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Export, Assembly-line FDI or FDI with the Possibility of Technology Diffusion: Optimal Entry Mode for Multinationals

Tanmoyee Banerjee (Chatterjee)
and Nilanjana Mitra

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Tanmoyee Banerjee (Chatterjee), *Department of Economics, Jadavpur University*
Nilanjana Mitra, *Department of Economics, Susil Kar College*

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Summary

The paper tries to evaluate the optimal entry mode of a Multinational Company that is choosing among export, fragmented production structure with assembly-line FDI in LDC or complete production in LDC with FDI. The results show that if the plant installation cost is sufficiently high then the firm will find it profitable to export the finished product to the LDC market and the Government will not exercise any IPR restriction. If plant installation cost is below a certain critical level the MNC chooses complete LDC production with FDI over assembly-line FDI if the IPR restriction is strong, where the model assumes that a fake producer can copy the product if complete production takes place in LDC. In such a situation government will choose to protect IPR if government earning exceeds the cost of IPR protection, otherwise no monitoring is the optimal strategy of the government and MNC will choose the strategy of fragmented production structure and assembly-line FDI will take place in LDC.

Keywords: Export, Assembly-line FDI, FDI with Complete Production, IPR Protection

JEL Classification: L11, O34

Address for correspondence:

Tanmoyee Banerjee(Chatterjee)
Department of Economics
Jadavpur University
Kolkata 700032
India
Email: tanmoyee@hotmail.com

1. Introduction

The relationship between strong intellectual property rights protection, foreign direct investment and technology transfer is an issue of great interest. Protection of intellectual property rights is becoming a challenge to less-developed and developing countries like India. An interesting report on THE ECONOMIC TIMES shows how counterfeit and fake products have infested the Indian market. The report says that India tops the world counterfeit pharma products. Over 35% of the automotive parts sold in India are fake while the value of counterfeit and pirated software is over $ 1.5 billion. Such a glaring figure shows the importance of IPR restrictions in a developing economy like India.[1]

Empirical evidences showed that poor IPR protection rate would lead to low level of technology transfer. The study by Bascavusoglu & Zuniga (2001) examines how international differences in foreign patent protection affect decisions to transfer technology. The paper empirically evaluates the role of intellectual property protection, technology endowments and market size on technology receipts of French firms from abroad. Results show that high technology sectors such as chemicals, pharmaceuticals, manufacturing of machines and instruments, electronics, etc. are indeed more sensitive to IPR protection overseas. On the other hand, IPR in low-technology sectors have a negative effect, but are not significant.

An empirical study by Wakasugi and Ito (2005) showed that for Japanese Multinational firms technology transfer measured by royalty payments of affiliate to parent firms is substantial in the countries where the enforcement of IPRs is strict, and that it increases in the countries where IPRs are strengthened. Another empirical study by Smarzynska Javorcik (2004) sheds light on the relationship between intellectual property right protections and structure of foreign direct investment using unique firm-level data set describing investment projects in Eastern Europe and the former Soviet Union. First, the study indicates that investors in sectors relying heavily on protection of intellectual property are deterred by a weak IPR regime in a potential host country. There is also some evidence that weak IPR protection may discourage all investors, not just those in the sensitive sectors. Second, the lack of IPR protection deters investors from undertaking local production and encourages them to focus on distribution of imported products. Interestingly, this effect is present in all sectors, not only those relying heavily on IPR protection.

Given the empirical findings Governments all over the world tries to create an investment friendly environments hoping that multinational corporations will bring new technologies,

[1] Page 3 of The Economic Times dated 30th July, 2007

management skills and marketing know-how[2]. In the light of the above findings the present study theoretically explains the relationship between IPR restriction and structure of foreign investment. The study tries to find out different social welfare maximizing rate of IPR protection on the basis of which a foreign multinational firm is deciding whether to enter the LDC market via foreign direct investment or just export the product and secondly if enters via FDI it also considers the choice between assembly-line FDI which implies a fragmented production structure where the high technology intensive production procedure is undertaken in developed IPR protected economies and assembly-line activities are transferred to less developed weak IPR protected economies [3] and finally FDI with transfer of disembodied technology and complete production process.[4]

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[2] A ready reference of the change in attitude is evident in the Indian Pharmaceutical Industry. After independence the Indian Patent Act, 1970 was enforced to ensure rapid industrialization in a newly independent country as well as serve public interest in a balanced manner. The main feature of the Patent Act of 1970 was complete absence of product patent for pharmaceutical, food and chemical based products. The industrial sector was also covered by process patent. In order to integrate the country with the global pharmaceutical industry the Patent Act, 1970 has been amended in March, 2005. The new Patent Act introduces a product patent regime, covering drugs, foods and chemicals. This is in compliance with the TRIPS Agreement of WTO designed to bring an end to the copy of drugs patented abroad by Indian pharma companies. This was allowed under the previous Act as long as the Indian companies used different manufacturing processes. Thus the Parliament of India approved the 3rd Patents (Amendment Bill), 2005 expecting to encourage foreign investment in research and development projects consequently benefiting the Indian economy. As expected the FDI in the pharma industry is estimated to be $ 172 million during 2005-06 recording a CAGR of 62.6% during the period 2002-06.In case of R&D, in 2005-06 the R&D expenditure of 50 major companies totaled $495.19 million growing at a rate of 26% over the previous year. This shift to a higher growth path is largely attributable to the new product patent act in 2005. Pharmaceutical Industry Analysis News by Bio Spectrum Asia: http:// www.biospectrumasia.com

[3] A common example of this type of FDI is in the case of Coca Cola - one of world's leading beverage suppliers. The MNC prepares the concentrate in the United States which is then exported to different countries where the bottling units of the MNC are located either as complete subsidiary units or as joint ventures.

