Technology Transfer, Quality Standards, and North-South Trade

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Abstract

This paper examines the economic consequences of technology transfer through licensing in a North-South model of vertical product differentiation, based on the product-line pricing framework of Mussa and Rosen (1978). With its limited technological expertise, the Southern firm cannot export to the Northern market without purchasing the Northern firm's “clean” and low-cost technology. With North-South cost-asymmetry, we conclude that the transfer of technology through licensing promotes trade, product variety and improves global welfare. However, without government intervention, the private levels of product quality chosen by firms tend to be lower than the socially-optimal levels. This finding helps to explain why developed countries often set quality standards for imported foreign products.

**JEL classification:** F12, F13, L13.

**Key words:** Licensing, Product Differentiation, Quality Standards, Trade.
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1. Introduction

The new trade theory, over its three decades of development, has identified love of variety and product differentiation as the main potential sources of trade (Krugman 1979; Helpman 2006; Melitz 2003). Following this focus, researchers have switched their attention to monopolistic competition from the previously dominant comparative advantage and specialization models in the traditional trade theory. The reason for this emphasis is based on several interesting patterns of international trade which have only emerged in recent decades: (i) the increasing intra-industry trade rather than inter-industry trade; (ii) multinational firms diversifying their activities in foreign countries to maximize the benefits of trade and foreign direct investment (FDI); and (iii) the burgeoning trend of technology licensing, including licensing between competing firms from different countries (Erkal 2005; Ciuriak 2010). The present paper looks at the last issue in light of Mussa and Rosen’s (1978) product differentiation model. This approach allows for investigation of the impact of licensing on the quality spectrum, an important topic that has not been examined in the trade literature but has important implications for trade and welfare.

The key research questions of the paper are as follows: (i) Is international technology licensing beneficial for the participating countries and the world as a whole? And (ii) When international technology licensing takes place, do firms produce socially-optimal product quality? These questions are explored in an international oligopoly model with technology licensing. There are three firms in our framework: a Northern firm with advanced technology, and two Southern firms with obsolete technology, that is, the Northern firm possesses a technology lead over the Southern firms. The firms produce products that are vertically differentiated in both regions. For the sake of simplicity, we assume that the Northern firm does not export to the South so that it can protect its technology. Likewise, the Southern firms do not export to the North because their products do not meet the quality standards of the North. However, when the Northern firm and one of the Southern firms engage in a

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1 Quality standards on imports are observed in many countries such as Japan, U.S., and many European countries.
licensing arrangement, the participating Southern firm can use the advanced technology of the Northern firm to produce products not only for sale in its home market but also for export to the Northern market.

With this framework, North-South technology licensing is found to promote trade, product variety and is beneficial for all firms. When the licensing agreement is privately arranged between the participating firms, consumers in both North and South benefit from the greater product variety, thus, both regions benefit. However, such a private licensing arrangement is not necessarily socially-optimal. This is because firms tend to supply the product at a lower than socially-optimal quality level.

One of the implications of our results is that governments around the world should intervene actively in international technology licensing. Government intervention is recommended because when products are vertically differentiated, licensing between competitors, in addition to more profits accruing to firms, induces firms to improve product quality which, in turn, benefits consumers. However, since private firms' decisions are not socially-optimal (as they tend to choose lower than socially-optimal quality products), interventions such as the application of quality standards would raise the importing country’s welfare.

