Trade Liberalization, Technology Transfer and Endogenous R&D

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(This version: 2013/7/11)

Abstract
It is generally believed that trade liberalization can impede technology transfers from aboard. By considering R&D behavior of the foreign firm, this paper shows contrarily that trade liberalization has a positive effect on the foreign firm’s R&D, resulting in a better technology to be transferred to the domestic firm and enhancing both the domestic and the world welfare. This result holds even if trade liberalization originates from non-tariff barriers such as quotas. Moreover, by comparing the levels of technology transfer between the two regimes, we find that if the trade barrier is high (low), the technology transferred from the foreign firm under the equivalent quota regime is superior (inferior) to that under the tariff regime. Finally, a ban on technology export by the foreign country may surprisingly induce the foreign firm to invest more on its R&D.

*JEL Classification:* D43; F13; L13

*Keywords:* Trade Liberalization; Technology Licensing; R&D; Social Welfare

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1. Introduction

International technology transfer has been burgeoning in the world.¹ Many firms in developing countries, such as China, endeavor to catch up the technology ladder via technology transfer from developed countries and then to become more competitive in a global market. It has been argued that a government can use a trade protection policy to induce foreign firms to transfer their superior technology to domestic firms e.g., Kabiraj and Marjit, 2003; Mukherjee and Pennings, 2006, among others. By employing an international duopoly Cournot model and treating the technology level as an endogenous variable, we shall show that a more superior technology will be transferred from aboard as trade barriers decrease. That is to say, a less restrictive trade policy can help the domestic firm acquire more advanced technology, a result which has not been documented in the literature.

The literature on trade policies and the protected firm’s technology choice is quite vast. For example, Reitzes (1991) shows that quotas and tariffs often result in opposite effects on the protected firm’s R&D investments. Miyagiwa and Ohno (1995) find that a permanent tariff accelerates the protected firm’s technology adoption, while a permanent quota procrastinates the protected firm’s adoption unless the quota is highly restrictive. Furthermore, Chiou et al. (2006) assume there is a foreign firm competing with a domestic firm in the domestic market and compare the effects of a tariffs and the equivalent quota on the domestic firm’s technology choice. They find that the technology level chosen by the protected firm is necessarily higher under a tariff than the equivalent quota if the two firms compete in Cournot fashion but the ranking is ambiguous if the two firms compete in Bertrand fashion. However, all these

¹ See Rostoker (1984) and Saggi (2002) for empirical surveys on this issue.
papers focus on how trade policies affect the protected firm’s indigenous technology choice, and fail to capture another technology development channel that firms can upgrade their technology through international technology licensing. The main purpose of this paper is therefore to investigate how trade protection affects the foreign firm’s R&D which in turn affects the technology level transferred to the domestic protected firm.

There is an extensive body of literature that investigates the relationship between trade policies and international technology licensing. Some of them are specifically relevant to our paper, including Kabiraj and Marjit (1993, 2003), Mukherjee and Pennings (2006) and Horiuchi and Ishikawa (2007). Kabiraj and Marjit (2003) consider a duopoly model where a foreign firm and a domestic firm compete in the domestic country and show that tariff may induce a technology transfer from the foreign firm to the domestic firm thereby making consumers in the domestic country better off. Our model differs from theirs in several ways. First, they treat the foreign technology as an exogenously binary whereas we allow the foreign firm to choose endogenously its R&D. Second, they consider only tariff barriers, but we study both tariff and non-tariff barriers and compare their effects on technology transfers. Finally, they assume the foreign firm adopts fixed-fee licensing whereas we assume it chooses royalty as the means of licensing. Mukherjee and Pennings (2006) set up a model in which the foreign monopolist can license its superior technology to either another foreign firm or to a domestic firm. They explore how the host government uses a tariff policy to affect the licensing decision and the domestic welfare. Both papers suggest that an increase in tariff encourages international technology transfer. Moreover, Horiuchi and Ishikawa (2007) show that either an increase in tariff which incurs a tariff-jumping effect or a decrease in tariff which results in an entry-deterring effect can induce technology transfer from foreign firms. However, these papers have
overlooked the fact that trade policies may alter the R&D behavior of the foreign firm and the technology level to be transferred to the domestic firm. By treating the R&D of the foreign firm to be endogenously determined, we shall show that trade liberalization can in fact help the domestic firm acquire a better technology as it induces the foreign firm to invest more on its R&D.

