Tariff Induced Fee Licensing and Consumers' Welfare

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(March 2012)

Acknowledgement: I like to thank Satwick Santra for providing some computational help.

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Abstract

In a Cournot duopoly with one foreign firm and one domestic firm we show that a tariff on foreign products can be an effective instrument to influence the licensing strategy of the foreign firm. Under free trade technology transfer occurs with a royalty contract, but a suitably designed tariff rate can induce the foreign firm transfer its superior technology to the domestic firm under the fee contract where consumers' welfare is maximized and social welfare is larger. Such a policy appears to be catchy from the viewpoint of a political party in power.

Keywords: Tariffs; Fee licensing; Royalty licensing; Consumers' welfare.

JEL Classifications: D43; F13; L13

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1. Introduction

Does a tariff benefit consumers? A government pursuing a tariff protection generally raises its domestic welfare but that often at the cost of a higher product price. So the consumers as a class become the worst sufferer. To a political party in power seeking to win the election, such a policy may not be desirable. After all, consumers form the largest electorate group; so consumers' welfare cannot be ignored.

In a recent paper Kabiraj and Marjit (2003) have constructed a duopolistic trade model to show that a well directed tariff can induce the foreign firm transfer its superior technology to its local rival, and under some situations such a tariff raises consumers' surplus relative to the free trade situation.[1] But they have restricted to the assumption of technology licensing under a fixed fee contract only, and thus the paper does not allow the foreign firm behave optimally. Secondly, in a duopoly set up, with patentee as insider, a fixed fee contract can occur only if the licensor's technology is close to that of the licensee in terms of the unit cost of production (e.g., Marjit (1990)). Therefore, the Kabiraj and Marjit (2003) paper has considered the possibility of transfer for only a subset of cost-reducing technologies. These two issues are important in view of the fact that in a duopoly, with insider patentee, not only transfer of any non-drastic innovation is profitable under the royalty contract to the licensor, but more importantly, the optimal royalty contract strictly dominates the fee contract from the perspective of the patentee. For this literature one may look at, among others, Wang (1998, 2002), Mukherjee and Balasubramanian (2001), Fauli-Oller and Sandonis (2002), and Kishimoto and Muto (2010). But then royalty licensing means the efficiency effect of the transferred superior technology for the consumers is forfeited or weakened. In fact, a royalty licensing with a positive tariff rate necessarily reduces consumers' surplus.

The present paper is an attempt to bring all these issues in the same thread with an objective to reconcile the ideas underlying Wang (1998) and Kabiraj and Marjit (2003), in particular. Hence we claim to have proposed a more consistent and enriched model. We construct a

[1] There are some other works (e.g., Jones and Takemori (1989), Helpman and Krugman (1989)) that show to have a favorable price effect of a tariff, but they don't have the possibility of a tariff induced technology transfer and the resultant change in consumers' welfare.

similar duopolistic trade model as in Kabiraj and Marjit (2003) (equivalently, it is the Wang (1998) model with one foreign firm and one local firm); the foreign firm owns the superior technology. But now the objective of the local government is to maximize consumers' welfare by means of manipulating the per unit tariff on foreign products. We show that a tariff can be strategically chosen so that it induces fee licensing to occur and consumers' welfare is maximized. We thus allow the patentee behave optimally, and at the same time seek to maximize consumers' welfare. The paper therefore shows how a tariff can be an instrument to influence the behavior of the technologically advanced foreign firm in favor of the interest of the target group of the domestic economy.

The intuition of our result is the following. Given asymmetric production technologies, and that the firms compete in quantities a la Cournot in the domestic market, the local government, by committing its tariff,[2] not only affects the effective unit cost of the licensor, but more importantly, it can influence the licensing strategies of the patentee. We restrict our analysis to the cases of fee licensing and royalty licensing only.[3] If the tariff rate is low, the licensor will go for a royalty licensing, whereas a high tariff will induce fee licensing to occur. If the tariff is too high (that is, prohibitive), it will be fee licensing with domestic monopoly. Under royalty licensing, consumers do not get the full benefit of the efficient technology, but under fee licensing they derive the full benefit of the transferred technology. In such a situation, not only consumers' welfare is maximized, but overall welfare also goes up because a positive tariff increases the reservation payoff of the local firm and also the local government captures a part of the foreign firm's profit as tariff revenue. Such a tariff policy is clearly catchy from the viewpoint of a political party in power.

Given that the foreign firm holds the superior technology, in the absence of a tariff, obviously it has unit production cost less than that of the local firm. But a per unit tariff on foreign products effectively increases foreign firm's selling (or marketing) cost; then the tariff inclusive unit cost of the patentee can even be higher than the unit cost of its rival. In that sense the structure of our paper is similar to Poddar and Sinha (2010) that discusses the possibility of technology licensing from the high-cost firm to the low-cost firm.

[2] For details of the commitment and no-commitment issue in the context of technology transfer in duopoly see Kabiraj and Marjit (2003) and Mukherjee and Pennings (2006).

[3] In the set up of our present model when tariff is in the intermediate range, `fee plus royalty licensing' is optimal from the perspective of the patentee. But since in our model the government likes to maximize consumers' welfare, which occurs only when fee licensing is induced by an appropriate choice of royalty, in (subgame perfect) equilibrium therefore fee plus royalty will never occur.

