Tariffs, Licensing Contracts and Consumers’ Welfare

By

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Abstract

In a duopolistic trade model we have shown that a tariff can influence the optimal licensing strategy of the foreign firm. A high tariff will induce fee licensing and a low tariff will result in a royalty licensing. From the viewpoint of the consumers both high tariff and high royalty are distortionary; hence there is a trade-off between a tariff and a royalty. Then the local government can suitably choose a tariff rate that will induce fee licensing, then consumers’ welfare is maximized.

Keywords: Tariffs; Fee licensing, Royalty licensing; Consumers’ welfare.

JEL Classifications: D43; F13; L13
1. INTRODUCTION

For a long time India and some other developing countries had followed a policy of protectionism. Under this policy, direct entry of the foreign firms was mostly restricted. For instance, foreign direct investment (FDI) was just not allowed in most of the sectors. Even to export their goods to India the foreign firms would have to face high tariffs. The local firms would generally lobby to the government for tariff protection and the government succumbed to their demand. So the local firms had a lot to gain. The local government would also collect tariff revenue. The party in power had also the opportunity of getting funds in the form of donation to the party fund from the firm lobby. Under this situation, however, consumers were worst sufferer; not only had they a very limited access to foreign brands, but, more importantly, they were to pay a much higher price for goods because the local firms under protection would charge near monopoly prices.

Under this protectionism environment, the foreign firms, however, had the opportunity to enter the domestic market by means of technological collaborations with the local firms. Under the collaboration agreements the foreign firms did transfer their superior technologies to the local firms against receiving payments in the form of fixed fees and/or royalties.

Now consider an initiation of the liberalization policy by these countries. Under liberalization environment entry of the foreign firms becomes gradually easier. Consider, in particular, lowering of tariff rates and entry of the foreign firms through exports in the home market. So, under this situation, the local firms begin to face competition from the foreign firms. This competition, however, benefits the consumers who now get goods at lower prices. Even under this situation the option of technology transfer from the low cost foreign firms to high cost local firms continues. This should generally be a win-win situation to the firms, because otherwise they would not agree to a transfer deal. Consumers are likely to gain further because under technology transfer production can be organized more efficiently with the help of superior technologies.

What will be the government’s role under this scenario? In particular, will it follow a zero tariff policy? We assume that the local government is concerned about maximizing consumers’ welfare. In a democratic country like India where a political party comes in
power through votes, the government in power cannot ignore the interest of the consumers who form the major electorate group. Then what will be the optimal tariff? Problems arise because tariffs can affect the optimal licensing strategy of the foreign licensors. Then the question is: how does the tariff affect the licensing strategy? If licensing occurs under a fixed fee contract, there will be no additional price distortion, hence consumers would get the full benefit of the transferred technology. On the other hand, if a technology is transferred under a quantity based royalty contract, the local firms’ cost will go up by the amount of royalty. Hence the full benefit of the lower cost technology cannot be captured. This distortion will raise the price. Therefore, from the viewpoint of the consumers, fee licensing is perhaps desirable.

In the present paper we show that fee licensing will occur if and only if tariffs are high. For example, if the tariff is prohibitive, the foreign firm cannot directly enter with the goods, hence it is optimal for the patentee to transfer a superior technology against a fixed fee so that industry profit is maximum. Thus under prohibitive tariffs, prices will be monopoly prices, and under non-prohibitive tariffs foreign firms’ costs go up by the amount of tariffs which then generate distortion. On the other, hand, if tariffs are very low or close to zero, we can minimize the distortion due to tariffs, but low tariffs will induce royalty licensing which increases local firms’ costs, hence distortion. Thus there is a trade-off between a tariff and an output based royalty -- tariffs raise foreign firms’ costs and royalties raise local firms’ costs, so both are distortionary.