Like the finding in our paper, Kabiraj and Marjit (1993) also show that the technologically advanced foreign firm may not transfer its best technology to the backward domestic firm, owing to the potential threat of competition from the licensee firm in other markets. However, there is no trade policy in their model and their focus is quite different from ours.

The main findings of this paper are as follows. In contrast to the findings in Kabiraj and Marjit (2003) and Mukherjee and Pennings (2006), we show that a higher tariff tends to impede the foreign firm’s R&D investment, causing the foreign firm to transfer an inferior technology to the domestic firm via licensing. A more restrictive quota has a similar effect. By comparing the technology transfers between a tariff and the equivalent quota, we find that the licensed technology under a tariff is superior (inferior) to that under the equivalent quota if the tariff rate is low (high). We also show, if the tariff rate is low (high), the domestic welfare under the tariff regime is indifferent from (higher than) that under the equivalent quota regime. This result is in parallel to Hwang et al. (2013). Furthermore, the ranking of the foreign welfare is ambiguous between the two regimes, depending on the licensing revenue and the R&D efficiency of the foreign firm.

Many developed countries impose a tight control on its technology export. In this paper, we have also examined the effect of such a policy on the foreign firm’s R&D. It

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2 Hwang et al (2013) examine the welfare effect of tariffication in a duopoly model with differentiated products and come up with the similar result. However, they do not consider international technology transfer.
is found with surprise that if the R&D efficiency of the foreign firm is high, a ban on technology export increases the foreign firm’s R&D investment. Finally, a global tariff reduction will definitely induce the foreign firm to transfer a better technology to firms in developing countries.

The remainder of the paper proceeds as follows. Section 2 sets out the basic model. Section 3 examines the effect of trade liberalization on the technology level transferred from aboard. Section 4 explores whether a quota or a tariff is more efficient in inducing superior technology transfer. Section 5 investigates the effect of a technology export control on the foreign firm’s R&D. Section 6 concludes the paper.

2. The basic model

Consider a domestic market with a domestic firm and a foreign firm producing a homogeneous good and competing in Cournot fashion. The foreign firm can reduce its marginal cost via R&D, \( x \), and the R&D cost function is defined as \( V(x;\nu) \) with

\[
\frac{\partial V}{\partial x} = V_s > 0, \quad \frac{\partial^2 V}{\partial x^2} = V_{ss} > 0, \quad \frac{\partial V}{\partial \nu} = V_v > 0, \quad \frac{\partial^2 V}{\partial x \partial \nu} = V_{sv} > 0,
\]

where \( \nu \) measures the R&D efficiency and a higher \( \nu \) means lower R&D efficiency. This R&D investment lowers the foreign firm’s marginal cost by \( x \) (i.e., the marginal cost of the foreign firm becomes \( c - x \)). To ensure licensing to take place, the technology of the foreign firm is assumed to be non-drastic throughout this paper, i.e., the R&D efficiency cannot be too high.\(^3\) Also, when licensing its technology, the foreign firm charges a per unit royalty rate, \( r \). Thus, after licensing, the marginal cost of the domestic firm is \( c - x + r \). Moreover, the inverse demand function for the good takes the following form: \( p = p(q + q^*) \) with \( p' < 0 \) and \( p'' = 0 \) where \( q \) and

\(^3\) If the innovation is drastic, the foreign firm acts as a monopolist in the domestic market and thus has no incentive to license its technology to the domestic firm (Wang, 1998). This case is very straightforward and shall not be pursued further in our paper.
\( q^* \) are respectively the outputs of the domestic firm and the foreign firm, “primes” refer to derivatives, and an asterisk is added to variables associated with the foreign firm. We further assume that the domestic government imposes either a quota or a specific tariff on imports from the foreign firm.