To briefly outline the related literature, consider first the works of Marjit (1990), Wang (1998), Kabiraj and Marjit (2003) and Poddar and Sinha (2010), which are closely related to the present work. All these papers talk about technology licensing from the technologically superior firm to the technologically backward firm. Marjit (1990) considers technology transfer under the fee contract only. It shows that if the initial asymmetry is below a critical level fee licensing will occur. Wang (1998) has shown that royalty licensing is not only always profitable compared to no licensing for any non-drastic innovation, it also strictly dominates fee licensing in view of total profits accrued to the patentee. In Poddar and Sinha (2010), the firm which owns the superior technology may not be cost efficient in marketing or selling the product; hence it discusses optimal licensing contracts when technology licensing occurs from the high-cost firm to the low-cost firm. The paper shows the possibility of fee licensing generating a higher profit than royalty licensing. In Kabiraj and Marjit (2003), however, the efficient firm is the foreign firm and the other firm is the local firm. Assuming the possibility of fee licensing only, the paper shows that the local government can choose a tariff optimally to maximize the domestic welfare where consumers can have a larger welfare compared to a zero tariff situation.

Then Wang (2002), Mukherjee and Balasubramanian (2001) and Fauli-Oller and Sandonis (2002) have considered technology licensing in a duopoly with differentiated products. They have discussed the question of optimal licensing contracts. In all these papers, generally royalty licensing dominates fee licensing. And from the viewpoint of the consumers, fee licensing is preferred. Fauli-Oller and Sandonis (2002) have, however, shown the possibility of welfare reducing licensing**.**[4] Kishimoto and Muto (2010) consider technology licensing in a Cournot duopoly where fee or royalty is determined through a process of Nash bargaining. Here again royalty licensing is preferred from the viewpoint of the firms as well as social welfare, but the consumers prefer fee licensing. Finally, Mukherjee and Pennings (2006) have discussed the commitment issue in the context of choosing a tariff rate and have shown that by committing its tariff the host country can induce the foreign incumbent to transfer its technology to a host country firm rather to a foreign entrant, and the country gains in terms of welfare.[5]

[4] This occurs when goods are close substitutes, firms compete in prices and the innovation is large enough.
[5]For the licensing contracts in oligopoly in a general set up one may look at Sen and Tauman (2007). The paper also discusses the related issues.

To say a few words about the local government's objective of consumers' welfare maximization, note that simple welfare maximization does not mean that consumers will benefit. In particular, in the absence of an effective and meaningful income transfer mechanism, consumers can be the worst suffers. The government in power generally cares the interest of the consumers who, after all, form the largest electorate group. So taking a policy that hurts the consumers, particularly in an election period, is unlikely to be pursued. In the present paper while the patentee has an option to decide its licensing strategy optimally, the local government can affect the behavior of the patentee with an objective to protect the interest of the consumers. In our framework consumers are never worse off and there are situations where consumers derive the maximum possible welfare.

The organization of the paper is the following. We present the model in section 2. Section 3 discusses the optimal licensing strategies of the patent holder. Then consumers' welfare and optimal tariffs is discussed in section 4. Finally, section 5 concludes the paper.

2. Model

One foreign firm (call firm 1) and one local firm (call firm 2) compete a la Cournot in the domestic market with a homogeneous good. The (inverse) market demand function is given by $P = a - Q = a - (q_1 + q_2)$, where P denotes price and Q represents industry output. Initially, both the firms had a production technology given by the constant unit cost of production c ($0 < c < a$). Then firm 1 comes up with a new innovation that reduces its unit cost of production by an amount $\varepsilon > 0$; then ε is the size of the innovation. We restrict to the assumption that the innovation is non-drastic or minor (i.e., $\varepsilon < a - c$) so that under Cournot duopoly both firms can operate at positive output levels. We assume that firm 1 has three options to decide before product market competition viz., no licensing, fee licensing and royalty licensing**,** but the local government seeks to influence the licensing strategy of the patent holder by means of a tariff, $\tau \geq 0$, on foreign products and maximize consumers' welfare measured by consumers' surplus.

The game in the paper is the following. In the first stage, the local government commits a tariff rate $\tau \in [0,\infty)$ per unit of foreign products with an objective to maximize consumers' welfare. In the second stage, given $\tau \geq 0$, the foreign firm decides its licensing strategy, that is, fee licensing, royalty licensing or no licensing, and the local firm accepts if it is not worse off. In the third and final stage, given the technological configuration at the end of the second stage, the firms compete in quantities in a Cournot fashion. We solve the game by backwards induction.

2.1 Licensing Strategies

We first consider the benchmark case, that is, no licensing situation, and then we discuss fee licensing and royalty licensing. Under fee licensing technology is transferred against a fixed fee, and under royalty licensing a royalty per unit of the transferee's product is charged. In the whole analysis innovation is assumed to be non-drastic in the sense that even in the absence of any tariff protection both firms will operate in the market at positive output levels.[6]

2.1.1 Benchmark Case: No Licensing

Consider non-drastic innovation (i.e., $\varepsilon < a - c$) and any non-prohibitive tariff $\tau \geq 0$. Hence no licensing equilibrium quantities under Cournot competition are:

$$q_1^{NL} = \frac{a-c+2\varepsilon-2\tau}{3} \quad \text{and} \quad q_2^{NL} = \frac{a-c-\varepsilon+\tau}{3}$$

and profits are:

$$\pi_1^{NL} = \frac{(a-c+2\varepsilon-2\tau)^2}{9} \quad \text{and} \quad \pi_2^{NL} = \frac{(a-c-\varepsilon+\tau)^2}{9} \tag{1}$$

Then, the assumption of initial duopoly requires that

$$0 \leq \tau < \frac{a-c+2\varepsilon}{2} \tag{2}$$

Clearly, if $\tau \geq \dfrac{a-c+2\varepsilon}{2}$, then tariff is prohibitive and the local firm will emerge as monopolist.

