



# research paper series

**Globalisation, Productivity and Technology Programme**

Research Paper 2003/37

*Foreign market entry: a theoretical analysis*

by

*Arijit Mukherjee and Soma Mukherjee*

The Centre acknowledges financial support from The Leverhulme Trust  
under Programme Grant F114/BF



**Leverhulme Centre**  
for Research on Globalisation and Economic Policy

## **The Authors**

Arijit Mukherjee is Lecturer in the School of Economics and an Internal Fellow of the Leverhulme Centre for Research on Globalisation and Economic Policy, University of Nottingham. Soma Mukherjee is Research Planning Officer in Keele University.

## **Acknowledgements**

The authors are solely responsible for the views presented here but not the Universities. We would like to thank the seminar participants at the University of Bonn and the participants of the “Southeast Theory and International Economics Meetings” held at the Georgetown University, USA, for stimulating discussions. The discussions with Michiel van Dijk, Paul A. de Hek and Arghya Ghosh were also quite rewarding. Arijit Mukherjee would like to acknowledge the Netherlands Technology Foundation (STW) for the financial support. Arijit Mukherjee also acknowledges financial support from The Leverhulme Trust under Programme Grant F114/BF. The usual disclaimer applies.

---

# Foreign market entry: a theoretical analysis

by

Arijit Mukherjee and Soma Mukherjee

**Abstract:** This paper considers investment strategies of a foreign firm in a host country. The foreign firm apprehends that knowledge spillover will encourage entry in the host country. We show that foreign firm delays its investment for sufficiently lower threat of entry. If threat of entry is sufficiently strong, it invests at the beginning with its superior technology. For intermediate threat of entry, we find that foreign firm brings its relatively inferior technology initially and superior technology in future when threat of entry has been eliminated. If inferior technology of foreign firm too creates threat of entry, it reduces effectiveness of introducing technologies sequentially. Further, we show that there may be a conflict between foreign firm's optimal decision and welfare of the host country.

JEL classification: F21, F23

Keywords: Foreign investment, Knowledge spillover, Technology choice, Welfare

## Outline

1. *Introduction*
2. *The basic model*
3. *Multiple technologies*
  - 3.1. *No entry with the inferior technology*
  - 3.2. *Entry with the inferior technology*
4. *Welfare implications*
5. *Conclusion*

## **Non-Technical Summary**

Many developing countries are liberalizing their economies to attract foreign investment. While some countries are successful in getting large amount of investments at the beginning, others are getting foreign investments gradually. Further, empirical evidence shows that foreign firms do not bring their state-of-the-art technology always.

This paper shows that these situations can be explained in a model where demand for the product reduces over time and there is knowledge spillover about foreign technology in the host country. For simplicity, in our analysis we consider a product with finite lifetime. However, one may find similar qualitative results in a model with decreasing demand.

If the foreign firm apprehends that knowledge spillover encourages entry in the host country, it may delay its investment or may bring its relatively inferior technology initially followed by the superior technology in the future period. We show that the decision of the foreign firm depends on the rate of knowledge spillover and the cost of technology adoption by the foreign firm and the host country firm. We also show that there may be a conflict between foreign firm's optimal decision and welfare of the host country.

# 1 Introduction

Many developing countries view foreign direct investment as a vehicle of technology transfer. This encourages them to liberalize their economies and allowing multinational firms to open their subsidiaries in these countries in order to attract foreign investments. However, it is found empirically that foreign firms are very prudent about knowledge spillover, which creates threat of entry in the host-country (see, e.g., Mansfield, 1994).

Also, a concern to the developing countries is that foreign firms are not interested in bringing their latest technologies to the host-countries (see United Nations, 1992). In fact, empirical studies show that foreign firms prefer to bring their inferior technologies to the host-countries (Mansfield and Romeo, 1980).

This paper shows that if foreign firms apprehend knowledge spillover in the host-country, they strategically choose their timing of foreign investment and technologies to be used in the host-country. We show that foreign firms may prefer to delay investment<sup>1</sup> in the host-country to eliminate threat of entry due to knowledge spillover. If foreign firms have multiple technologies to produce their products, they might prefer to bring their inferior technologies to the host-country in earlier periods.

