

INNOVATION UNDER THE THREAT OF DIRECT FOREIGN INVESTMENT

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We examine the implication of direct and indirect foreign competition on domestic innovation decision. In most of the existing theoretical analyses the foreign firms are assumed to enter the domestic-country market as an exporter and thus are subject to a tariff duty imposed by the local government. We consider a broader setting where the foreign firm also has the option of setting up a production unit in the domestic country to supply output to the domestic country. This enables it to avoid the tariff that it faces due to export. Once we allow for such a strategy option for the foreign firm, competition becomes more direct and intense since tariffs no longer discount for the technological inferiority of home firms. We show that innovation by the home firm will be discouraged at high tariffs under the threat of DFI. Again at low tariff rates exports by the foreign firm make market competition more intense and reduce the incentive for innovation. Hence the home firm always (never) innovates at low (high) R&D cost whatever be the tariff rate. For intermediate R&D cost the home firm innovates if the foreign firm opts for exports.

Keywords: Innovation, Tariff, Foreign Direct Investment, Foreign Competition

JEL classification: F12, F13, F21, L13, O31

1. INTRODUCTION

Innovation and product development are important survival strategies of the firms in the long run. But uncertainties in the outcome of R&D investment, weak patent laws prevent full appropriation of innovation benefits when it is successful and often discourages firms to invest large sums of money in R&D. Market structure, nature and intensity of competition and government policy also influence in one way or the other the innovation decision of firms (Dasgupta and Stiglitz (1999), Kamien and Schwartz (1991), Schumpeter (1943)).

Since the earliest investigations of the role of these factors, the implications of

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liberal government policies that put the incumbent local firms in competition with the foreign firms (who may be technologically superior) have been debated without generating any theoretical consensus. Competition from the foreign firms may be indirect - when tariffs are lowered to allow local traders and consumers to import goods that are similar to what has been locally produced - or, direct, when the foreign firms are allowed to set up their production units and to make business in the host country. There is a huge and well developed literature on the effect of liberal trade policies and indirect foreign competition on local firms' innovation decisions and innovation levels. In this context, analyses of Bouet (2001), Clemenz (1990), Reitzes (1991) and Rodrik (1992) deserve particular attention. Reitzes (1991) and Bouet (2001) show that tariff induces the local firm to increase its cost reducing R&D activities. Contrarily Rodrik (1992) argues that protection by ensuring a larger domestic market increases the domestic firm's incentive for cost reducing innovation. Clemenz (1990) compares R&D levels of a foreign firm and a home firm under autarky and free trade and shows that if the initial technological gap is sufficiently small free trade stimulates the R&D of both firms. Some studies also compare the effect of tariff with other instruments of trade policy, namely quota, voluntary export restriction, export subsidy etc. Bouet (2001) compares the effect of tariff with VER. Reitzes (1991) analyses different impact of quota and tariffs on cost reducing R&D.

On the other hand, there are some empirical studies regarding the effect of direct foreign competition in the form of DFI on R&D in host country. Hubert and Nigel (2001) investigate the impact of direct investment by the foreign-owned companies on technical progress in the UK manufacturing sector and find that the foreign-owned firms have a significant positive effect on the level of technical efficiency in domestic firms. Guoyong (2003) investigates the impact of DFI on the competition and innovation in China's telecom equipment manufacturing industry. He finds that entry of MNCs increases the degree of product market competition and promotes innovation. In the context of India, "with respect to the contribution of DFI to local technological capability and technology diffusion, the studies find a mixed evidence" (Kumar (2005)).

However, in a regime of liberal trade and investment policies in a developing country, indirect foreign competition (i.e., imports) and direct foreign competition (i.e., DFI) are not exogenous factors. Rather, these are the outcome of the decision of the foreign firms regarding the mode of entry. For example, the tariff-jumping theory of DFI argues that high tariff on imports may induce the foreign firms to set up subsidiaries in the host country if there is no restriction on such investments. This choice over the mode of entry and investment barriers which is falling down in the present era of globalization make it relevant to put together the disjoint literatures on the effect of foreign competition on local R&D decision as reviewed above. This is precisely what the present paper attempts.