International technology licensing that helps the licensee improve product quality and export has been observed in many countries. In 2010, Chinese automaker Geely purchased Ford's Volvo car unit in order to boost sales in the European market (Liu 2009). Even though the business under the brand name of Volvo is still going through tough times, according to many analysts, the huge benefits for Geely are that it gains access to resources and engineers who have been developing high-quality cars, and it gains access to the crash test facilities of Volvo located in Sweden. Crash tests has been one of the most difficult obstacles preventing Chinese automakers from selling their cars in the European market for many years.2 Likewise, Indonesian shrimp producers recently had to rely on technology transfers from Japan to regain access to the lucrative Japanese market after Japan refused to import shrimps from Indonesia as they contain chloramphenicol. In 2004, the Indonesian government had

2 Similarly, in 2004, the Chinese computer company Lenovo acquired IBM's personal computer division as a quick way to gain access to the high-end market and, at the same time, boost its sales in the U.S. (McGrath 2009).
established a commission on shrimp production to find ways to cope with European zero-
chloramphenicol requirements. It expressed the need for technical assistance from its trading
partners, since meeting the zero-chloramphenicol condition by the traditional production
methods in Indonesia is very costly because of limited expertise (Rina and Erwidodo 2008).

As reported by Anand and Khanna (2000), licensing is popular in various sectors such as
biotechnology. They also point out that, in the U.S., half of all licensing deals involve cross-
border transfers. Therefore, the question of whether international technology licensing is
beneficial for participating countries and the world as a whole has become increasingly
important and needs theoretical justifications.

Our paper is related to the broadly-defined literature on licensing and product differentiation.
Since the seminal contribution of Katz and Shapiro (1985), the literature thus far has focused
on horizontal product differentiation in which firms produce products that are substitutable.
Arora and Fosfuri (2003) study the relationship between the degree of product substitutability
and licensing in a model with N symmetric firms with advanced technology and many
potential entrants. They argue that as products become more similar, firms tend to license
their technology to potential entrants more often. Erkal (2005) examines royalty and fixed fee
licensing in a Cournot model with asymmetric costs between two competitors, and finds that
licensing between two firms raises social welfare unless the degree of product differentiation
is sufficiently low.

In this literature, few papers have discussed international technology licensing. Exceptions
investigate international technology licensing between a low-cost Northern firm and a high-
cost Southern firm who compete by producing homogeneous products. They show that
licensing is socially desirable in this context and the level of licensing depends on tariff rates.
Fess et al. (2009) explore international technology licensing in light of Salop’s (1979) spatial
model with two Northern firms and many Southern potential entrants. Licensing leads to
competition effect and business stealing effects. They show that depending on the probability
of entry, there will be no licensing or symmetric licensing equilibria. However, the welfare
impact of licensing is not discussed in Fess et al.’s (2009) paper.
At the same time, it is worth pointing out that our findings are also related to the growing literature on vertical product differentiation and trade. However, most researchers with this focus adopt the product line-pricing framework of Mussa and Rosen (1978) in one form or another to investigate different issues rather than international technology licensing. For instance, Das and Donnenfeld (1987, 1989) discuss the relationship between trade policy and the quality of imported goods (see also Toshimitsu 2005). Morita and Nguyen (2011) explore technology spillover from a Northern firm to a Southern firm in an international duopoly model of vertical product differentiation, and examine whether FDI by the Northern firm is beneficial for the North, the South and the world.3

Following this direction, several papers have discussed the welfare impact of quality standards under vertical product differentiation models (Falvey 1989; Boom 1995; Lutz 2000). The general argument is that, when a country sets quality standards (either a uniform standard on all products, or separate standards for imported products and locally produced products), firms’ profitability declines, consumer surplus increases, and social welfare is likely to increase. However, to the best of our knowledge, no previous papers have analyzed the effects of technology licensing and quality standards at the same time.

By adopting the vertical product differentiation framework of Mussa and Rosen (1978), this paper captures the implications of international technology licensing on welfare. Novel features of our model include: (i) the investigation of the case of asymmetric cost structures which comes as a result of technology licensing, and (ii) the comparison between private quality levels and socially-optimal quality levels. Our model shows that North-South technology licensing benefits not only participating firms but also outsider firms, and increases consumer surplus and social welfare in both regions. However, since firms privately choose product quality below socially-optimal levels, government intervention such as quality standards could raise social welfare in both regions. These findings are consistent with real world observations.

