclusively.

Moreover, since the trade costs t relative to ε are further lower in a drastic innovation than that in a non-drastic innovation measured by the area C in Figure 2, we can easily derive the result that an outside patent holder would like to license the patent exclusively for a fixed-fee licensing in the case of a drastic innovation. The same intuition applies to this case.

[11] We suspect that the outside patentee might license the patent non-exclusively for a fixed-fee licensing, as the degree of substitution between the products is sufficiently small in Muto's (1993) model. However, Muto (1993) did not pursue this analysis in his paper.

3.2. Royalty Licensing

In this sub-section, we explore the outside patentee's optimal royalty rate as it selects a royalty licensing. We can derive that the outside patentee would definitely license the patent non-exclusively in a royalty licensing, which are not reported here to save space.[12]

In the final stage, since both firms have the patent license, their marginal production costs are reduced to ($c - \varepsilon + r$). Given the Bertrand competition operating assumption, the licensees' limit prices can be derived as follows:

$$p_{1L}^{AR} = p_{2L}^{BR} = t + c - \varepsilon + r, \text{ for } t \le [(1-c)/2]. \tag{14}$$

Similarly, in the third stage, the maximum royalty rate is the innovation reduced marginal cost. In the second stage, the outside patentee's profit can be derived by using (1) and (14) as:

$$\Omega_L{}^{Rn} = 2r(1 - t - c + \varepsilon - r), \text{ for } t \le [(1-c)/2]. \tag{15}$$

Differentiating (15) with respect to r, we can derive the profit-maximizing condition for royalty rate as:

$$\partial\Omega_L{}^{Rn} / \partial r = 2[(1 - t - c + \varepsilon - r) - r] = 0, \text{ for } t \le [(1-c)/2]. \tag{16}$$

[12] The same result can be found in Muto (1993, p. 263) and Podda and Sinha (2004, p. 212-213). Intuitively, this result emerges because the competition between firms is more intense in the case where both firms have identical marginal cost in a non-exclusive licensing than that where the two firms have different marginal costs in an exclusive licensing under Bertrand competition. Thus, the licensed firms produce more aggregate output and the outside patentee can earn higher royalty revenues and profit in the former case. The details are available by the authors upon the request.

Solving (16), we have:[13]

$$r_L^{Rn} = (1 - t - c + \varepsilon)/2, \quad \text{for } [(1-c)/2] \geq t \geq [1 - c - \varepsilon], \qquad (17.1)$$
$$= \varepsilon, \quad \text{for } t \leq [1 - c - \varepsilon] \text{ and } t \leq [(1-c)/2]. \qquad (17.2)$$

Eq. (17.1) shows that the optimal royalty rate, which is smaller than the innovation reduced marginal cost ε, is an interior solution measured by the sum of the areas B_i^n, B_i^e and C in Figure 3, where $B_i^n \cup B_i^e \equiv \{(t,\varepsilon) \mid (1-c)/2 \geq t \geq 1 - c - \varepsilon, t \geq \varepsilon - (1-c)\}$, and the subscript "*i*" denotes the areas associated with the case of an interior solution. Eq. (17.2) shows that the optimal royalty rate is a corner solution equaling ε measured by the sum of the areas B_c^n, B_c^e and A in Figure 3, where $B_c^n \cup B_c^e \equiv \{(t,\varepsilon) \mid t \leq 1 - c - \varepsilon, t \leq (1-c)/2\}$ and the subscript "*c*" denotes the areas associated with the case of a corner solution.

(Insert Figure 3 here)

Substituting (17) into (15), we can obtain the outside patentee's profit for a non-exclusive royalty licensing as:

$$\Omega_L^{Rn} = (1 - t - c + \varepsilon)^2/2, \quad \text{for } (t, \text{å}) \in B_i^n \cup B_i^e \cup C, \qquad (18.1)$$
$$= 2\varepsilon(1 - t - c), \quad \text{for } (t, \text{å}) \in A \cup B_c^n \cup B_c^e. \qquad (18.2)$$

4. The Outside Patentee's Optimal Licensing Policy

[13] The second-order condition is fulfilled.

