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Tariff-induced licensing contracts, consumers' surplus and welfare revisited

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Abstract

In a trade model with technology transfer, Kabiraj and Kabiraj (2017) showed that a tariff on foreign products could induce fee licensing with zero royalty, resulting in the maximization of both consumers' surplus and domestic welfare. In this paper, we reexamine their model with an unconstrained two-part tariff licensing contract and show that if the foreign firm subsidizes the domestic firm's production via negative royalty, a higher tariff can induce a two-part tariff licensing contract, which leads to an increase in consumers' surplus and overall welfare.

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1. Introduction

Previous studies have explored the relationship between tariffs and licensing contracts within a strategic trade model, demonstrating that a committed tariff can induce foreign firms to transfer their superior technology to domestic rivals.[1] Kabiraj and Kabiraj (2017) examined a trade model incorporating technology transfer and showed that a well-directed tariff on foreign products could induce fee licensing with zero royalty, thereby maximizing both consumers' surplus and domestic welfare.[2] However, their analysis was limited to contracts with non-negative constraints on royalty and fixed fee. Within this subset of restricted contract, they found that fixed fee licensing is optimal for the foreign firm, leading to a higher consumers' surplus and domestic welfare.

The policy-relevant questions at hand are twofold: (1) What if the foreign firm is capable of subsidizing the domestic firm's production through negative royalty? and (2) Should the government intervene to prevent the implementation of a negative two-part tariff licensing contract?" These questions are of particular importance in the context of trade policy, as they have significant policy implications for both domestic welfare and foreign competition. Therefore, a thorough analysis of the two-part tariff licensing contracts with negative royalty can contribute to the strategic trade policy.

In this paper, we examine the optimal two-part tariff licensing contract with the possibility of a subsidy in the technology licensing contract by a foreign competitor.[3] We demonstrate that compared to fee licensing by Kabiraj and Kabiraj (2017), a higher tariff can induce a two-part tariff licensing contract with a negative royalty and a higher fixed-fee. This results in higher consumers surplus and overall welfare, as the domestic firm can increase output via a subsidized royalty, leading to increase in consumers' surplus. Additionally, the government can increase the tariff and reduce the rent-leakage effect to the foreign licensor that imposes a higher fixed fee on the domestic firm. This implies that under certain conditions, the government can allow a subsidized royalty contract to the foreign firm (such as payback contract) and impose a higher tariff to increase consumers' surplus and domestic welfare. Finally, we also show that the optimal tariff with an unconstrained two-part licensing is positively related to the technology gap, which might be opposite direction in a fee licensing scenario in Kabiraj and Kabiraj (2017). Our finding provides useful policy implications on the strategic choice of a tariff that can resolve the conflict between the licensor and domestic welfare.

2. The model and the results

We reexamine the duopolistic trade model used by Kabiraj and Kabiraj (2017, henceforth KK) where a foreign firm and a domestic firm, denoted by firm f and firm h, respectively, compete in quantities a la Cournot in the domestic market. The firms produce perfect

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[1] The credibility of commitment in the tariff-induced technology transfer is a contemporary issue in the literature. For example, Kabiraj and Marjit (2003), and Mukherjee and Pennings (2006) emphasised the role of government in technology licensing under an open economy in which tariff policy induces fee licensing rather than royalty licensing.

[2] Yang *et al.*,(2020) also extended their model into foreign Stackelberg leadership competition.

[3] Liao and Sen (2005) and Alipranti et al. (2014) also revealed that a subsidized royalty can be an equilibrium strategy of the inside innovator.

substitute goods. The inverse demand function is given by $P = a - Q$, where $Q = q_h + q_f$ denotes market outputs and q_h and q_f are the outputs of the foreign and domestic firms, respectively. Initially, both firms have unit cost of production c, while a foreign firm, that is, firm 1, comes up with a new innovation that reduces production cost to $c - \varepsilon$ where $\varepsilon > 0$ represents the size of the innovation. Moreover, the foreign firm will license its superior technology to the domestic firm with a two-part tariff licensing contract which consists of an upfront fee and a quantity-based royalty, that is, $T(F, r)$ where *r* is a per-unit royalty and F is a fee. The domestic government can impose the tariff rate, $\tau \geq 0$, on foreign products.