The game in question consists of three stages. In the first stage, the foreign firm, given the trade policy of the domestic government, determines its optimal technology level. In the second stage, taking the technology level as given, the foreign firm licenses its superior technology to the domestic firm through a royalty contract. In the third stage, the two firms compete in quantity in the domestic market. Before the first stage of the game, the domestic government can impose a trade policy, being an import tariff or an import quota. We shall examine how trade protection affects the R&D of the foreign firm and the technology acquired by the domestic firm. This gives rise to a subgame perfect equilibrium in the three-stage game. We shall solve this equilibrium by the standard backward induction.

3. Trade liberalization and technology transfer

In this section, we examine the impact of trade liberalization on the technology level transferred from the foreign firm when tariff is taken as the protection policy. To solve the subgame perfect equilibrium, we begin with the third-stage game. The profit functions of the domestic firm and the foreign firm can be specified respectively as follows.

\[
\pi(q, q^*) = (P - c + x)q - rq, \tag{1}
\]

\[
\pi^*(q^*, q) = (P - c + x - t)q^* + rq - V, \tag{2}
\]

where \( t \) is the specific tariff imposed by the domestic government.

By differentiating (1) with respect to \( q \) and (2) with respect to \( q^* \), the
first-order conditions for profit maximization in the third-stage game are derivable as follows:

\[
\frac{d\pi}{dq} = P - c + x - r + P'q = 0, \quad (3)
\]

\[
\frac{d\pi^*}{dq^*} = P - c + x - t + P'q^* = 0. \quad (4)
\]

The second-order conditions are satisfied as \(d^2\pi/dq^2 = 2P' < 0\) and \(d^2\pi^*/dq^{*2} = 2P' < 0\), and the stability condition is also satisfied as \(H = (d^2\pi/dq^2)(d^2\pi^*/dq^{*2}) - (d^2\pi/dq dq^*)(d^2\pi^*/dq dq^*) = 3(P')^2 > 0\). From (3) and (4), we can derive the following comparative static effects:

\[
\frac{dq}{dt} = \frac{-1}{3P'}, \quad \frac{dq}{dr} = \frac{2}{3P'}, \quad \text{and} \quad \frac{dq}{dx} = \frac{-1}{3P'}; \quad (5)
\]

\[
\frac{dq^*}{dt} = \frac{2}{3P'}, \quad \frac{dq^*}{dr} = \frac{-1}{3P'}, \quad \text{and} \quad \frac{dq^*}{dx} = \frac{-1}{3P'}. \quad (6)
\]

These equations indicate that the domestic firm’s output increases with tariff and the foreign firm’s technology level but decreases with the royalty rate while the foreign firm’s output increases with the royalty rate and its technology level but decreases with the tariff.

We now move to the second-stage game to derive the optimal royalty rate. By substituting \(q(r, x)\) and \(q^*(r, x)\) derived from (3) and (4) into (1), we can rewrite the profit function of the foreign licensor firm as follows:

\[
\begin{align*}
\max_r \pi^* (q(r), q^*(r), r; x, v) &= (P - c + x - t)q^* + rq - V(x, v), \\
\text{s.t. } &\quad (P(r, x) - c - x + r)q(r, x) \geq (P(x) - c)q(x).
\end{align*}
\]