More specifically, we find that foreign firm delays its investment for sufficiently lower threat of entry. But, foreign firm invests initially with its superior technology for sufficiently strong threat of entry. For intermediate threat of entry, foreign firm brings its relatively inferior technology initially and its superior technology in the future when threat of entry has eliminated. Effectiveness of introducing technologies sequentially reduces if inferior technology of foreign firm too creates threat of entry.

We further show that whether availability of more foreign technologies increases welfare of the host country is ambiguous. If foreign firm has single technology and delays (does not delay) investment, more foreign technologies increase (reduce) welfare of the host country.

Our results provide a rationale for different countries experiencing different amounts of foreign investments. For example, while number of foreign direct

---

<sup>1</sup> Capel (1992) and de Hek and Mukherjee (2003) also show possibility of delayed foreign investment when profits are uncertain.

investment (FDI) in 1990 – 91 from Japan to China was 165, FDI from Japan to India was only 7 for that period. While this number in 1992 – 93 had increased to 490 for China, it had increased to only 15 for India (Chawla, 1995). Also, amount of foreign investment indicates significantly different trend for different industries.

The present paper is quite closely related to Horstmann and Markusen (1987). In their paper, Horstmann and Markusen (1987) have argued that a foreign firm may prefer to invest in a host-country quickly if foreign investment pre-empts entry of domestic firm. In contrast, we show that foreign firm may prefer to delay its investment to eliminate threat of domestic-entry. Delayed investment by foreign firm reduces profit of the domestic firm and pre-empts domestic-entry when discounted total profit of the domestic firm does not cover its cost of entry. Further, possibility of multiple foreign technologies might induce foreign firm to introduce technologies sequentially in the host-country. So, contrary to Horstmann and Markusen (1987), we show that future benefits from foreign investment might dominate initial benefits.

Earlier, Buckley and Casson (1981) have argued how market size of the host-country can influence timing of foreign investment. In this paper we have included a new element, viz., knowledge spillover, which affects either timing of foreign investment or choice of technology to be used in the host-country.

The present paper also complements that of Wang and Blomstrom (1992) and Lin and Saggi (1999), where issue of foreign investment has been addressed in presence of knowledge spillover in the host-country. While the former paper has considered the strategy of a monopolist investor, the latter paper has focused on the strategies of two competing foreign firms. Unlike these two papers, the present paper focuses on competition between foreign firm and domestic firm. Further, we consider a product with finite lifetime. Finite lifetime of the product helps the foreign firm to adjust timing of investment and quality of technology so that it can eliminate threat of entry. Further, with a single foreign investor, the present paper does not consider any external benefits like Lin and Saggi (1999).

The remainder of the paper is organized as follows. Section 2 provides the basic model of foreign direct investment where foreign firm has single technology of production. Section 3 examines the role of multiple technologies on foreign direct investment. Section 4 discusses welfare implications. Section 5 concludes.

## 2 The basic model

Consider a country, called domestic or host country, that had protectionist policies so far and was restricting foreign investments in the country. The host country now opened up its economy to foreign investors and allowed foreign direct investment.

Assume that there is a foreign firm, called firm 1, who has know-how to produce a product and wants to invest in the host country. To focus on foreign investment strategy, we assume that due to the existence of tariff and/or the transportation cost, export is not a feasible option to firm 1. Assume that foreign firm needs to incur a cost,  $F_1$ , to make its technology, called  $x_1$ , usable in the host-country.<sup>2</sup> It may be because foreign technology needs some modifications before using it to the host-country.

We assume that the product of firm 1 has a finite life from 0 to  $N$ . This assumption of finite lifetime implicitly assumes that firm 1 expects new products to come in the market after  $N$ , which will make the present product obsolete. While the assumption of finite lifetime simplifies our analysis, our results hold also for the products with infinite lifetime but with declining demand over time, as considered in Ghemawat and Nalebuff (1985).

Firm 1, however, apprehends that technological know-how will be diffused after time  $t_i$  since its investment in the host-country<sup>3</sup> and will encourage entry of a domestic firm, called firm 2. We further assume that the domestic firm also needs to incur cost  $I_2$  as development cost (see, e.g., Mansfield et al., 1981 and Wang and Blomstrom, 1992).