[4] In this respect we must mention the Public Notice No. 60 issued by the Ministry of Commerce, Government of India in December 1997, to increase the technology intensive FDI in automobile sector of India. The policy placed import of capital goods and automotive components under open general license, but restricted import of cars and automotive vehicles in Completely Built Unit (CBU) form or in Completely Knocked Down (CKD) or in Semi Knocked Down (SKD) condition. Car manufacturing units were issued licenses to import components in CKD or SKD form only on executing a Memorandum of Understanding (MOU) with the Director General Foreign Trade (DGFT). 11 companies signed MOUs with DGFT under which they agreed to:

1. Establish actual production of cars and not merely assemble vehicles;
2. Bring in a minimum foreign equity of US $ 50 Million if a joint venture involved majority foreign equity ownership;
3. Indigenise components up to a minimum of 50% in the third and 70% in the fifth year or earlier from the date of clearance of the first lot of imports. Thereafter the MOU and import licensing will abate;
4. Neutralise foreign exchange outgo on imports (CIF) by export of cars, auto components etc. (FOB). This obligation was to commence from the third year of start of production and to be

A large number of theoretical papers have dealt with the matter of technology transfer and entry of foreign firms in the LDC market.[5] However none of the papers considered the case of multinational firms' decision over assembly line FDI vis-à-vis transfer of complete technology and production in the LDC via FDI under different IPR regime.

The paper on IPR and the mode of technology transfer by Viswasrao (1993) formulates a model where the lack of IPR protection in the Southern countries affect the nature of licensing contract offered by the North as well as the mode of technology transfer. The choices available are examined in a partial equilibrium game theoretic setting where asymmetric information adversely affects licensing of low cost technologies to the South. The paper concludes that northern firm may opt for subsidiary production or monopoly licensing which lowers Southern welfare. Nicholson (2000) in a theoretical paper considered the manner in which multinational enterprises facilitate technology transfer from the North to the South, and the role-played by the protection of intellectual property. Different industries respond to changes in intellectual property protection (IPP) regimes differently, and alter their mode of entry accordingly. Firms with complex but easily imitable products will tend to internalize production through foreign direct investment, but firms that face a lower risk of imitation will tend to license production to non-affiliated Southern firms.

Paper by Zigic (1998) rejects the common belief that the South generally benefits from relaxing IPR protection while the North is worse off in a North- South duopoly framework with technological spill over. In this respect the congruence of interest with respect to Southern IPR

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fulfilled during the currency of the MOU. From the fourth year imports were to be regulated in relation to the exports made in the previous year.

However this notice was abolished with effect from 01-04-2001. On December 21, 2001, the World Trade Organisation's dispute settlement body (DSB) arrived at a decision that the 'indigenisation' condition, as contained in Public Notice No. 60 and in the MoUs entered into there under, is in violation of Article III:4 of GATT 1994 as at the date of its establishment. With the Panel having announced its decision, India would not be able to impose, in any manufacturing area, conditions of the kind specified in its December 1997 notification, so long as it remains a member of the WTO.

Sources:

a) Auto Policy, Government of India, Ministry of Heavy Industries and Public Enterprises, Department of Heavy Industry, New Delhi, March 2002.

b) Frontline, Volume 19,Issue 1, Jan05-18, 2002, Published by The Hindu, http://www.hinduonnet.com/fline/fl1901/19011030.htm

[5] According Maskus (1998) the increase in international investments in nineties and problem of protection of IPR in the same period has led to the inquisitiveness about the link between technology transfer and IPR protection. A number of papers (Helpman (1993), Lai (1998), Yang and Muskus (2001)) used endogenous growth models to show that protecting IPR could benefit the South by increasing the flow of technology to the South. The papers also considered the role of IPR protection on rate of FDI and rate of innovation.

protection regime should not be an exceptional or impossible state of affairs. Paper by Zigic (2000) analyzed the issue of optimal tariffs when the Northern and Southern firms compete in quantities in an imperfectly competitive Northern market and there are potentially varying degrees of intellectual property rights (IPR) violation by the South. IPR violation is reflected through the leakage of technological knowledge ("spillovers") from the Northern to the Southern firm creating unit cost reduction. It is shown that optimal tariffs in this framework are always higher than in the simple duopoly model. However this paper did not discuss the matter of foreign direct investment.

Similarly Again a paper by Mattoo, Olarreaga & Saggi (2003) explores the preferences of a foreign firm and a welfare maximizing host country government over two modes of FDI - direct entry or acquisition of existing domestic firms in the presence of costly technology transfer. The paper shows that a purely welfare maximizing government might use FDI restrictions in order to influence the foreign firms choice between different modes of entry. However this paper does not give insights about the intellectual property right protection and entry of foreign firm in the LDC market.

The model developed by Eicher and Kang (2004), tried to integrate optimal entry modes as a function of market size, FDI, fixed cost tariffs and transport costs. The results highlight that even in presence of high tariffs large countries are more likely to attract accusation investment while intermediate sized countries may be predominantly served by trade. In this case also the issue of IPR protection has not been analysed.

The matter of IPR protection and FDI decision is analysed in the paper by Naghavi (2005) in a North South framework. The model endogenizes Southern IPR policy and the Northern firm's decision on whether to serve the Southern market through exports to obstruct exposure of its technology or by engaging in FDI to avoid trade costs. Southern firm is assumed to be incapable of acquiring the production technology unless the Northern firm moves production to the South. In other words, the Northern firm acquires a monopoly position by producing at home. If the Northern firm chooses to move production to the South, the Southern firm can enter the market and the two firms compete in a Cournot duopoly setting. Furthermore, the Northern firm is capable of engaging in R&D aimed at innovating more cost-effective production technologies. Knowledge gained through R&D is however assumed to have a public good character and can be imitated at zero cost. The model results show that a strict IPR regime is optimal for Southern firm as it triggers technology transfer by inducing FDI in less R&D intensive industries and stimulates innovation by pushing multinationals to deter entry in high-technology sectors.

In the present paper we try to analyze the optimal entry mode for multinationals where the choice for the MNC firm is from any of the following options:

• Conduct the entire production in the developed IPR protected country and then export the finished product to the LDC

• Fragment the production between DC and LDC and shift the assembly-line units to LDC

• Implementing the entire production in the LDC

Like Nagavi (2005) the model assumes that the imitator firm in LDC market is incapable of acquiring the production technology unless the Northern firm moves complete production to the LDC market. If the MNC chooses to move production to the LDC, the imitator firm can enter the market and the two firms compete in a duopoly setting where MNC acts as a Stackelberg leader. In other words the product imitation is not possible if the MNC adopts the export strategy or the fragmented production strategy and thereby invests in assembly-line units only. In this case also we have endogenised the choice of IPR protection rate by the LDC Government and it appears as a monitoring authority extracting a penalty in case of IPR violations from the fake LDC firm. Lastly the welfare implications of the different modes of entry are examined.

