Protecting consumers through protection: The role of tariff-induced technology transfer ☆

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Received 1 February 2000; accepted 12 February 2002

Abstract

We consider a duopolistic trade model where a tariff induces the foreign firm to transfer its superior technology to the domestic rival. Contrary to the conventional wisdom, such a tariff raises consumers' surplus relative to the free trade situation. We characterize the optimal tariff with and without precommitment on the part of the local government. Possibility of technology transfer reduces the optimal tariff rate compared to the no-transfer situation.

JEL classification: D43; F13; L13

Keywords: Technology transfer; Tariff protection; Consumers' welfare

1. Introduction

Protection has always been criticized as a policy which distorts consumption and forces consumers to pay a higher price for the import-competing good. Even when an 'optimal tariff' policy is pursued, whereby a country can tilt the terms of trade in its favor, the local consumers become worse off to the extent they have to pay a higher price for the imported product. While a lump-sum compensation can be potentially designed to bribe those who suffer due to protection, consumers represent the group which is likely to be affected most. Protectionist lobbies are often formed by entrepreneurs and laborers of import-competing sectors, and definitely not by consumers. Hence, free trade seems to be the best choice for local consumers. However, we show in this paper

☆ This is a shortened version of an earlier draft presented in seminars at Jawaharlal Nehru University, Erasmus University, Cornell University and Pennsylvania State University.

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that under some situations a restrictive trade policy may help the local consumers by inducing the foreign firm to transfer its superior production knowledge to the local rival.

The empirical background of the paper is the following. Until 1991, many developing countries were observed to adopt a policy of technology import and acquisition of superior technologies through foreign multinationals as a means for technological upgradation and economic development.[1] These countries have been observed to have encouraged technology licensing, while maintaining tariffs on foreign products, and somewhat restricting direct foreign investment (DFI). We provide a theoretical justification of this observation and argue that restricted trade may induce a foreign firm to alter its strategy from pure exports to exports and technology licensing, and such a move can be welfare improving for the consumers relative to the situation of free trade and direct foreign investment.

The result that a tariff can reduce the local price of a product sounds similar to the well-known idea of the 'Metzler's paradox' in international trade. But ours is a strategic model with emphasis on the nature of imperfect competition, and conditions that drive our main result are very different from the pathological conditions one needs for 'Metzler's paradox'. The issue of technology transfer (TT) and the credibility of committed policies are hotly debated contemporary issues which are absent in the traditional models. Jones and Takemori (1989) have provided an analysis on optimal tariff policy for a small open economy, and in particular, have shown that tariffs may have a favorable price effect. This, however, has no connection with technology transfer. Helpman and Krugman (1989) report two other cases, one with transport cost and economies of scale, and the other with free exit and fixed costs. Again, they do not discuss the possibility of tariff-induced technology transfer and the resultant change in consumers' welfare. In our paper, the beneficial effect of tariffs comes from the fact that a well-conceived tariff policy results in technology transfer, which in turn increases consumers' surplus as well as overall national welfare. We further show that the optimal tariff, which induces technology transfer, is even less compared to the one when no technology transfer is allowed. Hence, an optimal tariff policy may be used in order to implement technology transfer. We have also analyzed the case when tariffs cannot be precommitted. Even under this situation technology transfer occurs and consumers' welfare goes up. But the inability of the government to precommit its tariff, before the firms make their licensing decisions, means a higher tariff rate and lower welfare compared to the commitment case.