Assume that if only one firm produces in the market, it yields a flow of profit  $M$ . If both firms produce the good with technology  $x_1$ , each of them gets a flow of profit  $D < M$ . The common discount rate is assumed to be  $r$ .

Therefore, if firm 1 invests at time 0, its discounted lifetime payoff is

$$\frac{M(1 - e^{-rt_i})}{r} + \frac{D(e^{-rt_i} - e^{-rN})}{r} - F_1. \quad (1)$$

---

<sup>2</sup> See, e.g., Teece (1976) and Kumar (1994) for discussions on costs of technology adoption by foreign firms.

<sup>3</sup> One can think that  $t_i$  shows time necessary for the domestic firm to adopt foreign technology economically.

Define  $t_e$  as the time period so that entry cost of firm 2 is equal to its discounted lifetime payoff starting from  $t_e$ . Therefore, at  $t_e$

$$I_2 = \frac{D(1 - e^{-r(N-t)})}{r}. \quad (2)$$

From (2), it is easy to find that for  $t = 0$ , left hand side (LHS) of (2) < right hand side (RHS) of (2) (which is necessary for the profitable entry of firm 2), but for  $t = N$ , LHS of (2) > RHS of (2). This ensures the existence of  $t_e$ . Therefore, for  $t_e < t_i$ , firm 1 does not face any threat of entry from firm 2. We assume away this case and in the following analysis consider that  $t_e > t_i$ . It makes threat of entry of firm 2 credible.

Realizing threat of entry, firm 1, however, may choose its timing of investment in a way so that it can eliminate threat of entry. It is clear from (2) that if firm 1 invests on or after time  $t_p$ , where  $t_p = t_e - t_i$ , there will be no entry. This possibility creates a value from waiting and may induce firm 1 to postpone its investment until  $t_p$ .<sup>4</sup>

The following proposition shows optimal entry strategy of firm 1.

**Proposition 1:** *Assume that firm 1 apprehends credible threat of entry. If  $t_p$  is sufficiently (low) high, it is better for firm 1 to (delay investment) invest immediately.*

**Proof:** If firm 1 invests in the host country at time  $t_p$ , its discounted lifetime payoff is

$$\frac{M(e^{-rt_p} - e^{-rN})}{r} - e^{-rt_p} F_1. \quad (3)$$

However, investing in the host-country at time  $t_p$  is profitable to firm 1 provided its future benefits are greater than initial losses, i.e.,

$$e^{-rt_i} \frac{(M - D)(1 - e^{-r(N-t_i)})}{r} + F_1(1 - e^{-rt_p}) > \frac{M(1 - e^{-rt_p})}{r}. \quad (4)$$

---

<sup>4</sup> It is easy to check that if foreign firm does not enter immediately, it will enter at time  $t_p$ .



It is easy to check that LHS of (4) is greater than RHS of (4) at  $t_p = 0$  but LHS of (4) is less than RHS of (4) if  $t_p$  is sufficiently large, say  $t_p = N$ .<sup>5</sup> Since, LHS and RHS of (4) are continuous in  $t_p$ , it implies that condition (4) holds (does not hold) for sufficiently low (high)  $t_p$ , which proves the result. Q.E.D.

LHS of (4) shows the premium that firm 1 earns in future periods if it invests at time  $t_p$ . RHS of (4) shows cost of postponing investment up to time  $t_p$ . Therefore, value from waiting exists provided condition (4) holds.

If  $t_p$  is sufficiently low, firm 1 needs to wait for sufficiently short time periods to eliminate threat of entry. The above proposition shows that, in this situation, it is optimal for firm 1 to delay its investment. In other words, if firm 1 faces credible threat of entry but not strong enough, it is better for firm 1 to delay its investment since it can get rid of this threat of entry by waiting for short time period. But, in case of stronger threat of entry, firm 1 needs to wait for long time periods to eliminate threat of entry and hence, waiting does not pay firm 1. Therefore, under strong threat of entry, it is better for firm 1 to invest immediately and to accommodate firm 2 later.