The above equation indicates that the foreign firm’s optimal royalty rate is subject to an incentive constraint such that the domestic firm makes no less profits after licensing, so as to ensure the licensing contract to be accepted by the domestic firm. By differentiating (7) with respect to \(r\) and utilizing (3) and (4), we can derive the first-order condition for profit maximization as follows:
From (8) and utilizing (5), it is straightforward to show that \( d\pi^*/dr = 5q/3 > 0 \) if \( t = 0 \). This implies that the marginal profit with respect to the royalty rate is definitely positive under free trade. In this context, the licensor firm would set the royalty rate as high as possible and the optimal royalty rate has the corner solution of \( r = x \) owing to the participating constraint of the licensee firm. Furthermore, this marginal profit decreases with \( t \) as \( d^2\pi^*/drdt = 1/(9p') < 0 \). By setting (8) to zero, we can derive that the marginal profit drops to zero at \( t = -5P'q/2 > 0 \equiv \hat{t} \). Therefore, the licensor firm always has an incentive to set \( r = x \) if \( 0 < t < \hat{t} \). When \( t \) is at this interval, it is straightforward to show that the foreign firm is better off but the domestic firm is indifferent after the licensing. On the other hand, if \( t \geq \hat{t} \), the marginal profit in (8) can be positive, zero or negative, depending on the royalty rate. Under such a circumstance, the optimal royalty rate has an interior solution and is definitely smaller than \( x \). As a result, both the foreign and the domestic firms are better off after the licensing. In sum, the optimal royalty rate can take either a corner or an interior solution, depending on the magnitude of the tariff:

\[
r = \begin{cases} 
  x & \text{if } 0 < t < \hat{t} \\
  -P'(q^* + \frac{3}{2}q) & \text{if } t \geq \hat{t} .
\end{cases}
\]

(9)

Moreover, utilizing (5) and (6), we can also derive the following comparative static effect:

\[
\frac{\partial r}{\partial x} = \begin{cases} 
  1 & \text{if } 0 < t < \hat{t} \\
  1/2 & \text{if } t \geq \hat{t} .
\end{cases}
\]

(10)

Given these properties, we can specify the profit function of the foreign firm for the first-stage game as follows:

\[
Max_{r} \pi^*(q(r(x), x; v), q^*(r(x), x), r(x), x; v) = (P - c + x - t)q^* + rq - V(x; v).
\]
The optimal R&D of the foreign firm can be derived by differentiating (11) with respect to $x$ which leads to the following first-order condition for profit maximization:

$$\frac{d\pi^*}{dx} = \frac{\partial \pi^*}{\partial q} \frac{dq}{dx} + \frac{\partial \pi^*}{\partial r} \frac{dr}{dx} + \frac{\partial \pi^*}{\partial x} = (P'q^*) \frac{dq}{dx} + \frac{q^*}{q - \frac{V}{2}} r + \frac{\partial}{\partial x} + \frac{V}{2} = 0. \quad (12)$$

The second-order condition requires $\pi^*_{xx} < 0$ which is satisfied if $V_{xx} > -1/2 P'$. We shall assume this is the case in the following analysis.

Equation (12) shows that there are four terms jointly determining the foreign firm’s optimal technology level. The first term is called the strategic effect which is positive. It indicates a greater $x$ (i.e., a better technology) lowers the output of the domestic firm, increasing the profit of the foreign firm. The second term is called the cost-saving effect, which captures the cost saving from the existing output and is also positive. The third term is called the licensing revenue effect. The sign of this effect is ambiguous as $r_q$ is concave in $x$. The last term which is negative, measures the marginal cost of R&D investment.

By substituting $dq/dx = (\partial q/\partial r)(\partial r/\partial x) + \partial q/\partial x = \begin{cases} 1/3 P' & \text{if } 0 < t < \hat{t} \\ 0 & \text{if } t \geq \hat{t} \end{cases}$ (by (5) and (10)) into (12) and making use of (10), we obtain:

$$\frac{d\pi^*}{dx} = \begin{cases} (P'q^* + x)(\frac{1}{3P'}) + q^* + q - V_x = 0 & \text{if } 0 < t < \hat{t} \\ q^* + q - \frac{V}{2} = 0 & \text{if } \hat{t} \leq t \end{cases} \quad (13)$$

From (13), we can derive the optimal R&D investment as a function of the tariff rate, i.e., $x'(t)$, which is continuous but kinked at $\hat{t}$.