Hence our problem in the present paper is to examine whether tariffs can be strategically chosen so that fee licensing occurs and consumers’ welfare is maximized. We construct a model of asymmetric duopoly consisting of an advanced foreign firm and a technologically backward local firm. Both firms compete in the domestic market. The foreign firm transfers its technology to its local competitor whenever it is profitable. The foreign firm decides whether it will transfer under a fee contract or a royalty contract. Finally, the local government suitably chooses a tariff to maximize consumers’ welfare. It is shown that if the cost asymmetry is large, a suitably designed tariff will induce fee licensing and consumers’ welfare is maximized. However, if the firms are close in terms of their unit costs of production, a zero tariff will be the optimal choice, although it will induce a royalty contract.
The paper most closely related to the present work is by Kabiraj and Marjit (2003). It has constructed a duopolistic trade model and shown that an appropriate tariff rate can induce the foreign firm transfer its superior technology to its domestic rival and raise consumers’ welfare. However, the paper restricts the analysis to the fee licensing only, hence it does not allow the foreign firm decide its optimal licensing strategy. Mukherjee (2007) has the similar duopoly set up and it discusses the optimal licensing contracts from the perspective of the licensor. In Mukherjee (2007), ‘trading costs’ behave in the similar way as tariffs in our paper, but the paper does not attempt to derive the implication of a higher trading cost for the consumers in the context of technology transfer.¹

There are a number of other celebrated papers which discuss licensing contracts. For instance, Wang (1998) discusses technology transfer in a duopoly and has shown that a royalty contract generates a larger payoff to the patent holder. That royalty licensing dominates fee licensing also follows from the works of Wang (2002), Mukherjee and Balasubramanian, (2001), and Fauli-Oller and Sandonis (2002). These papers have considered a differentiated duopoly. In Kishimoto and Muto (2012) fee and royalty are determined through a process of Nash bargaining. In all these papers royalty licensing is generally preferred from the viewpoint of the firms, but fee licensing generates a larger consumer surplus. Fauli-Oller and Sandonis (2002) have however, shown the possibility of welfare reducing licensing. This generally occurs when goods are close substitutes, firms compete in prices and the innovation is large enough.

Among other papers on licensing, Poddar and Sinha (2010) have considered an interesting possibility of licensing from the high cost firm to the low cost firm. This happens because the firm owning the superior technology may not necessarily be cost efficient. This result has implication in the context of our present paper in that the tariff-inclusive effective cost of the superior technology owning firm may be larger than the production cost of the domestic backward firm. The issue of technology licensing and its welfare implications in a Stackelberg structure are discussed in Kabiraj (2005). Finally, in an international duopoly set up Wang, Wang and Zhao (2012) have shown that consumer friendly initiatives on the part of the foreign firm invite a lower tariff that benefits all parties involved.

¹ See Sen and Tauman (2007) for the licensing contracts in oligopoly in a general set up. The paper also discusses the related issues.
In the empirical literature we observe all sorts of licensing contracts, viz., fee licensing only, royalty licensing only, and also both fee and royalty (that is, two-part tariff licensing) contracts.\(^2\) In the present paper we restrict our analysis to the cases of fee licensing and royalty licensing only. In the set up of our paper when tariffs are in the intermediate range, ‘fee plus royalty licensing’ can be shown to be 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 the tariff rate, in (subgame perfect) equilibrium, therefore, fee plus royalty will never occur.

The paper is organized as follows. Section 1 presents the model and Section 3 discusses the optimal licensing strategies of the patent holder. Then in Section 4 consumers’ welfare and optimal tariffs are discussed. Finally, Section 5 concludes the paper.

2. MODEL

Consider that initially one foreign firm (call firm 1) and one local firm (call firm 2) are competing in the local market in a Cournot fashion. The market demand for a homogenous product is given by the linear function, \( P = a - Q = a - (q_1 + q_2) \), where \( P \) denotes the price of the product and \( Q \) is the industry output. The local firm’s technology is represented by the constant marginal cost of production \( c \) \((0 < c < a)\). The foreign firm holds a superior technology given by the marginal cost of production \((c - \varepsilon)\) where \( \varepsilon > 0 \) represents the extent of cost saving, that is, the size of the innovation. We further assume that the innovation is minor or non-drastic in the sense that the backward (here local) firm will have a positive market share. Hence we restrict to the assumption that\(^3\) \( \varepsilon < a - c \).