We consider a model of duopoly, with one foreign firm and a local firm. We then study welfare implications, for the local consumers and producers, of an induced technology transfer from the foreign to local firm. We assume technology licensing with a fixed fee contract. The underlying presumption is that the transferred technology can be imitated immediately after transfer at a zero cost, and if the tariff is below the prohibitive one, the local firm cannot credibly prevent the licensor from exporting its product after the transfer. This means, post-transfer market structure remains

[1] See, for instance, the Reserve Bank of India survey reports (1968–1985); Bagchi (1987), Pack and Saggi (1997), and a host of articles in the Economic and Political Weekly (1985) Special Number.

duopoly.[2] In such a framework, a profitable technology transfer will depend on the degree of "closeness" of the firms in terms of their initial technologies (Marjit, 1990; Mukhopadhyay et al., 1999). Elsewhere we have used this duopoly structure to study the question of obsolete technology transfer under potential threat of entry (Kabiraj and Marjit, 1992, 1993). Marjit et al. (1999) discuss the issue of brand-name collaboration and how tariffs affect the conditions for such collaborations, while the present paper considers the standard homogeneous good case and emphasizes the issue of consumers' surplus and the relative comparison of technology transfer and DFI.

The intuition of the result that a suitable tariff policy may induce technology transfer and increase consumers' surplus as well as overall welfare is the following. When the initial costs of the two firms are close enough, licensing occurs even under free trade. If, however, the initial cost disparity is large, licensing would not occur under free trade. Then in such a situation, a unit tariff can make the effective ex ante costs of the multinational and the local firm close enough to ensure that licensing takes place. At the critical tariff rate which induces technology transfer, there is a discrete hike in consumers' surplus. Producers' surplus increases because the transfer fee internalizes the impact of a tariff. At the same time the local government collects tariff revenues. Clearly, such an outcome dominates free trade. Such a tariff policy is attractive to the local government which has to satisfy different interest groups of the country.

The paper proceeds as follows. Section 2 provides the model and presents the results of the paper and Section 3 concludes.

2. Model

Consider a local market for a homogenous good where two firms, foreign and local, are competing in quantities. The foreign multinational exports the good to the local market. We call the foreign and local firms, firm 1 and firm 2, respectively.

There is technological asymmetry, and the foreign firm is assumed to have a superior technology. The production technologies are represented by constant average costs of production, and there is no other costs of production. So the ith firm's cost function is

$$C_i = c_i q_i, \tag{1}$$

where q_i is the ith firm's output level, $0 \leqslant c_1 < c_2$. To simplify, we further assume $c_1 = 0$. Obviously, nothing changes if c_1 is positive.

We assume that the market demand for the product is linear[3] and is given by the equation

$$P = a - (q_1 + q_2), \quad a > 0, \tag{2}$$

where P is price of the product. The industry output is $Q = q_1 + q_2$.

[2] In the literature there are evidence to prove that the foreign firm had, in fact, after writing a technology licensing (and joint venture) agreement with the local firm, entered the same market. A royalty contract may emerge as optimal when imitation is imperfect and/or patent protection is perfect (Wang, 1998). The detailed taxonomy of the optimal licensing contracts between competing duopolists with differentiated technologies can be found in Rockett (1990).

[3] The main result of the paper can be proved without the linearity assumption.

Given the specification of demand and cost functions, the assumption of an initial duopoly implies

$$0 < c_2 < \bar{c}_2, \tag{3}$$

where $\bar{c}_2 = a/2$ is the monopoly price with $c_1 = 0$ as the marginal cost. So for all $c_2 \geqslant \bar{c}_2$, the foreign firm will have monopoly.

Assume that initially there is no tariff, and so we are in a 'free-trade' world. Now, if we would allow technology transfer from the technologically advanced foreign firm to the local firm under a fixed fee contract (such that the foreign firm would compete in the same market in the post-transfer situation), a profitable technology transfer agreement would take place if and only if the post-transfer industry profits exceed the pre-transfer profits of the industry. Denote the industry profit by $\Omega(c_1, c_2)$. Then transfer of c_1 to firm 2 is profitable if and only if $\Omega(c_1, c_1) > \Omega(c_1, c_2)$.