3 Two useful papers which have been used in several parts of our analysis include Aoki and Prusa (1996) and Boccard and Wauthy (2005). Even though neither paper addresses licensing, their results for the case of a symmetric cost duopoly game are the starting point of our analysis.
The paper will proceed as follows. Section 2 lays out the structure of the model. Section 3 analyses the game under autarky and trade regimes. Section 4 discusses welfare implications of international technology licensing, and Section 5 concludes.

2. The Model

In this section, an augmented model of vertical product differentiation is introduced, based on the product-line pricing framework of Mussa and Rosen (1978). We focus on duopolistic competition between firms with both symmetric and asymmetric cost structures and technology licensing.

There are two countries, S (South) and N (North), and three firms. Firms 1 and 2 are located in S, and firm 3 is located in N. The firms compete by producing products differentiated by quality. We assume that there is no cost of production, but that each firm $i \in \{1,2,3\}$ incurs a cost $C_i(q_i) = k_i q_i^2$ to develop its product quality, $q_i (\leq 1)$, where $k_i \geq 0$ is an efficiency parameter. Higher $k_i$ implies firm $i$ is less efficient in the production of the product. We also assume that $k$ is country-specific, and let $k_3 = 0$ and $k_1 = k_2 = k = 1/2$. That is, Northern technologies are assumed to be superior to that of the South so that, when firm 3 and firm $i \in \{1,2\}$ produce a product with similar quality then firm 3 incurs lower quality development cost. In other words, the Northern country has some technological advantages over the Southern country. Firm 3’s products are also assumed to be cleaner than that of firms 1 and 2 (for example, they meet environmental requirements). These assumptions, which are consistent with real world observations (for instance, see the examples in previous section), help us simplify the model and illustrate our results more intuitively.

Both countries consist of a continuum of nonatomic consumers of mass 1, where each consumer is indexed by a taste parameter, $\theta \in [0,1]$, and endowed with a reservation utility equal to zero.\(^4\) A consumer $j$ indexed by $\theta_j$ buys one or zero unit of the product to derive a gross benefit of $\theta_j q_i$, where $q_i$ is the quality level of the product she purchases. We assume that demand in both countries is identical and does not change over time.

\(^4\) Our results are mostly unchanged, $\theta$ is in an interval.
The game is structured as follows. In the first stage, the firms choose their supply strategy (or which market to serve). In the second stage, they choose the quality level for their product in each market. Finally, in the last stage, firms set prices for their product in each market and consumers make purchasing decisions.

The set-up of the model allows us to conduct the treatment under two separate regimes, namely, the autarkic and the international trade regime. The supply strategy of each firm depends on the regime in place. Under the autarkic regime, denoted by a superscript $a$ in subsequent analysis, firms only serve their home market (i.e., firms 1 and 2 sell their product in market S, and firm 3 sells in market N only). Under the international trade regime, denoted by a superscript $t$, firm 3 and one of the firms in S engage in a licensing contract. If such a licensing arrangement between firm 3 and firm $j (j = 1, 2)$ in S is successful, firm 3 receives a fixed amount of rent, $D$, transferred directly from firm $j$. At the same time, firm $j$ can use firm 3’s “clean” and low-cost technology for production to serve its home consumers and also export to market N. Thus, the supply strategy for firm $j$ under the international trade

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To focus on the implications of international technology licensing, we assume throughout that under the autarkic regime, firms in S cannot export to market N because their technology is not “clean” enough. Likewise, firm 3 does not export its product to market S due to high imitation rates in the South. These assumptions are supported by real-world observations.

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regime is different compared to that under the autarkic regime.\textsuperscript{6} To simplify the analysis, we assume that there are no trade costs between the two countries.

3. Analysis

First, the equilibrium of the game under each of the regimes introduced above is explored. Notice that under the autarkic regime, competition in market S is between two symmetric firms, 1 and 2, with the same cost structures, while firm 3 monopolizes market N. Under the international trade regime, where firm $j$ is the licensee of the technology from firm 3, competition in S is between two asymmetric firms (with different cost structures), whereas competition in N is between two symmetric firms, $j$ and 3. Asymmetric costs form firm heterogeneity in our set-up and play an important role in subsequent equilibrium characterization and welfare analysis.