### 3 Multiple technologies

So far, we have assumed that firm 1 has single technology to produce its product. Now, we relax this assumption and assume that firm 1 has multiple technologies.<sup>6</sup> For simplicity, we assume that firm 1 has another technology, called  $x_1'$  along with the technology  $x_1$ , which is being considered in section 2, and that  $x_1'$  is inferior to  $x_1$ . Assume that  $x_1'$  yields  $M' < M$ , if only one firm produces the product with  $x_1'$  and yields  $D' < D$ , if both firms use  $x_1'$ . Consider that firm 1 incurs cost  $F_1'$  to use technology  $x_1'$  in the host-country and that  $F_1' < F_1$ . For simplicity, we further assume that the technologies of firm 1 are drastic in nature, i.e., the optimal output of a firm is zero if it produces with inferior technology and its competitor produces with superior technology.<sup>7</sup>

---

<sup>5</sup> It is possible to have  $t_p = N$ , if  $t_i = 0$  and  $I_2$  is such that  $t_e = N$ .

<sup>6</sup> Different technologies may also be interpreted as different models of the product.

<sup>7</sup> Our qualitative results will hold even if foreign technologies are non-drastic.

We also assume that knowledge spillover of  $x_1'$  technology is instantaneous. The introduction of a lag in knowledge spillover for  $x_1'$  does not change our basic conclusions. We further assume that firm 2 incurs costs  $I_2$  and  $I_2'$  to adopt the technologies  $x_1$  and  $x_1'$  respectively with  $I_2 > I_2'$ .

In our analysis below, we assume that the following condition holds:

$$\frac{(M - M')(1 - e^{-r(N-t_p)})}{r} > F_1. \quad (5)$$

Assumption (5) shows that it is better for firm 1 to produce with its superior technology  $x_1$  at  $t_p$  when it produces with  $x_1'$  initially.<sup>8</sup>

Since  $x_1'$  yields less profit to a firm, then, given the development cost and the time of knowledge spillover, it decreases threat of entry. If  $x_1'$  is less complicated, firm 2 may adopt it more easily and incur lower cost to adopt it. This possibility increases threat of entry. As a result, technology  $x_1'$  creates either higher or lower threat of entry.

### 3.1 *No entry with the inferior technology*

In this subsection we assume that if firm 1 produces with  $x_1'$  technology from the beginning, it is not optimal for firm 2 to enter in the market with this technology. Therefore, if both firms produce with  $x_1'$ , the lifetime payoff of firm 2 does not cover the cost of adoption, i.e.,

$$I_2' > \frac{D'(1 - e^{-rN})}{r}. \quad (6)$$

Condition (6) guarantees that firm 1 does not face any threat of entry from firm 2 if it uses  $x_1'$  technology in the host-country whereas the assumption of  $t_e > t_i$  ensures that firm 1 faces threat of entry if it uses  $x_1$  before time  $t_p$ .<sup>9</sup>

---

<sup>8</sup> If foreign firm uses superior technology before  $t_p$  then it encourages competition from the domestic firm and, hence, it eliminates the benefits from waiting. Therefore, if foreign firm decides to wait to introduce  $x_1$  then it is optimal to wait until  $t_p$ .

**Proposition 2:** *Suppose condition (5) holds.*

(a) *Firm 1 has incentive to introduce its inferior technology only if  $\frac{M'(1-e^{-rt_p})}{r} > F_1'$ .*

(b) *Suppose condition (4) holds. Given  $F_1' > 0$ , if  $t_p$  is very small, firm 1 does not bring its inferior technology but invests at  $t_p$  with its superior technology.*

(c) *Suppose condition (4) does not hold.*

(i) *If  $t_p$  is not sufficiently large, firm 1 will invest at the beginning with its superior technology.*

(ii) *If  $t_p$  is sufficiently large, firm 1 may invest with its inferior technology at the beginning and introduce its superior technology at  $t_p$ .*

**Proof:** (a) Given condition (5), it is always optimal for firm 1 to introduce its superior technology  $x_1$  at time  $t_p$ . If only firm 1 produces the product, it has the incentive to introduce its inferior technology  $x_1'$  only if its discounted payoff from  $x_1'$  over  $[0, t_p]$  is greater than its cost of adopting  $x_1'$ , i.e.,  $\frac{M'(1-e^{-rt_p})}{r} > F_1'$ .