With the linear demand function (2), we can easily check that $\Omega(c_1, c_2)$ is continuous in c_2 and U-shaped, with $\Omega(c_1, c_1) < \Omega(c_1, \bar{c}_2) = \pi_m(c_1)$. Hence,

$$\exists \tilde{c}_2 \mid \Omega(c_1, c_1) > \Omega(c_1, c_2) \quad \Leftrightarrow \quad c_2 < \tilde{c}_2, \tag{4}$$

where $\tilde{c}_2 = (2a + 3c_1)/5$. Quite obviously, with $c_1 = 0$, $\tilde{c}_2 = 2a/5$. This gives the following proposition.

Proposition 1. *There is a lower bound on c_2 beyond which technology transfer will not occur, and for a small cost gap, technology transfer is always possible.*

The implication of the result is that we can always find a tariff which might induce a technology transfer agreement between these asymmetric firms. [4]

We further assume that

$$c_2 \in (\tilde{c}_2, \bar{c}_2) \equiv \left(\frac{2a}{5}, \frac{a}{2}\right), \tag{5}$$

i.e., free trade does not induce technology transfer. Then free trade equilibrium payoffs of the foreign and local firms are $\pi_1(0, c_2) = (a + c_2)^2/9$ and $\pi_2(0, c_2) = (a - 2c_2)^2/9$, and the corresponding industry output is $Q(0, c_2) = (2a - c_2)/3$.

We shall now characterize the optimal tariff policy with the possibility of technology transfer. The optimal tariff calculation will depend on whether tariffs can be pre-committed or not before the firms make their licensing decisions. Before, we go to estimate the optimal tariff rate, let us first establish, in general terms, the following proposition.

Proposition 2. *There exists a tariff, $t > 0$, which, compared to a situation of free-trade, generates greater overall welfare as well as larger consumer surplus.*

[4] Instead of Cournot competition we can think of price competition with differentiated products. Then we can show that there exists a lower bound on c_2 beyond which technology transfer will not occur if the degree of product differentiation is not 'too' large.

Proof. To show this, first note that at zero tariff, by assumption, $\Omega(c_1, c_2) > \Omega(c_1, c_1)$. Then technology transfer is always profitable at a tariff $\bar{t} \equiv c_2 - c_1$, because

$$\Omega(c_1 + \bar{t}, c_1) = \Omega(c_2, c_1) = \Omega(c_1, c_2) > \Omega(c_1, c_1) > \Omega(c_2, c_2) = \Omega(c_1 + \bar{t}, c_2).$$

With $\bar{t}$, the post-transfer industry output becomes

$$Q(c_1 + \bar{t}, c_1) = Q(c_2, c_1) = Q(c_1, c_2),$$

that is, at $\bar{t}$, consumers' welfare has not fallen at least, when compared to the free trade situation. Again, given the tariff rate, the post-transfer reservation payoff of the local firm becomes $\pi_2(c_1 + \bar{t}, c_2) > \pi_2(c_1, c_2)$. Also compared to the free trade situation, tariff revenue becomes positive i.e., $\bar{t}q_1(c_1 + \bar{t}, c_1) > 0$.

Now we show that any t close to $\bar{t}$, in fact, generates larger overall welfare as well as larger consumer surplus. Let us define

$$\Delta(t) = \Omega(c_1 + t, c_1) - \Omega(c_1 + t, c_2).$$

Then, Δ is continuous in t, with $\Delta < 0$ at $t = 0$ (by (5)), and $\Delta > 0$ at $t = \bar{t}$ (as shown above). Hence $\exists \varepsilon > 0$ such that $\Delta(\bar{t} - \varepsilon) > 0$, that is, at $\bar{t} - \varepsilon$ technology transfer is mutually profitable. When technology transfer occurs at this tariff rate, the industry output becomes

$$Q(c_1 + \bar{t} - \varepsilon, c_1) > Q(c_1, c_2).$$

This means, consumer surplus must go up compared to the free trade situation. □

This is the main result of our paper. Note that we do not need any assumption on the demand function except that we need valid reduced-form profit functions. We now move to characterize the optimal tariff policy and its implication to overall welfare and consumers' surplus.