3.1. The autarkic regime

Consider the autarkic regime, where the firms only serve their home market. In N, as a monopolist, firm 3 chooses its quality level $q_3^a$ and price $p_3^a$. The marginal consumer, who is indifferent about buying firm 3’s product or not buying it, has the taste parameter $\theta_N$. It then follows that the net utility for this person equals the reservation utility (zero), or $\theta_N q_3^a - p_3^a = 0$, which gives us $\theta_N = \frac{p_3^a}{q_3^a}$. The problem for firm N at stage 3 is to choose $p_3^a$ to maximize its profit.

$$\max_{\theta_N} \int_{\theta_N}^1 p_3^a d\theta = \left(1 - \frac{p_3^a}{q_3^a}\right) p_3^a \quad (1)$$

\textsuperscript{6} One possible explanation for technology licensing being the gateway for firm $j$ to enter the Northern market are the quality standards requirements in developed countries that developing countries’ firms with dated technologies cannot satisfy, unless they purchase licenses directly from the Northern firms, or obtain licenses from a quality-assurance agency. For instance, in the U.S. and Europe, there are various requirements for seafood, textiles, ore, and footwear products imported from developing countries.
The solution is given by \( p_3^q = \frac{q_3^a}{2} \). With this result, stage 1’s profit for firm 3 is \( \pi_3^a = \frac{q_3^a}{4} \), so that firm 3 chooses \( q_3^a = 1 \), thus \( p_3^a = \frac{1}{2} \) and \( \theta_N = \frac{1}{2} \). This yields profit for firm 3, consumer surplus for country N, and its total welfare.

\[
\pi_3^a = \frac{1}{4}; \quad CS_N^a = \int_{\frac{1}{2}}^{1} \left( \theta - \frac{1}{2} \right) d\theta = \frac{1}{4}; \quad W_N^a = \frac{1}{2} \quad (2)
\]

In contrast, competition in S is a duopoly game between firm 1 and firm 2. It can easily be established that there will be three possible equilibria: (i) firm 1 and firm 2 choose the same quality level at stage 1; (ii) firm 1 chooses a higher quality level than firm 2 at stage 1; and (iii) firm 2 chooses a higher quality level than firm 1 at stage 1. Equilibrium (i) leads to a Bertrand pricing game in the second stage and both firms make zero profit, so that it is always dominated by either equilibrium (ii) or (iii). Since (ii) and (iii) are the same if we swap the roles of firms 1 and 2, to simplify the analysis, we assume throughout that firm 2 chooses the higher quality in S in equilibrium of the autarkic regime.

**Lemma 1.** In equilibrium in the autarkic regime, firm 1 and firm 2 choose different quality levels for their products.

It can be shown that the equilibrium quality levels for the firms are given by \( q_1^a = 0.048, q_2^a = 0.252 \), and equilibrium prices are \( p_1^a = 0.01, p_2^a = 0.107 \). The equilibrium level of profit for the firms, consumer surplus for country S, and its total welfare are given by:

\[
\pi_1^a = 0.0015; \quad \pi_2^a = 0.024; \quad CS_S^a = 0.043; \quad W_S^a = 0.069 \quad (3)
\]