For the purpose we consider a broader setting where the foreign firm has two modes of entry. It can set up a new plant in a domestic (or host) country to produce output and supply to the local market or it may export the product by giving tariff to local

government. Generally there are two modes of DFI; one greenfield DFI (new plant investment) and other non-green field DFI (mergers and acquisition). In this model only green field DFI (setting of a new plant) is considered. The reason behind it is that when firms have firm-specific knowledge, they presumably want to engage in greenfield DFI instead of mergers and acquisition to minimize the chance that others would gain access to this knowledge (Neven and Siotis (1996)). We also ignore technology or productivity spillover effect because economists are not unanimous about the spillover effect of DFI. Once we allow for such a strategy option for the foreign firm, competition becomes more direct and intense since tariffs no longer discount for the technological inferiority of the home firms. Of course, this is quite in line with the liberal trade and investment policies of the developing countries. We assume that in competition the home firm may innovate a fixed amount with some fixed R&D cost. In this set up, we examine the implication of foreign competition on the innovation decision of home firm, i.e., whether it will innovate or not. At comparatively high tariff rates the foreign firm opts for DFI, but this discourages innovation of the home firm. On the other hand, at low tariff rates exports by the foreign firm is profitable. But such indirect competition reduces the incentive of innovation as well. The result we obtain is that the possibility of domestic innovation is very much restricted under liberalization unless the innovation cost itself is very low.

The rest of the paper is organized as follows. Section 2 provides a duopoly model to show the innovation decision of the home firm when we allow two modes of entry by the foreign firm under liberalization. Subsection 2.1 describes the strategies of the firms and subsection 2.2 describes the structure of the model. Section 3 is devoted to the determination of choices of strategies by the firms under liberalization.

2. MODEL

2.1. Firms and Strategies

In protective regime there is only one home firm in the industry which has monopoly power in the home market. In the post liberalization situation there are two firms in the industry; one is home firm and another is foreign firm and they are engaged in Cournot duopoly game. The home firm is technologically inefficient which is reflected in its higher marginal cost of production, c , relative to the foreign marginal cost, c^* . The home firm has, however, an option of investing in a cost reducing R&D. The foreign firm has two options. It can produce the good in its own country and export the output at zero cost or it can set up production unit in the home country. If it decides to cater to the home market through exports, it faces an import duty imposed by the local government. The disincentive for DFI is, on the other hand, the cost of setting up a plant.

2.2. Structure of the Model

Demand Function

Let the demand function of the i th firm be linear and in inverse form is given by the equation

$$p = \alpha - q_i - q_j, \quad i \neq j; \quad i, j = 1, 2, \quad (1)$$

where p is the price of the product and q_i is quantity demanded for the i th firm's product and products are homogenous.

Cost Function

Under protection production technology of home firm be denoted is constant marginal cost, c . After liberalization we assume that only one foreign firm enters with superior technology of production shown by constant marginal cost c^* such that $c > c^*$ and we assume $c^* = 0$ to simplify the algebra. Thus the larger is the value of home marginal cost c , higher will be the initial difference in technical efficiency. The technology gap is $c - c^* = c$. The foreign firm may export the product by giving tariff, t to the domestic government or it may invest directly for local production. There is a fixed amount of DFI, say F . In competition with the foreign firm, the home firm may undertake process innovating R&D in order to reduce the marginal cost of production. We assume that the output of R&D is fixed and it is equal to the technology gap, c and there is a fixed R&D cost, say, R . This means by doing R&D home firm will equalize its marginal cost with foreign firm.

3. CHOICE OF STRATEGIES BY THE FIRMS

We assume that in competition at first the firms choose their strategies simultaneously. Then they simultaneously decide on their output levels. In this case, we essentially have two stages. In the first stage, the firms simultaneously decide about their strategy options as defined above, given the import tariff t , R and F and in the second stage they decide about how much to supply and profits are realized thereafter. Let us begin with the second stage.

Second Stage

Given the linear demand function as defined in (1), the profit level of the foreign firm is given by, where outputs of the home firm and foreign firm are denoted by q_1 and q_2 respectively

$$\pi_2^E = [\alpha - q_1 - q_2 - t]q_2, \quad (2)$$

when it decides to cater the domestic country through exports and

$$\pi_2^{DFI} = [\alpha - q_1 - q_2]q_2 - F, \quad (3)$$

when it decides to set up a plant at the home country at a fixed cost F .