(b) Assume that condition (4) holds, which is possible for small values of  $t_p$ , as shown in Proposition 1. So, firm 1 has incentive for immediate investment with its inferior technology  $x_1'$  if and only if

$$\frac{M'(1-e^{-rt_p})}{r} > F_1'. \quad (7)$$

Given  $F_1' > 0$ , if  $t_p$  is sufficiently small, condition (7) does not hold. Hence, in this situation, firm 1 does not bring its inferior technology and invest directly at  $t_p$  with its superior technology.

(c) If condition (4) does not hold, we have

$$e^{-rt_i}(M-D)(1-e^{-r(N-t_i)}) + rF_1'(1-e^{-rt_p}) < M(1-e^{-rt_p}). \quad (8)$$

---

<sup>9</sup> With a lag in knowledge spillover, condition (6) becomes  $I_2' > \frac{D'(1-e^{-r(N-t_k)})}{r}$ , where  $t_k$  shows the lag.

It implies that if firm 1 has only  $x_1$  technology, it will invest in the host-country initially and its discounted lifetime payoff will be

$$\frac{M(1-e^{-rt_i})}{r} + e^{-rt_i} \frac{D(1-e^{-r(N-t_i)})}{r} - F_1. \quad (9)$$

Since firm 1 has also  $x_1'$  technology, it can use  $x_1'$  at the beginning (since it does not create threat of entry) and introduce its  $x_1$  technology at time  $t_p$ .

(i) Firm 1 will introduce its inferior technology only if condition (7) holds. Given  $F_1' > 0$ , (7) does not hold if  $t_p$  is not sufficiently large. So, if  $t_p$  is not sufficiently large, firm 1 invests in the host country from the beginning with its superior technology.

(ii) If (7) holds, i.e.,  $t_p$  is sufficiently large, firm 1 may have incentive to bring its inferior technology at the beginning and its superior technology at time  $t_p$ .

Discounted payoff of firm 1 under this strategy is

$$\frac{M'(1-e^{-rt_p})}{r} + \frac{M(e^{-rt_p} - e^{-rN})}{r} - (F_1' + e^{-rt_p} F_1). \quad (10)$$

From (9) and (10) we find that firm 1 prefers to bring in the technologies sequentially rather than producing with  $x_1$  technology from the beginning provided

$$M'(1-e^{-rt_p}) + e^{-rt_i} (M-D)(1-e^{-r(N-t_i)}) + rF_1(1-e^{-rt_p}) - rF_1' > M(1-e^{-rt_p}). \quad (11)$$

If condition (7) holds, it is possible that conditions (8) and (11) also hold simultaneously. In that case, firm 1 invests at the beginning with its inferior technology and introduces its superior technology at  $t_p$ . Q.E.D.

Reason for the above proposition is as follows. Condition (5) implies that firm 1 will certainly switch to superior technology at  $t_p$  even if it introduces inferior technology at the beginning. Since, inferior technology does not create threat of entry, firm 1 has incentive to introduce the inferior technology only if its discounted monopoly payoff over  $[0, t_p]$  is greater than the cost of adopting the inferior technology, i.e.,  $\frac{M'(1-e^{-rt_p})}{r} > F_1'$ .

If entry of firm 2 is sufficiently costly, it creates little threat of entry. This implies that firm 1 needs to wait for short periods if it wants to delay its investment,

i.e.,  $t_p$  is very small. Due to this small waiting period, introduction of inferior technology may not be beneficial to firm 1 (i.e., condition (7) does not hold). These things together induce firm 1 to delay investment when threat of entry is sufficiently low.

If threat of entry is sufficiently stronger firm 1 needs to wait for longer periods to deter entry. However, if waiting period is not long enough, i.e.,  $t_p$  is not very large, it is not profitable for firm 1 to introduce its inferior technology, i.e., (7) does not hold. So, here, neither waiting period up to  $t_p$  nor introduction of inferior technology is beneficial to firm 1 and encourages it to invest immediately with superior technology.

