Cross-border Technology Licensing with R&D Opportunity and Government Intervention*
(Running title: Cross-border Licensing and Rent-shifting)

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Abstract

Technology holders may have strategic incentive to offer licensing contracts that deter (potential) rivals from doing their own R&D. This study builds a simple model of technology licensing from a foreign firm to a home firm where R&D is an alternative way for the home firm to enter the market. We first derive the optimal licensing fees with differentiated goods and two-part tariffs. Depending on parameter values, three types of licensing contracts arise: i) by means of a fixed fee alone, ii) by means of a royalty alone, and iii) by means of a fixed fee plus a royalty. We then specifically investigate home government intervention: withholding taxes on royalties and R&D subsidies. A withholding tax may improve welfare without imposing any burden on consumers. Committing itself to an R&D subsidy, the home government can reduce licensing fees without any cost.

Key words: International oligopoly, Licensing, Withholding tax, R&D subsidy, Rent-shifting

JEL classification numbers: F12, H25, L13, L24

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1 Introduction

International technology licensing is well documented in the global economy (e.g., Saggi 2002; Athreye and Cantwell, 2007; Arora and Gambardelaa, 2010). In particular, it has been observed widely that technology holders transfer their superior technology to (potential) rivals.[1] For example, Mitsubishi Motors transferred production technology to Proton (a Malaysian automaker) and Hyundai Motor at the time of their establishment. Toyota has introduced technology from Tesla without developing its own electric vehicle technology in the past. Samsung Electronics entered a number of licensing contracts with foreign rivals in the 1980's.[2] Samsung has since stepped up its technology and offered a technology licensing deal to Apple.

One of the motives for technology transfer to (potential) rivals is that they may develop their own production technology and enter markets even if technology is not transferred.[3] Obviously, technology holders can receive some payments in the case of technology licensing but no payments in the case of rival's R&D. Thus, technology holders may have strategic incentive to offer licensing contracts that deter (potential) rivals from doing their own R&D.

When foreign licensors set licensing payments, they would extract as much rent from home licensees as possible. However, the home government may mitigate such rent extraction by policy instruments. A typical example is withholding taxes on royalties from home licensees to foreign licensors, which are fairly common.[4] The tax is expected to bring tax revenue but discourage licensing. Moreover, many countries subsidize R&D

[1] According to Zuniga and Guellec (2009), more than 20% of European firms and 25% of Japanese firms license patents to non-affiliated firms.

[2] Samsung Electronics obtained technologies of microwave oven from Toshiba, color TV from Philips, and DRAM from Micron.

[3] The main purpose of R&D in Asian NIEs in the 1980's was producing goods for established markets to decrease dependence on foreign technology including licensing (Hobday, 1995).

[4] See the following web page: https://www.deloitte.com/content/dam/assets-shared/legacy/docs/analysis/2022/dttl-tax-withholding-tax-rates.pdf

(OECD, 2020). R&D subsidies provided in the home country are likely to influence international technology licensing because they encourage local firms to develop their own technology.

The purpose of this study is to build a simple model of cross-border technology licensing under an international oligopoly where R&D is an alternative way for a potential licensee to enter the market and explore the effects of the tax and the subsidy just mentioned above. In the model, a foreign firm and a home firm compete in the home market. However, the home firm has to acquire production technology through either R&D or licensing from the foreign rival. The foreign firm is willing to offer a licensing contract which deters the home firm from doing its own R&D, leading to room for home policy intervention.

In our analysis, we first derive the optimal licensing contracts for the licensor (the foreign firm). According to Rostoker (1983), the shares of licensing by means of a royalty alone, a fixed fee alone, and a fixed fee plus a royalty are, respectively, 39%, 13%, and 46%. However, most of the existing literature on international licensing focuses on contracts with royalty alone or fixed-fee alone.[5] We specifically consider licensing with differentiated goods and two-part tariffs and show that depending on the parameter values, the three types of licensing payment scheme arise.