By totally differentiating the above equation, we can derive the effect of $t$ on $x$ as follows.

$$\frac{dx}{dt} = \begin{cases} \frac{5}{2 + 9P'V_{xx}} < 0 & \text{if } 0 < t < \hat{t} \\ \frac{1}{1 + 2P'V_{xx}} < 0 & \text{if } \hat{t} \leq t \end{cases}. \quad (14)$$

It shows that a higher tariff induces a lower technology to be transferred from the foreign firm to the domestic firm. This leads to the following proposition.
**Proposition 1:** A tariff hinders the R&D investment of the foreign firm, inducing an inferior technology to be transferred to the domestic rival.

This result is opposite to that derived by Kabiraj and Marjit (2003). They assume the technology of the foreign firm to be exogenously given and conclude that a tariff induces the foreign firm to transfer its superior technology to the domestic firm. If the technology of the foreign firm is endogenously determined, a tariff weakens the strategic effect and the cost-saving effect, causing the foreign firm to invest less in its R&D and resulting in an inferior technology to be transferred to the domestic firm.

Moreover, we can infer from (14) that the marginal effect of the tariff on the R&D investment of the foreign firm is discontinuous at the critical level of $\hat{\tau}$. It is high (low) for a high (low) tariff. The intuition for this discrepancy is as follows. Note that the optimal royalty rate is discontinuous at the critical tariff rate. As shown in (9), if the tariff is higher than the critical level ($\hat{\tau}$), the foreign firm charges a full royalty and extracts the entire rent of the domestic firm from the new technology. This increases the marginal revenue of the R&D investment and causes the foreign firm to engage in more R&D. Contrarily, if the tariff is higher than the critical level, the foreign firm can extract only a partial rent of the domestic firm from the new technology, causing the foreign to engage in less R&D.

4. International technology transfer under quotas

Instead of tariffs, the domestic government can also take non-tariff barriers as its protection policy. Among non-tariff barriers, import quota is most popular. In this section, we shall examine how a change in import quota affects the R&D of the foreign firm and the following international technology transfer.
In the quota regime, the profit functions of the domestic firm and the foreign firm become as follows:

\[ \pi(q) = (P - c + x)q - rq , \]  
\[ \pi^* = (P - c + x)\bar{q}^* + rq - V(x) . \]  

where \( \bar{q}^* \) is the (effective) quota set by the home government.\(^4\)

As the foreign firm’s output is subject to the quota constraint, the domestic firm behaves as a Stackelberg leader in the home market. By differentiating (15) with respect to \( q \), we can derive the first-order condition for profit maximization for the domestic firm as follows.

\[ \frac{d\pi}{dq} = P - c + x - r + P'q = 0 . \]  

The second-order condition is satisfied as \( \pi_{qq} < 0 \). Moreover, by totally differentiating (17), we can derive the following comparative static effects:

\[ \frac{dq}{dr} = \frac{1}{2P'} , \quad \frac{dq}{dx} = \frac{-1}{2P'} , \quad \frac{dq}{d\bar{q}^*} = \frac{-1}{2} . \]  

Expressions in (18) indicate that an increase in the import quota or the royalty rate has negative effects whereas an increase in the level of the technology has a positive effect on the domestic firm’s output. Moreover, different from that in (5) where the effects of the royalty rate or the R&D on the domestic firm’s output are opposite in sign but at different magnitudes, they now have the same magnitude.

By substituting \( q(r, x) \) derived from (17) into (15), we can rewrite the profit function of the foreign licensor firm as follows:

\[ \max \pi^* (q(r), r, x, v) = (P - c + x)\bar{q}^* + rq - V(x, v) , \]  
\[ \text{s.t. } (P(r, x) - c + x - r)q(r, x) \geq (P(x) - c)q(x) . \]  

The constraint represents the licensee firm’s incentive constraint, ensuring that

\(^4\) A quota is effective if the market price is higher than the marginal cost of the exporting firm. We shall assume this to be the case throughout the analysis.
the domestic firm is not worse off after licensing. By totally differentiating (19) with
respect to \( r \) and utilizing (17), we can derive the first-order condition for profit
maximization of the foreign firm as follows:

\[
\frac{d\pi^*}{dr} = \frac{\partial\pi^*}{\partial q} \frac{dq}{dr} + \frac{\partial\pi^*}{\partial r} \frac{dr}{dr} + (P' \tilde{q}^* + r) \frac{\partial q}{\partial r} + q - q^*/2 - (2P - 2c + 2x - 3r)/2P' > 0. \tag{21}
\]