The rest of the paper is structured as follows: Section 2 describes the basic model and the assumptions. Section 3 gives the optimal strategy choice of the MNC. Section 4 describes the welfare maximizing choice of IPR protection rate by Government. Finally Section 5 gives the conclusion.

2. Model

The model considers a MNC located in the Developed Country (DC) with the following options for production:

(1) It can produce entirely in the DC market and export the finished product to the LDC with a per unit positive shipment cost.

(2) It can fragment the production process in two stages between the DC and the LDC. In the first stage, production of the core material takes place in the DC.

In the second stage assembling of the core material takes place in the LDC. A common example of this type of production is in the case of Coca Cola - one of world's leading beverage suppliers. The MNC prepares the concentrate in the United States, which is then exported to different countries where the bottling units are located.

(3) It can undertake the entire production in the LDC by opening up the entire manufacturing and assembling unit with FDI. Here the Government is introduced as a monitoring authority to restrict technology leakage to other competing LDC firms. The model assumes that, in the third case,

where the production of core materials is taking place in LDC market, leakage of technology can take place.

This will in turn lead to entry of competitive domestic firm if the IPR protection regime is weak.

The model considers the following functional forms.

The DC firm is facing a linear demand function which is given as

$$q = a - p \qquad 1.$$

where q = quantity demanded

p = price of the final product

a = market size parameter introduced as a positive constant

Specification of 'a' is given in the following way:

If a > 1 the LDC market is large.

If 0 < a < 1 the LDC is not sufficiently large.

Given this demand function we proceed with the production option for the DC firm under the three different production options.

Case 1: Production Conducted Entirely in DC and product exported to LDC.

First, we consider the situation where the foreign firm is undertaking the entire production process in her own country.

The Total Cost function of the DC firm is defined as follows:

$$c_{DC} = cq + A + tq \qquad 2.$$

The model assumes that the production process is divided in two stages. In the first stage of production core material are produced by undertaking the sunk cost *A*. and in the second stage of production the assembling or finishing tasks are undertaken by incurring a per unit variable cost *c* and *t* be the per unit positive shipment cost for transferring the finished product from the DC to the LDC.

The profit function of DC firm is defined as follows:

$$\begin{aligned} \pi_{Export} &= pq - cq - tq - A \\ &= (a - q)q - cq - tq - A \end{aligned} \qquad 3.$$

From the First Order profit maximizing conditions we get the monopoly output, price and profit of the DC firm as follows:

$$q_{export} = \frac{(a - c - t)}{2}$$

$$p_{export} = \frac{(a + c + t)}{2} \qquad 4.$$

$$\pi_{export} = \frac{(a - c - t)^2}{4} - A$$

Case 2: Fragmented Production Structure between DC and LDC

Secondly the DC firm may choose the strategy of fragmenting the production between the DC and LDC. Thus it can conduct the manufacturing part in the DC, (thus bringing in embodied technology to the LDC) and complete the assembling part in the LDC. The Total Cost function of the DC firm is given by

$$c_{Frag} = wq + A + tq + F \qquad 5.$$

Where w is the per unit cost of assembling the semi finished product in the LDC. It is assumed that $w < c$ due to cheap labor in the LDC. t is the per unit shipment cost to transfer the intermediate product to the LDC. For simplicity it is assumed to be same as the shipment cost of the finished product and F is the initial plant installation cost to transfer the production partly to the LDC. A is the sunk cost of production undertaken in the DC to manufacture the core material. The profit function of the DC firm under fragmentation is given as

$$\begin{aligned} \pi_{Frag} &= pq - wq - tq - a - F \\ &= (a - q)q - wq - tq - a - F \end{aligned} \qquad 6.$$

From the first order profit maximizing conditions equilibrium quantity, price level and profit are given as follows:

$$q_{Frag} = \frac{(a - w - t)}{2}$$

$$p_{Frag} = \frac{(a + w + t)}{2} \qquad 7.$$

$$\pi_{Frag} = \frac{(a - w - t)^2}{4} - A - F$$

The price output combinations are the monopoly combinations of the DC firm since the firm is the sole producer of the good in the LDC market.

Case 3. Complete Production in the LDC

The third alternative to the DC firm is to produce entirely in the LDC through FDI and undergo complete technology transfer. That is in this case the DC firm is bringing in disembodied technology to the LDC. The DC firm will act as a monopolist in the LDC until and unless a fake

producer (producing with diffused technology from the DC firm) enters the market. Thus with the entry of the fake producer both the firms will operate as duopolists reaching a Sub Game Perfect Nash Equilibrium (SPNE) where incumbent DC firm acts as a leader and fake firm operates as follower. The impact of IPR restrictions is introduced in the form of a Government Sector acting as a monitoring authority trying to resist technology diffusion and entry of the fake producer. Extracting a penalty or lump sum punishment charge from the fake producer does this.

Thus the game plan for the DC firm or the foreign investor is

(1) Initiate production entirely in the LDC as a monopolist.

(2) Technology diffuses to another LDC firm who enters the market by producing exact replica of the original product. Both the firms operate as quantity competitors in a leadership follower-ship

(3) The Government enters and tries to detect the fake producer. The probability of detection of the fake producers is $(1-\alpha)$ where $0 < \alpha \leq 1$.[6] If detected the DC firm or the foreign investor continue acting as the monopolist otherwise he can at best be a Stackelberg leader with the fake producer acting as a follower.

Assumptions

Let α be the probability of the entry of the fake producer.

Let A be the sunk cost of production incurred by the foreign investor and F be the plant installation cost of the foreign firm in the LDC. As assumed in the previous model w (this symbol is different) is per unit assembling cost of the semi-finished product in the LDC. Let G be the government punishment/penalty cost to be paid by the fake producer if detected. Let C be the cost of acquiring technology to be incurred by the fake producer. The fake producer does not have to incur the fixed cost F for plant installation.