Following KK (2017, p.442), under no licensing, each firm's profit function is as follows:

$$\pi_f^{NL} = pq_f - (c - \varepsilon + \tau)q_f \text{ and } \pi_h^{NL} = pq_h - cq_h. \tag{1}$$

The Cournot quantities and profits of the firms under no licensing equilibrium given are given in Eqs (2) and (3),

$$q_f^{NL} = \frac{a - c + 2\varepsilon - 2\tau}{3} \text{ and } q_h^{NL} = \frac{a - c - \varepsilon + \tau}{3}, \tag{2}$$

$$\pi_f^{NL} = \frac{(a - c + 2\varepsilon - 2\tau)^2}{9} \text{ and } \pi_h^{NL} = \frac{(a - c - \varepsilon + \tau)^2}{9}. \tag{3}$$

In the below, we only consider the case that tariffs are non-prohibitive and thus the foreign firm produces output in the domestic market. That is,

$$\tau < \frac{(a - c + 2\varepsilon)}{2}. \tag{4}$$

Under a two-part tariff licensing, each firm's profit function is given as follows:

$$\pi_f^T = pq_f - (c - \varepsilon + \tau)q_f \text{ and } \pi_h^T = pq_h - (c - \varepsilon)q_h. \tag{5}$$

Then, the two-part tariff licensing equilibrium quantities of the firms are given by Eq. (6) as follows:[4]

$$q_f^T = \frac{a - c + \varepsilon - 2\tau + r}{3} \text{ and } q_h^T = \frac{a - c + \varepsilon + \tau - 2r}{3}. \tag{6}$$

Designing the optimal two-part licensing contract comprises of the following constrained maximizing problem where the constraints (C2) and (C3) in KK (2017) are eliminated:[5]

$$\max_{r,F} \pi_f^T + rq_h^T + F \ s.t. \ F \leq \pi_h^T - \pi_h^{NL}. \tag{C1}$$

As the equilibrium in (C1) must be satisfied with strict equality, we get $r^* = r = \frac{a - c + \varepsilon - 5\tau}{2}$ and $F^* = F(r) = \frac{(5\tau - a + \varepsilon + c)(a - \varepsilon - c + 7\tau)}{9}$. Note that r^* is

[4] The superscript T denotes the two-part tariff licensing equilibrium. Note that the profit functions of a foreign firm and a licensed domestic firm are the same as in KK (2017), while we do not impose any non-negative constraint in the two-part licensing contract.

[5] Specifically, the constraints are $F \geq 0$ (C2) and $r \geq 0$ (C3).

decreasing in τ, but it can be positive or negative, that is, $r^* = r \gtreqless 0$ if $\tau \lesseqgtr \frac{(a-c+\varepsilon)}{5}$.

Note that if $\tau > \frac{a-c+\varepsilon}{3}$, then $q_f^\tau \leq 0$ at the optimal r^*, which becomes domestic monopoly.[6] That is, the feasible region of duopolistic competition without non-negative constraint is $0 < \tau < \tau_N$ where $\tau_N = \frac{a-c+\varepsilon}{3}$.

The following proposition then defines the optimal licensing contracts with possible subsidies.[7] Note that it includes new possible strategies (d) and (e), compared to KK (2017).

Proposition R1. The optimal licensing contracts $T(F^*, r^*)$ under two-part tariffs consist of the followings:

(a) $F^* = 0$, $r^* = \varepsilon$, if $\tau = \frac{a-c-\varepsilon}{5}$;

(b) $F^* = F(0)$, $r^* = 0$ if either $\tau = \frac{a-c+\varepsilon}{5}$ or $\tau \geq \frac{a-c+\varepsilon}{3}$;

(c) $F^* = F(r^*) > 0$, $0 < r^* < \varepsilon$, if $\frac{a-c-\varepsilon}{5} < \tau < \frac{a-c+\varepsilon}{5}$;

(d) $F^* = F(r^*) < 0$, $r^* > \varepsilon$, if $\tau < \frac{a-c-\varepsilon}{5}$;

(e) $F^* = F(r^*) > 0$, $r^* < 0$, if $\frac{a-c+\varepsilon}{5} < \tau < \frac{a-c+\varepsilon}{3}$.