[6] If the innovation is drastic, a positive tariff greater than a critical level is required to ensure initial duopoly.

2.1.2 Licensing by a Fixed Fee

Under fee licensing the local firm will produce at unit cost $c-\varepsilon$ and firm 1 will extract the surplus profit of firm 2 by means of a fixed fee, $F>0$. Hence under fee licensing, the quantities they will produce are,

$$q_1^F=\frac{a-c+\varepsilon-2\tau}{3} \quad \text{and} \quad q_2^F=\frac{a-c+\varepsilon+\tau}{3}$$

The corresponding profits are

$$\pi_1^F=\frac{(a-c+\varepsilon-2\tau)^2}{9} \quad \text{and} \quad \pi_2^F=\frac{(a-c+\varepsilon+\tau)^2}{9}$$

And fixed fee is

$$F=\pi_2^F-\pi_2^{NL}=\frac{4\varepsilon(a-c+\tau)}{9}$$

Therefore, licensor's total profit under fee licensing is

$$\Pi_1^F=\pi_1^F+F=\frac{(a-c+\varepsilon-2\tau)^2}{9}+\frac{4\varepsilon(a-c+\tau)}{9} \tag{3}$$

Then fee licensing is preferred to no licensing if and only if $\Pi_1^F>\pi_1^{NL}$, that is,

$$\tau>\frac{3\varepsilon-2(a-c)}{8} \tag{4}$$

Note that if $\varepsilon<2(a-c)/3$, the above condition is satisfied even for $\tau=0$, but if $\varepsilon\geq 2(a-c)/3$, then fee licensing can occur if and only if the above condition holds. This gives the following lemma.

Lemma 1: Given any $\varepsilon<a-c$, fee licensing is preferred to no licensing[7] if and only if $\tau\in[\max\{0,\ \frac{3\varepsilon-2(a-c)}{8}\},\ \frac{a-c+2\varepsilon}{2})$.

We present all our results in the paper in *Figure* 1, taking $a-c=1$. In the figure, all points (ε,τ) in the area $\Delta\equiv OQTLO$ satisfy the initial restrictions that $0<\varepsilon<a-c$ and

[7] If the innovation is drastic, i.e., $\varepsilon\geq a-c$, without tariffs it is monopoly of the foreign firm, but a tariff protection may yield a duopoly market. Then the assumption of initial duopoly requires the restriction that $\varepsilon-(a-c)\leq\tau<\frac{a-c+2\varepsilon}{2}$.

$0 \leq \tau < \dfrac{a-c+2\varepsilon}{2}$ (except of course the relevant boundary points). Then for all (ε, τ) in $\Delta_F \equiv OPRTLO$, fee licensing is preferred to no licensing. Therefore,

$$\Delta = \{(\varepsilon, \tau) \mid \varepsilon \in (0, a-c) \ \& \ \tau \in [0, \frac{a-c+2\varepsilon}{2})\}$$

$$\Delta_F = \{(\varepsilon, \tau) \mid \varepsilon \in (0, a-c) \ \& \ \tau \in [\max\{0, \frac{3\varepsilon - 2(a-c)}{8}\}, \frac{a-c+2\varepsilon}{2})\}$$

$$\Delta_F \subset \Delta$$

2.1.3 Licensing by a Royalty

Consider licensing by means of a royalty $r \geq 0$ only, given that the initial market structure is duopoly. The equilibrium quantities are

$$q_1^R = \frac{a-c+\varepsilon-2\tau+r}{3} \quad \text{and} \quad q_2^R = \frac{a-c+\varepsilon+\tau-2r}{3}$$

and the corresponding profits are

$$\pi_1^R = \frac{(a-c+\varepsilon-2\tau+r)^2}{9} \quad \text{and} \quad \pi_2^R = \frac{(a-c+\varepsilon+\tau-2r)^2}{9}$$

Then licensor's total income under royalty licensing is

$$\Pi_1^R = \pi_1^R + r\, q_2^R = \frac{(a-c+\varepsilon-2\tau+r)^2}{9} + r\frac{(a-c+\varepsilon+\tau-2r)}{3} \tag{5}$$

So the optimal royalty r^* solves the problem:

$$\max_r \Pi_1^R \quad \text{subject to} \quad \pi_2^R \geq \pi_2^{NL} \text{ (i.e., } r \leq \varepsilon\text{)}.$$

Free maximization of the problem generates

$$r = \frac{5(a-c+\varepsilon)-\tau}{10} = \frac{a-c+\varepsilon}{2} - \frac{\tau}{10} \equiv \bar{r}$$

We can check that

$$\varepsilon \ \substack{< \\ >} \ \bar{r} \quad \text{according as } \tau \ \substack{< \\ >} \ 5(a-c) - 5\varepsilon \equiv \tilde{\tau} \tag{6}$$