The expected profit of the incumbent DC firm is given by

$$\begin{aligned}\pi_{Incumbent} &= \{(1-\alpha)((a-q_1)q_1 - wq_1) + \alpha(q_1(a-q_1-q_2) - wq_1)\} - A - F \\ &= \{q_1(a-q_1) - wq_1 - \alpha q_1 q_2 - A - F\}\end{aligned} \qquad 8.$$

Where q_1 be the output of the incumbent DC firm and q_2 be the output of the fake producer.

The expected profit of the fake producer may be given as:

$$\pi_{fake} = \alpha[(a-q_1-q_2)q_2 - wq_2 - A] - (1-\alpha)G - C \qquad 9.$$

$(1-\alpha)G$ be the expected penalty paid by the fake producer if detected. Solving for $\frac{\delta \pi_{fake}}{\delta q} = 0$ gives

[6] $\alpha > 0$ implies that perfect monitoring is impossible as monitoring by the government is costly.

$$q_2 = \frac{a - q_1 - w}{2} \qquad 10.$$

This is the reaction function of the fake producer. Given the reaction function of the fake producer the reduced form profit of the incumbent DC firm is defined in the following way:

$$\pi_{Incumbent} = \{q_1(a - q_1) - wq_1 - \alpha q_1(a - q_1 - w)/2 - A - F\}$$

Maximising this with respect to q_1 gives

$$q_{1LDC} = \frac{(a - w)}{2} \qquad 11.$$

From (10) the equilibrium output level of fake producer is given as

$$q_{2LDC} = \frac{(a - w)}{4} \qquad 12.$$

Let p_{LDC} be the expected price under this situation[7]. It is given as

$$p_{LDC} = \alpha\left(\frac{a + 3w}{4}\right) + (1 - \alpha)\left(\frac{a + w}{2}\right) = \left(\frac{a(2 - \alpha) + w(2 + \alpha)}{4}\right)$$

The equilibrium profits of the incumbent and fake firm are given as:

$$\pi_{Incumbent} = \frac{(a - w)^2(2 - \alpha)}{8} - A - F \qquad 8a.$$

$$\pi_{fake} = \frac{\alpha(a - w)^2}{16} - \alpha A - (1 - \alpha)G - C \qquad 9a.$$

$$\pi_{fake} \geq 0$$

$$\Rightarrow \alpha \geq \frac{16(G + C)}{(a - w)^2 - 16A + 16G} = \hat{\alpha} \qquad 13.$$

Thus the fake producer enters the market for $\alpha \in [\hat{\alpha}, 1]$[8]

Thus a high punishment level (G) or a high cost of copying technology C, or a high level of sunk cost of production deters the entry of fake producer.

For $\alpha < \hat{\alpha}$ the incumbent firm acts as a monopolist and earns his monopoly profit given as

$$\pi^{mono}_{Incumbent} = \frac{(a - w)^2}{4} - A - F \qquad 8b.$$

In the next section we try to find the optimal strategy choice by the DC firm under different IPR regime and different level of plant set up cost in LDC under foreign direct investment.

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[7] In this case when both incumbent and the fake producer operates in the market the price is given as *(a+3w)/4* and if the fake producer does not enter the market the price is given as *(a+w)/2*.

[8] A high value of G will increase $\hat{\alpha}$, and that will reduce the profitability of fake production.

3. Optimal Strategy Choice of the MNC.

As already mentioned the DC firm has three possible strategies:

First it can choose the export strategy where the production is taking place in the developed country.

Second it can fragment the production process. In this case core materials are produced in the developed country only the finishing or the assembling part takes place in the LDC.

Third it can produce the commodity entirely in the LDC.

First we compare the profit of the DC firm under export and fragmented production process

Proposition 1

For certain values of plant installation cost (below the critical level given by F) the incumbent firm prefers the fragmented production structure than the export strategy. Again larger market size prefers this move while the higher transport cost discourages such effort, where* $F^* = \frac{(2a - w - c - 2t)(c - w)}{4}$.

Proof:

$$\pi_{Frag} - \pi_{export}$$

$$= \left[\frac{(a - w - t)^2}{4} - A - F\right] - \left[\frac{(a - c - t)^2}{4} - A\right]$$

Now $\pi_{Frag} \geq \pi_{export}$ implies that

$$F \leq \frac{(a - w - t)^2}{4} - \frac{(a - c - t)^2}{4} = \frac{(2a - w - c - 2t)(c - w)}{4} \qquad 14$$

It is assumed that $F^* = \frac{(2a - w - c - 2t)(c - w)}{4}$ 15

F* be the critical level of cost of opening a production or assembly line unit in the less developed country. If actual value of F is above this level, from equation (14) it is clear that the foreign firm will choose the export strategy over the fragmentation strategy, only a low level of F will induce the fragmented production structure.

Now let us analyze the impact of different parameters on the critical value of F.

(1) Impact of market size parameter on F*

$$\frac{\delta F^*}{\delta a} = \frac{1}{2} > 0$$

If the market size increases the critical value of F increases. This increases the range of values of cost of foreign investor to set up a plant in the LDC for which the fragmented production

structure is profitable than the export strategy. Thus a large market size encourages fragmented market structure.

(2) Impact of transport cost on critical value of F*

$$\frac{\delta F^*}{\delta t} = -\frac{1}{2} < 0$$

If the transport cost (cost of exporting the finished product to the LDC or transferring the intermediate product to the LDC) increases, the critical value of F decreases. This implies that increase in transport cost reduces the fragmented profit at the higher rate than the profit under export strategy for higher values of plant setup cost, that is critical value of F decreases for increase in transport cost. Thus a higher transport cost discourages the fragmented production structure compared to export strategy.

Next we compare the profit under fragmented and complete LDC strategy.