### 3.2. The international trade regime

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7 Aoki and Prusa (1996) solve the model with two symmetric firms competing on quality. The case of a simultaneous move is similar to our set-up here so that we can replace \( k = \frac{1}{2} \) in their framework to characterize the equilibrium.
In the international trade regime, the case is considered where firm 3 licenses its technology to firm 2 who has higher quality than firm 1 under autarkic regime equilibrium. Let us first explore the competition between firms 2 and 3 in N. Since firm 3 remains as the market leader (in terms of quality) in N, it chooses a higher quality level than firm 2 (see Boccard & Wauthy 2005, for the argument that the firm that chooses higher quality makes more profit). Equilibrium quality levels in N for firms 3 and 2 are given by $q_3^t = 1; q_{2N}^t = 0.571$ which yield equilibrium prices, $p_{2N}^t = 0.071$, $p_3^t = 0.25$ and the taste parameter for the consumer who earns zero utility from buying firm 2’s product of 0.125, and the taste parameter for the consumer who is indifferent about buying firm 2’s and firm 3’s product of 0.42 (see the analysis for the case of no quality development costs in Boccard & Wauthy 2005). The equilibrium level of profit for firm 2 in market N is $\pi_{2N}^t = 0.021 - D$ (where $D$ is the licensing fee). Hence, consumer surplus for country N is found to be $CS_N^t = \int_{0.125}^{0.42} (0.571\theta - 0.071)d\theta = 0.292$. To summarize, the equilibrium profit for firm 3, consumer surplus of country N and its total welfare are given by:

$$\pi_3^t = 0.146 + D; CS_N^t = 0.292; W_N^t = 0.438 + D \quad (4)$$

In S, competition under the international trade regime is between firms 1 and 2, where firm 2 has a cost advantage and chooses a higher quality in equilibrium. Denote by $\tilde{\theta}$ and $\theta_S$ the taste parameter of the marginal consumer who is indifferent about buying firm 1’s product and firm 2s product, and the marginal consumer who is indifferent about buying firm 1’s product and buying zero unit of the product. It can easily be established that the demand for firm 2’s product from S is $(1 - \tilde{\theta})$ and that for firm 1 is $(\tilde{\theta} - \theta_S)$. Given that firm 1 chooses its quality $q_1^t$, and subsequent price $p_1^t$, while firm 2 chooses quality $q_{2S}^t$ and subsequent price $p_{2S}^t$, it follows that the incentive constraints, $\tilde{\theta} q_1^t - p_1^t = \tilde{\theta} q_{2S}^t - p_{2S}^t; \theta_S q_1^t - p_1^t = 0$, must hold. Thus, $\theta_S = \frac{p_1^t}{q_1^t}, \quad \tilde{\theta} = \frac{p_{2S}^t - p_1^t}{q_{2S}^t - q_1^t}$.

At stage 3, firm 1 chooses the price $p_1^t$ to maximize its profit:

$$\max_\theta \tilde{\theta} p_1^t d\theta - \frac{q_1^t}{2} \quad (5)$$
at the same time, firm 2 chooses the price $p_{2S}^1$ to maximize its profit:

$$\max \int_0^1 p_{2S}^1 d\theta \quad (6)$$

Solving the above problems of firms 1 and 2, we can derive the profit function for firm 2 captured from S: $\pi_{2S}^2 = \frac{4q_{2S}^2}{4q_{2S}^2 - q_1^1}$. It follows that $\frac{d\pi_{2S}^2}{dq_{2S}^2} > 0$, so that firm 2 chooses $q_{2S}^2 = 1$. Anticipating this, firm 1 chooses $q_{1}^1 = 0.058$, which also leads to $p_{1}^1 = 0.014; p_{2S}^2 = 0.483$. The profits in S captured by firm 2 is $\pi_{2S}^2 = 0.242$. The consumer who earns zero utility from buying firm 1’s product has taste parameter 0.24, and the consumer who is indifferent about buying firm 1’s and firm 2’s products has taste parameter 0.495. Hence, consumer surplus for country S is found to be $CS^S = \int_{0.014}^{0.495} (\theta - 0.48) d\theta = \int_{0.24}^{0.495} (0.058 - 0.014\theta) d\theta = 0.137$. We then summarize total profit for each firm, consumer surplus of country S and its total welfare as:

$$\pi_1^1 = 0.0018; \pi_2^1 = 0.262 - D; CS^S = 0.137; W_S^S = 0.402 - D \quad (7)$$

We can now present our first result by comparing the level of product differentiation in both countries under the autarkic and international trade regime.