Game 1: Tariffs are precommitted. In this game, we assume that the local government can commit to a tariff rate before the firms make their licensing decisions. We have the following sequence of moves. In the first stage, the local government decides whether technology transfer will be allowed or not. In the second stage, the government chooses a tariff, t, (optimally) which is committed. In the third stage, firms decide whether they will make a licensing agreement or not. (Quite obviously, if in the first stage technology transfer is not allowed, firms' decisions do not matter.) Finally, firms choose their quantities simultaneously and compete in the market place under Cournot conjectures. The game is portrayed in Fig. 1.

First consider the subgame at node n_2 after "TT Allowed". We have the following result.

Proposition 3. *When the local government can precommit a tariff rate before the firms make their licensing decisions, the optimal tariff is* $t^*(= a/3 - (4/9)c_2)$ *which induces technology transfer.*

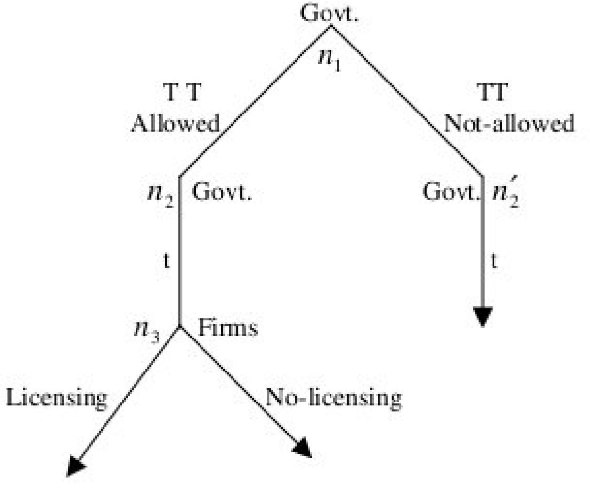

Fig. 1. Game tree for Game 1.

Let us explain the result.[5] For any tariff rate t, the firms will make a licensing agreement (under the fixed fee contract) if and only if the industry profit under licensing exceeds that under no-licensing, i.e.,

$$\Omega(t,0) > \Omega(t,c_2) \quad \Leftrightarrow \quad t > \tilde{t} \equiv (5/8)c_2 - a/4.$$

Thus, if the government's choice of tariff is $t > \tilde{t}$, technology transfer will occur, and the corresponding domestic welfare under technology transfer (TT) regime is defined to be

$$W_{\mathrm{TT}}(t) = CS(t,0) + [\pi_2(t,0) - F] + tq_1(t,0),$$

where $F = \pi_2(t,0) - \pi_2(t,c_2)$ is the fixed fee associated with the transfer of technology to the local firm.[6]

Similarly, under no-transfer (NT) situation (i.e., $t \leqslant \tilde{t}$) the welfare is defined to be

$$W_{\mathrm{NT}}(t) = CS(t,c_2) + \pi_2(t,c_2) + t\,q_1(t,c_2).$$

Thus effectively, W_{TT} is defined for $t > \tilde{t}$ and W_{NT} for $t \leqslant \tilde{t}$. This has been depicted in Panel (a) of Fig. 2. As is shown in the figure, the optimal technology-transfer-inducing tariff is t^* which is obtained from the following maximization problem:

$$\max_t W_{\mathrm{TT}} \quad \text{s.t. } t > \tilde{t}.$$

The corresponding welfare is $W_{\mathrm{TT}}(t^*)$. Similarly, the optimal t to the problem

$$\max_t W_{\mathrm{NT}} \quad \text{s.t. } t \leqslant \tilde{t}$$

is $\tilde{t}$. Here the constraint is binding. The corresponding maximum welfare is $W_{\mathrm{NT}}(\tilde{t})$.

[5] The formal proof of the proposition is available to the authors.