On the other hand, the home firm's profit is equal to

$$\pi_1^I = [\alpha - q_1 - q_2]q_1 - R, \quad (4)$$

when it invests a fixed sum R in R&D which lowers its marginal cost to the level of that of foreign firm (which is set to zero) with certainty.¹ But if it decides not to invest in the R&D, it can realize

$$\pi_1^{NI} = [\alpha - q_1 - q_2 - c]q_1. \quad (5)$$

Given these profit functions, it is easy to check the following profit maximizing output levels and realized profit levels under different strategy combinations (as indicated by super scripts):

$$q_1^{I,E} = \frac{\alpha + t}{3}, \quad q_2^{I,E} = \frac{\alpha - 2t}{3}, \quad (6)$$

$$\pi_1^{I,E} = \frac{1}{9}(\alpha + t)^2 - R, \quad (7)$$

$$\pi_2^{I,E} = \frac{1}{9}(\alpha - 2t)^2, \quad (8)$$

$$q_1^{I,DFI} = \frac{\alpha}{3} = q_2^{I,DFI}, \quad (9)$$

$$\pi_1^{I,DFI} = \frac{1}{9}\alpha^2 - R, \quad (10)$$

$$\pi_2^{I,DFI} = \frac{1}{9}\alpha^2 - F, \quad (11)$$

$$q_1^{NI,E} = \frac{\alpha - 2c + t}{3}, \quad q_2^{NI,E} = \frac{\alpha + c - 2t}{3}, \quad (12)$$

¹ Uncertainty in R&D output will not give any quantitative change of our results but will unnecessarily complicate the algebra.

$$\pi_1^{NI,E} = \frac{1}{9}(\alpha - 2c + t)^2, \quad (13)$$

$$\pi_2^{NI,E} = \frac{1}{9}(\alpha + c - 2t)^2, \quad (14)$$

$$q_1^{NI,DFI} = \frac{\alpha - 2c}{3}, \quad q_2^{NI,DFI} = \frac{\alpha + c}{3}, \quad (15)$$

$$\pi_1^{NI,DFI} = \frac{1}{9}(\alpha - 2c)^2, \quad (16)$$

$$\pi_2^{NI,DFI} = \frac{1}{9}(\alpha + c)^2 - F. \quad (17)$$

Both second order and stability conditions hold in all the four cases. However, for the existence of duopoly equilibrium, we need to impose certain restrictions on the parameters of the model. First, as evident from (6), the foreign firm will export a positive amount, given that the home firm invests in cost reducing R&D only if the level of tariff is not too high in the sense that,

$$t < \frac{\alpha}{2} \equiv t^*. \quad (18)$$

Otherwise, the foreign firm will not enter the domestic market as an exporter and the home firm will continue to enjoy its monopoly position. The restriction defined in (18) also ensures that the foreign firm will supply a positive amount even when the home firm does not innovate. Secondly, when the home firm does not innovate, the foreign firm will export a positive amount if $t \leq \frac{\alpha + c}{2}$.² Otherwise the foreign firm will not enter at all as exporter.

On the other hand, from (15) it appears that when the foreign firm sets up a plant in the domestic country and produces all its output there, the home firm can survive in the competition, when it does not innovate, if its marginal cost is not too high:

$$c < \frac{\alpha}{2}. \quad (19)$$

This also guarantees, though not necessary, that the home firm survives in competition even when the foreign firm enters as an exporter (and the home firm does

² More precisely, in such a case, $q_2^{NI,E} > 0$ even for $t \in \left[\frac{\alpha}{2}, \frac{\alpha + c}{2} \right]$. Thus, the level of prohibitive tariff differs.

not innovate).

There are in addition the following two viability conditions requiring that innovation by the home firm and organizing production in the domestic country by the foreign firm are indeed profitable. When the foreign firm chooses DFI option, viability condition for innovation requires

$$R \leq \frac{1}{9} \alpha^2 . \quad (20i)$$

It also ensures the viability of innovation when the foreign firm exports. On the other hand, when the home firm innovates, DFI is profitable if

$$F \leq \frac{1}{9} \alpha^2 . \quad (20ii)$$

It also ensures the profitability of DFI, even when the home firm does not innovate.

Of course, these restrictions by themselves do not imply that DFI is profitable to the export option. Two comments are warranted. First, the usual tie-breaking rule is applied, i.e., if the net profit from innovation (or DFI) is exactly zero, the firm innovates (produces). Second, the same restrictions ensure that the home (foreign) firm will innovate (produce) regardless of the strategy of the foreign (home) firm.

First Stage

Given these output decisions and consequent profit levels realized in the second stage, we now look at the strategy choices in the first stage. For non-trivial strategy choices we will confine ourselves with any tariffs defines in (18), because only for these tariff levels positive output and profit levels can be realized for the “exporting” foreign firm regardless of whether the home firm innovates or not.