If  $t_p$  is very large then sufficiently longer waiting period makes introduction of inferior technology profitable. Therefore, if threat of entry is sufficiently strong, it is more likely that firm 1 invests with its inferior technology initially and brings its superior technology at time  $t_p$ .<sup>10</sup>

The above proposition explains the phenomenon that often foreign firms do not prefer to bring their superior technologies at the time of entering a host country. Foreign firm may prefer to bring its technologies sequentially to the host country even if it can introduce the superior technology initially. These findings imply that opening up of an economy does not necessarily mean immediate inflow of foreign investments. It depends on other things like the possibility of entry of domestic firms and availability of various technologies to foreign firms. Our results suggest that liberalized economies may experience lower amount of foreign direct investments or foreign direct investments with relatively inferior technologies in earlier periods.

Patent protection of a country and/or complexity of technologies may have negative relationship with knowledge spillover. Above findings show that if patent protection of a country is sufficiently strong but not perfect and/or technologies are very complex so that creating sufficiently low knowledge spillover, foreign firms may delay investment in that country. On the other hand, with weak patent protection and/or with relatively simpler technologies, foreign firms may prefer to invest at the beginning but with relatively inferior technologies.

---

<sup>10</sup> If monopoly profit from the inferior technology is more than duopoly profit of a firm producing with the superior technology then this outcome is more likely when condition (7) holds. Otherwise, foreign firm brings its superior technology initially.

Before, concluding this subsection, we want to briefly examine the implication of condition (5). If condition (5) does not hold, it implies that firm 1 does not introduce its superior technology at time  $t_p$  when it has already introduced its inferior technology. In other words, this implies that if firm 1 introduces the inferior technology, it produces with this technology in all future periods.

The next proposition shows that if condition (5) does not hold, it may be optimal for firm 1 to use its inferior technology always.

**Proposition 3:** *Suppose condition (5) is not satisfied but condition (4) holds. It may be optimal for firm 1 to use its inferior technology always.*

**Proof:** If condition (5) does not hold but condition (4) holds, firm 1 has two options: (i) use its superior technology from  $t_p$  or, (ii) use its inferior technology from the beginning. Firm 1 will prefer to use its inferior technology provided

$$\frac{M'(1 - e^{-rt_p})}{r} - (F_1' - e^{-rt_p} F_1) > \frac{(M - M')(e^{-rt_p} - e^{-rN})}{r}. \quad (12)$$

It is easy to check that both conditions (4) and (12) may hold simultaneously, which proves the result. Q.E.D.

Condition (12) interprets that lower monopoly profits in all periods may be greater than higher monopoly profits over the time period  $[t_p, N]$ . Therefore, to safeguard it from domestic competition, firm 1 may never bring its state-of-the-art technology to the host country. Even if conditions (4) and (5) do not hold, it can be shown that, given the values of  $D$ ,  $M$  and  $M'$ , firm 1 may find it optimal to use its inferior technology in all periods.

### 3.2 *Entry with the inferior technology*

This subsection briefly discusses the situation where firm 1's inferior technology also creates threat of entry, i.e.,

$$I_2' < \frac{D'(1 - e^{-rN})}{r}, \quad (13)$$

and shows that this possibility reduces incentive for sequential introduction of the technologies. Condition (13) says that if firm 1 brings its inferior technology at the

beginning and produces with this technology throughout the lifetime, it creates a credible threat of entry.

Like the above analysis, we assume that knowledge spillover about firm 1's inferior technology is instantaneous and condition (5) holds.

**Proposition 4:** *Suppose the technologies of firm 1 are drastic and condition (5) holds.*

(a) *Assume that condition (4) holds.*

(i) *If  $I_2' > \frac{D'(1 - e^{-rt_p})}{r}$ , result of Proposition 2(b) holds.*

(ii) *If  $I_2' < \frac{D'(1 - e^{-rt_p})}{r}$ , incentive for introducing inferior technology initially reduces.*

(b) *Assume that condition (4) does not hold.*

(i) *If  $I_2' > \frac{D'(1 - e^{-rt_p})}{r}$ , results of Proposition 2(c) hold.*

(ii) *If  $I_2' < \frac{D'(1 - e^{-rt_p})}{r}$ , incentive for introducing inferior technology reduces compared to the situation when there is no threat of entry with inferior technology.*

**Proof:** (a) Suppose, condition (4) holds, i.e., without inferior technology, firm 1 introduces its superior technology at time  $t_p$ .