Proposition 2

The developed country firm chooses to produce completely in the LDC for the values of α *in the interval* $\alpha \in [0, max(\alpha^*, \hat{\alpha})]$*, otherwise chooses the strategy of fragmented production, where*

$$\frac{16(G+C)}{(a-w)^2 - 16A + 16G} = \hat{\alpha} \text{ and } \frac{4t(a-w) - 2t^2}{(a-w)^2} = \alpha^*$$

Proof:

It has been shown that if the actual value of $\alpha < \hat{\alpha}$ then incumbent firm operates as a monopolist in the market and gains a profit given by equation 8b. This profit always dominates the profit under fragmentation given by equation 7 as long as the transportation cost t is positive. Hence for $\alpha < \hat{\alpha}$ the firm always chooses the complete LDC strategy to fragmentation.

Alternatively if $\alpha \geq \hat{\alpha}$, the fake producer operates at the market along with the incumbent firm. In that case, comparing profits of the incumbent firm to that of fragmentation strategy we get the following results:

$$\pi_{Incumbent} - \pi_{Frag} \geq 0$$

$$= \left[\frac{(a-w)^2(2-\alpha)}{8} - A - F\right] - \left[\frac{(a-w-t)^2}{4} - A - F\right] \geq 0$$

Implies that $\alpha \leq \frac{4t(a-w) - 2t^2}{(a-w)^2} = \alpha^*$ 16

Thus, if the fake producer actually operates in the LDC market (i.e. if $\alpha \geq \hat{\alpha}$) then the incumbent DC firm chooses complete LDC strategy if $\alpha \leq \alpha^*$.

As already mentioned the DC firm always chooses the complete LDC strategy to fragmentation strategy for $\alpha < \hat{\alpha}$.

So when $\hat{\alpha} < \alpha^*$, the firm chooses complete LDC up to $\alpha = \alpha^*$, beyond which fragmented strategy is adopted. Alternatively if $\hat{\alpha} > \alpha^*$ then the firm chooses complete LDC up to $\alpha = \hat{\alpha}$ as in the interval $0 < \alpha \leq \hat{\alpha}$ it operates as a monopolist. Beyond $\hat{\alpha}$ again fragmentation will take place.

The comparative static analysis with respect to market size 'a' and the transport cost gives the following result.

1) $$\frac{\delta \alpha^*}{\delta a} = \frac{-4t(a-w-t)}{(a-w)^3} < 0$$

As well as $\frac{\delta \hat{\alpha}}{\delta a} < 0$ which implies a higher market size encourages the fake producer to enter the market.

So a higher market size discourages complete DC production. The logic is intuitive. Higher the market size, greater will be the profitability of production of incumbent firm as well as fake producer. So more stringent IPR restriction is required for transfer of disembodied technology otherwise FDI is channeled to assembly line sectors only.

Again $$\frac{\delta \alpha^*}{\delta t} = \frac{4(a-w-t)}{(a-w)^3} > 0$$

So if t increases α^* decreases implying a higher transport cost favoring complete production in LDC with FDI.

Next we compare the profit under export strategy and complete LDC strategy and draw the following results.

Proposition 3

1. The firm will choose export strategy over complete LDC strategy if $F \geq F_1^*$.
2. *For* $F < F_1^*$ *the incumbent firm chooses complete LDC production where* $\alpha \in [0, max(\hat{\alpha}, \alpha_1^*)]$, *otherwise export strategy is chosen.*

Thus the firm chooses complete LDC if the monitoring is strong.

Where $$\frac{16(G+C)}{(a-w)^2 - 16A + 16G} = \hat{\alpha} \qquad \alpha_1^* = \frac{8(F^* - F)}{(a-w)^2} + \alpha^*$$

$$F^* + \left\{\frac{(2(a-w)-t)t}{4}\right\} = F_1^* \qquad F^* = \frac{(2a-w-c-2t)(c-w)}{4}$$

Proof: First we compare the export strategy profit of the monopolist to monopoly profit of the incumbent firm under complete LDC strategy when the fake producer is not entering the market. This is possible for $0 < \alpha < \hat{\alpha}$.

$$\pi_{Incumbent}^{Monopoly} - \pi_{Export}$$

$$= \left[\frac{(a-w)^2}{4} - A\right] - \left[\frac{(a-c-t)^2}{4} - A - F\right] \geq 0$$

$$\Rightarrow F \leq F^* + \left\{\frac{(2(a-w)-t)t}{4}\right\} = F_1^* \qquad 17.$$

For values of plant installation cost above F_1^*, export strategy is always adopted, as in this case even the monopoly profit under complete LDC strategy is less than that of export strategy. Next we compare the profits for these two strategies when the fake producer operates in the market along with incumbent firm.

$$\pi_{Incumbent} - \pi_{Export} \geq 0$$

$$\Rightarrow \left[\frac{(a-w)^2(2-\alpha)}{8} - A - F\right] - \left[\frac{(a-c-t)^2}{4} - A\right] \geq 0$$

$$\frac{(a-w)^2 - (a-c-t)^2}{4} - F \geq \frac{\alpha(a-w)^2}{8}$$

$$\frac{(2a-w-c-t)(c+t-w)}{4} - F \geq \frac{\alpha(a-w)^2}{8}$$

This equation can be written as[9]

$$\frac{(4F^* + 2t(a-w) - t^2) - 4F}{4} \geq \frac{\alpha(a-w)^2}{8}$$

$$\frac{8(F^* - F)}{(a-w)^2} + \frac{(4t(a-w) - 2t^2)}{(a-w)^2} \geq \alpha \qquad 18.$$

$$\alpha_1^* \geq \alpha$$

Thus for values of α less than α_1^* the incumbent firm chooses complete LDC strategy as compared to export strategy when fake producer operates in the market (i.e. $\alpha \geq \hat{\alpha}$).

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[9] $(2a-c-w-t)(c+t-w)$ can be written as

$((2a-c-w-2t)+t)((c-w)+t) = (2a-c-w-2t)(c-w) + t(2a-2w-2t) + t^2$.

$= 4F^* + t(2a-2w-2t) + t^2 = 4F^* + 2t(a-w) - t^2$

Where From 14 we have $F^* = \frac{(2a-w-c-2t)(c-w)}{4}$

From 15 we have $\frac{4t(a-w)-2t^2}{(a-w)^2}=\alpha^*$.