Let us start with *the strategy choice of the home firm*. If the foreign firm adopts the DFI strategy, then the home firm will innovate if the relative profit under innovation is higher, i.e.,

$$\pi_1^{I,DFI} - \pi_1^{NI,DFI} \geq 0 ,$$

which boils down to, after substitution of values from (10) and (16),

$$\frac{4}{9} c(\alpha - c) \geq R . \quad (21)$$

For $c < \alpha/2$, this obeys the viability condition of innovation given in (20i). Strict equality defines the value of R for which the home firm is indifferent between

innovation and no-innovation.

$$R^{DFI} \equiv \frac{4}{9}c(\alpha - c) = R. \quad (22)$$

On the other hand, if the foreign firm chooses to export, then the home firm will innovate if the relative profit under innovation is higher, i.e.,

$$\pi_1^{I,E} - \pi_1^{NI,E} \geq 0,$$

which boils down to, after substitution of values from (7) and (13)

$$\frac{4}{9}c(\alpha - c + t) \geq R. \quad (23)$$

Strict equality defines the pair of t and R such that local firm is indifferent between innovation and no-innovation. Thus

$$R^E(t) \equiv \frac{4}{9}c(\alpha - c + t) = R. \quad (24)$$

Note that $\frac{\partial R^E}{\partial t} = \frac{4c}{9} > 0$, and $R^E|_{t=0} = \frac{4c}{9}(\alpha - c)$, $R^E|_{t=\alpha/2} = \frac{2c}{9}(3\alpha - 2c)$.

For $\frac{\alpha}{2} \leq t \leq \frac{\alpha + c}{2}$, the home firm possesses monopoly power if it innovates.

Otherwise there is duopoly in domestic market. In this case home firm will innovate if the relative monopoly profit for innovation is higher, i.e.,

$$\begin{aligned} \pi_{MI}^I &> \pi_1^{NI,E}, \\ \text{or, } \frac{1}{4}\alpha^2 - \frac{1}{9}(\alpha - 2c + t)^2 &\geq R, \\ \text{or, } (5\alpha - 4c + 2t)(\alpha + 4c - 2t) &\geq 36R. \end{aligned} \quad (25)$$

Note that $\frac{\partial R^E}{\partial t} = -\frac{2}{9}(\alpha - 2c + t) < 0$, for $\frac{\alpha}{2} < t < \frac{\alpha + c}{2}$, and $R^E|_{t=\frac{\alpha+c}{2}} = \frac{c}{4}(2\alpha - c)$.

These curvature properties and inequalities help us to draw Figure 1. The curves R^{DFI} and $R^E(t)$ divide the decision space of the home firm leveled as (a), (b), (c), (d) in Figure 1 for different strategies of foreign firm.

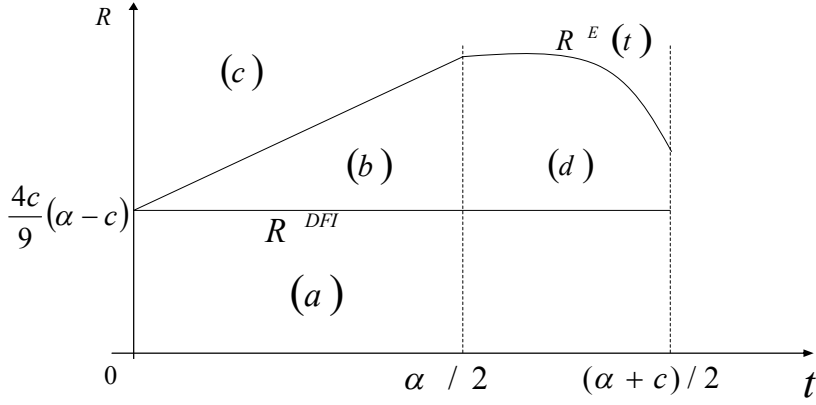


Figure 1. Decision Space of Home firm

Lemma 1. $\forall R < R^{DFI}$, innovation is the dominating strategy of the home firm.

Proof

From (22) and (24) it follows that

$$R^{DFI} < R^E(t) \quad \forall t. \quad (26)$$

Thus, by (21) and (23) $\forall R < R^{DFI}$.

$$\pi_1^{I,DFI} > \pi_1^{NI,DFI},$$

$$\pi_1^{I,E} > \pi_1^{NI,E}.$$

Hence the claim.