Now since the foreign firm possesses the superior technology, we assume that before product market competition takes place the foreign firm has three options to decide, viz., no licensing, fee licensing and royalty licensing. However, the local government which likes to maximize the consumers’ welfare will try to influence the licensing strategy of the foreign firm by

\(^2\) See Rostoker (1984), for instance.

\(^3\) Under Cournot equilibrium, with zero tariff, the local firm’s output is \( q_2 = (a - c - \varepsilon)/3 \). Therefore it survives if and only if \( \varepsilon < a - c \).
means of manipulating its only available instrument here, namely a tariff, \( \tau \geq 0 \), on foreign products. Consumers’ welfare is measured by consumers’ surplus.

The game in the paper is the following. In the first stage, the local government decides 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; the local firm is assumed to accept the contract if it is not worse off. In the third or final stage, based on the technological configuration emerged at the end of the second stage, the firms play Cournot and decide their quantities. We solve the game by backwards induction method.

2.1 Licensing Strategies

In this section we consider the scenario of each of no licensing, 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.\(^4\)

2.1.1 Benchmark Case: No Licensing

Given the assumption that the innovation is non-drastic (i.e., \( \varepsilon < a - c \)), for any non-prohibitive tariff \( \tau \geq 0 \), no licensing equilibrium quantities under Cournot competition are:

\[
q_{1NL} = \frac{a - c + 2\varepsilon - 2\tau}{3} \quad \text{and} \quad q_{2NL} = \frac{a - c - \varepsilon + \tau}{3}
\]

Note that if the tariff be prohibitive, the foreign firm will cease to operate and the local firm will emerge as monopolist. This occurs if \( \tau \geq \frac{a - c + 2\varepsilon}{2} \). Hence under non-prohibitive tariffs market structure will be duopoly. We assume an initial duopoly. Hence we restrict to the assumption that tariffs are non-prohibitive, that is,

\[
0 \leq \tau < \frac{a - c + 2\varepsilon}{2} \quad (1)
\]

\(^4\) If the innovation is drastic, a positive tariff greater than a critical level is required to ensure the initial duopoly.
The corresponding profits under no-licensing scenario are:

\[
\pi_{1}^{NL} = \frac{(a-c+2\varepsilon-2\tau)^2}{9} \quad \text{and} \quad \pi_{2}^{NL} = \frac{(a-c-\varepsilon+\tau)^2}{9}
\]  

(2)

2.1.2 Licensing by a Fixed Fee

Under fee licensing while both the firms will have the same production technology, but firm 2’s at unit cost of production will be \(c-\varepsilon\), and firm 1’s unit cost will be \(c-\varepsilon+\tau\); however, 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

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

(3)

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

\[
\tau > \frac{3\varepsilon-2(a-c)}{8}
\]

(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 if and only if
\[
\tau \in \left[ \max\{ 0, \frac{3\varepsilon - 2(a-c)}{8} \}, \frac{a-c + 2\varepsilon}{2} \right).
\]

Intuition of the result is simple. In a duopoly superior technology transfer has two effects. While *competitive effect* dissipates industry profit, *efficiency effect* enhances it. Now, if the initial technological gap between the firms is large, competitive effect will dominate efficiency effect and industry profit will fall. Therefore, fee licensing is profitable if and only if their unit cost difference is smaller. A tariff on foreign product reduces the effective cost difference and fee licensing becomes privately profitable. On the other hand, given any technological gap, a very high tariff can prohibit all imports.

We present all our results in the paper in *Figure 1*, taking \( a-c=1 \). In the figure, all points \((\varepsilon, \tau)\) in the area \( \Delta = OQTLO \) satisfy the initial restrictions that \( 0 < \varepsilon < a-c \) and
\[
0 \leq \tau < \frac{a-c + 2\varepsilon}{2}
\]
(except of course the relevant boundary points). Then for all \((\varepsilon, \tau)\) in \( \Delta_f = OPRTLO \), fee licensing is preferred to no licensing; \( \Delta_f \subset \Delta \). Formally to define,
\[
\Delta = \{ (\varepsilon, \tau) \mid \varepsilon \in (0, a-c) \ \& \ \tau \in [0, \frac{a-c + 2\varepsilon}{2}] \}
\]
\[
\Delta_f = \{ (\varepsilon, \tau) \mid \varepsilon \in (0, a-c) \ \& \ \tau \in \left[ \max\{ 0, \frac{3\varepsilon - 2(a-c)}{8} \}, \frac{a-c + 2\varepsilon}{2} \right) \}
\]