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[6] In this case, it is still optimal for a foreign licensor to provide a superior technology and set negative royalty but it does not produce. This is because it can return back the monopoly profits of the domestic firm by setting higher fixed fee under the higher tariff. However, this case can reduce domestic welfare, compared to duopolistic competition.

[7] All the proofs are provided in Appendix.

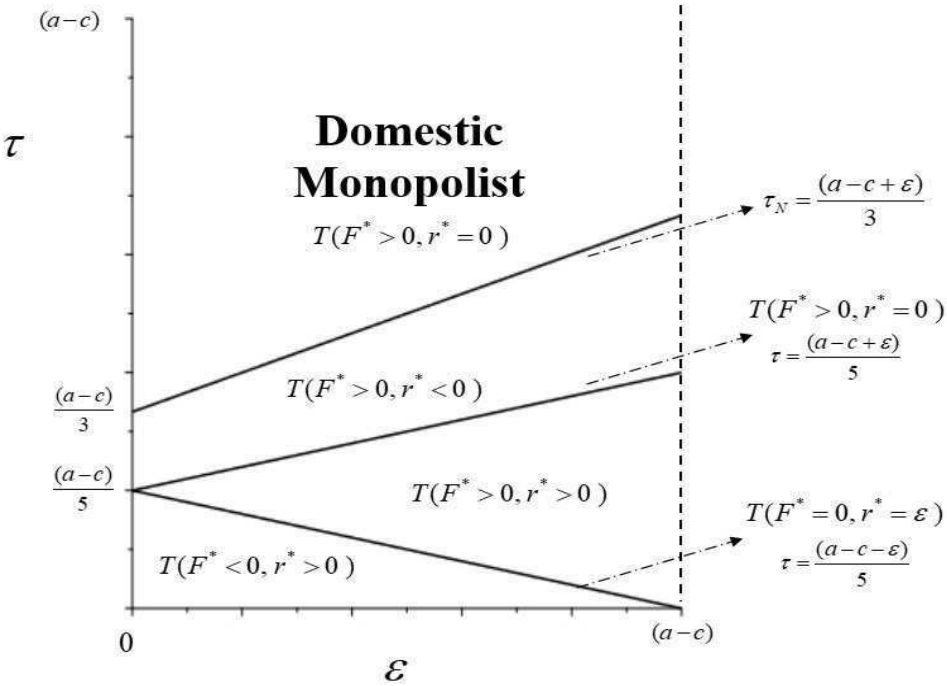

Fig. R1. Optimal licensing strategies with non-restrictive constraint of τ .

Proposition R1 provides that the optimal contracts can have not only usual constrained two-part licensing contracts with (a) royalty only, (b) fixed fee only, and (c) a positive royalty and a fixed fee, but have unconstrained two-part licensing contracts with (e) a positive fee plus negative royalty (subsidy) or (d) a negative fee plus a positive royalty. Fig. R1. shows the optimal licensing strategies of the foreign firm without non-negative constraints.

We now examine consumers' surplus (CS) which is measured by $CS = \frac{1}{2}Q^2$, and overall domestic welfare. We first examine the case that the objective of the domestic government is to maximize CS.

Proposition R2. Given any $\varepsilon \in (0, a-c)$, consumers' surplus maximizing tariff rate is $\tau^* \approx \frac{a-c+\varepsilon}{3}$ which induces fee plus negative royalty licensing.

Under the constrained two-part tariff licensing in KK (2017), consumers' surplus can be maximized at either $\tau^* = 0$ if $\varepsilon < \frac{(a-c)}{4}$, which induces royalty licensing, and $\tau^* = \frac{(a-c+\varepsilon)}{5}$ otherwise, which induces fee licensing in Fig.1 in KK (2017, p.443). However, as shown in Fig. R1, the optimal tariff under the unconstrained two-part tariff licensing is higher than those in KK (2017). This is because the domestic firm can increase its output via a negative royalty and the foreign firm can increase its profit via a higher fixed fee while the government can reduce the rent-leakage effect via a higher tariff.