We then explore government intervention related to licensing. It is expected that a withholding tax on licensing revenue generates tax revenue, leading to a positive welfare effect. However, what is not very obvious is that the tax may not impose any burden on consumers. Under certain situations, consumers actually gain from the tax. An R&D subsidy is basically a transfer within the home country. However, in our model, the home government can strategically use the subsidy as a device for rent-shifting from the foreign firm to the home firm. As a result, home welfare improves. An interesting point is that the home government does not need to pay any subsidy in equilibrium.

[5] Exception includes Mukherjee and Pennings (2006) and Mukherjee (2007).

Cross-border technology transfer to rivals has been analyzed extensively in the context of international oligopoly (e.g. Mukherjee, 2002; Kabiraj and Marjit, 2003; Mukherjee and Pennings, 2006; Ishikawa, 2007; Gosh and Saha, 2008; Horiuchi and Ishikawa, 2009; Yang and Maskus, 2009; Nabin et al. 2013; Ghosh and Ishikawa, 2018; Ishikawa et al., 2020). However, the focus of the present study is completely different from that in the previous studies.[6] The government (strategic) intervention in the presence of licensee's R&D opportunity is rather novel. In particular, as far as we know, no study has theoretically investigated the effects of withholding taxes on cross-border licensing between independent firms and economic welfare.[7]

The strategic use of licensing as a deterrent to entry has been pointed out and studied by the literature on industrial organization (e.g. Gallini, 1984; Rockett, 1990; Yi, 1999). However, these papers deal with a closed economy and therefore do not make it possible to consider cross-border rent-shifting. More importantly, they do not investigate government intervention related to such licensing.

2 Basic Model

There are two countries (Home and Foreign) with a single firm in each: firm h in Home and firm f in Foreign. Firms h and f, respectively, produce goods X and Y. To produce good X, firm h needs to acquire production technology through either R&D or technology licensing from firm f. In the case of R&D, firm h has to incur fixed costs (FCs), F, to conduct R&D. R&D may fail but the firm h's expected profits with R&D are positive. We assume for simplicity that the probability that R&D succeeds is constant. In the case of licensing, firm h pays the licensing fee which consists of a fixed fee, R, and a per-unit

[6] Most of the previous studies are primarily concerned with how the home government can induce foreign technology transfer through trade policies such as tariffs.

[7] Juranek et al. (2018) and Juranek et al. (2020) examine withholding taxes on royalty payments when multinational enterprises (MNEs) are engaged in "intra-firm" licensing. Their main focus is on MNE's transfer pricing. By contrast, our analysis has nothing to do with MNEs.

royalty, r. Negative royalties are not viable, i.e., $R \geq 0$ and $r \geq 0$.

Only Home consumes the goods.[8] The inverse demand for goods X and Y is given by

$$p_x = \alpha - x - \phi y, p_y = \beta - y - \phi x,$$

where p_i $(i = x, y)$ is the price, x and y are the quantities demanded, $\alpha(> 0)$ and $\beta(> 0)$ are parameters, and $0 \leq \phi \leq 1$ is a parameter indicating the degree of substitutability between the goods. The goods are independent if $\phi = 0$ and are perfect substitutes if $\phi = 1$ (and $\alpha = \beta$). If the goods are substitutes, the firms engage in Cournot competition.