[6] We have assumed that all surplus are extracted by the foreign firm; however, this is not necessary. If the local firm can retain a share λ of the surplus generated through technology transfer, the optimal tariff based on maximizing the corresponding welfare function will be $t^*(\lambda) = (3a - 4c_2(1-\lambda))/9 > \tilde{t}$.

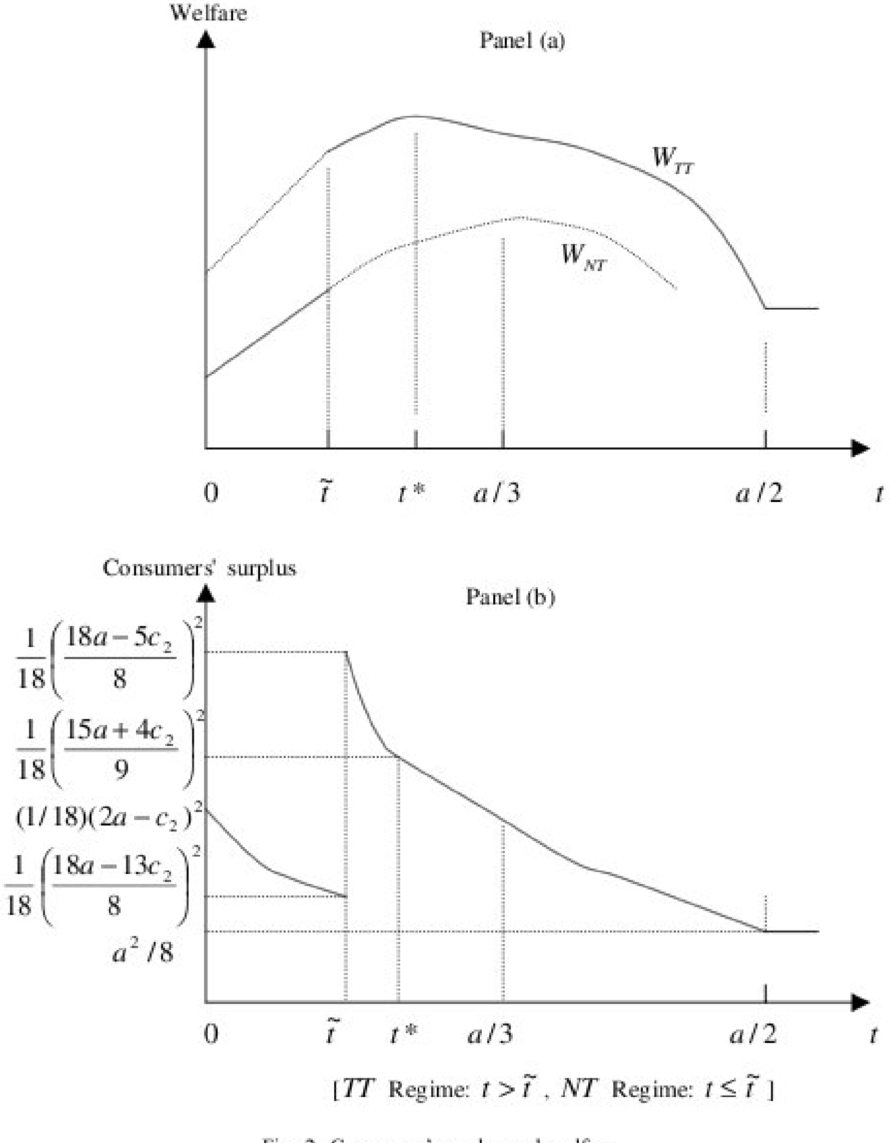

Fig. 2. Consumers' surplus and welfare.

Finally, the solution to the subgame at node n_2 (of Game 1) is t^*, because $W_{\mathrm{TT}}(t^*) > W_{\mathrm{NT}}(\tilde{t})$, which states that the optimal transfer-inducing tariff yields a higher domestic welfare than the optimal non-transfer-inducing tariff.