We proceed to explore the outside patentee's optimal licensing policy. We first analyze the case where the innovation is non-drastic with local monopoly measured by the area A in Figure 3.

We find from the area A that the restriction $t > (1 - c - \varepsilon)$ can never occur in this area. It follows that the possibility of the interior solution for the optimal royalty rate, i.e., eq. (17.1), is ruled out, and hence the outside patentee's profit for (18.1) is also excluded. Thus, the difference in the outside patentee's profit between a non-exclusive fixed fee licensing and a royalty licensing can be obtained by subtracting (18.2) from (8) as:

$$\Omega_L^{Fn} - \Omega_L^{Rn} = 2\varepsilon^2 > 0, for(t, \varepsilon) \in A. \tag{19}$$

Eq. (19) shows that the outside patentee's profit for a non-exclusive fixed-fee licensing is definitely higher than that in a non-exclusive royalty licensing, as the innovation is non-drastic with local monopoly. Thus, we can derive:

Proposition 3. *Assume that firms engage in Bertrand competition and trade costs relative to the innovation reduced marginal cost are so high that the innovation is non-drastic with local monopoly. The outside patent holder would like to choose a non-exclusive fixed-fee licensing rather than a royalty licensing.*

Next, we turn to examine the case, in which trade costs relative to the innovation reduced marginal cost lie in the medium range such that the innovation is non-drastic with global monopoly, measured by the sum of the areas B_c^n, B_i^n, B_c^e and B_i^e in Figure 3. We find from (13) that the outside patentee would like to license the patent non-exclusively in a fixed-fee licensing for $(t, \varepsilon) \in B_c^n \cup B_i^n$, while licensing exclusively for $(t, \varepsilon) \in B_c^e \cup B_i^e$. In what follows, we are going to analyze these two cases in that order.

For the case of $(t, \varepsilon) \in B_c^n \cup B_i^n$, since in this case, the outside patentee licenses the patent non-exclusively in a fixed-fee licensing, we can derive the difference in the outside patentee's profit between a non-exclusive fixed fee licensing and a royalty licensing by subtracting (18) from (12) as follows:

$$\Omega_G^{Fn} - \Omega_L^{Rn} = (1-c-t+\varepsilon)[5t-(1-c+\varepsilon)]/20, \text{ for } (t,\varepsilon)\in B_i^n, \quad (20.1)$$

$$= 2[t(1-c-t)-\varepsilon(1-c-2t)], \quad \text{for } (t,\varepsilon)\in B_c^n. \quad (20.2)$$

We can calculate from (20.1) that $\Omega_{nG}^{FT*} - \Omega_{nL}^{RT*} > (<)\ 0$ if $t > (<)\ t_1^C \equiv (1-c+\varepsilon)/5$, and from (20.2) that $\Omega_{nG}^{FT*} - \Omega_{nL}^{RT*} > (<)\ 0$ if $t > (<)\ t_2^C \equiv [2\varepsilon + (1-c) - \sqrt{4\varepsilon^2 + (1-c)^2}]/2$. We can figure out that $t_1^C > t_1$ and $t_2^C > t_1$ for all ε.[14] It follows that the outside patentee's profit for a non-exclusive fixed-fee licensing is higher (lower) than that in a non-exclusive royalty licensing, as trade costs are relatively higher, say $t > (<)\ t_1^C$, $t > (<)\ t_2^C$ for all ε in the areas $B_c^n \cup B_i^n$.

[14] The proof of the relationship among them is available by the authors upon the request.