The sign of (21) is positive due to \( r \leq x < P-c \) by (20) and the assumption of
non-drastic innovation.\(^5\) Equation (21) implies that the foreign firm’s optimal royalty
rate is the rate that extracts all the increased profits of the domestic firm, i.e., \( r = x \).
Utilizing this property, we can rewrite the profit function of the foreign firm for the
first-stage game as follows:

\[
\begin{align*}
\text{Max } \pi^* & (q(r(x), x), r(x), x; v) = (P - c + x)q^* + rq - V(x; v). \tag{22}
\end{align*}
\]

By totally differentiating (22) with respect to \( x \), we can derive the optimal
royalty rate under the quota regime from the following first-order condition for profit
maximization of the foreign firm as follows:

\[
\frac{d\pi^*}{dx} = \frac{\partial\pi^*}{\partial q} \frac{dq}{dx} + \frac{\partial\pi^*}{\partial r} \frac{dr}{dx} + \frac{\partial\pi^*}{\partial x}
\]

\[
= (P' \tilde{q}^* + \tilde{q}^* + \tilde{q}^* r - \tilde{q}^* V) + \tilde{q} \frac{\partial q}{\partial r} + \tilde{q} \frac{\partial q}{\partial x} + \tilde{q} \frac{\partial r}{\partial x} + \tilde{q} \frac{\partial r}{\partial x} - V \tag{23}
\]

\[
= \tilde{q}^* + q - V_x = 0. \tag{24}
\]

The second-order conditions is satisfied as \( d^2\pi / dx^2 = -V_{xx} < 0 \). Thus, we can
solve (22) to derive the optimal R&D investment under the quota regime, \( x(v) \).

Since \( r = x \) by (20), the domestic firm’s effective marginal cost and hence the
output are unchanged after licensing. As a result, the strategic effect vanishes and the
foreign firm’s marginal revenue from better technology is now equal to its saved
production cost. The optimal technology is determined when this marginal revenue is

\(^5\) By (20), the licensee firm accepts the licensing contract if \( r \leq x \). In addition, the non-drastic
innovation assumption requires the output of the domestic firm be positive which requires
\( x < P-c \leq a-c \) by Wang (1998), where \( a \) represents the willingness to pay of consumers.
equal to the marginal cost. Furthermore, by totally differentiating (24), we can derive the comparative static effect of quota on the optimal R&D as follows:

\[ \frac{dx}{dq} = \frac{1}{2V_{xx}} > 0. \tag{25} \]

A less restrictive quota policy encourages the foreign firm to choose a higher technology and license this higher technology to the domestic firm. The intuition is as follows. An increase in quota increases the total market output by (17) which raises the marginal revenue of the R&D investment and induces the foreign firm to engage in more R&D. Based on the finding, we can establish the following Proposition.

**Proposition 2. The higher the quota, the better is the transferred technology.**

Propositions 1 and 2 have shown that either a lower tariff or a higher quota can induce a better transferred technology. It implies that with an endogenous R&D by the foreign firm, trade liberalization, rather than trade protection, results in better technology to be transferred from the foreign firm to the domestic firm. This result is again contrary to the finding of Kabiraj and Marjit (2003).

We have investigated the optimal R&D levels of the foreign firm under the tariff and the quota regimes. In what follows, we shall compare the two R&D level to find which trade policy can induce a better technology to be transferred from the foreign firm to the domestic firm.