Hence

$$\Rightarrow \alpha_1^* = \frac{8(F^*-F)}{(a-w)^2}+\alpha^* \qquad 19.$$

From 19 we have

$$\alpha_1^* \underset{<}{\overset{>}{-}} \alpha^* \text{ for } F \underset{>}{\overset{<}{-}} F^*$$

Now if F is sufficiently high (for $F \geq F_1^*$)[10] then $\alpha_1^* \leq 0$. In this case export strategy is chosen for all values of α. Basically if $F \geq F_1^*$, and $0 < \alpha < \hat{\alpha}$ it is shown that monopoly LDC profit is strictly less than that of export strategy. For $\alpha \geq \hat{\alpha}$ when fake firm enters the market the duopoly profit of the incumbent firm will be higher than the profit under export strategy if and only if actual value of α is less than α_1^*. In this case if $F \geq F_1^*$ then $\alpha_1^* \leq 0$ and $\alpha \leq \alpha_1^*$ is impossible as $0 < \alpha \leq 1$. Hence export strategy is always adopted.

From 19 it is clear that $\alpha_1^* > 0$ if $F < F_1^*$. In that case if $\alpha_1^* > \hat{\alpha}$ then the complete LDC is chosen for $\alpha \in (0, \alpha_1^*]$. In this interval the firm will act as a monopolist for $0 < \alpha \leq \hat{\alpha}$, as it is not profitable for the fake firm to enter the market for the corresponding values of α. The incumbent firm receives the duopoly profit in the interval $\hat{\alpha} < \alpha \leq \alpha_1^*$. Alternatively if $\alpha_1^* < \hat{\alpha}$ the incumbent firm will choose complete LDC strategy for $\alpha \in (0, \hat{\alpha}]$. The incumbent firm receives the monopoly profit in this entire range of α values as the fake firm does not enter the market for $\alpha < \hat{\alpha}$. Combining the results it is obtained that if $F < F_1^*$ the complete LDC strategy is chosen in the interval $\alpha \in [0, max(\hat{\alpha}, \alpha_1^*)]$, otherwise export strategy is chosen. *(Hence Proved.)*

Thus combining the above three propositions the optimal strategy choice of the foreign firm can be given as follows:

Proposition 4

1. *For $F \geq F_1^*$ the foreign firm always chooses the export strategy.*

[10] *i.e. for* $F > F^* + \alpha^*(a-w)^2/8 = F^* + \frac{t(2(a-w)-t)}{4} = F_1^*$

2. *$F^* < F < F_1^*$ the foreign firm chooses the complete LDC strategy for $\alpha \in [0, max(\hat{\alpha}, \alpha_1^*)]$, otherwise export strategy is chosen.*
3. *For $0 \le F \le F^*$ the foreign firm chooses the complete LDC strategy if $\alpha \in [0, max(\hat{\alpha}, \alpha^*)]$, otherwise fragmented strategy is adopted.*

The proof follows from the three other propositions.

From proposition 4 it is clear that if the cost of plant installation in LDC is very high (i.e. $F > F_1^*$) then the firm prefers to choose the export strategy rather than involving in any type of FDI in the LDC. Alternatively the foreign firm will be involved in transferring disembodied technology via FDI if and only if the rate of IPR protection is strong. In this framework disembodied technology transfer will take place and firm will undertake the complete production in the LDC if and only if the rate of monitoring is strong and falling in the range given by $\alpha \in [0, max(\hat{\alpha}, min(\alpha_1^*, \alpha^*)]$. Given the assumption that transfer of complete production process to LDC may lead to entry of fake producer supplying imitation product with diffused technology from the DC firm, the incumbent firm transfer complete production if and only if IPR protection rate is high. When IPR protection rate is low but the cost of plant installation in LDC is also low the incumbent firm prefers to open the assembly line units in LDC and imports embodied technology to the LDC. [11] This fragmentation strategy is chosen if $\alpha > max(\alpha^*, \hat{\alpha})$ and the plant installation charge $F \le F^*$.

4.Social Welfare Analysis

The Social Welfare comparison of the different modes of production also gives important insights to the different modes of production chosen by the DC firm. The Social Welfare can be defined as the sum total of profit retained by the foreign firm in the LDC, consumer surplus and Government surplus less the cost of production, monitoring etc.

The assumption made here is that under FDI, the DC firm fully repatriates profit thus leaving Social Welfare as the sum total of

SW = Consumer Surplus + Government Surplus - Costs

In case when production is conducted entirely in the DC, the Government Surplus and Costs are both zero. The model assumes that if the product is exported to LDC then the probability of product imitation does not exist. Hence Government does not incur any monitoring cost to protect IPR of exported product. So under export strategy the social welfare is defined as

[11] The model assumed that import of embodied technology does not have any technology spillover effect.

$$SW_{Export} = \frac{(a-c-t)^2}{8} \qquad 20.$$

In case of fragmentation strategy the social welfare is defined as follows:

$$SW_{Frag} = \frac{(a-w-t)^2}{8} \qquad 21.$$

Finally we consider the situation where the fake producer enters the market. The fake producer will profitably operate in the market if and only if $\alpha > \hat{\alpha}$.

Then the ex ante level of social welfare is defined as follows:

SW_{LDC}= Expected profit of fake producer+ Expected net level of consumer surplus + Government Earnings.

The expected profit of the fake producer is given by 9a as

$$\pi_{fake} = \frac{\alpha(a-w)^2}{16} - \alpha A - (1-\alpha)G - C$$

The expected consumer surplus is as follows:[12]

$$CS_{LDC} = \frac{(a-w)^2(4+5\alpha)}{32} \qquad 22.$$

The net government surplus is defined as

$$GS_{LDC} = (1-\alpha)G - d(\alpha) \qquad 23.$$

Where $d(\alpha)$ is assumed to be the government monitoring cost such that $d'(\alpha) < 0$ that is as the monitoring cost increases the probability of entry of the fake producer decreases and vice versa. Again $d''(\alpha) > 0$, implying that the monitoring cost increases at an increasing rate. Finally it is assumed that the complete monitoring is impossible implying that

$d(\alpha) \to \infty$ when $\alpha \to 0$.