In region (a) of Figure 1, the dominating strategy of the home firm is innovation.

Lemma 2. $\forall R > R^E(t)$, dominating strategy of the home firm is no-innovation.

Proof

Given (26), it immediately follows that $\forall R > R^E(t)$.

$$\pi_1^{I,E} < \pi_1^{NI,E}.$$

$$\pi_1^{I,DFI} < \pi_1^{NI,DFI}.$$

Hence the claim.

In Region (c) of Figure 1, the dominating strategy of the home firm is no-innovation.

Lemma 3. For $R^{DFI} < R < R^E(t)$, the home firm's strategy is conditional upon the strategy choice of the foreign firm.

Proof

When R is within the intermediate range i.e., $R^{DFI} < R < R^E(t)$, no such dominating strategy exists. Optimal strategy of the home firm then depends on the strategy chosen by the foreign firm. If foreign firm goes for DFI, the home firm prefers no-innovation. On the other hand if foreign firm exports, the home firm innovates.

$$\forall R > R^{DFI}, \text{ by (21) } \pi_1^{I,DFI} < \pi_1^{NI,DFI},$$

$$\forall R < R^E(t), \text{ by (23) } \pi_1^{I,E} > \pi_1^{NI,E}.$$

Hence the claim.

Region (b) of Figure 1 corresponds to all (t, R) , $\forall t < \alpha/2$ for which $R^{DFI} < R < R^E(t)$ holds. In Region (d), $\forall R < R^E(t)$, $\forall \frac{\alpha}{2} < t < \frac{\alpha+c}{2}$, $\pi_{MI}^I > \pi_I^{NI,E}$ by (25).

Thus in Region (b) the home firm adopts two different strategies for different strategy choices of the foreign firm. But in region (d), where $t > \alpha/2$ the foreign firm has only one mode of entry, i.e., DFI if the home firm does not innovate. So in Region (d) the home firm possesses monopoly power by innovating or it does not innovate if the foreign firm goes for DFI.

Let us now consider *the strategy choice of the foreign firm*.

If the home firm chooses to innovate, then the foreign firm prefers DFI if its relative profit from DFI is higher, i.e.,

$$\pi_2^{I,DFI} - \pi_2^{I,E} \geq 0, \quad \forall t < \alpha/2,$$

which boils down to, after substitution of values from (8) and (11),

$$\frac{4}{9}t(\alpha - t) \geq F, \quad \forall t < \alpha/2. \quad (27)$$

It satisfies the viability condition of DFI given in (20ii). The strict equality defines the pair of t and F such that foreign firm is indifferent between DFI and export when the home firm innovates:

$$F^I(t) \equiv \frac{4}{9}t(\alpha - t) = F. \quad (28)$$

It is easy to check that F^I is an increasing (and concave) function of the tariff level $\forall t < \alpha/2$.³

The output and profit of foreign firm from export become zero when $t = \alpha/2 = t_p^{I,E}$. So foreign firm may export the product for $0 < t < \alpha/2$ and then for $\alpha/2 < t < (\alpha + c)/2$ the only option open to the foreign firm is DFI given the viability condition (20ii).

Finally under no-innovation by the home firm, the foreign firm adopts the DFI strategy if the relative profit of the foreign firm is higher from DFI, i.e.,

$$\pi_2^{NI,DFI} - \pi_2^{NI,E} \geq 0.$$

Which boils down to, after substitution of values from (14) and (17),

$$\frac{4}{9}t(\alpha + c - t) \geq F. \quad (29)$$

Once again the strict equality defines the pair of t and F such that the foreign firm is indifferent between DFI and export when the home firm does not innovate:

$$F^{NI}(t) \equiv \frac{4}{9}t(\alpha + c - t) = F. \quad (30)$$

F^{NI} is an increasing (and concave) function of the tariff level for $t < \frac{\alpha + c}{2}$.