### 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

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5 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 \( \varepsilon - (a-c) \leq \tau < \frac{a-c + 2\varepsilon}{2} \).
\[
\pi_i^R = \frac{(a - c + \varepsilon - 2\tau + r)^2}{9} \quad \text{and} \quad \pi_i^L = \frac{(a - c + \varepsilon + \tau - 2r)^2}{9}
\]

Then licensor’s total income under royalty licensing is
\[
\Pi_1^R = \pi_i^R + r q_i^R = \frac{(a - c + \varepsilon - 2\tau + r)^2}{9} + r \frac{(a - c + \varepsilon + \tau - 2r)}{3}
\]  \tag{5}

So the optimal royalty \( r^* \) solves the problem:
\[
\max_r \Pi_1^R \quad \text{subject to} \quad \pi_i^L \geq \pi_i^{NL} \quad (i.e., \ r \leq \varepsilon).
\]

Free maximization of the problem generates
\[
r = \frac{5(a - c + \varepsilon) - \tau}{10} = a - c + \varepsilon - \frac{\tau}{10} \equiv \bar{r}
\]

We can check that
\[
\varepsilon < \bar{r} \quad \text{according as} \quad \tau \leq 5(a - c) - 5\varepsilon = \bar{\tau}
\]  \tag{6}

This gives the optimal royalty rate under the royalty contract as
\[
r^* = \varepsilon \quad \text{if} \quad \varepsilon \leq \bar{r} \quad \text{i.e.,} \quad \tau \leq \bar{\tau}
\]
\[
= \bar{r} \quad \text{if} \quad \varepsilon > \bar{r} \quad \text{i.e.,} \quad \tau > \bar{\tau}
\]  \tag{7}

Hence firm 1’s total income under the optimal royalty contract is
\[
\Pi_1^R = \pi_i^R + r q_i^R = \begin{cases} 
\Pi_1^{R(\varepsilon)} & \text{if} \quad \tau \leq \bar{\tau} \\
\Pi_1^{R(\tau)} & \text{if} \quad \tau > \bar{\tau}
\end{cases}
\]  \tag{8}

where,
\[
\Pi_1^{R(\varepsilon)} = \frac{(a - c + 2\varepsilon - 2\tau)^2}{9} + \varepsilon \frac{(a - c - \varepsilon + \tau)}{3}
\]
\[
\Pi_1^{R(\tau)} = \frac{(a - c + \varepsilon - \tau)^2}{4} + \frac{\tau^2}{5}
\]

Then we can easily check that for all \((\varepsilon, \tau) \in \Delta\) we have
\[
\Pi_1^R > \pi_i^{NL}\]  \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 \((\varepsilon, \tau)\) in the area \(\Delta_{R(\varepsilon)} = \triangle QKLO\) we have \(r^* = \varepsilon\),
and in the area \(\Delta_{R(\tau)} = \triangle QTKQ\) we have \(r^* = \bar{r}\). We call these two regimes as \(\varepsilon\)-regime and \(\bar{r}\)-regime. Formally to define,
\[ \Delta_{R(\varepsilon)} = \{(\varepsilon, \tau) \mid \varepsilon \in (0, a - c) \text{ and } \tau \in [0, \min\{5(a - c) - 5\varepsilon, \frac{a - c + 2\varepsilon}{2}\}] \} \]

\[ \Delta_{R(\tau)} = \{(\varepsilon, \tau) \mid \varepsilon \in (0, a - c) \text{ and } \tau \in (5(a - c) - 5\varepsilon, \frac{a - c + 2\varepsilon}{2})\} \]

\[ \Delta_R = \Delta_{R(\varepsilon)} \cup \Delta_{R(\tau)} = \Delta. \]

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

Under royalty licensing the rival’s competitive prowess remains checked, but the use of efficient technology due to licensing generates a surplus that can be extracted by the transferor by means of a royalty. Hence royalty licensing is always profitable.