**Proposition 1.** When the licensing arrangement between firm 3 and firm 2 is successful, the degree of product differentiation increases in country S. In N, products become differentiated with the entry of firm 2.

Under the international trade regime, firm 2, by using firm 3’s advanced technology, offers the best quality possible to market S. Consequently, compared to the autarkic regime, firm 2 leaves some consumers with low-taste parameters to firm 1, giving firm 1 an incentive to raise its product quality slightly above the level it offered in autarky. At the same time, firm 2 also exports product with an intermediate quality to market N (i.e., $q_{2N}^2 = 0.571$), giving consumers in N the choice of differentiated products, which did not happen under autarky (where firm 3 monopolized the market). This explains the logic behind Proposition 1.
Next, Proposition 2 compares the profitability for each firm under the autarkic and the international trade regimes.

**Proposition 2.** When the licensing arrangement between firm 3 and firm 2 is successful:
- \( \pi_1^t > \pi_1^a; \)
- \( \pi_2^t > (\leq,=)\pi_2^a \) if \( D < (>,=)0.239; \) and
- \( \pi_3^t > (\leq,=)\pi_3^a \) if \( D > (,<,=)0.104 \) hold.

**Proof.** The proof follows immediately from (3) and (7). QED.

Proposition 2 tells us that, when firms 2 and 3 engage in a licensing arrangement, firm 1 can also benefit from the implementation of such an arrangement. The simple reason is that its market share (in S) becomes larger as products become more differentiated, as explained above. When the licensing fee happens to be in an intermediate range (i.e., \( D \in (0.104,0.239) \)), Proposition 2 also says that all firms are better off under the international trade regime. The intuition behind this result is straightforward: too high a licensing fee only benefits firm 3 and does not induce firm 2 to buy the technology, whereas too low a licensing fee does not compensate firm 3 for the loss of its market share (nor the monopoly power) in market N. Thus, without any government intervention, the licensing fee should not be too high or too low. This is further illustrated in Figure 2.

*Figure 2: Firms' profitability and licensing fee*
4. Welfare Analysis and Policy Implications

Next, the welfare implications of technology transfer through licensing are investigated. The analysis will help us to understand why the governments of less-developed countries around the world always encourage local firms to seek technology transfer from firms in developed countries.\(^8\) Quality standards and optimal subsidies in this context are also discussed.

Proposition 3 below states that, without any government intervention, the transfer of technology through licensing benefits the world as a whole by improving each of the participating countries’ welfare. The logic behind this finding is simple: in addition to the extra profits that the firms could capture, as explained by Proposition 2, technology licensing also promotes product variety in both countries and that is beneficial for consumers.

**Proposition 3.** When the licensing arrangement between firm 3 and firm 2 is successful, the level of welfare for both countries, N and S, increases, and thus global welfare increases. In other words, international technology licensing is welfare enhancing for both countries involved, and for the world.

*Proof.* From (3) and (6), \(W^t_S > W^a_s \leftrightarrow D < 0.333\). Likewise, from (2) and (4), \(W^t_N > W^a_N \leftrightarrow D > 0.062\). Since \(0.104 < D < 0.239\), we have that \(W^t_S > W^a_s, W^t_N > W^a_N\) hold. QED.

Next, whether or not the level of product quality that firm 1 chooses in market S and firm 2 chooses in market N under the international trade regime is socially-optimal is examined.

**Proposition 4.** When the licensing arrangement between firm 3 and firm 2 is successful, firm 2’s choice of quality in market N and firm 1’s choice of quality in market S are both less than socially-optimal levels. Thus, government intervention in the form of quality standards can raise social welfare.