For the case of $(t, \varepsilon) \in B_c^e \cup B_i^e$, since in this case, the outside patentee licenses the patent exclusively in a fixed-fee licensing, we can derive the difference in the outside patentee's profit between an exclusive fixed fee licensing and a royalty licensing by subtracting (18) from (11) as follows:

$$\Omega_G^{Fe} - \Omega_L^{Rn} = -[(1-c-\varepsilon)^2 + t^2]/2 < 0, \text{ for } (t,\varepsilon) \in B_i^e, \quad (21.1)$$

$$= -t(1-c-\varepsilon) < 0, \quad \text{for } (t,\varepsilon) \in B_c^e. \quad (21.2)$$

Eq. (21) shows that the outside patentee's profit for a non-exclusive royalty licensing is higher than that in an exclusive fixed-fee licensing, as trade costs are relatively lower, say $(t, \varepsilon) \in B_c^e \cup B_i^e$.

In summary, we conclude the corresponding combinations of (t, ε) for the outside patentee's optimal polices with a graphic illustration as shown in Figure 4. We find from (19) that the area A, and from (20) that part of areas B_i^n and B_c^n where $t > t_1^C$ and $t > t_2^C$, denoted by the areas B_i^F and B_c^F, in Figure 4, measure the combinations of (t, ε) for an outside patentee to choose a non-exclusive fixed-fee licensing. On the other hand, we find from (20) that part of areas B_i^n and B_c^n where $t < t_1^C$ and $t < t_2^C$, and from (21) that the areas B_i^e and B_c^e, measure the combinations of (t, ε) for an outside patentee to choose a non-exclusive royalty licensing. These combinations can be denoted by the sum of the areas B_c^R and B_i^R in Figure 4.

(Insert Figure 4 here)

Based on the above analysis, we have:[15]

Proposition 4. *Assume that firms engage in Bertrand competition and trade costs relative to the innovation reduced marginal cost lie in the medium range such that the innovation is non-drastic with global monopoly. The outside patent holder would like to choose a non-exclusive fixed-fee licensing rather than a non-exclusive royalty licensing as the trade costs are relatively higher, while the reverse occurs as the trade costs are relatively lower.*

The result derived in Propositions 3 and 4 is in sharp difference from that derived in Muto (1993), in which the royalty is optimal for an outside patentee for small innovations, but the fee is optimal for large innovations.[16] However, in the paper the fee is superior to the royalty for relatively small innovations, while the reverse occurs for relatively large innovations. The intuition behind the result in the paper can be stated as follows. Limit pricing in the presence of trade costs leads to the outcome that each firm becomes a local monopolist and earns the monopoly

[15] Following the same procedure, we can derive the result that the outside patent holder would like to choose a non-exclusive royalty licensing rather than an exclusive fixed-fee licensing, as trade costs relative to the innovation reduced marginal cost are so small that the innovation is drastic measured by the area *C* in Figure 4. The detailed procedure is available from the authors upon the request.

[16] See Motu (1993, p. 264 and p.267). This statement is true for the case where the products are not close substitutes, whereas Muto (1993) indicates that the "auction" is optimal for large innovations for close substitute products in page 264. Nevertheless, the fee is superior to the royalty for large innovations in his model once the auction is excluded in the analysis.

profit in the advantageous market. Moreover, the bigger the trade costs are, the higher will be the monopoly profit for a fixed-fee licensing. As a result, the outside patentee's profit for a fixed-fee licensing is higher than that for a royalty licensing, as trade costs relative to the innovation reduced marginal cost are higher. In contrast, there exist no trade costs and corresponding monopoly rents in Muto (1993). Since, the degree of competition in a non-exclusive royalty licensing is more intense than that in an exclusive fixed-fee licensing, the aggregate outputs of the former are larger than those of the latter.[17] Thus, in Muto (1993), the royalty revenue and profit derived in a non-exclusive royalty licensing will be higher than the one derived in an exclusive fixed-fee licensing for small innovations, while the reverse occurs for large innovations.