3. Optimal Licensing Strategy: 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 \(\tau\). 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 \(\varepsilon\) as the royalty rate), that is, \(\Pi^F_1\) and \(\Pi^R_1\), we see that
\[ \Pi_i^F > \Pi_i^{R(c)} \quad {\text{iff}} \quad \tau > \frac{a-c}{5} \equiv \tau \]  

(10)

In the figure, \( \Pi_i^F > \Pi_i^{R(c)} \) occurs for all \( (\varepsilon, \tau) \) in the area \( \Delta_1 \equiv MNKLM \), where

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

Then royalty licensing will occur for any \( (\varepsilon, \tau) \) in the area QNMO. Note that in the area \( \Delta_2 \equiv OPSNMO \), we have \( \Pi_i^{R(c)} > \Pi_i^F \), and in the area \( \Delta_3 \equiv PQSP \) only royalty licensing is profitable, fee licensing is not; \( \Delta_1 \cup \Delta_2 \cup \Delta_3 = \Delta_{R(c)} \).

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., \( \Pi_i^F > \Pi_i^{R(c)} > \pi_i^{NL} \)); and if \( (\varepsilon, \tau) \in \Delta_2 \cup \Delta_3 \), royalty licensing is preferred to fee licensing and no licensing.

Note that for \( (\varepsilon, \tau) \in \Delta_2 \), we have \( \Pi_i^{R(c)} > \Pi_i^F > \pi_i^{NL} \) and for \( (\varepsilon, \tau) \in \Delta_3 \) we have \( \Pi_i^{R(c)} > \pi_i^{NL} > \Pi_i^F \).

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

\[ \Pi_i^F > \Pi_i^{R(F)} \quad {\text{iff}} \quad \tau > 5(a-c) + 45\varepsilon - 4\sqrt{30}\varepsilon(a-c) + 125\varepsilon^2 \equiv \hat{\tau}(\varepsilon) \]  

(11)

In the figure, \( \Pi_i^F > \Pi_i^{R(F)} \) occurs for all \( (\varepsilon, \tau) \) in the area \( \Delta_4 \equiv TKNWT \), and \( \Pi_i^F < \Pi_i^{R(F)} \) occurs for all \( (\varepsilon, \tau) \) in the area \( \Delta_5 \equiv NWQN \). Therefore,

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

\[ \Delta_5 = \{ (\varepsilon, \tau) \mid \varepsilon \in (0, a-c) \quad \& \quad \tau \in (5(a-c) - 5\varepsilon, \hat{\tau}(\varepsilon)) \} \]

\[ \Delta_4 \cup \Delta_5 = \Delta_{R(F)} \]

Formally, \( \Delta_2 = \{ (\varepsilon, \tau) \mid \varepsilon \in (0, a-c) \quad \& \quad \tau \in [\max\{0, \frac{3\varepsilon - 2(a-c)}{8}\}, \min\{\frac{a-c}{5}, 5(a-c) - 5\varepsilon]\} \} \) and \( \Delta_3 = \{ (\varepsilon, \tau) \mid \varepsilon \in (\frac{2(a-c)}{3}, a-c) \quad \& \quad \tau \in [0, 5(a-c) - 5\varepsilon]\} \).
**Proposition 1(b):** For any \((\varepsilon, \tau)\) 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 \(\bar{r} \).\(^7\)

Intuition of the results underlying Proposition 1 is the following. Although the foreign firm possesses a superior technology, a tariff increases its effective cost of production and it is perfectly possible that the tariff inclusive unit cost of production of the foreign firm is even larger than the unit cost of the local firm in the pre-license situation. Under prohibitive tariffs fee licensing will strictly dominate royalty licensing because royalty licensing creates a distortion and the full benefit of efficiency effect cannot be obtained. On the other hand, when the tariff is low, so that effective cost of the foreign firm is not large relative to the unit cost of the local firm, royalty licensing will strictly dominate fee licensing. Therefore, fee licensing will occur if the tariff be set above a critical level.