We consider the following three-stage game. In the first stage, firm f decides whether to provide a take-it-or-leave-it licensing offer to firm h. In the second stage, if firm f decided to offer a licensing contract, firm h chooses either to accept the offer or to conduct R&D. If firm f offers no contract, firm h conducts R&D. In the last stage, the firms supply their products to the market.[9]

In the case of R&D (a subscript R stands for R&D), the firm h's expected profits and the firm f's profits are, respectively,

$$\pi_R^h = \lambda\{(p_x - c_x)x\} - F, \pi_R^f = (p_y - c_y)y,$$

where c_i $(i = x, y)$ is constant marginal costs (MCs) of production and $0 < \lambda \leq 1$ is the probability that R&D succeeds. In the case of licensing (a subscript L stands for licensing), the profits are

$$\pi_L^h = (p_x - c_x)x - (R + rx), \pi_L^f = (p_y - c_y)y + (R + rx).$$

[8] This is a situation in which the home and the foreign markets are segmented and firm h cannot compete in the foreign market even if it obtains the production technology. This is often observed when goods are differentiated and Home is a developing country while Foreign is a developed country.

[9] We focus on the duopoly case. Under a range of parameterizations, firm f may exit the market after providing the license, enabling firm h to earn the monopoly profits and extracting possibly a higher rent through a fixed fee. As Mukherjee (2007) points out, however, the firm f's commitment for not entering the market may not be credible. Even if firm h becomes a monopolist, the essence of our results remains unchanged.

We assume for simplicity that firm h's MCs are the same between licensing and R&D.[10]

For given (r, R), the third-stage equilibrium outputs are

$$\begin{cases} \widetilde{x}_R = \frac{2A-\phi B}{4-\phi^2}, \widetilde{y}_R = \frac{2B-\phi A}{4-\phi^2} \text{ if R\&D succeeds,} \\ \widetilde{x}_R = 0, \widetilde{y}_R = \frac{B}{2} \text{ if R\&D fails,} \end{cases}$$

$$\widetilde{x}_L(r) = \frac{2(A-r)-\phi B}{4-\phi^2}, \widetilde{y}_L(r) = \frac{2B-\phi(A-r)}{4-\phi^2},$$

where $A \equiv \alpha - c_x$ and $B \equiv \beta - c_y$. As the size of the market, $\alpha(\beta)$, increases and/or the MC, $c_x(c_y)$, decreases, $A(B)$ becomes larger. We call $A(B)$ "the effective market size" for good $X(Y)$.

The (expected) profits of firms h and f are

$$\begin{cases} \widetilde{\pi}_R^h = \lambda \left(\frac{2A-\phi B}{4-\phi^2}\right)^2 - F \equiv \Pi(>0), \\ \widetilde{\pi}_R^f = \lambda \left(\frac{2B-\phi A}{4-\phi^2}\right)^2 + (1-\lambda)\left(\frac{B}{2}\right)^2, \end{cases}$$

$$\begin{cases} \widetilde{\pi}_L^h(r,R) = \left(\frac{2(A-r)-\phi B}{4-\phi^2}\right)^2 - R, \\ \widetilde{\pi}_L^f(r,R) = \left(\frac{2B-\phi(A-r)}{4-\phi^2}\right)^2 + R + r\left(\frac{2(A-r)-\phi B}{4-\phi^2}\right). \end{cases}$$

3 Licensing

First, we consider the optimal licensing contracts for firm f (i.e., the optimal combination of r and R, (r^*, R^*)). Licensing enables firm h to save the cost associated with the R&D and firm f can always fully extract such saving from firm h by setting the fixed fee equal to the saving (i.e., $(1-\lambda)\left(\frac{2A-\phi B}{4-\phi^2}\right)^2 + F(\equiv \overline{R})$). However, the use of a royalty together with a fixed fee enables more efficient rent extraction for firm f. Because firm f can extract any surplus of firm h under the licensing contract using a fixed fee, firm f has incentive to set the payment to maximize the sum of profits of the two firms, which may entail a negative royalty or a negative fixed fee. However, the constraint on licensing allows neither of them. Moreover, firm f has to take the outside option for firm h, Π, (i.e., firm h's profits with R&D) into account when making a licensing offer.

[10] Even without this assumption, the essence of our results remain unchanged if firm f has incentive to deter firm h's R&D through licensing.