We next examine overall domestic welfare and the optimal tariff rate. Welfares of each licensing strategies are the same as Eqs (10), (12), and (13) in KK (2017, p.444). In Regime 1, the optimal tariff under royalty is the same, that is, $\tau_1^{**} = \frac{a-c-\varepsilon}{5}$ for all ε. In Regime 2, the optimal tariff under the two-part tariff licensing is either $\hat{\tau}_2^{**} = \frac{a-c+\varepsilon}{3}$ for $\varepsilon < \frac{7(a-c)}{17}$ and $\tilde{\tau}_2^{**} = \frac{35(a-c)+19\varepsilon}{91}$ for $\varepsilon \geq \frac{7(a-c)}{17}$. It is different from KK (2017). In Regime 3, the optimal tariff under fixed-fee licensing is $\tau_3^{**} = \frac{(a-c+\varepsilon)}{5}$ for all ε. It is also different from KK (2017). As a result, we have the following overall welfare functions with the revised equation numbers.

$$W_1^* \equiv W_1\,(F^* = 0, r^* = \varepsilon, \tau_1^{**} = \frac{a-c-\varepsilon}{5}) = \frac{19(a-c)^2}{50} + \frac{\varepsilon(a-c+2\varepsilon)}{25}, \qquad \text{(R12)}$$

$$\hat{W}_2^* \equiv W_2\,(F^*, r^*, \hat{\tau}_2^{**} = \frac{a-c+\varepsilon}{3}) = \frac{34(a-c)^2 + \varepsilon[20(a-c)+22\varepsilon]}{81}, \qquad \text{(R13-1)}$$

$$\tilde{W}_2^* \equiv W_2\,(F^*, r^*, \tilde{\tau}_2^{**} = \frac{35(a-c)+19\varepsilon}{91}) = \frac{11(a-c)^2}{26} + \frac{\varepsilon[42(a-c)+53\varepsilon]}{182}, \qquad \text{(R13-2)}$$

$$W_3^* \equiv W_3\,(F^* > 0, r^* = 0, \tau_3^{**} = \frac{a-c+\varepsilon}{5}) = \frac{19(a-c)^2}{50} + \frac{\varepsilon[102(a-c)+131\varepsilon]}{450}. \qquad \text{(R14)}$$

Finally, we compare our result with that of KK (2017).

Proposition R3. The overall welfare is maximized at τ_2^{**} under the unconstrained two-part tariff licensing contract.

$$\tau_2^{**} = \begin{cases} \hat{\tau}_2^{**} = \frac{a-c+\varepsilon}{3} & \text{if } \varepsilon < \frac{7(a-c)}{17} \\ \tilde{\tau}_2^{**} = \frac{35(a-c)+19\varepsilon}{91} & \text{if } \varepsilon \geq \frac{7(a-c)}{17} \end{cases}$$