By evaluating (13) at the technology level derived from (24) and utilizing the condition of equivalent import volume under the two regimes, i.e. \( q^*(t) = \bar{q}^* \), we can obtain:

\[
\frac{d\pi^*(q^*(t))}{dx} \bigg|_{q^*(t)=\bar{q}^*,x(t)=\bar{x}} = \begin{cases} 
(P^* - \bar{x})^2 / (3P^*)^2 \geq 0 & \text{if } 0 < t \leq \hat{t} \\
-\bar{q} / 2 & \text{if } \hat{t} < t \leq \hat{\bar{t}}. 
\end{cases} \tag{25} 
\]
The above equation shows that the technology difference between a tariff and the equivalent quota depends on the level of trade protection. When $0 < t < \hat{t}$, the sign of the above equation is ambiguous. By setting $(P'q^* + x)/(3P') = 0$, we can derive that the equation holds at $t = \hat{t}$. That is to say, $\hat{t}$ is the tariff rate blow (above) which the foreign firm has higher (lower) R&D incentive under tariff regime. As a result, for a low level of trade protection ($0 < t < \hat{t}$), a tariff policy is more effective in technology transfer as it can induce the foreign firm to transfer a better technology to the domestic firm. However, if the level of trade protection is high ($\hat{t} \leq t$), the above ranking is reversed, making quota the better policy. Thus, we can establish the following proposition.

**Proposition 3. If the trade barrier is high (low), the technology transferred from the foreign firm under the equivalent quota regime is superior (inferior) to that under the tariff regime.**

The intuition of the above proposition is as follows. If the trade barrier is high, the foreign firm charges a full royalty under the quota regime but only a partial royalty (i.e., smaller than the innovation level) under the tariff regime. It gives the foreign firm an incentive to invest more in R&D and transfer a superior technology to the domestic firm under the quota regime. In contrast, if the trade barrier is low, the foreign firm charges a full royalty under both regimes. By comparing (12) and (23), we find that they differ only on the strategic effects and the licensing effects. Specifically, the quota (tariff) policy has no (a positive) strategic effect but a larger (smaller) licensing revenue effect. Or equivalently, the tariff policy is better (worse) than the quota policy in technology transfer in terms of the strategic
(licensing-revenue) effect. When the trade barrier is low, the former dominates the latter, making the tariff policy more efficient in technology transfer.

Note that when the trade barrier is low \((t < \hat{t})\), the foreign licensor firm charges \(r = x\), and the effective marginal cost of the domestic firm remains at \(c\) under both regimes. This together with the assumption of the same import volume leads to the same total output and the same domestic welfare under the two regimes if the tariff revenue is set equal to the quota rent.\(^6\) On the other hand, if the trade barrier is high, the royalty rate is smaller than the marginal cost reduction of the licensee firm under the tariff regime but they are equal under the quota regime. This implies that the domestic firm can enjoy a lower marginal cost and a higher profit under the tariff regime. In addition, domestic consumer surplus is also higher under the tariff regime as the total output is higher. If we further set the tariff revenue equal to the quota rent, the domestic welfare should be higher under the tariff regime. Based on the above discussions, we can establish the following proposition.

**Proposition 4.** Assume the quota rent is equal to the tariff revenue. If the trade barrier is low, the domestic welfares are the same under the tariff and the quota regimes. On the other hand, if the trade barrier is high, the domestic welfare is higher under the tariff regime.

WTO has long been pursuing trade liberalization and tarrification. According to our findings, tarrification (i.e., converting non-tariff barriers into tariff barriers) can help the importing country acquire a better technology from the foreign firm, resulting in higher domestic welfare if the trade barrier is high.

\(^6\) The domestic welfare consists of the domestic firm’s profit and the domestic consumer surplus whilst the world welfare comprises the domestic welfare and the foreign firm’s profit.
5. A ban on technology export

In this section, we assume the foreign government imposes a ban on technology export and examine whether this ban stimulates or suppresses the foreign firm’s R&D incentive.

It is generally believed that licensing gives the licensor firm an extra channel to make profits and thus has a positive effect on its R&D. Based on this argument, a firm’s R&D should decline if its government imposes a ban on technology transfer. In this subsection, we shall use the free trade model to show that this argument is misleading if the foreign firm is efficient in its R&D.