This gives the optimal royalty rate under the royalty contract as

$$\begin{aligned} r^* &= \varepsilon \ \text{ if } \varepsilon \leq \bar{\mathrm{r}} \ \text{ i.e., } \tau \leq 5(\mathrm{a-c}) - 5\varepsilon \\ &= \bar{\mathrm{r}} \ \text{ if } \varepsilon > \bar{\mathrm{r}} \ \text{ i.e., } \tau > 5(\mathrm{a-c}) - 5\varepsilon \end{aligned}. \tag{7}$$

Hence firm 1's total income under the optimal royalty contract is

$$\Pi_1^R = \pi_1^R + r\, q_2^R = \begin{cases} \Pi_1^{R(\varepsilon)} & \text{if } \ \tau \le 5(a-c)-5\varepsilon, \\ \Pi_1^{R(\bar{r})} & \text{if } \ \tau > 5(a-c)-5\varepsilon \end{cases} \tag{8}$$

where,

$$\Pi_1^{R(\varepsilon)} = \frac{(a-c+2\varepsilon-2\tau)^2}{9} + \varepsilon\frac{(a-c-\varepsilon+\tau)}{3}$$

$$\Pi_1^{R(\bar{r})} = \frac{(a-c+\varepsilon-\tau)^2}{4} + \frac{\tau^2}{5}$$

Then we can easily check that for all $(\varepsilon,\tau)\in\Delta$ we have

$$\Pi_1^R > \pi_1^{NL} \tag{9}$$

In *Figure 1*, condition (9) is satisfied (i.e., royalty licensing is preferred to no licensing) for all $(\varepsilon,\tau)\in\Delta$, therefore, $\Delta_R = \Delta$; for all (ε,τ) in the area $\Delta_{R(\varepsilon)} \equiv OQKLO$ we have $r^* = \varepsilon$ and in the area $\Delta_{R(\bar{r})} \equiv QTKQ$ we have $r^* = \bar{\mathrm{r}}$. We call these two regimes as ε-regime and $\bar{r}$-regime. Formally to define,

$$\Delta_{R(\varepsilon)} = \{(\varepsilon,\tau) \mid \varepsilon\in(0,a-c) \ \& \ \tau\in[0, \ \min\{5(\mathrm{a-c})-5\varepsilon, \ \frac{a-c+2\varepsilon}{2}\}]\}$$

$$\Delta_{R(\bar{r})} = \{(\varepsilon,\tau) \mid \varepsilon\in(0,a-c) \ \& \ \tau\in(5(\mathrm{a-c})-5\varepsilon, \ \frac{a-c+2\varepsilon}{2})\}$$

$$\Delta_R = \Delta_{R(\varepsilon)} \cup \Delta_{R(\bar{r})} = \Delta.$$

Lemma 2: Given any (ε,τ), royalty licensing is always preferred to no licensing $\forall\tau\in[0,\frac{a-c+2\varepsilon}{2})$ with royalty rate $r^* = \varepsilon$ if $\tau\le 5(a-c)-5\varepsilon$ and $r^* = \bar{r}$ if $\tau > 5(a-c)-5\varepsilon$.

3. Fee vs. Royalty Licensing

Given any $\varepsilon\in(0,a-c)$, whether the optimal licensing scheme will be fee licensing, royalty licensing or no licensing depends on the value of τ. First, consider the case of prohibitive tariff, that is, $\tau \geq \frac{a-c+2\varepsilon}{2}$. Under no licensing situation the domestic firm has absolute monopoly. Under this situation the optimal licensing contract must be fee licensing, and the licensor will extract all surplus from the licensee, i.e., $F = \frac{(a-c+\varepsilon)^2}{4} - \frac{(a-c)^2}{4}$.

Now, consider the case of non-prohibitive tariff, i.e., $\tau \in [0, \frac{a-c+2\varepsilon}{2})$. Since, by Lemma 2, royalty licensing is always preferred to no licensing, so we examine the situations when fee licensing generates a larger profit to the licensor than royalty licensing. First consider the scenario described by all $(\varepsilon,\tau) \in \Delta_F \cap \Delta_{R(\varepsilon)}$, that is, the area OPSKLO in *Figure 1*.

Now given any $(\varepsilon,\tau) \in \Delta_F \cap \Delta_{R(\varepsilon)}$, comparing total profits under each of fee licensing and royalty licensing (with ε as the royalty rate), that is, Π_1^F and $\Pi_1^{R(\varepsilon)}$, we see that

$$\Pi_1^F > \Pi_1^{R(\varepsilon)} \quad \text{iff} \quad \tau > \frac{a-c}{5} \equiv \underline{\tau} \tag{10}$$

In the figure, $\Pi_1^F > \Pi_1^{R(\varepsilon)}$ occurs for all (ε,τ) in the area $\Delta_1 \equiv MNKLM$, where

$$\Delta_1 = \{(\varepsilon,\tau) \mid \varepsilon \in (0, a-c) \ \& \ \tau \in [\frac{a-c}{5}, \ \min\{5(\mathrm{a-c}) - 5\varepsilon, \ \frac{a-c+2\varepsilon}{2}\}]\}$$

Then royalty licensing will occur for any (ε,τ) in the area OQNMO. Note that in the area $\Delta_2 \equiv OPSNMO$, we have $\Pi_1^{R(\varepsilon)} > \Pi_1^F$, and in the area $\Delta_3 \equiv PQSP$ only royalty licensing is profitable, fee licensing is not;[8] $\Delta_1 \cup \Delta_2 \cup \Delta_3 = \Delta_{R(\varepsilon)}$.