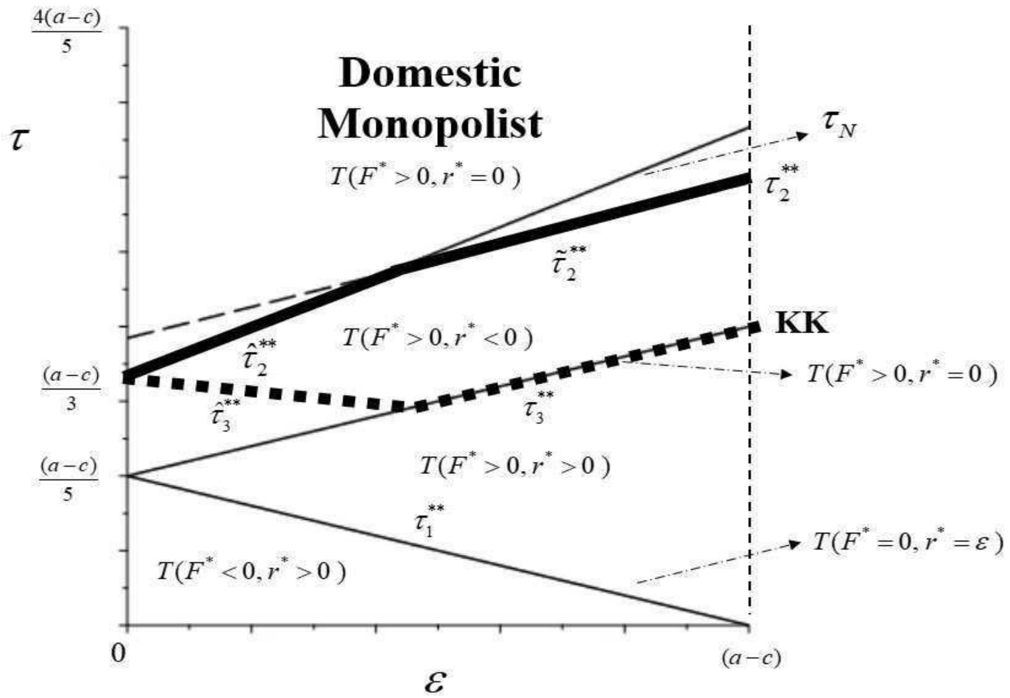

Fig. R2. Welfare maximizing tariffs in different regimes.

Under the constrained two-part tariff licensing in KK (2017), the overall welfare can be maximized at the kinked dashed lines (KK) which are $\hat{\tau}_3^{**}$ if $\varepsilon < \frac{3(a-c)}{7}$ and τ_3^{**} if $\varepsilon \geq \frac{3(a-c)}{7}$ in Eq. (15) and Fig.2 in KK (2017, p.444). However, under the unconstrained two-part tariff licensing in Fig. R2, the kinked dashed (KK) line induces welfare losses and the government should increase the tariff rate up to τ_2^{**} to improve welfares.[8] This is because the domestic firm can increase its output via a negative royalty and the foreign firm can increase its profit via a higher fixed fee while the government can reduce the rent-leakage effect via a higher tariff. Therefore, the optimal tariff under the unconstrained two-part tariff licensing is higher than those in KK (2017) which is indicated with a thick line in Fig.R2. Note also that the optimal tariff in KK (2017), $\hat{\tau}_3^{**}$ in Fig. R2, might be negatively related to the technology gap when the size of innovation is not so large. However, under the unconstrained two-part tariff licensing, the optimal tariff, τ_2^{**}, is positively related to the technology gap, It provides higher welfare than fee licensing in KK (2017) as the foreign firm switches from fee licensing to two-part tariff licensing.

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[8] Comparisons between Eqs. (R13-1, R13-2) and the welfare of KK (2017, Fig.2 in p.444) yield the followings:

(i) For $0 < \varepsilon < 7(a-c)/17$, $W_2(\hat{\tau}_2^{**}) - W_3(\hat{\tau}_3^{**}) = 5(a-c)^2 + \varepsilon[10(a-c) - 11\varepsilon]/162 > 0$,

(ii) For $7(a-c)/17 \leq \varepsilon < 3(a-c)/7$, $W_2(\tilde{\tau}_2^{**}) - W_3(\hat{\tau}_3^{**}) = 4(a-c)^2/117 + 4\varepsilon[84(a-c) - 89\varepsilon]/7371 > 0$, and

(iii) For $\varepsilon \geq 3(a-c)/7$, $W_2(\tilde{\tau}_2^{**}) - W_3(\tau_3^{**}) = 2[21(a-c) + \varepsilon]^2/20475 > 0$.

3. Conclusion

This study found that a higher tariff can induce a two-part tariff licensing contract with a negative royalty and a higher fixed fee, resulting in higher consumer surplus and overall welfare. It shows that under certain circumstances, two-part tariff licensing contracts can be more optimal than fee licensing contracts in Kabiraj and Kabiraj (2017), particularly when the foreign firm subsidizes the domestic firm's production via negative royalty. Additionally, we also showed that the optimal tariff with an unconstrained two-part licensing is positively related to the technology gap. This suggests that the technology gap between the domestic and foreign firms can play a crucial role in determining the optimal licensing and tariff policies, which is different from the result obtained in Kabiraj and Kabiraj (2017) for fee licensing contracts.