*Proof.* When \(q^t_S = 1\), the social planner of N chooses \(q^t_{2N} = q\) to solve her problem

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\(^8\) For instance, the Chinese government encourages local automakers to obtain technology from abroad so as to boost car exports (Qiu 2005).
Routine calculations yield equilibrium prices \( p_{2N}^t = \frac{q(1-q)}{4-q} \) and \( p_3^t = \frac{2(1-q)}{4-q} \), thus \( W_N^t = \int_0^1 \left( \theta - \frac{2(1-q)}{4-q} \right) d\theta + \int_0^{q/4} \left( \theta q - \frac{q(1-q)}{4-q} \right) d\theta + \int_{q/4}^{1-q/4} \left( \frac{2q(1-q)}{4-q} \right) d\theta + \int_{1-q/4}^{1} \left( \frac{q(1-q)}{4-q} \right) d\theta + 0.242 - 0.024 = \frac{12q^2 - 2q^3}{2(4-q)^2} \). It can be established that \( \frac{dW_N^t}{dq} = \frac{10(1-q)}{(4-q)^3} > 0 \). However, when \( q_{2N}^t = q_3^t = 1 \) then \( \pi_2^t = 0 \) and \( \pi_3^t = D = 0.218 < 0.25 = \pi_3^a \). Thus, this is not feasible. At the same time, if \( q_{2N}^t = 0.94 \) then \( \pi_3^t = 0.25 = \pi_3^a \), so that \( q_{2N}^t = 0.94 \) is socially-optimal level of quality firm 2 chooses in market N. By the same token, we can solve the problem of maximizing country S's welfare, \( W_S^t(q_2^t) = CS_S^t(q_2^t) + \pi_3^t(q_1^t) + \pi_S^t(q_2^t) \) with respect to \( q_1^t \) when \( q_{2S}^t = 1 \) is fixed. It can be established that \( q_1^t = 0.335 \) will maximize \( W_S^t(q_1^t) \).

In a market with differentiated quality, the firm that chooses a higher quality level makes more profit. Thus, as the market leader, firm 3 chooses \( q_3^t = 1 \) in equilibrium. Hence, the level of quality offered by firm 2 will determine the amount of licensing fee, consumer surplus, and welfare of N. Proposition 4 says that, in light of the licensing, the government of N should push firm 2 to increase its product quality to above the private level it would choose in equilibrium. In practice, Northern countries (or developed countries) often impose quality standards on imports of a developing country’s product (or a minimum quality requirement).

To see the logic more intuitively, it is first assumed that the minimum quality requirement in N (imposed on firm 2's product), \( q \), is below 0.571 so that firm 2 chooses \( q_{2N}^t = 0.571 \) in equilibrium. Now, let us increase \( q \) such that \( q > 0.571 \). Then, firm 2 has to choose a product quality greater than this value if it wants to enter market N. It follows that, firm 2 will also charge a higher price to compensate for its loss in profitability due to minimum quality requirements. However, in market N, the marginal consumer, who is indifferent about whether to purchase firm 2's product or not buy anything, now has a lower taste parameter. That is, an increase in firm 2's product quality extends the coverage of the market, which in turn makes consumers in N better off. Does this improve social welfare for N? We find that the increase in consumer surplus of N is more than enough to off-set the reduction in firm 3's profit and licensing fee, \( D \), thus, it benefits country N as a whole. In other words, the higher
minimum quality requirement the government of N can successfully impose on firm 2’s product, the higher the level of welfare it can generate for N as a whole.

Similarly, the government of country S can also push firm 1, who is the outsider in the licensing arrangement, to improve its product quality. This is because the higher quality offered by firm 1 raises the consumer surplus (given firm 2 has already fixed the quality at \(q_{2S} = 1\) more than enough to off-set the loss in both firms' profit. In other words, by observing the licensing arrangement between firms 2 and 3, the government of S can set the minimum quality requirement for products sold in market S to raise the level of social welfare. It is worth pointing out that the socially-optimal minimum quality for country S is lower than that for country N.

Finally, we investigate the case of the technology licensing arrangement between firm 3 and firm 2, which is difficult as both firms are reluctant to participate. Our analysis suggests that some intervention, such as a government subsidy by either of the two countries to the firms, can resolve the problem. Furthermore, since country S is likely to gain more, it should offer a higher level of subsidy to firm 2 than that which the government of N can offer to firm 3, as formalized below.