For an intuition of the result look at Fig. 2, Panel (a). Given the initial asymmetry in technologies, under free trade there will be no technology transfer. Now as the tariff rate goes up, effectively asymmetry falls. Also tariffs result in profit shifting from the foreign firm to the local firm. Tariff revenue also goes up initially. So domestic welfare begins rising. Once the tariff rate crosses the critical level at which technology transfer becomes profitable, technology transfer occurs, and there is a discontinuous hike in consumer surplus as well as overall welfare. Finally, welfare reaches a maximum at t^*.

Note that the solution for the optimal tariff in the subgame at node n_2' (after "TT Not Allowed") is obtained by maximizing the unconstrained function W_{NT}. This gives $t=\hat{t}\equiv a/3$, and the corresponding maximum attainable welfare is $W_{\mathrm{NT}}(\hat{t})$.

Proposition 4. *The solution to Game 1 is ("TT Allowed", "t^*", "Licensing").*

Proof. Allowing technology transfer, the maximum welfare under the optimal tariff policy is $W_{\mathrm{TT}}(t^*)$ (see Proposition 3). When technology transfer is not allowed, the optimal tariff is $\hat{t}$, and the corresponding maximum welfare is $W_{\mathrm{NT}}(\hat{t})$.

Now by definition, $W_{\mathrm{TT}}(t^*) > W_{\mathrm{TT}}(\hat{t})$, and it is easy to prove that $W_{\mathrm{TT}}(\hat{t}) > W_{\mathrm{NT}}(\hat{t})$. Then $W_{\mathrm{TT}}(t^*) > W_{\mathrm{NT}}(\hat{t})$, and hence the proposition. □

We can immediately get following corollaries.

Corollary 1. *If the government can precommit a tariff, the optimal tariff increases the welfare of the local consumers.*

The result is shown in Panel (b) of Fig. 2. Starting from the free trade situation, as t rises, consumers' surplus begins falling. But just after $\tilde{t}$, technology transfer occurs and so there is a discontinuous jump in consumer surplus at $\tilde{t}$. Thereafter consumer surplus falls as t increases. The optimal tariff level is reached at t^*, but compared to free trade situation, consumers' surplus is higher at t^*.

Corollary 2. *Allowing the possibility of technology transfer reduces the optimal tariff compared to no technology transfer possibility.*

A direct comparison of $\hat{t}=a/3$ and $t^*=a/3-(4/9)c_2$ yields $t^*<\hat{t}$. It is instructive to get the intuition of this result in a general setting. The unconstrained W_{NT} reaches maximum at $t=\hat{t}$. Therefore, it must mean that at $\hat{t}$, marginal cost of imposing a further tariff in terms of lost consumers' surplus is just compensated by changes in producers' surplus and tariff revenue. Now, if technology transfer takes place at $t=\hat{t}$, immediately consumers' surplus goes up. Then, a further increase in $\hat{t}$ has a heavier impact in terms of marginal cost, as the base level consumers' surplus is higher. Since we leave the local firm on the pre-transfer level of payoff, nothing changes in term of producers' surplus. But foreign firm's output falls. This means, tariff revenue is affected more now, because higher tariff will work with a lower base. Thus, the revenue augmenting rate of tariff is weaker. As marginal cost is higher and marginal benefit is lower, it pays to cut down the tariff rate.