Moreover it increases faster than $F^I(t)$.⁴

It can also be verified that the value of F^{NI} at the prohibitive tariff $t_p^{NI,E} = (\alpha + c)/2$, at which it reaches its maximum value is $(\alpha + c)^2/9$.

$$F^{NI}(t_p^{I,E}) = \frac{\alpha}{9}(\alpha + 2c) > F^I(t_p^{I,E}).$$

$$^3 \frac{dF^I}{dt} = \frac{4}{9}(\alpha - 2t) > 0 \quad \forall t < \frac{\alpha}{2} \quad \text{and} \quad \frac{d^2F^I}{dt^2} = -\frac{8}{9} < 0.$$

$$^4 \frac{dF^{NI}}{dt} = \frac{4}{9}(\alpha + c - 2t) > \frac{dF^I}{dt} = \frac{4}{9}(\alpha - 2t) > 0 \quad \forall t < \frac{\alpha}{2} \quad \text{and} \quad \frac{d^2F^I}{dt^2} = -\frac{8}{9} < 0.$$

These curvature properties and inequalities help us draw Figure 2. The curves $F^I(t)$ and $F^{NI}(t)$ divide the decision space of the foreign firm labeled (e), (f), (g), (h) in Figure 2 for different strategies of the home firm.

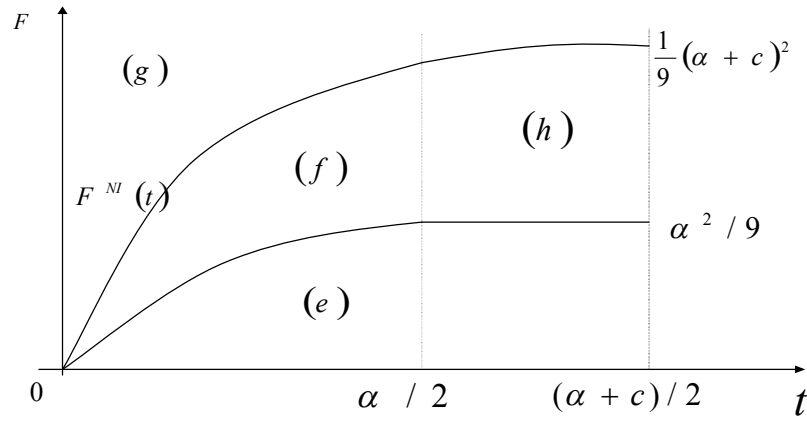


Figure 2. Decision Space of the Foreign Firm

The following Lemmas are then immediate

Lemma 4. $\forall F < F^I(t)$, DFI is the dominating strategy of the foreign firm.

Proof

From (28) and (30), it follows that

$$F^I(t) < F^{NI}(t) \quad \forall t. \quad (31)$$

Thus, by (27) and (29) $\forall F < F^I(t)$,

$$\pi_2^{I,DFI} > \pi_2^{I,E},$$

$$\pi_2^{NI,DFI} > \pi_2^{NI,E}.$$

Hence the claim.

In region (e) of Figure 2, the dominating strategy of the foreign firm is DFI.

Lemma 5. $\forall F > F^{NI}(t)$, export is the dominating strategy of the foreign firm.

Proof

Given (33), it immediately follows that $\forall F > F^{NI}(t)$,

$$\pi_2^{NI,DFI} < \pi_2^{NI,E},$$

$$\pi_2^{I,DFI} < \pi_2^{I,E}.$$

Hence the claim.

In region (g) of Figure 2, the dominating strategy of the foreign firm is export.

Lemma 6. $\forall F^I(t) < F < F^{NI}(t)$, the foreign firm's strategy is conditional upon the strategy choice of the home firm.

Proof

When F is within the intermediate range i.e., $F^I(t) < F < F^{NI}(t)$, no such dominating strategy exists. Optimal strategy of the foreign firm is subject to the strategy chosen by the home firm. If the home firm innovates, the foreign firm's optimal strategy will be export. If the home firm prefers no-innovation, foreign firm's optimal strategy is DFI for

$$\forall F > F^I(t), \text{ by (27) } \pi_2^{I,DFI} < \pi_2^{I,E}, \quad \forall t < \alpha/2,$$

$$\forall F < F^{NI}(t), \text{ by (29) } \pi_2^{NI,DFI} > \pi_2^{NI,E} \quad \forall t < (\alpha + c)/2.$$

Hence the claim.

Region (f) of Figure 2 corresponds to all (t, F) for which $F^I(t) < F < F^{NI}(t)$ holds. Thus in region (f) foreign firm adopts two different strategies for different strategy choice of home firm. But in Region (h) the foreign firm has only one choice, DFI, if home firm does not innovate. If the home firm innovates, the foreign firm does not enter at all.

We are now in a position to determine the Nash equilibrium of simultaneous decision making game when both the home firm and the foreign firm simultaneously choose their optimal strategies. The Nash equilibrium strategy pairs for different parametric configurations are summarized in Table 1 and are shown in Figure 3.