In addition to the difference from the result in Muto (1993), our result is also sharply different from that in Poddar and Sinha (2004), in which the non-exclusive royalty licensing is the best policy for an outside patentee for both drastic and non-drastic innovations. Poddar and Sinha (2004) employ a Hotelling's linear city model, in which the total output is fixed in the model. Therefore, a rise in the royalty rate does not reduce the total production for the licensees. Given that the outside patentee charges a royalty rate equals the innovation reduced marginal cost,

[17] The differentiation of the degree of competition arises from the fact that the marginal costs between firms are identical for non-exclusive royalty licensing, while those are different for exclusive fixed-fee licensing.

the whole benefits from innovation licensing are completely extracted by the patentee. Thus, the outside patentee can earn the maximum patent profit by choosing a non-exclusive royalty licensing. On the other hand, the mill price will fall with the decrease in the marginal cost of the licensee caused by an exclusive fixed-fee licensing. Thus, the patent profit is lower in an exclusive fixed-fee licensing. As a result, the non-exclusive royalty licensing is the best policy for an outside patentee for both drastic and non-drastic innovations in Poddar and Sinha (2004). However, this result may not be true if the total production for the firms is not fixed because a rise in the royalty rate will decrease the total outputs.

Finally, we find from (21.2) that this difference in the outside patentee's profit equals zero, if the trade costs are nil. This shows that the fee and royalty licensing are equivalent for an outside patent holder, which is the same as that derived in Kamien and Tauman (1986) and Kamien *et al*. (1992). This result occurs because our model is degenerated into the case of the homogeneous good as the trade costs equal zero. Thus, we can establish the following Proposition:

Proposition 5. *Assume that firms engage in Bertrand competition and trade costs equal zero*. *The fee and royalty licensing are equivalent for an outside patent holder*.

5. Concluding Remarks

This paper has developed a two-country model to take into account trade costs in exploring the outside patentee's optimal licensing policy under Bertrand competition with a homogenous product. The focus of the paper is on the impact of trade costs to determine the licensing policy via the monopoly profit generated by the trade costs. The bigger the trade costs relative to the innovation reduced marginal cost are, the higher will be the monopoly profit. Several striking results are derived as follows.

First of all, we show that a fixed-fee licensing is optimal for an outside patent holder under Bertrand competition, as trade costs relative to the innovation reduced marginal cost are higher, while a royalty licensing is optimal, otherwise. This result is significantly different from that derived in Muto (1993) and Poddar and Sinha (2004). Secondly, related literature indicates that the outside patentee licenses a fixed-fee licensing exclusively under Bertrand competition. However, we show that the outside patentee would choose a fixed-fee licensing non-exclusively, as trade costs relative to the innovation reduced marginal cost are higher. Lastly, we show that the fee and royalty licensing are equivalent for an outside patent holder, as trade costs equal zero. This result is the same as that derived in Kamien and Tauman (1986) and Kamien *et al*. (1992).

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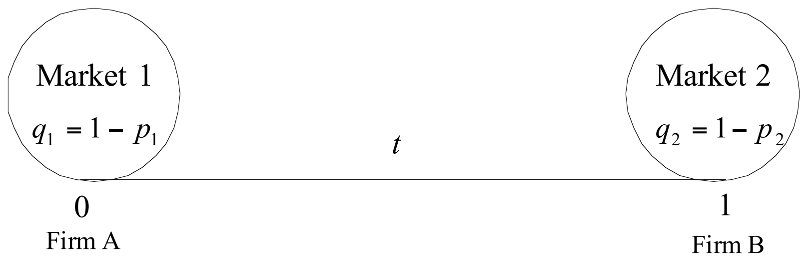