Thus social welfare under complete LDC strategy when the fake producer is operating in the market (i.e. $\alpha > \hat{\alpha}$) is defined as follows:

$$SW_{LDC} = \frac{(a-w)^2(7\alpha+4)}{32} - \alpha A - C - d(\alpha) \qquad 24.$$

---

[12] CS_{LDC}= (Probability that fake producer gets detected) *(Consumer surplus when incumbent firm operates as monopolist)+ (Probability that fake producer cannot be detected)*(Consumer surplus when fake producer operates along with the incumbent firm.)= $\alpha \frac{9}{32}(a-w)^2 + (1-\alpha)\frac{1}{8}(a-w)^2 = \frac{(a-w)^2}{32}(4+5\alpha)$

From 24 we have the following results:

1. $\frac{dSW_{LDC}}{d\alpha} = \frac{7(a-w)^2}{32} - A - d'(\alpha) > 0$ 24a.

As $d'(\alpha) < 0$ and $\frac{7(a-w)^2}{32} - A > 0$ (this follows from the profitability condition of the fake producer.)

2. $\frac{d^2 SW}{d\alpha^2} = -d''(\alpha) < 0$ 24b.

Otherwise in the absence of fake producer (i.e. $\alpha \le \hat{\alpha}$) the social welfare is defined as follows:

$$SW_{LDC} = \frac{(a-w)^2}{8} - d(\alpha) \qquad 25.$$

Finally it can be shown that equation (24) dominates equation (25) around $\alpha = \hat{\alpha}$.

Thus the social welfare function under complete LDC strategy is increasing in α and discontinuous at $\alpha = \hat{\alpha}$.

Next we compare the level of social welfare for three possible strategies and get the following proposition:

Proposition 5

i) For $F \ge F_1^*$ the government chooses the no monitoring strategy and foreign firm always chooses the export strategy.

ii) For $0 \le F \le F^*$

when $\hat{\alpha} < \alpha^*$ and government budget is balanced or at surplus the government chooses $\alpha_{opt} = \alpha^*$. In this case the complete LDC strategy is the sub game perfect Nash equilibrium of the game and the fake firm operates in the market.

Alternatively when $\hat{\alpha} \ge \alpha^*$ government chooses $\alpha_{opt} = \hat{\alpha}$ if $SW_{LDC}\big|_{\alpha \le \hat{\alpha}} > SW_{Frag}$ at $\alpha = \hat{\alpha}$ and complete LDC strategy is the sub game perfect Nash equilibrium of the game and foreign firm operates as a monopolist in the market, otherwise no monitoring is the optimal government strategy and fragmented strategy is the sub game perfect Nash equilibrium of the game.

iii) $F^* < F < F_1^*$

when $\hat{\alpha} < \alpha_1^*$ and government budget is balanced or at surplus the government chooses $\alpha_{opt} = \alpha_1^*$. In this case the complete LDC strategy is the sub game perfect Nash equilibrium of the game and the fake firm operates in the market.

Alternatively when $\hat{\alpha} \geq \alpha_1^*$ *government chooses* $\alpha_{opt} = \hat{\alpha}$ *if* $SW_{LDC}\big|_{\alpha \leq \hat{\alpha}} > SW_{Export}$ at $\alpha = \hat{\alpha}$ *and complete LDC strategy is the sub game perfect Nash equilibrium of the game and foreign firm operates as a monopolist in the market, otherwise no monitoring is the optimal government strategy and export strategy is the sub game perfect Nash equilibrium of the game.*

Proof:

Comparison of social welfare for export strategy and fragmented strategy gives as the following results:

$$SW_{Frag} - SW_{Export}$$
$$= \frac{(2a - w - c - 2t)(c - w)}{8} = \frac{F^*}{2} > 0 \qquad \text{(From 15)}$$

The consumer surplus under fragmentation strategy is higher than that of export strategy, which is obvious as the price of the product under fragmentation strategy is lower than that of the export strategy.

From proposition 4 it is clear that for $F \geq F_1^*$ the foreign firm always chooses the export strategy Thus in this range for plant installation cost the domestic Government does not incur any cost to Protect IPR and optimal value of α is $\alpha_{opt} = 1$.

Secondly we compare the social welfare under complete LDC strategy and fragmented strategy. But from Proposition 4 it is clear that complete LDC strategy is chosen only if $\alpha \in [0, max(\hat{\alpha}, \alpha^*)]$, otherwise fragmented strategy is chosen when 0<F<F*.

For $\alpha \leq \hat{\alpha}$ the fake firm does not enter the market, so the difference between the Social welfare under Fragmented strategy and Complete LDC Strategy is obtained by comparing equations (21) and (25) as follows:

$$SW_{LDC}\big|_{\alpha \leq \hat{\alpha}} - SW_{Frag} = \left[\frac{(a - w)^2}{8} - \frac{(a - w - t)^2}{8}\right] - d(\alpha) \qquad 26.$$

The first part is always positive, but given the assumption that $d(\alpha) \to \infty$ when $\alpha \to 0$, the equation (26) will assume negative values for lower values of α and as α increases and cost of monitoring declines then (26) may assume a positive value.

Given proposition 4, for 0<F<F*, if $\alpha^* < \hat{\alpha}$, the foreign firm chooses the complete LDC strategy in the interval $0 < \alpha \leq \hat{\alpha}$, and beyond this level fragmented production is chosen. Given that the Social Welfare under complete LDC strategy increases with α, the optimal value of α is $\hat{\alpha}$, if

$SW_{LDC}\big|_{\alpha\le\hat{\alpha}} \ge SW_{Frag}$ at $\alpha = \hat{\alpha}$ and Complete LDC Strategy constitutes the sub game perfect Nash equilibrium of the game. Otherwise if $SW_{LDC}\big|_{\alpha\le\hat{\alpha}} < SW_{Frag}$ at $\alpha = \hat{\alpha}$, the optimal value of α is unity and fragmentation will be the sub game perfect Nash equilibrium of the game.[13]

At $\alpha = \hat{\alpha}$ we have

$$(SW_{LDC}\big|_{\alpha\le\hat{\alpha}} - SW_{Frag})_{\alpha=\hat{\alpha}}$$

$$= \left[\frac{(a-w)^2}{8} - \frac{(a-w-t)^2}{8}\right] - d(\hat{\alpha}) \qquad 27.$$

The first bracketed term is always positive. Higher the value of transport cost, higher will be the gain in consumer surplus from Complete LDC production. However for lower values of t, gain in consumer surplus may not be enough to cover the cost of IPR protection. In that situation the social welfare under fragmentation may dominate that of complete LDC production and Government chooses $\alpha = 1$ and fragmentation strategy will be the sub game perfect Nash equilibrium of the game. Hence assembly line FDI takes place.