**Proposition 5.** The maximum amount of subsidy the government of S is willing to provide to firm 2 is greater than the maximum amount of subsidy the government of N is willing to provide to firm 3.

When only one of the firms is active in the licensing arrangement, the negotiation can be difficult because of the other party's willingness to pay for (or to sell) the technology. Consider the case where firm 2 wants to purchase the technology from firm 3, but firm 3 does not want to sell the technology. Then, without government intervention, firm 3 can set the licensing fee, \(D\), such that \(D > 0.239\), which automatically rules out the possibility of a licensing contract. However, since the maximum gain for country S is \(0.402 - 0.069 = 0.333\), country S's government can offer a subsidy of 0.094 to firm 2 to induce it to purchase the technology. The analogous argument for the case, if firm 3 wants to license the technology but firm 2 is reluctant, leads to a subsidy of 0.042 that the government of N should offer to firm 3.
In summary, technology transfer through licensing benefits participating firms and participating countries. Our analysis provides an explanation for why governments around the world, particularly those of developing countries, usually promote technology transfer between domestic firms and foreign firms. It also helps to justify the usual practice of governments in developed countries of setting quality standards on imports of foreign products.

4.1. Robustness

In this subsection, we relax the assumption we made on the quality development cost in country S. More specifically, we analyze the game for any value of $k$. Recall that firm $i (\in \{1,2\})$ incurs a cost $C_i(q_i) = kq_i^2$ to develop its product quality. Then, in autarky, equilibrium quality is given by $q_1^a = \frac{0.024}{k}$ and $q_2^a = \frac{0.126}{k}$ (see more in Aoki & Prusa 1996). Consequently, if $k = 0.126$ then $q_2^a = 1$. When $q_2^a = 1$, the first order condition facing firm 1, under both the autarkic and international trade regimes, is given by:

$$2kq_1(4 - q_1)^3 + 7q_1 - 4 = 0 \quad (9)$$

and thus, $\frac{dq_1}{dk} < 0$. Figure 3 intuitively shows the reactions of firms 1 and 2 under both the autarkic and international trade regimes.

Figure 3: Firms’ choices of quality under autarky and international trade regimes
Finally, it can easily be established that \( \frac{dc_S}{dk} < 0 \) and \( \frac{dw_S}{dk} < 0 \). This implies that our analysis holds for any \( k \) which can induce technology transfer through licensing.

5. Conclusion

We investigated optimal international technology licensing in a model of vertical product differentiation (Mussa and Rosen 1978). With cost asymmetry, it was found that the licensing of Northern technology to the South raises the level of welfare in both countries so that it is socially desirable. This reinforces the results of previous research in international licensing using the approach of horizontal product differentiation (for example, Kabiraj & Marjit 1993). We further find that without government intervention, firms tend to choose a quality level below the socially-optimal level. This helps to explain the usual practice of the imposition of quality standards on imports that many developed countries (especially U.S., Japan and European countries) have adopted in recent years.

Since international technology licensing is a channel for cross-border technology transfer, the results of the present paper are also helpful at the global forum level. In particular, the World Trade Organization (WTO) states that it lends strong support to international technology transfer. In the Trade Related Aspects of Intellectual Property Rights (TRIPS), WTO points out that it wants to contribute to the “promotion of technological innovation and to the transfer and dissemination of technology ... in a manner conducive to social and economic welfare”. This aim is further reinforced by our model and results.

It is worth mentioning that we have incorporated some parameter restrictions to illustrate our results, including the assumption that firms 1 and 2 has similar cost structure under autarky and firm 3 incurs no cost. These assumptions have enabled the analysis of cost asymmetry in light of technology licensing, which leads to new results that are also consistent with reality as discussed above. The analysis for the general case (i.e. all firms have different cost structure) is left for future research.
References