Proposition 1(a): Given $\varepsilon \in (0, a-c)$, if $\tau \geq \frac{a-c+2\varepsilon}{2}$, fee licensing with domestic firm monopoly will occur; if $(\varepsilon,\tau) \in \Delta_1$, then fee licensing is preferred to royalty licensing and no licensing (i.e., $\Pi_1^F > \Pi_1^{R(\varepsilon)} > \pi_1^{NL}$); and if $(\varepsilon,\tau) \in \Delta_2 \cup \Delta_3$, royalty licensing is preferred to fee licensing and no licensing.

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[8] Formally, $\Delta_2 = \{(\varepsilon,\tau) \mid \varepsilon \in (0, a-c) \ \& \ \tau \in [\max\{0, \frac{3\varepsilon - 2(a-c)}{8}\}, \ \min\{\frac{(\mathrm{a-c})}{5}, \ 5(\mathrm{a-c}) - 5\varepsilon\}]\}$ and $\Delta_3 = \{(\varepsilon,\tau) \mid \varepsilon \in (\frac{2(a-c)}{3}, a-c) \ \& \ \tau \in [0, \ 5(\mathrm{a-c}) - 5\varepsilon]\}$.

Note that for $(\varepsilon,\tau)\in\Delta_2$, we have $\Pi_1^{R(\varepsilon)} > \Pi_1^F > \pi_1^{NL}$ and for $(\varepsilon,\tau)\in\Delta_3$ we have $\Pi_1^{R(\varepsilon)} > \pi_1^{NL} > \Pi_1^F$.

Now consider any (ε,τ) in the $\bar{r}$-regime, i.e., $(\varepsilon,\tau)\in\Delta_{\mathrm{R}(\bar{\mathrm{r}})}$, that is the area QTKQ in the figure. Then comparing total profits under each of fee licensing and royalty licensing, that is, Π_1^F and $\Pi_1^{R(\bar{r})}$, we see that

$$\Pi_1^F > \Pi_1^{R(\bar{r})} \quad \text{iff} \quad \tau > 5(a-c)+45\varepsilon-4\sqrt{30\varepsilon(a-c)+125\varepsilon^2} \equiv \hat{\tau}(\varepsilon) \qquad (11)$$

In the figure, $\Pi_1^F > \Pi_1^{R(\bar{r})}$ occurs for all (ε,τ) in the area $\Delta_4 \equiv TKNWT$, and $\Pi_1^F < \Pi_1^{R(\bar{r})}$ occurs for all (ε,τ) in the area $\Delta_5 \equiv NWQN$. Therefore,

$$\Delta_4 = \{(\varepsilon,\tau)\mid \varepsilon\in(0,a-c) \ \&\ \tau\in(\max\{5(\mathrm{a-c})-5\varepsilon, \hat{\tau}(\varepsilon)\}, \frac{a-c+2\varepsilon}{2})\}$$

$$\Delta_5 = \{(\varepsilon,\tau)\mid \varepsilon\in(0,a-c) \ \&\ \tau\in(5(\mathrm{a-c})-5\varepsilon, \hat{\tau}(\varepsilon))\}$$

$$\Delta_4 \cup \Delta_5 = \Delta_{R(\bar{r})}$$

Proposition 1(b): For any (ε,τ) in QTKQ, fee licensing will occur if and only if $\tau > 5(a-c)+45\varepsilon-4\sqrt{30\varepsilon+125\varepsilon^2}$; otherwise, royalty licensing will occur, with royalty rate $\bar{r}$.[9]

The following corollary follows from Proposition 1(a) and (b) is useful for the following analysis.

Corollary 1: If $\tau^* = 0$, then we have $\Pi_1^R > \Pi_1^F \ \forall\varepsilon\in(0,\mathrm{a-c})$, that is, if tariff rate is zero, royalty licensing will occur with royalty rate $r^* = \varepsilon$.

4. Consumers' Welfare and the Optimal Tariff Rate

First consider consumers' welfare under different licensing schemes, given any (ε,τ). Consumers' welfare is measured by consumers' surplus (CS). With linear demand function,

[9] Note that for all (ε,τ) in QRSQ, only royalty licensing is profitable (fee licensing is not), therefore royalty contract with $r^* = \bar{\mathrm{r}}$ will occur.

$(CS) = (1/2)Q^2$. Then given any $\varepsilon \in (0, a-c)$ and $\tau \in [0, \frac{a-c+2\varepsilon}{2})$, under various licensing schemes the industry outputs are:

$$Q^{NL}(\tau) = q_1^{NL} + q_2^{NL} = \frac{1}{3}[2(a-c) + \varepsilon - \tau]$$

$$Q^{F}(\tau) = q_1^{F} + q_2^{F} = \frac{1}{3}[2(a-c) + 2\varepsilon - \tau]$$

$$Q^{R(\varepsilon)}(\tau) = q_1^{R} + q_2^{R} = \frac{1}{3}[2(a-c) + \varepsilon - \tau]$$

$$Q^{R(\bar{r})}(\tau) = q_1^{R} + q_2^{R} = \frac{1}{10}[5(a-c+\varepsilon) - 3\tau]$$

Therefore, given any (ε, τ), we have

(i) $Q^F > Q^{R(\varepsilon)} = Q^{NL}$ and (ii) $Q^F > Q^{R(\bar{r})} > Q^{NL}$.