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

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

4. Consumers’ Welfare and the Optimal Tariff Rate

In this section we derive optimal tariff rates, under different scenarios, that maximize consumers’ welfare. First consider consumers’ welfare under different licensing schemes, given any \((\varepsilon, \tau)\). Consumers’ welfare is measured by consumers’ surplus (CS). With linear demand function, \((CS) = (1/2)Q^2\). 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:

\[
Q_{NL}^\varepsilon (\tau) = q_{1NL}^\varepsilon + q_{2NL}^\varepsilon = \frac{1}{3}[2(a - c) + \varepsilon - \tau]
\]

Note that for all \((\varepsilon, \tau)\) in QRSQ, only royalty licensing is profitable (fee licensing is not), therefore royalty contract with \(r^* = \bar{r}\) will occur.

\(^7\) Note that for all \((\varepsilon, \tau)\) in QRSQ, only royalty licensing is profitable (fee licensing is not), therefore royalty contract with \(r^* = \bar{r}\) will occur.
Therefore, given any \((c, \tau)\), we have

(i) \(Q^F > Q^{R(c)} = Q^{NL}\) and (ii) \(Q^F > Q^{R(\tau)} > Q^{NL}\).

Hence,

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

that is, consumers’ welfare is largest under fee licensing,\(^8\) given any \(c\) and \(\tau\). In our model \(c\) is a parameter exogenously specified whereas \(\tau\) is a variable to be decided by the local government. Moreover, we have seen that the choice of \(\tau\) influences the optimal licensing decision of the licensor. We now discuss the optimal choice of \(\tau\), given any \(c\), so as to maximize consumer’s welfare (equivalent to maximizing industry output). Note that each of \(Q^F\), \(Q^{R(c)}\) and \(Q^{NL}\) goes up as \(\tau\) falls. On the other hand, if \(\tau \geq \frac{a-c+2c}{2}\), fee licensing will occur, and the corresponding industry output is \(Q^M(\tau) = \frac{a-c+c}{2}\).

**Optimal Tariff Rate**

Recall that we have defined the following.

\[\tau = \frac{a-c}{5}; \quad \tilde{\tau} = 5(a-c)-5c; \quad \breve{\tau} = 5(a-c)+45c-4\sqrt{30c(a-c)+125c^2}\]

Correspondingly,

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

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

\(^8\) 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 \(c\). 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.
\[ Q^F(\tau) = \frac{1}{3}[-3(a-c) - 43\varepsilon + 4\sqrt{30\varepsilon(a-c) + 125\varepsilon^2}] \equiv Q^{F(\tau)} \]

Further,\(^9\)

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

Then,

\[ Q^{F(c)} > Q^R \iff \varepsilon > \frac{a-c}{5} \]

\[ Q^R > Q^M \forall \varepsilon < (a-c) \]

\[ Q^{F(c)} > Q^{F(\tau)} \iff \varepsilon < \frac{24(a-c)}{25}, \tau > 0 \]

\[ Q^R > Q^{R(\tau)}(\tau) \forall \varepsilon \in \left(\frac{24(a-c)}{25}, a-c\right) \]

Now, we can determine the consumers’ welfare maximizing tariff rate \( (\tau^*) \), given any \( \varepsilon \). Consider the following cases.\(^\text{10}\)

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

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

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

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

If \( \tau \) is chosen from \( \left[\frac{(a-c)}{5}, \frac{a-c+2\varepsilon}{2}\right] \), 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 \( \tau = \frac{(a-c)}{5} \), that is, \( Q^F(\tau) = \frac{1}{3}\left[\frac{9(a-c)}{5} + 2\varepsilon\right] = Q^{R(c)} \).

\(^9\) Note that \( Q^{R(\tau)}(0) \) will never occur because \( \varepsilon < a-c \).