Thus, noting R depends on r, firm f faces the following maximization problem:

$$\max_r \widehat{\pi}_L^f(r);\ s.t.\ \widetilde{\pi}_L^h \geq \Pi, r \geq 0, R(r) \geq 0, \tag{2}$$

where

$$\begin{aligned}\widehat{\pi}_L^f(r) &\equiv (\widetilde{y}_L(r))^2 + r\widetilde{x}_L(r) + (\widetilde{x}_L(r))^2 - \Pi \\ &= \left(\frac{2B - \phi(A-r)}{4-\phi^2}\right)^2 + r\left(\frac{2(A-r)-\phi B}{4-\phi^2}\right) \\ &\quad + \left(\frac{2(A-r)-\phi B}{4-\phi^2}\right)^2 - \left(\lambda\left(\frac{2A-\phi B}{4-\phi^2}\right)^2 - F\right),\end{aligned} \tag{3}$$

which takes its maximum value at $r = \phi\frac{-4B+4A\phi-B\phi^2}{2(3\phi^2-4)} (\equiv r^M)$. Since $3\phi^2 - 4 < 0$, $r^M < 0$ if $\phi(4B + B\phi^2 - 4A\phi) < 0$ and $r^M > 0$ if $\phi(4B + B\phi^2 - 4A\phi) > 0$. Thus, given $r \geq 0$, the optimal licensing contracts (r^*, R^*) are as follows. Firm f sets $r^* = 0$ and $R^* = \overline{R}$ when $\phi(4B + B\phi^2 - 4A\phi) \leq 0$. When $\phi(4B + B\phi^2 - 4A\phi) > 0$, we have two cases depending on the size of the maximum royalty firm f can charge, $\overline{r}$, which satisfies

$$(\widetilde{x}_L(\overline{r}))^2 = \Pi.$$

Thus,

$$\overline{r} = A - \frac{1}{2}B\phi + \frac{1}{2}\sqrt{\Pi}(\phi^2 - 4) > 0.$$

Given $R \geq 0$, firm f sets $r^* = \overline{r}$ and $R^* = 0$ if $r^M \geq \overline{r}$. However, if $r^M < \overline{r}$, firm f sets $r^* = r^M$ and

$$R^* = \left(\frac{2(A-r^M)-\phi B}{4-\phi^2}\right)^2 - \Pi \equiv R^M > 0.$$

Therefore, depending on the parameter values, we obtain three licensing contracts: fixed-fee, royalty, and hybrid contracts.[11]

Lemma 1 *Suppose that licensing arises. When $\phi(4B + B\phi^2 - 4A\phi) \leq 0$, firm f sets (i) $r^* = 0$ and $R^* = \overline{R}$. When $\phi(4B + B\phi^2 - 4A\phi) > 0$, firm f sets (ii) $r^* = r^M$ and $R^* = R^M$ if $0 < r^M < \overline{r}$, and (iii) $r^* = \overline{r}$ and $R^* = 0$ if $r^M \geq \overline{r}$.*

[11] This result is elicited in Ishikawa and Okubo (2013). A similar result is also obtained in Kitagawa et al. (2014).

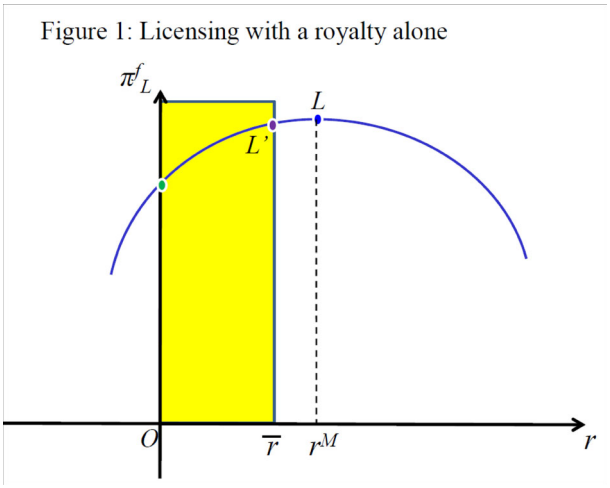

Figure 1:

Figure 1 illustrates the third case (i.e., (3) with $\phi(4B+B\phi^2-4A\phi) > 0$ and $r^M \geq \overline{r}$).[12] Point L gives the largest profits, but it is not realized because r^M is above the domain of royalty (i.e., $0 \leq r \leq \overline{r}$). Thus, we have a corner solution (point L') where licensing by means of a royalty alone arises. If $r^M < 0$ (i.e., (3) with $\phi(4B + B\phi^2 - 4A\phi) \leq 0$), then we have the other corner solution where licensing by means of a fixed fee alone arises. If $0 \leq r^M \leq \overline{r}$, then point L is an interior solution, implying that licensing by means of a fixed fee plus a royalty arises.

To grasp the intuition behind the above lemma, note that an increase in r affects each term of (3) in the following manner. The first term (i.e., firm f's profits from producing good Y) increases, while the third and fourth terms (i.e., the licensing revenue from a fixed fee) decrease. The second term (i.e., the licensing revenue from royalties) may or may not increase, because r increases but x_L decreases. When the effective market size for good Y, B, is small relative to that for good X, A, the increase in firm f's profits from producing good Y is relatively small, but the decrease in the licensing revenue from the fixed fee is relatively large. If $\phi(4B + B\phi^2 - 4A\phi) \leq 0$, the decrease in the licensing

[12] The intercept indicates the profits with licensing by means of a royalty alone: $\widehat{\pi}^f_L(0) = \left(\frac{2B-\phi A}{4-\phi^2}\right)^2 + (1-\lambda)\left(\frac{2A-\phi B}{4-\phi^2}\right)^2 + F$.

revenue from the fixed fee dominates the other two effects,[13] implying that firm f charges for its license only in the form of a fixed fee. If $\phi(4B + B\phi^2 - 4A\phi) > 0$, on the other hand, firm f sets $r > 0$. The maximum royalty firm f can charge (i.e., $\overline{r}$) is determined by firm h's outside option (i.e., Π).

Next we examine whether firm f actually has incentive for licensing. For this, we compare firm f's profits with licensing π_L^{f*} and those with R&D $\widetilde{\pi}_R^f$. In all types of licensing contract, we can readily verify:

Lemma 2 *(a)* $\pi_L^{f*} > \widetilde{\pi}_R^f$ *with* $\lambda = 1$*, (b)* $\pi_L^{f*} > \widetilde{\pi}_R^f$ *with* $\lambda = 0$ *and* $\phi = 0$*, and (c)* $\pi_L^{f*} < \widetilde{\pi}_R^f$ *with* $\lambda = 0$ *and* $\phi = 1$*.*

This lemma implies that there exists a threshold value $\overline{\lambda} \in [0, 1]$ such that $\pi_L^{f*} \geq \widetilde{\pi}_R^f$ holds for any $\phi \in [0, 1]$ if and only if $\lambda \geq \overline{\lambda}$. Intuitively, the higher the probability that firm h succeeds in R&D, the more benefits firm f receives from deterring firm h's R&D. Even if $\lambda < \overline{\lambda}$, there exists a threshold value $\overline{\phi} \in [0, 1]$ such that $\pi_L^{f*} \geq \widetilde{\pi}_R^f$ holds if and only if $\phi < \overline{\phi}$. The lower the degree of substitutability between the goods, the less loss firm f suffers from firm h's entry into the market. Thus, firm f's benefit from licensing becomes larger. In the following, we assume that $\pi_L^{f*} \geq \widetilde{\pi}_R^f$ holds and hence firm f has incentive for licensing.