Game 2: Precommitment of tariffs not possible. The optimal tariff derived for the case of Game 1 is based on the assumption that the tariff is precommitted, that is, firms believe that the tariff once imposed by the local government is not going to be

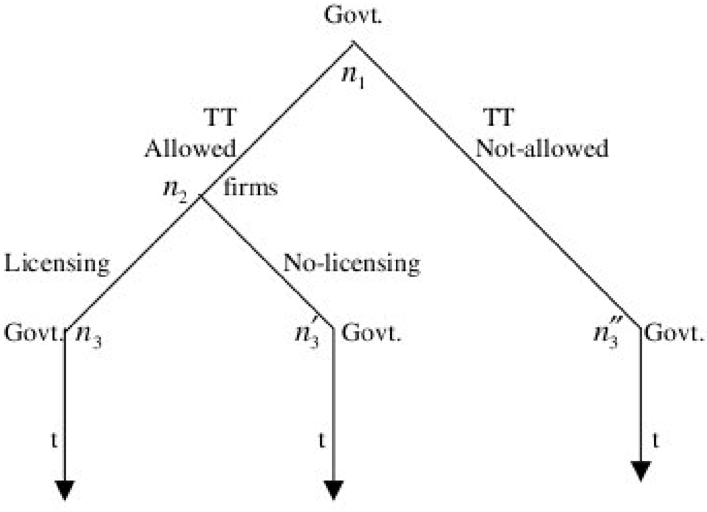

Fig. 3. Game tree for Game 2.

changed under any circumstance, whatever be the firms' behavior following the tariff. But this belief will make sense only if such a tariff is time consistent. As we see in this section, the tariff obtained above is not time-consistent. Hence, the assumption of precommitting a tariff is questioned.

Consider the following game. In the first stage the local government decides whether technology transfer will be allowed or not. In the second stage, firms decide whether they will make a licensing agreement or not. (When technology transfer is not allowed in the first stage, licensing or no-licensing decisions do not matter.) In the third stage, the local government decides its tariff policy optimally, and finally in the fourth stage, firms play Cournot game. The game is portrayed in Fig. 3.

Proposition 5. *When the local government can credibly choose a tariff only after the firms make their licensing decisions, the optimal policy of the government is to allow technology transfer and charge a tariff,* $\hat{t}(=a/3)$*, in which case technology transfer will indeed occur.* [7]

Proof. When technology transfer is not allowed, the optimal tariff (i.e., the solution of the subgame at n_3'') is $\hat{t}$, giving the maximum welfare, $W_{\mathrm{NT}}(\hat{t})$. When technology transfer is allowed but firms decide not to make any licensing contract, the optimal tariff (i.e., the solution of the subgame at n_3') and the corresponding welfare will be the same as above.

But if firms make a licensing agreement, we have to redefine the welfare function because when the government sets its tariff, the fixed fee paid by the local firm is

[7] The subgame of Game 2 at node n_2 may be thought of as a simultaneous move game where the decisions regarding the optimal tariff rate by the local government and licensing or no-licensing decisions by the firms are taken simultaneously. Then unique Nash equilibrium of the game is ("$\hat{t}$", "Licensing").

a sunk cost. Hence, the relevant contribution of the local firm's profit to the welfare function is $\pi_2(t,0)$, not $\pi_2(t,c_2)$. With this change, the welfare function becomes

$$\bar{W}_{\mathrm{TT}} = CS(t,0) + \pi_2(t,0) - F + t\,q_1(t,0),$$

where F at this stage is treated as constant, whereas in the expression of W_{TT} it is a function of t.

The optimal solution of t at node n_3 of Game 2, as obtained by maximizing $\bar{W}_{\mathrm{TT}}$ with respect to t, is $\hat{t}(=a/3)$. In fact, the optimal solutions of t at nodes n_3, n_3' and n_3'' are the same and equal to $\hat{t}$.

Since $\hat{t} > \tilde{t}$, the optimal decision of the firms at node n_2 must be "Licensing", with the corresponding maximum welfare under "TT Allowed" is $\bar{W}_{\mathrm{TT}}(\hat{t})$. Now comparing $\bar{W}_{\mathrm{TT}}(\hat{t})$ and $W_{\mathrm{NT}}(\hat{t})$ we see that

$$\bar{W}_{\mathrm{TT}}(\hat{t}) > W_{\mathrm{NT}}(\hat{t}).$$

Hence, technology transfer will be allowed. This proves the proposition. □

The following corollary immediately follows.