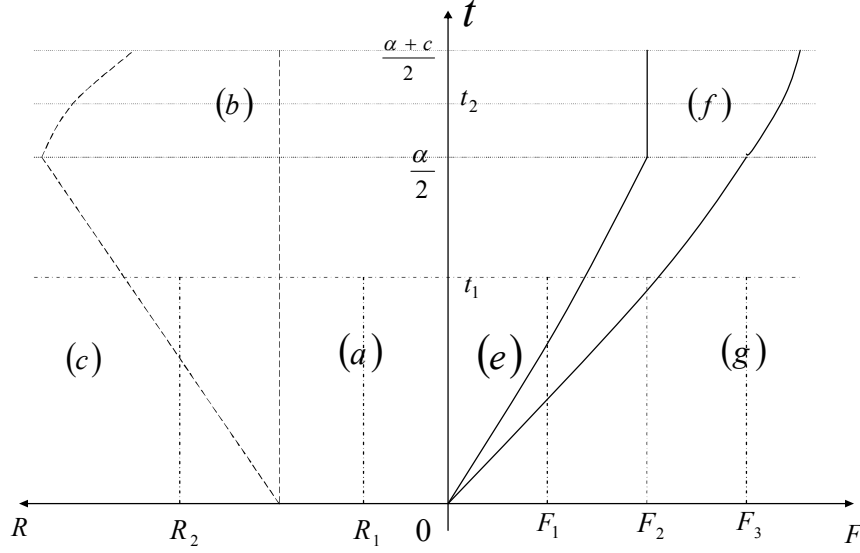


Figure 3. Optimum Decision Space of the Foreign and the Home Firm

We will analyse whether Nash equilibrium exists for each regions. Let s_j^* be the optimal strategy of j th firm. In case of sufficiently low R&D cost, i.e., $0 < R < \frac{4c}{9}(\alpha - c)$.

For the combination (R_1, F_1, t_1) , $s_1^* = I \quad \forall \quad s_2$ and $s_2^* = DFI \quad \forall \quad s_1$.
 $\therefore (s_1^*, s_2^*) = (I, DFI)$.

For the combination (R_1, F_3, t_1) , $s_1^* = I \quad \forall \quad s_2$ and $s_2^* = E \quad \forall \quad s_1$.
 $\therefore (s_1^*, s_2^*) = (I, E)$.

For the combination (R_1, F_2, t_1) , $s_2^* = \begin{cases} E & \text{if } s_1 = I \\ DFI & \text{if } s_1 = NI \end{cases}$ but $s_1^* = I \quad \forall \quad s_2$.
 $\therefore (s_1^*, s_2^*) = (I, E)$.

In case of moderate R&D cost, i.e., $\frac{4}{9}c(\alpha - c) < R < \frac{4}{9}c(\alpha - c + t)$,

for the combination (R_2, F_1, t_1) , $s_1^* = \begin{cases} I & \text{if } s_2 = E \\ NI & \text{if } s_2 = DFI \end{cases}$ but $s_2^* = DFI \quad \forall \quad s_1$.
 $\therefore (s_1^*, s_2^*) = (NI, DFI)$.

for the combination (R_2, F_3, t_1) , $s_1^* = \begin{cases} I & \text{if } s_2 = E \\ NI & \text{if } s_2 = DFI \end{cases}$ but $s_2^* = E \quad \forall s_1$.
 $\therefore (s_1^*, s_2^*) = (I, E)$.

for the combination (R_2, F_1, t_2) , $s_1^* = \begin{cases} I & \text{under monopoly} \\ NI & \text{if } s_2 = DFI \end{cases}$ and $s_2^* = DFI \quad \forall s_1$.
 $\therefore (s_1^*, s_2^*) = (NI, DFI)$.

for the combination (R_2, F_3, t_2) , $s_1^* = \begin{cases} I & \text{under monopoly} \\ NI & \text{if } s_2 = DFI \end{cases}$ but $s_2^* = E \quad \forall s_1$.

Here Nash equilibrium does not exist.

for the combination (R_2, F_2, t_2) ,

$$s_1^* = \begin{cases} I & \text{under monopoly} \\ NI & \text{if } s_2 = DFI \end{cases} \quad \text{and} \quad s_2^* = \begin{cases} \text{no option} & \text{if } s_1 = I \\ DFI & \text{if } s_1 = NI \end{cases}$$

Hence multiple Nash equilibrium exist.

$$\therefore (s_1^*, s_2^*) = (NI, DFI), \quad (\text{monopoly power with } I, E).$$

From the above analysis, let us summarize the strategy choice of the home firm and the foreign firm.