Hence,

$$(CS)^F > (CS)^R \geq (CS)^{NL}$$

that is, consumers' welfare is largest under fee licensing,[10] given any ε and τ. In our model ε is a parameter exogenously specified whereas τ is a variable to be decided by the local government. Moreover, we have seen that the choice of τ influences the optimal licensing decision of the licensor. We now discuss the optimal choice of τ, given any ε, so as to maximize consumer's welfare (equivalent to maximizing industry output). Note that each of Q^F, $Q^{R(.)}$ and Q^{NL} goes up as τ falls. On the other hand, if $\tau \geq \frac{a-c+2\varepsilon}{2}$, fee licensing will occur, and the corresponding industry output is $Q^M(\tau) = \frac{a-c+\varepsilon}{2}$.

Optimal Tariff Rate

Recall that we have defined the following.

$$\underline{\tau} \equiv \frac{(a-c)}{5}; \quad \tilde{\tau} \equiv 5(a-c) - 5\varepsilon; \text{ and } \hat{\tau} \equiv 5(a-c) + 45\varepsilon - 4\sqrt{30\varepsilon(a-c) + 125\varepsilon^2}$$

Correspondingly,

[10] If fee licensing could be enforced, consumers' welfare would be the highest with $\tau = 0$. But the problem is that if $\tau = 0$, the technology will be transferred under the royalty contract with royalty rate ε. Then in this case there will be no increase in consumers' surplus under licensing, and a royalty contract with $\tau > 0$ will reduce consumers' surplus.

$$Q^F(\underline{\tau}) = \frac{1}{3}[\frac{9(a-c)}{5} + 2\varepsilon] \equiv \overline{Q}^{F(\varepsilon)};$$

$$Q^F(\tilde{\tau}) = \frac{1}{3}[7\varepsilon - 3(a-c)] \equiv \overline{Q}^{F(\bar{r})}$$

$$Q^F(\hat{\tau}) = \frac{1}{3}[-3(a-c) - 43\varepsilon + 4\sqrt{30\varepsilon(a-c) + 125\varepsilon^2}\,] \equiv \overline{Q}^{F*(\bar{r})}$$

Further,[11]

$$Q^{R(\varepsilon)}(0) = \frac{1}{3}[2(a-c) + \varepsilon] \equiv \overline{Q}^R$$

Then,

$$\overline{Q}^{F(\varepsilon)} \underset{<}{\overset{>}{-}} \overline{Q}^R \Leftrightarrow \varepsilon \underset{<}{\overset{>}{-}} \frac{a-c}{5}$$

$$\overline{Q}^R > \overline{Q}^M \quad \forall \varepsilon < (a-c)$$

$$\overline{Q}^{F(\varepsilon)} > \overline{Q}^{F(\bar{r})} \Leftrightarrow \varepsilon < \frac{24(a-c)}{25},\ \tau > 0$$

$$\overline{Q}^R > Q^{R(\bar{r})}(\tau) \ \ \forall \varepsilon \in (\frac{24(a-c)}{25},\ a-c)$$

Now, we can determine the consumers' welfare maximizing tariff rate (τ^*), given any ε. Consider the following cases.[12]

Case 1: $0 < \varepsilon < \frac{3(a-c)}{4}$

If τ is chosen from $[0, \frac{(a-c)}{5})$, royalty licensing will occur with royalty rate ε (see (10)).

The corresponding industry output under royalty licensing is $Q^{R(\varepsilon)}(\tau) = \frac{1}{3}[2(a-c) + \varepsilon - \tau]$.

Hence $Q^{R(\varepsilon)}(\tau)$ is maximum at $\tau = 0$; therefore, $Q^{R(\varepsilon)}(0) = \frac{1}{3}[2(a-c) + \varepsilon] \equiv \overline{\mathrm{Q}}^{\mathrm{R}}$.

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[11] Note that $Q^{R(\bar{r})}(0)$ will never occur because $\varepsilon < a - c$.

[12] Consider the following critical values of ε. The intersection point of $\tau = \frac{a-c+2\varepsilon}{2}$ and $\tau = 5(a-c) - 5\varepsilon$ gives $\varepsilon = \frac{3(a-c)}{4}$ and that of $\tau = 5(a-c) - 5\varepsilon$, $\tau = \frac{a-c}{5}$ and $\tau \equiv 5(a-c) + 45\varepsilon - 4\sqrt{30\varepsilon(a-c) + 125\varepsilon^2}$ gives $\varepsilon = \frac{24(a-c)}{25}$.

If τ is chosen from $[\frac{(a-c)}{5}, \frac{a-c+2\varepsilon}{2})$, then fee licensing will occur. The corresponding industry output under fee licensing is $Q^F(\tau) = \frac{1}{3}[2(a-c)+2\varepsilon-\tau]$. Hence $Q^F(\tau)$ is maximum at $\tau = \underline{\tau} \equiv \frac{(a-c)}{5}$, that is, $Q^F(\underline{\tau}) = \frac{1}{3}[\frac{9(a-c)}{5}+2\varepsilon] \equiv \overline{\mathrm{Q}}^{\mathrm{F}(\varepsilon)}$.