(i) Now, assume that firm 1 introduces its inferior technology initially and the superior technology at time  $t_p$ . Introduction of inferior technology initially does not encourage entry of firm 2 if following condition holds:

$$I_2' > \frac{D'(1 - e^{-rt_p})}{r}. \quad (14)$$

Therefore, if condition (14) holds, there is no credible threat of entry from firm 2 and result of Proposition 2(b) holds.

(ii) But, if (14) does not hold, introduction of inferior technology initially creates credible threat of entry from firm 2. In this situation, firm 1 always introduces the inferior technology before  $t_p$  when

$$\frac{D'(1 - e^{-rt_p})}{r} > F_1', \quad (15)$$

which is stronger requirement than (7).

Even if condition (15) holds, firm 1 may not prefer to introduce inferior technology initially. Following the logic of Proposition 1 we may say that firm 1 may introduce  $x_1'$  at a time between 0 and  $t_p$  if delayed introduction of the inferior technology increases firm 1's profit over  $[0, t_p]$ . This proves that the incentive for introducing inferior technology initially reduces.

(b) Assume that condition (4) does not hold.

(i) If (14) holds then effectively inferior technology creates no threat of entry and the result of the Proposition 2(c) holds.

(ii) If condition (14) does not hold, firm 1 faces threat of entry over the interval  $[0, t_p]$ . However, if condition (15) holds, which is stronger requirement than (7), firm 1 may have incentive to introduce its inferior technology between  $[0, t_p]$ . If it introduces inferior technology at the beginning, it earns duopoly profits over  $[0, t_p]$ . On the other hand, if firm 1 introduces inferior technology between  $[0, t_p]$ , it gets zero payoffs in the initial periods but monopoly profits between the time of introduction and  $t_p$ , since it is delaying the introduction of inferior technology to eliminate threat of entry with it. However, whether firm 1 introduces the inferior technology at the beginning or between  $[0, t_p]$ , its discounted payoff over  $[0, t_p]$  is less than its discounted monopoly payoffs from this technology over this period, which it receives when the inferior technology does not create threat of entry. This proves that possibility of entry with the inferior technology reduces incentive to introduce it.

Q.E.D.

## 4 Welfare implications

It is easy to understand that when firm 1 has only  $x_1$  technology and delays investment, it reduces welfare of the host country compared to the situation where firm 1 invests at the beginning. If firm 1 does not invest immediately, there are no productions in the early periods and it will become a monopolist over the period  $t_p$  to  $N$ . If firm 1 invests immediately, there will be positive productions in all periods and after some periods (i.e., after time  $t_i$ ) the market will be characterized by a duopoly.



While delayed investment is better for firm 1, welfare of the host-country is higher if it invests immediately compared to the situation where it delays investment.

Now, we examine whether more foreign technologies are beneficial for the host country. For this purpose we will concentrate only on the situation where inferior technology does not create threat of entry. However, the qualitative result will be similar even if we consider the situation where inferior technology creates threat of entry. To avoid repetition, we will not analyze the situation where inferior technology creates threat of entry.

Let us first consider the situation where condition (4) is satisfied. If condition (7) holds, it is optimal for firm 1 to use  $x_1'$  technology initially and  $x_1$  technology from  $t_p$ . On the other hand, if firm 1 has only  $x_1$  technology then it invests at time  $t_p$  since condition (4) holds. So, in this situation, there will be no production before  $t_p$ . Hence, it implies that welfare of the host country is higher when firm 1 has both technologies compared to the situation where firm 1 has only  $x_1$  technology.

Next, consider the situation where condition (4) is not satisfied. If firm 1 has only  $x_1$  technology, it uses this technology from the beginning. Therefore, there will be foreign monopoly up to  $t_i$  and duopoly afterwards. But, if firm 1 has both the technologies and conditions (7) and (11) hold, it uses the inferior technology  $x_1'$  initially and brings its superior technology  $x_1$  at  $t_p$ . This strategy of firm 1 creates foreign monopoly in all periods. Up to  $t_p$ , it is foreign monopoly with the inferior technology  $x_1'$  but after that it is foreign monopoly with the superior technology  $x_1$ . Hence, industry output and consumer surplus are lower under sequential use of foreign technologies compared to the situation where firm 1 has only the superior technology  $x_1$ . So, welfare of the host country is lower with more foreign technologies if condition (4) does not hold.