4 Home Government's Intervention

With licensing, firm f sets licensing payments to extract as much rent from firm h as possible. Then the home government may take some policy measures to shift the rent from firm f to Home. However, such measures may worsen home welfare. This section specifically investigates withholding taxes on licensing revenue as direct measures for rent-shifting and R&D subsidies as indirect measures. To this end, we extend the three-stage game to the four-stage game by assuming that the home government commits itself

[13] If B is quite small relative to A, an increase in r increases the license revenue from royalties.

to adopting a policy before the firms move (i.e., at stage 0).

4.1 Withholding taxes on licensing revenue

We assume that the home government sets an ad valorem tax rate T on firm f's licensing revenue, Ω. In the presence of the withholding tax, (2) is modified as follows:

$$\max_r \widehat{\pi}^f_{LT};\ s.t.\ \widetilde{\pi}^h_L \geq \Pi, r \geq 0, R(r) \geq 0,$$

where

$$\begin{aligned} \widehat{\pi}^f_{LT}(r) &\equiv (\widetilde{y}_L(r))^2 + (1-T)\Omega(r) \qquad (4) \\ &= \left(\frac{2B-\phi(A-r)}{4-\phi^2}\right)^2 + (1-T)\left\{r\left(\frac{2(A-r)-\phi B}{4-\phi^2}\right)\right. \\ &\quad \left. + \left(\frac{2(A-r)-\phi B}{4-\phi^2}\right)^2 - \left(\lambda\left(\frac{2A-\phi B}{4-\phi^2}\right)^2 - F\right)\right\}. \end{aligned}$$

Given T, $\widehat{\pi}^f_{LT}(r)$ takes its maximum value at $r = \phi\frac{4B-4A\phi+B\phi^2+2AT\phi-BT\phi^2}{2(-4T-3\phi^2+2T\phi^2+4)} (\equiv r^M_T(T))$. Note that a change in T affects neither $\overline{r}$ or $\overline{R}$, implying a withholding tax does not cause tax shifting at all if $r^M_T(T) < 0$ or $r^M_T(T) > \overline{r}$. This is because the tax-shifting leads firm h to engage in R&D itself. To deter firm h's R&D, firm f has to keep the licensing payment firm h faces. However, the following lemma holds:

Lemma 3 *$r^{M\prime}_T(T) > 0$ holds if and only if $B\phi^2 - 2(2B - A\phi) < 0$.*

The intuition of this lemma is as follows. Firm f would mitigate the loss from an increase in T. The condition $B\phi^2 - 2(2B - A\phi) < 0$ is more likely to hold when $2B - A\phi$ is large and hence the share of the first term (i.e., the profits from selling good Y) in (4) is large. Thus, firm f has incentive to increase the first term by increasing r. On the other hand, when $2B - A\phi$ is small, firm f has incentive to increase Ω by decreasing r.

The lemma implies that a change in T may induce a switch of the licensing scheme. If $B\phi^2 - 2(2B - A\phi) < 0$ holds, for example, an increase in T increases r^M_T and may

switch the scheme from a contract with $r^* = 0$ to a contract with $r^* = r_T^M(T)$, or from a contract with $r^* = r_T^M(T)$ to a contract with $r^* = \overline{r}$, or from a contract with $r^* = 0$ to a contract with $r^* = \overline{r}$.

We now examine the welfare effect of withholding taxes. Home welfare with licensing consists of firm h's profits, tax revenue, and consumer surplus, $CS(T)$:

$$\begin{aligned} W_{LT}(T) &\equiv \Pi + T\Omega(T) + CS(T) \\ &= \Pi + T\left(r(T)x_L(T) + (x_L(T))^2 - \Pi\right) + \frac{x_L^2(T) + y_L^2(T)}{2} + \phi x_L(T)y_L(T) \end{aligned} \tag{5}$$

Note that withholding taxes do not affect firm h's profits with licensing which are equal to Π. We differentiate (5) with respect to T:

$$W_{LT}'(T) = \Omega(T) + T\Omega'(T) + CS'(T). \tag{6}$$

If $r_T^M(T) < 0$ or $r_T^M(T) > \overline{r}$ remains to hold with a change in T, $\Omega(T)$ and $CS(T)$ are constant and (6) simply becomes $W_{LT}'(T) = \Omega(T) > 0$. That is, the home government can levy a withholding tax on licensing revenue without generating any burden on consumers. Thus, we obtain the following proposition.