Corollary 3. *Even when the government has no power of commitment, the consumer surplus will go up under the optimal tariff policy.*

Now comparing the results of the two situations based on the assumption of whether the tariff is pre-committed or not, we get the final proposition.

Proposition 6. *The optimal tariff is less and the domestic welfare is larger under precommitment compared to no-commitment situation.*

Proof. The optimal tariff under precommitment is t^* and the corresponding welfare level is $W_{\mathrm{TT}}(t^*)$ (see Proposition 4), and that under no-commitment is $\hat{t}$, with the corresponding welfare level being $\bar{W}_{\mathrm{TT}}(\hat{t})$ (see Proposition 5). Under both situations technology licensing occurs. We already know that $t^* < \hat{t}$ (see Corollary 2). Now we prove that $W_{\mathrm{TT}}(t^*) > \bar{W}_{\mathrm{TT}}(\hat{t})$.

In the no-commitment game, given that the government will choose in equilibrium a tariff, $\hat{t}$, the firms in the earlier stage will strike a licensing deal, with the corresponding fixed fee in equilibrium being $F = \pi_2(\hat{t},0) - \pi_2(\hat{t},c_2)$. Plugging this value in $\bar{W}_{\mathrm{TT}}$ we have

$$\bar{W}_{\mathrm{TT}}(\hat{t}) = W_{\mathrm{TT}}(\hat{t}).$$

Since t^* maximizes $W_{\mathrm{TT}}(t)$ and $t^* < \hat{t}$, we must have

$$\bar{W}_{\mathrm{TT}}(\hat{t}) = W_{\mathrm{TT}}(\hat{t}) < W_{\mathrm{TT}}(t^*). \qquad \square$$

Before we go to the concluding section, let us briefly mention why in our structure it is optimal for the domestic welfare-maximizing local government to restrict DFI. From the viewpoint of the local country's welfare, DFI and direct export of goods by the foreign firm are equivalent, as under DFI technology transfer does not take place. From the perspective of the foreign firm, given that DFI involves a sunk investment, direct export of goods will dominate if the tariff rate is zero or low. With a tariff above a critical level, a tariff-jumping foreign investment may, however, be a better alternative to the foreign firm. In any case, a partial tariff policy generates strictly larger welfare compared to free trade and tariff-jumping foreign investment. Then, if the government can restrict DFI why cannot it restrict the entry of the foreign firm once technology is transferred and thereby promote exclusive licensing? The simple reason is that if the local government is concerned about consumers' welfare, it must keep the threat of entry alive and hence not encourage exclusive licensing. Our paper presents the taxonomy of alternative scenarios and it is clear from our analysis that more competition, provided technology is transferred, is always a better option.

3. Conclusion

In this paper we have portrayed situations where a well-directed restrictive trade policy not only increases an overall welfare of the country, but also it helps consumers to get a better price. This happens when a tariff induces the foreign firm to transfer its superior technology to the local competitor. We have shown that in general such a tariff exists, it induces technology transfer and increases domestic as well as consumers' welfare. We have also characterized the optimal tariff both under the situation when tariffs are committed before firms make their licensing decisions and when such pre-commitment is not possible. We have shown that under each case transfer would indeed occur and the consumers' welfare would go up. Moreover, allowing the possibility of technology transfer reduces the optimal tariff compared to the no-transfer case. [8]

Acknowledgements

The authors would like to thank two anonymous referees and the co-editor of this journal for their comments and suggestions. The general disclaimer applies.

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[8] It is possible that typically a tariff will be decided on political considerations. Our result can be accommodated in a political–economic framework where the foreign firm may have some political power to lobby for a subsidy to counter the tariff and the local government may escalate the tariff rate because of the producers' lobby. Whatever be the case, it can be shown under reasonable assumption that such a "tariff-subsidy equilibrium" can easily accommodate greater consumers' surplus relative to free trade.

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