The following proposition summarizes the discussion on welfare implications.

**Proposition 5:** (a) *Welfare of the host country is lower under delayed investment of firm 1 compared to no delay in investment.*

(b) *Whether presence of more foreign technologies increases welfare of the host country is ambiguous.*

## 5 Conclusion

Researchers working on international economics have addressed various issues related to foreign direct investment. However, theoretical literature has paid little attention to the importance of the timing of foreign investment as well as the use of the quality of the technologies to be used in the host country. This paper focuses on these issues.

We show that if foreign firm apprehends knowledge spillover in the host country, which may create threat of entry, then it may prefer to delay foreign investment. Delayed investment helps to eliminate threat of entry by making entry unattractive to the domestic firm. While under this strategy foreign firm sacrifices earlier profits, this strategy increases its profits in the future. If the latter effect dominates the former, it is optimal for foreign firm to delay its investment in the host country. However, delayed foreign investment reduces welfare of the host country compared to the situation where foreign firm investments at the beginning.

If foreign firm has multiple technologies, it may prefer to bring its inferior technology at the beginning and the superior technology in future. This strategy helps foreign firm to earn positive profits in earlier periods and also to eliminate threat of entry. Effectiveness of this strategy reduces when inferior technology of the foreign firm too creates threat of entry. We also show that there are situations where foreign firm prefers to use the inferior technology always and does not introduce the superior technology at all. The effect of more foreign technologies on welfare of the host country is ambiguous.

## References

- Buckley, P. J. and M. Casson**, 1981, 'The optimal timing of a foreign direct investment', *Economic Journal*, **91**: 75 –87.
- Capel, J.**, 1992, 'How to service a foreign market under uncertainty: a real option approach', *European Journal of Political Economy*, **8**: 455 – 75.
- Chawla, R.L.**, 1995, 'Prospects of the Indo-Japan investment potential', in S. P. Gupta et al. (eds), 'Prospects of foreign direct investment in India in post liberalisation era' *Indian Council For Research On International Economic Relations*, 81 – 99.
- de Hek, P. A. and A. Mukherjee**, 2003, 'On foreign market entry under uncertainty', *GEP Research Paper*, 2003/18, University of Nottingham.
- Ghemawat P. and B. Nalebuff**, 1985, 'Exit', *Rand Journal of Economics*, **16**: 184 – 94.
- Horstmann, I. J. and J. R. Markusen**, 1987, 'Strategic investments and the development of multinationals', *International Economic Review* **28**: 109 – 21.
- Lin, P. and K. Saggi**, 1999, 'Incentives for foreign direct investment under imitation', *Canadian Journal of Economics*, **32**: 1275 – 98.
- Kumar, N.**, 1994, 'Multinational enterprises and industrial organization: The case of India', *Sage Publications*, New Delhi, India.
- Mansfield, E.**, 1994, 'Intellectual property rights, foreign direct investment and technology transfer', *Discussion Paper No. 19*, International Finance Corporation, The World Bank, Washington, D.C.
- Mansfield, E. and A. Romeo**, 1980, 'Technology transfer to overseas subsidiaries by U.S.-based firms', *Quarterly Journal of Economics* **95**: 737 – 50.
- Mansfield, E., M. Schwartz and S. Wagner**, 1981, 'Imitation costs and patents: An empirical study', *Economic Journal* **91**: 107 – 81.
- Teece, D. J.**, 1976, 'The multinational corporation and resource cost of international technology transfer', *Ballinger, Cambridge, Massachusetts*.
- United Nations**, 1992, 'World investment report: Transnational corporations as engines of growth', *United Nations, New York*.
- Wang, J. and M. Blomstrom**, 1992, 'Foreign investment and technology transfer: A simple model', *European Economic Review* **36**: 137 – 55.