When technology transfer is banned, there is no licensing and the game degenerates to two stages. The foreign firm determines its optimal R&D in the first stage, and the two firms compete in the output market in the second stage. The output game is the same as before and shall not be repeated here. But we need to re-derive the equilibrium for the first-stage game. With no licensing, the first-order condition to derive the optimal R&D of the foreign firm becomes:

\[
\frac{d\pi^*}{dx} = \left( p'q^* \right) \frac{\partial q}{\partial x} + \frac{q^*}{V'(x)} - \frac{4q^*}{3} = 0,
\]

(26)

Moreover, given the second-order condition is satisfied and \( \frac{\partial^2 V}{\partial x \partial v} > 0 \), it is straightforward to show that \( dx/dv < 0 \). The difference between (26) and (12) is that there is no licensing effect in the above equation as technology export is banned now.

We can compare the foreign firm’s optimal R&D levels with and without the ban on technology export. Note that if there is no such a ban, the optimal royalty rate is equal to \( x \) when \( t < \hat{t} \) by (9).\(^7\) Hence, the outputs of the two firms are the same with and without the ban. Evaluating (26) at the optimal R&D level derived from (12)

\(^7\) We shall pursue only this case. The result for the other case of \( t > \hat{t} \) is similar to the current one and can be similarly derived.
and utilizing the property of \( r = x \), we can obtain:

\[
\frac{d\pi^*(q^*)}{dx}\bigg|_{r=x} = -q(v) - \frac{x(v)}{3P'} = \begin{cases} 
> 0 & \text{if } v = \bar{v} \\
< 0 & \text{otherwise}
\end{cases} \quad (27)
\]

The sign of (27) is ambiguous. It is positive if the foreign firm’s R&D efficiency is high. Given this result, we can construct the following proposition.

**Proposition 5.** When the R&D efficiency of the foreign firm is high, a ban on technology export has a positive effect on the foreign firm’s technology development.

The intuition of this proposition is as follows. When technology export is not banned, the foreign firm can earn revenues via two channels --- sales of its output and technology licensing. The revenue from the former is higher, if the foreign firm has higher R&D efficiency as it leads to a higher technology and a lower marginal cost. But this is not the case for the licensing revenue as by definition its magnitude depends on the output of the “domestic” firm. If technology export is banned, the foreign firm does not need to take into account its effect on the output of the domestic firm while making its technology choice and should choose a better technology.

6. Conclusions

It is well known in the trade literature that trade protection can induce international technology transfer via licensing. It implies that a country can use trade protection to help its firms to acquire better technology from a foreign firm. This paper argues that this result does not hold if the R&D of the foreign licensor firm is determined endogenously. We have shown that trade protection has a negative effect on the foreign firm’s R&D and hence on its technology transferred to the home country. It
implies that a technology importing country should liberalize its trade protection if it intends to import better technology.

Trade liberalization can raise the foreign firm’s R&D investment, resulting in a better technology to be licensed to the domestic firm. This better technology can lower the production cost of the domestic and the foreign firms and also the price in the domestic country, leading to high domestic, foreign and world welfare. This result can be used to justify trade liberalization policies advocated by the WTO.

We have also compared the effects on international technology transfer between a tariff and the equivalent quota policy and the resulting welfare implications. It is found that when the trade barrier is low, a tariff policy is better than the equivalent quota policy in acquiring better technology. The opposite holds if the trade barrier is high. Furthermore, the domestic welfare is indifferent under the two regimes if the trade barrier is low but it is higher under the tariff regime if the trade barrier is high. This result suggests that tariffication, advocated by WTO, can help the domestic country acquire a better technology and results in better social welfare if the trade barrier is low.

Finally, we have investigated how the R&D of the foreign firm and the transferred technology are affected by the foreign government’s ban on technology export and by the existence of an international market. We have found that a ban on technology export entails a positive (negative) effect on the technology of the foreign firm if its R&D efficiency is high (low). Moreover, global trade liberalization has a positive effect on the R&D investment as well as the transferred technology.

REFERENCES