Finally, if $\tau \geq \frac{(a-c+2\varepsilon)}{2}$, it is domestic monopoly under fee licensing. The corresponding industry output under royalty licensing is $Q^M(\tau) = \frac{(a-c+\varepsilon)}{2} \equiv \bar{Q}^M$. Now, since $\overline{Q}^{F(\varepsilon)} \gtrless \overline{\mathrm{Q}}^{\mathrm{R}} \Leftrightarrow \varepsilon \gtrless \frac{a-c}{5}$, $\overline{Q}^{F(\varepsilon)} > \overline{Q}^M$ and $\overline{Q}^{R(\varepsilon)} > \overline{Q}^M$, we can write the following lemma.

Lemma 3: The optimal tariff is $\tau^* = 0$ if $0 < \varepsilon < \frac{(a-c)}{5}$, and $\tau^* = \frac{a-c}{5}$ if $\frac{(a-c)}{5} \leq \varepsilon < \frac{3(a-c)}{4}$; in the first case royalty licensing will occur and in the second case fee licensing will occur.

Case 2: $\frac{3(a-c)}{4} \leq \varepsilon < \frac{24(a-c)}{25}$

In this case, given ε, royalty licensing will occur if $\tau < \frac{a-c}{5}$ and fee licensing will occur if $\tau \in [\frac{a-c}{5}, \frac{\mathrm{a-c}+2\varepsilon}{2})$. Note that τ can be chosen either from $\bar{r}$-regime or from ε-regime (see (10) and (11)). Industry output under fee licensing in $\bar{r}$-regime is maximized at $\tau = \tilde{\tau}$ and in ε-regime at $\tau = \underline{\tau}$, giving the corresponding industry output $\overline{Q}^{F(\bar{r})}$ and $\overline{Q}^{F(\varepsilon)}$ respectively, and the maximum industry output under royalty licensing is achieved at royalty rate zero. But in this case we have $\overline{Q}^{F(\varepsilon)} > \overline{Q}^{F(\bar{r})}$, given $\varepsilon < \frac{24(a-c)}{25}$, and $\overline{Q}^{F(\varepsilon)} > \overline{Q}^R > \overline{Q}^M$ since $\tau < \varepsilon$. Hence,

Lemma 4: If $\frac{3(a-c)}{4} \leq \varepsilon < \frac{24(a-c)}{25}$, the optimal tariff is $\tau^* = \frac{a-c}{5}$ which induces fee licensing to occur.

Case 3: $\dfrac{24(a-c)}{25} \le \varepsilon < a-c$

For this interval of ε, if $\tau > 5(a-c)+45\varepsilon-4\sqrt{30\varepsilon(a-c)+125\varepsilon^2}$, fee licensing will occur; otherwise, it will be royalty licensing. But the royalty rate will be ε or $\bar{r}$ depending on whether $\tau \le 5(a-c)-5\varepsilon$ or $\tau > 5(a-c)-5\varepsilon$. The corresponding industry output is either $Q^{R(\varepsilon)}$ or $Q^{R(\bar{r})}$. In either case of royalty licensing the industry output is maximized at $\tau = 0$, giving the maximum possible industry output under royalty contract to be $\overline{Q}^R (> \overline{Q}^M)$. On the other hand, under fee contract, the industry output is maximized at $\tau = \hat{\tau} \equiv 5(a-c)+45\varepsilon-4\sqrt{30\varepsilon(a-c)+125\varepsilon^2}$. The corresponding industry output is $Q^F(\hat{\tau}) = \dfrac{1}{3}[-3(a-c)-43\varepsilon+4\sqrt{30\varepsilon(a-c)+125\varepsilon^2}] \equiv \overline{Q}^{F*(\bar{r})}$. But we have $\overline{Q}^{F*(\bar{r})} > \overline{Q}^R$ in the given interval of ε. This gives the following lemma.

Lemma 5: If $\dfrac{24(a-c)}{25} \le \varepsilon < a-c$, industry output is maximized at $\tau = 5(a-c)+45\varepsilon-4\sqrt{30\varepsilon(a-c)+125\varepsilon^2}$ which induces fee licensing to occur.

Considering the results underlying Lemma 3 through 5, we have the final proposition.

Proposition 2: Given any $\varepsilon < (a-c)$, (i) if $\varepsilon < \dfrac{(a-c)}{5}$, consumers' welfare maximizing tariff rate is $\tau^* = 0$ which results in a royalty contract with royalty rate ε, and (ii) for all other values of ε, fee licensing is induced by the choice of optimal tariff τ^* where $\tau^* = \dfrac{a-c}{5}$ if $\varepsilon \in [\dfrac{a-c}{5}, \dfrac{24(\mathrm{a}-\mathrm{c})}{25})$ and $\tau^* = 5(a-c)+45\varepsilon-4\sqrt{30\varepsilon(a-c)+125\varepsilon^2}$ for $\varepsilon \in [\dfrac{24(a-c)}{25},\ a-c)$.