Fig. 1. The two-country model

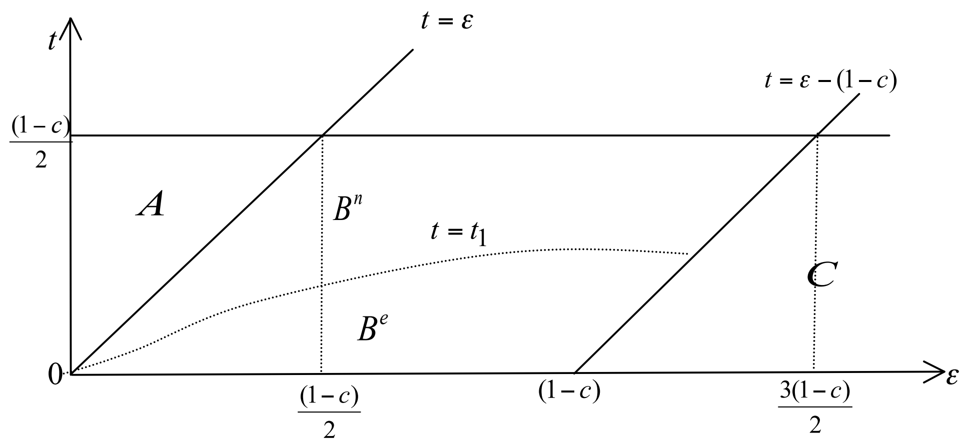

Fig. 2. Areas for the drastic and non-drastic innovations

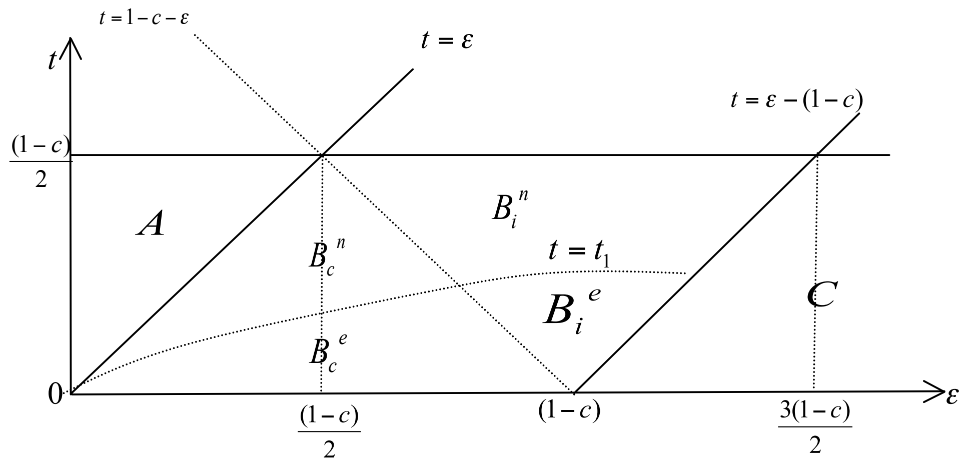

Fig. 3. Areas for the interior and corner solutions of the optimal royalty rate

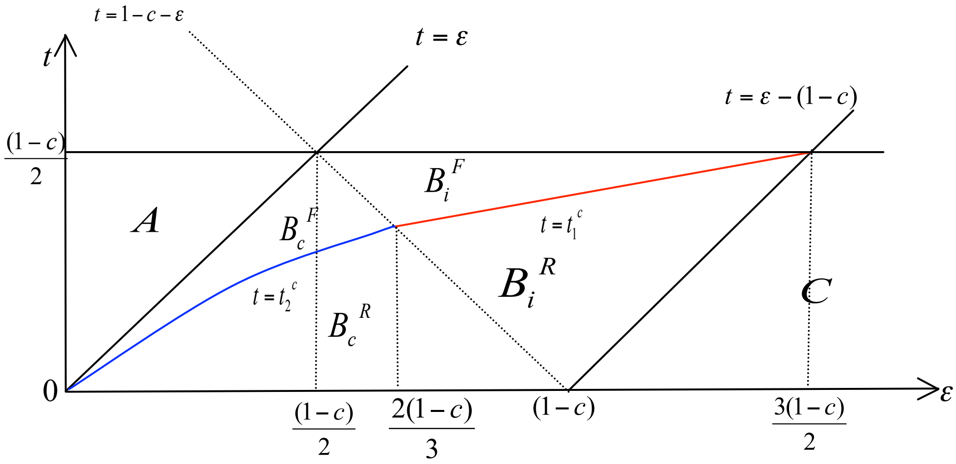

Fig. 4. Areas for the outside patentee's optimal policies