\(^\text{10}\) Consider the following critical values of \( \varepsilon \). 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 \( \tau = 5(a-c) + 45\varepsilon - 4\sqrt{30\varepsilon(a-c) + 125\varepsilon^2} \) gives \( \varepsilon = \frac{24(a-c)}{25} \).
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 $\bar{Q}^{F(\varepsilon)} > \bar{Q}^R \Leftrightarrow \varepsilon > \frac{a-c}{5}$, $\bar{Q}^{F(\varepsilon)} > \bar{Q}^M$ and $\bar{Q}^{R(\varepsilon)} > \bar{Q}^M$, 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 $\varepsilon$, royalty licensing will occur if $\tau < \frac{a-c}{5}$ and fee licensing will occur if $\tau \in \left[\frac{a-c}{5}, \frac{a-c+2\varepsilon}{2}\right)$. Note that $\tau$ can be chosen either from $\bar{r}$-regime or from $\varepsilon$-regime (see (10) and (11)). Industry output under fee licensing in $\bar{r}$-regime is maximized at $\tau = \bar{r}$ and in $\varepsilon$-regime at $\tau = \bar{\varepsilon}$, giving the corresponding industry output $\bar{Q}^{F(\tau)}$ and $\bar{Q}^{F(\varepsilon)}$ respectively, and the maximum industry output under royalty licensing is achieved at royalty rate zero. But in this case we have $\bar{Q}^{F(\varepsilon)} > \bar{Q}^{F(\tau)}$, given $\varepsilon < \frac{24(a-c)}{25}$, and $\bar{Q}^{F(\varepsilon)} > \bar{Q}^R > \bar{Q}^M$ 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:** $\frac{24(a-c)}{25} \leq \varepsilon < a-c$

For this interval of $\varepsilon$, 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 $\varepsilon$ or $\bar{r}$ depending on whether $\tau \leq 5(a-c) - 5\varepsilon$ or $\tau > 5(a-c) - 5\varepsilon$. The corresponding industry output is either
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 \( \tau = \hat{\tau} = 5(a-c) + 45\varepsilon - 4\sqrt{30\varepsilon(a-c)+125\varepsilon^2} \). The corresponding industry output is \( Q^F(\hat{\tau}) = \frac{1}{3}[-3(a-c) - 43\varepsilon + 4\sqrt{30\varepsilon(a-c)+125\varepsilon^2}] \equiv \overline{Q}^{F(\tau)} \). But we have \( \overline{Q}^{F(\tau)} > \overline{Q}^R \) in the given interval of \( \varepsilon \). This gives the following lemma.

**Lemma 5:** If \( \frac{24(a-c)}{25} \leq \varepsilon < a-c \), 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 \( \varepsilon < \frac{(a-c)}{5} \), consumers’ welfare maximizing tariff rate is \( \tau^* = 0 \) which results in a royalty contract with royalty rate \( \varepsilon \), and (ii) for all other values of \( \varepsilon \), fee licensing is induced by the choice of optimal tariff \( \tau^* \) where \( \tau^* = \frac{a-c}{5} \) if \( \varepsilon \in [\frac{a-c}{5}, \frac{24(a-c)}{25}] \) and \( \tau^* = 5(a-c) + 45\varepsilon - 4\sqrt{30\varepsilon(a-c)+125\varepsilon^2} \) for \( \varepsilon \in [\frac{24(a-c)}{25}, a-c] \).

Thus our result shows that if the innovation is small (i.e., \( \varepsilon < \frac{(a-c)}{5} \)), then \( \tau^* = \varepsilon \) 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. Therefore, to maximize consumers’ welfare a tariff is set at a level that just induces fee licensing.
5. CONCLUSION

In this paper we have constructed a duopolistic trade model and considered technology transfer from the advanced foreign firm to the backward domestic firm when both of them compete a la Cournot in the same domestic market. We show that the local government can, by means of a tariff, influence the licensing strategy of the foreign firm. In particular, if the tariff rates are low, technology transfer occurs under a royalty contract, and if the tariffs are high, fixed fee licensing contract is optimal for the patent holder. A tariff raises the effective cost of the foreign firm and a quantity based royalty increases the unit cost of the local firm; hence from the viewpoint of the consumers’ welfare, both are distortaionary. Therefore, there is a trade-off between a tariff and a royalty rate. The local government which likes to care the interest of the consumers can manipulate the tariff rate and strategically choose a tariff that induces the foreign firm transfer its superior technology to the local firm under a fee contract. This will maximize consumers’ welfare. When the extent of cost saving under the transferred technology is too small, a zero tariff is optimal; under this situation royalty licensing will occur.
References


Figure 1: Fee vs. royalty licensing at different values of \( \varepsilon \) and \( \tau \). [Scale: \( (a - c) = 1 \)]