Proposition 1 *Suppose that the licensing scheme remains to be either fixed-fee alone or royalty alone after an increase in the tax on firm f 's licensing revenue in Home. Neither firm h nor consumers are affected but tax revenue increases, and hence home welfare necessarily improves.*

On the other hand, if $0 < r_T^M(T) < \overline{r}$ remains to hold with a change in T, the welfare effect of a change in T is rather complicated. Therefore, we consider the welfare effect of introducing a small tax on licensing revenue. The effect is given by evaluating (6) at $T = 0$:

$$W_{LT}'(0) = \Omega(0) + CS'(0).$$

Home welfare improves if $CS'(0) > 0$, but can deteriorate if $CS'(0) < 0$. We can readily verify that an increase in r decreases consumer surplus and benefits consumers. Thus,

noting Lemma 3, we obtain the following proposition.[14]

Proposition 2 *Suppose that the licensing scheme remains to be a hybrid contract after imposing a small tax on firm f's licensing revenue in Home. The tax brings tax revenue but has no effect on firm h's profits. The tax benefits consumers if and only if* $B\phi^2 - 2(2B - A\phi) > 0$ *holds, and hence home welfare improves if* $B\phi^2 - 2(2B - A\phi) > 0$.

4.2 R&D subsidies

Next, we explore a lump-sum R&D subsidy, S, to firm h. Note that no R&D subsidy is required to induce R&D, because $\widetilde{\pi}_R^S > 0$ and hence firm h has incentive for R&D even without any subsidy. With R&D, therefore, a subsidy merely shifts the rent from the home government to firm h, implying that the subsidy does not affect home welfare at all. With licensing, however, the subsidy is useful in shifting rent from firm f to firm h. How such a subsidy could shift the rent can clearly be seen when we consider the licensing contract with $r = 0$ and $R = \overline{R}$. When an R&D subsidy is announced, firm f would set $R^* = \overline{R} - S$ to deter firm h's R&D. Thus, as long as $S \leq \overline{R}$, the fixed fee becomes lower as the subsidy increases but the home government pays no subsidy in equilibrium.

Formally, with an R&D subsidy, (2) is modified as follows regardless of the type of licensing payments:

$$\max_r \widehat{\pi}_{LS}^f;\ s.t.\ \widetilde{\pi}_L^h \geq \Pi + S, r \geq 0, R(r) \geq 0,$$

where

$$\begin{aligned}\widehat{\pi}_{LS}^f(r) \equiv & \left(\frac{2B - \phi(A-r)}{4-\phi^2}\right)^2 + r\left(\frac{2(A-r) - \phi B)}{4-\phi^2}\right) \\ & + \left(\frac{2(A-r) - \phi B}{4-\phi^2}\right)^2 - \left(\lambda\left(\frac{2A - \phi B}{4-\phi^2}\right)^2 - (F-S)\right).\end{aligned}$$

Affecting the constraint, the home government can use the R&D subsidy as a device to extract the rent from firm f. An R&D subsidy improves firm h's outside option (i.e., firm

[14] We have $r_T^M(0) = r^M$.