In general the possible Nash equilibrium for different parametric configurations are summarized in Table 1 below.

Table 1. Strategy Choice of the Firms for $0 < t < \alpha/2$

	$0 < R < R^{DFI}$	$R^{DFI} < R < R^E(t)$	$R^E(t) < R$
$0 < F < F^I(t)$	(I, DFI)	(NI, DFI)	(NI, DFI)
$F^I(t) < F < F^{NI}(t)$	(I, E)	(I, E), (NI, DFI)	(NI, DFI)
$F^{NI}(t) < F$	(I, E)	(I, E)	(NI, E)

Thus, whereas the nature of Nash equilibrium for $\forall t < \alpha/2$ depends on the values of R and F , for $R^{DFI} < R < R^E(t)$ and $F^I(t) < F < F^{NI}(t)$, there are two Nash equilibrium strategy pairs. For this intermediate range of innovation cost emerges another interesting outcome which is summarized in proposition below.

Proposition 1. *Possibility of DFI by itself lowers the incentive of innovation $\forall R^{DFI} < R < R^E(t)$.*

Proof

For these moderate R&D costs, i.e., $R^{DFI} < R < R^E(t)$ by Lemma 3 and a Nash equilibrium strategies described in Table 1, the home firm innovates only if the foreign firm chooses exports as its mode of entry. But when the foreign firm prefers DFI, the home firm does not innovate. That is, (I, DFI) can never be a Nash equilibrium $\forall R^{DFI} < R < R^E(t)$.

Hence proved.

What emerges from Proposition 1 is that more intense foreign competition in the form of DFI lowers the incentive for innovation by the home firm. The intuition is that more intense competition lowers the post-innovation profit for the home firm and accordingly lowers the relative profitability of R&D processes with sufficiently high R.⁵

4. CONCLUSION

In this paper we have studied the impact of trade and investment liberalization on the domestic process innovation level where a foreign firm has two modes of entry in the home market; it may export the product by giving tariff to local government or it may opt for direct production in the home country by investing a fixed amount to avoid tariff. In competition with the foreign firm, the home firm may innovate a fixed amount in order to reduce its marginal cost with some fixed R&D cost. Under this scenario, we have analysed the implication of foreign competition on the innovation decision of the home firm. Obviously time structure of decision making affects the optimal strategies by the firms. Under liberalized regime when both firms choose their strategies simultaneously, the possibility of domestic innovation would be much restricted compared to the case where the foreign firm has only one mode of entry, i.e., exports. The home firm always innovates (does not innovate) if the innovation cost is itself very low (high) whatever be the mode of entry by the foreign firm. For the intermediate range of innovation cost, the home firm would not innovate if the foreign firm goes for DFI; otherwise it innovates.

We may extend this theoretical analysis where the firms move sequentially. For this purpose we may construct a three stage game. If the foreign firm moves first, it decides about its own strategy option in the first stage. After this choice in the second stage the home firm decides about its strategy and then in the third stage they simultaneously

⁵ For $\frac{\alpha}{2} < t < \frac{\alpha+c}{2}$, if the home firm innovates, high tariff prohibits the export mode of entry. For the intermediate range of F , innovation becoming the strictly dominating strategy of the home firm prohibits the entry of FDI. Thus, SPE is innovation and no-entry. For moderate R&D costs multiple equilibrium exists, i.e., either innovation and no-entry or no-innovation and FDI.

decide about their outputs and realized profits. Obviously for the intermediate range of R&D cost the foreign firm choose DFI instead of exports in order to avoid tariff. Hence the home firm decides not to innovate as it becomes impossible for it to reap the return of investment under direct competition through DFI. Thus when the foreign firm moves first the scope of innovation is much restricted compared to the case of simultaneous movement. However if the sunk cost of DFI is very high, then only the foreign firm will export the product and the home firm decides to innovate. On the other hand, the domestic innovation may be higher when the home firm takes its innovation decision first before the decision taken by the foreign firm about its mode of entry. As the first mover the home firm chooses to innovate in the intermediate range excepting the case of sufficiently low sunk cost of DFI. Again it decides to innovate for some higher R&D cost also and deters the entry of the foreign firm through DFI.

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