Thus our result shows that if the innovation is small (i.e., $\varepsilon < \dfrac{(a-c)}{5}$), then $r^* = \varepsilon$ and $\tau^* = 0$. In this case consumers have nothing to gain or lose either. On the other hand, if the innovation is large (i.e., $\varepsilon > \frac{(a-c)}{5}$), a suitably designed tariff results in a fee licensing and consumers benefit to the fullest extent.

5. CONCLUSION

This paper discusses whether in an imperfect competition a tariff can benefit the consumers. We have raised this issue in a framework of asymmetric duopoly where the foreign firm possesses the superior production technology and it likes to raise its profit by means of licensing its technology to the backward domestic firm. The foreign firm decides whether it will make fee licensing or royalty licensing. In the absence of any government intervention it is optimal for the foreign firm to adopt royalty licensing where consumers have nothing to gain. The paper shows that a strategic choice of a per unit tariff on foreign products can influence the licensing decision of the patent holder. In particular, a suitably designed tariff rate can induce the foreign firm transfer its technology by means of fee licensing. Then distortionary effect of tariffs on product price vanishes and the full beneficial effect of the superior technology is reaped. A tariff rate can be chosen where consumers' benefit is maximized. Social welfare also goes up because the local firm gains from its higher reservation payoff under the tariff and the local government also acquires a part of the foreign firm's profit in the form of tariff revenue.

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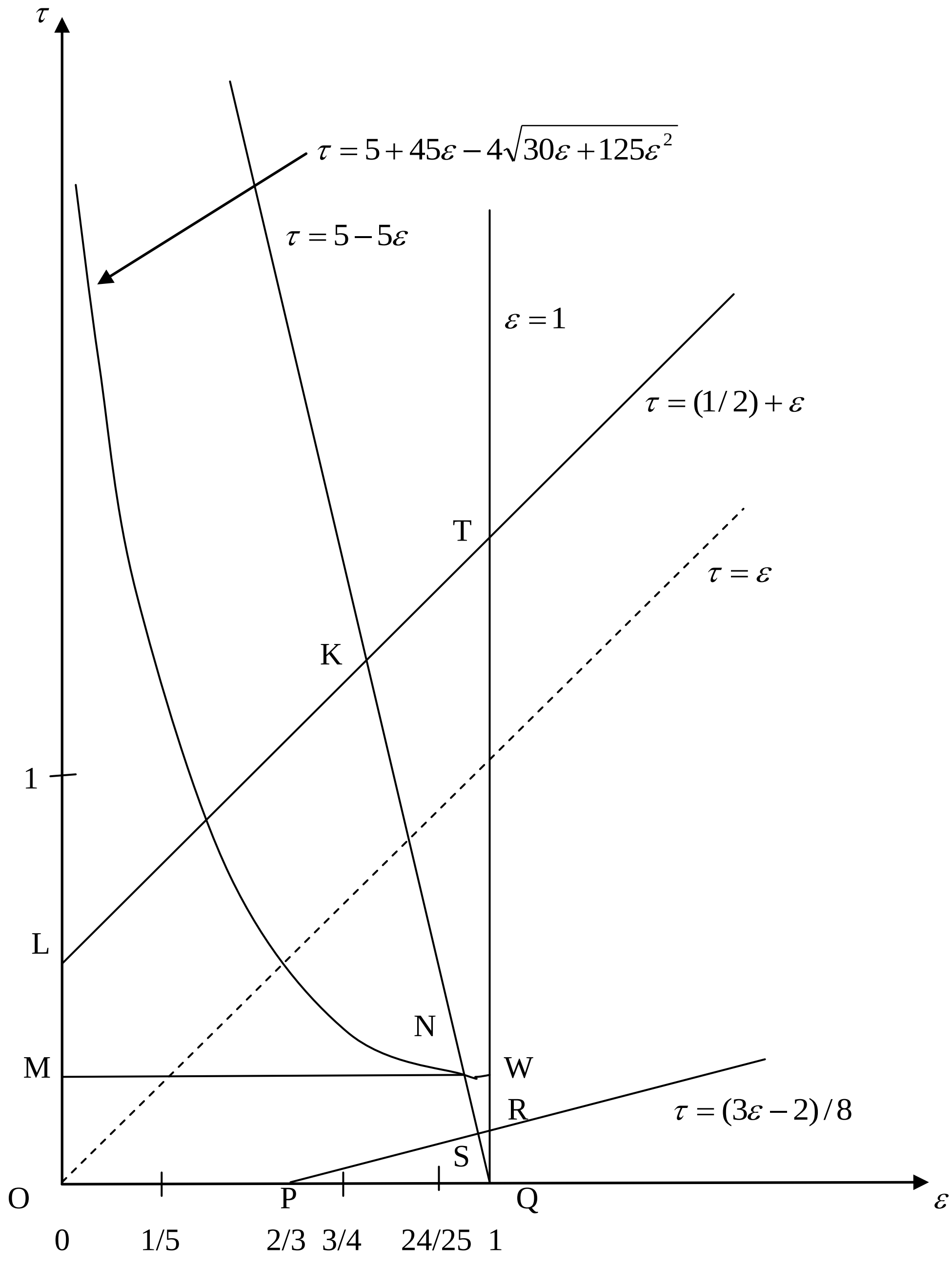

Figure 1: Fee vs. royalty licensing at different values of ε and τ. [Scale: $(a-c)=1$]