The proposed extension to consider the effect of product differentiation between domestic and foreign firms and how it alters incentives for technology transfer and optimal tariffs is an interesting avenue for future research. It would provide insights into how different market structure affects the strategic behavior of firms and the role of government intervention in technology licensing contracts. Additionally, exploring the impact of other factors, such as asymmetric information or environmental regulations, on the optimal licensing and tariff policies could provide further policy implications for technology transfer and trade.

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Appendix:

The Proof of Proposition R1: We define $\Pi_f^T = \pi_f^T + r^* q_h^T + F^*$ as cases of (c), (d), and (e). $\Pi_f^R = \pi_f^R + r^* q_h^R$ as a case of (a). $\Pi_f^F = \pi_f^T + F^*$ as a case of (b). Then we have

$\Pi_f^T - \Pi_f^R = \frac{(a-c-\varepsilon-5\tau)^2}{36} > 0$ and $\Pi_f^T - \Pi_f^F = \frac{(a-c+\varepsilon-5\tau)^2}{36} > 0$ for all ε and τ. That means that it is always possible with two-part tariff licensing for all ε and τ. Let us define that $\Pi_h^R = \pi_h^R - r^* q_h^R$, $\Pi_h^F = \pi_h^T - F^*$, and $\Pi_h^T = \pi_h^T - r^* q_h^T - F^*$. It is also hold that $\Pi_h^T \geq \Pi_h^R$ and $\Pi_h^T \geq \Pi_h^F$.■

The Proof of Proposition R2: The result of (e) is only different from that of KK (2017) while the rest of other contracts are the same. The maximum possible industry outputs under various scenarios are given:

(a) *No Licensing*: $\bar{Q}^{NL} = \frac{[2(a-c)+\varepsilon]}{3}$,

(b) *Prohibitive Tariff Regime*: $\bar{Q}^{M} = \frac{[a-c+\varepsilon]}{2}$,

(c) *Fee Licensing*: When $\tau = \frac{a-c+\varepsilon}{5}$, $\bar{Q}^{F} = \frac{3[a-c+\varepsilon]}{5}$,

(d) *Fee Plus Royalty Licensing*: When $\tau \in (0, \frac{a-c+\varepsilon}{3})$, $Q^T = \frac{[(a-c)+\varepsilon+\tau]}{2}$ which is increasing in τ. Thus, the maximum possible industry outputs is $MaxQ^T(\tau) \equiv \lim_{\tau \to \frac{(a-c+\varepsilon)}{3}} Q^T(\tau) = \frac{2(a-c+\varepsilon)}{3}$. Then, $Max_\tau Q^T(\tau) > \bar{Q}^F$ and $Max_\tau Q^T(\tau) > \bar{Q}^R$,

(e) *Royalty Licensing*: When $\tau = \frac{a-c-\varepsilon}{5}$, $\bar{Q}^{R} = \frac{[2(a-c)+\varepsilon]}{3}$. Then, $Max_\tau Q^T(\tau) > \bar{Q}^F \geq \bar{Q}^R$ iff $\varepsilon \geq \frac{a-c}{4}$ while $Max_\tau Q^T(\tau) > \bar{Q}^R > \bar{Q}^F$ iff $\varepsilon < \frac{a-c}{4}$.■

The Proof of Proposition R3

(i) For $0 < \tau < \frac{7(a-c)}{17}$,

$\hat{W}_2^* - W_3^* = \frac{[161(a-c)-79\varepsilon](a-c+\varepsilon)}{4050} > 0$ and $\hat{W}_2^* - W_1^* = \frac{[161(a-c)+194\varepsilon](a-c+4\varepsilon)}{4050} > 0$,

(ii) For $\tau \geq \frac{7(a-c)}{17}$,

$\bar{W}_2^* - W_3^* = \frac{2[21(a-c)+\varepsilon]^2}{20475} > 0$ and $\bar{W}_2^* - W_1^* = \frac{[14(a-c)+31\varepsilon]^2}{4550} > 0$. ■