h's profits with R&D).[15] $\widehat{\pi}^f_{LS}(r)$ takes its maximum value at $r = \phi\frac{4B-4A\phi+B\phi^2}{2(4-3\phi^2)}$ which equals r^M. From Lemma 1, we have $r^* = 0$ and $R^* = \overline{R}-S(\equiv (1-\lambda)\left(\frac{2A-\phi B}{4-\phi^2}\right)^2+F-S)$ if $r^M \leq 0$; $r^* = \overline{r}_S\left(\equiv A - \frac{1}{2}B\phi + \frac{1}{2}\sqrt{\Pi+S}(\phi^2-4)\right)$ and $R^* = 0$ if $r^M \geq \overline{r}_S$; and $r^* = r^M$ and $R^* = R^M - S$ if $0 < r^M(t) < \overline{r}_S$. Note that r^M does not depend on S, but $\overline{r}_S$ decreases as S increases. Thus, an increase in S does not affect r^* as long as $r^M \leq \overline{r}_S$ remains to hold. However, R^* decreases. On the other hand, an increase in S decreases r^* as well as R^* if $r^M > \overline{r}_S$.

With licensing, home welfare is composed of firm h's outside option and consumer surplus:

$$\begin{aligned} W_{LS}(S) &\equiv (\Pi + S) + CS(S) \\ &= (\Pi + S) + \left(\frac{x_L^2(S) + y_L^2(S)}{2} + \phi x_L(S) y_L(S)\right). \end{aligned}$$

As Π is constant, we obtain

$$W'_{LS}(S) = 1 + CS'(S).$$

Since a decrease in r increases CS, an increase in S benefits consumers as well as firm h with $r^M > \overline{r}_S$. Thus, the following holds: $W'_{LS}(S) = 1$ if $r^M \leq \overline{r}_S$ while $W'_{LS}(S) = 1 + CS'(S) > 0$ if $r^M > \overline{r}_S$. That is, the home government can improve home welfare by increasing the subsidy rate. Note that $\pi^{f*}_{LS} = \widetilde{\pi}^f_R$ holds with $S = \overline{R}$, implying firm h obtains the license without any payment with $S = \overline{R}$.

We thus obtain the following proposition.

Proposition 3 *Suppose that the home government commits itself to a lump-sum R&D subsidy $S(\leq F)$. The commitment benefits firm h by decreasing the licensing payments. It also benefits consumers as long as $r^M > \overline{r}_S$ holds. Thus, home welfare necessarily improves.*

[15] Mukherjee (2002) obtains a somewhat similar result with both licensing and production subsidies. In his model, the home firm is technologically less efficient and cannot compete with the foreign firm without a home production subsidy. He points out that a home production subsidy can induce foreign firm's technology licensing. However, neither rent-shiftng nor the effect on consumers is considered.

5 Concluding Remarks

We have constructed a simple model of licensing in an international duopoly where R&D is an alternative way for firm h to enter the market and explored the effects of withholding taxes on licensing fees and R&D subsidies. When two-part tariffs are available, we obtained three types of optimal licensing contracts for firm f: licensing with fixed-fee, royalty, and hybrid contracts. Withholding taxes result in shifting the rent associated with licensing from firm f to Home. The withholding tax may not constitute any burden on consumers. By committing itself to an R&D subsidy, the home government can enhance its welfare. These outcomes are not be necessarily well-understood or known in the literature on international licensing and related government intervention.

Note that firm f can charge licensing fees because firm h's profits under licensing without any fees are greater than those under R&D. That is, licensing arises because of the scope for arbitrage for firm f. Taxes on licensing fees and R&D subsidies can reduce the scope for the arbitrage. As a result, rent associated with licensing can be shifted back from firm f. This implies that any policy measures that reduce the scope for arbitrage for firm f work for reducing licensing payments.

The presence of R&D plays a crucial role in arriving at the results obtained here. To mainly focus on the licensing, only the minimum features of R&D have been modeled in this study. That is, the structure of R&D is kept very simple and R&D simply plays the role of an outside option for the home firm. However, the structure of R&D is more complicated and R&D may generate externalities such as technology spillovers to other sectors. The analysis on R&D with more complete features is left for future research.

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