Alternatively if for 0<F<F*, and $\alpha^* \ge \hat{\alpha}$, the foreign firm chooses the complete LDC strategy in the interval $0 < \alpha \le \alpha^*$, and beyond this level fragmented production is chosen. Given that $\alpha^* \ge \hat{\alpha}$, the incumbent firm chooses the complete LDC production strategy and acts as a monopolist in the interval $0 < \alpha \le \hat{\alpha}$ and acts as a duopolist in the interval $\hat{\alpha} < \alpha \le \alpha^*$.

For $\alpha > \hat{\alpha}$

$$SW_{LDC}\big|_{\alpha>\hat{\alpha}} - SW_{Frag}$$

$$= \frac{(a-w)^2(7\alpha+4)}{32} - \alpha A - C - d(\alpha) - \frac{(a-w-t)^2}{8}$$

$$= \left[\frac{t(2(a-w)-t)}{8}\right] + \alpha\left[\frac{7(a-w)^2}{32} - A\right] - C - d(\alpha) \qquad 28.$$

From (16) the above expression can be written as

$$SW_{LDC}\big|_{\alpha>\hat{\alpha}} - SW_{Frag} = \left[\frac{\alpha^*(a-w)^2}{16}\right] + \alpha\left[\frac{7(a-w)^2}{32} - A\right] - C - d(\alpha) \qquad 28a.$$

As we have mentioned SW_{LDC} is increasing in α and discontinues at $\alpha = \hat{\alpha}$. Given the strategy of the foreign firm that it chooses complete LDC strategy only in the interval $0 < \alpha \le \alpha^*$,

[13] It can be shown that $(SW_{LDC}\big|_{\alpha\le\hat{\alpha}} - SW_{Frag})_{\alpha=\hat{\alpha}}$ is ambiguous in sign even if we assume that the government budget is balanced.. For Proof see appendix A1.

otherwise chooses fragmented strategy, the optimal strategy for government is to choose $\alpha = \alpha^*$ if $SW_{LDC}\big|_{\alpha>\hat{\alpha}} \geq SW_{Frag}$ at $\alpha = \alpha^*$.

Otherwise Government chooses $\alpha = 1$.

In this case it can be shown that $SW_{LDC}\big|_{\alpha>\hat{\alpha}}$ is higher than SW_{Frag} at $\alpha = \alpha^*$ when government budget is balanced or have a surplus. [14]

Thus when 0<F<F*, if $\alpha^* \geq \hat{\alpha}$, the optimal strategy of the government is to choose $\alpha = \alpha^*$ when the government budget is balanced or have a surplus. Otherwise if cost of monitoring is very high such that $SW_{LDC}\big|_{\alpha>\hat{\alpha}} - SW_{Frag} < 0$ at $\alpha = \alpha^*$, the 'no monitoring' is chosen so that $\alpha = 1$ and 'Fragmentation' is the sub game perfect Nash equilibrium of the game. Thus in situation of costly monitoring assembly line FDI may take place in LDC.

Finally we consider the social welfare maximizing value of α for $F^* < F < F_1^*$. For this range of plant installation cost in the LDC market from proposition 4 it is clear that the foreign firm chooses complete LDC strategy if $\alpha \in [0, max(\hat{\alpha}, \alpha_1^*)]$ otherwise export strategy is chosen. Like the earlier case there will be two cases.

Firstly we consider the situation where $\alpha_1^* < \hat{\alpha}$ along with $F^* < F < F_1^*$. In this case the complete LDC strategy chosen for $0 < \alpha < \hat{\alpha}$. (As the imitator does not enter the market in this interval.). So the comparison of social welfare under export strategy and complete LDC Strategy gives the following result:

$$SW_{LDC}\big|_{\alpha\leq\hat{\alpha}} - SW_{export} = \left[\frac{(a-w)^2}{8} - \frac{(a-c-t)^2}{8}\right] - d(\alpha) \qquad 29.$$

Given the assumption that $(w < c + t)$, the first bracketed term is always positive. However $d(\alpha) \to \infty$ when $\alpha \to 0$, so for lower values of α the difference is always negative. Thus equation (29) is always ambiguous in sign. Given proposition 4 under this situation if $SW_{LDC}\big|_{\alpha\leq\hat{\alpha}} > SW_{export}$ for $\alpha = \hat{\alpha}$, the government chooses $\alpha_{opt} = \hat{\alpha}$ and complete LDC strategy will be the sub game perfect equilibrium strategy. Otherwise $\alpha_{opt} = 1$ and export strategy will be the sub game perfect equilibrium strategy.

Next we consider the case where $\alpha_1^* \geq \hat{\alpha}$ along with $F^* < F < F_1^*$. Given that $\alpha_1^* \geq \hat{\alpha}$, the incumbent firm chooses the complete LDC production strategy and acts as a monopolist in the

[14] For proof see appendix A2.

interval $0 < \alpha \leq \hat{\alpha}$ and acts as a duopolist in the interval $\hat{\alpha} < \alpha \leq \alpha_1^*$. Given that social welfare under complete LDC strategy increases with α, the government will choose $\alpha_{opt} = \alpha_1^*$ if $SW_{LDC}\big|_{\alpha>\hat{\alpha}} > SW_{export.}$ at $\alpha = \alpha_1^*$, otherwise chooses $\alpha = 1$ and export strategy will be the sub game perfect Nash equilibrium when $F^* < F < F_1^*$.

$$SW_{LDC}\big|_{\alpha>\hat{\alpha}} - SW_{export.}$$

$$= \frac{(a-w)^2(7\alpha+4)}{32} - \alpha A - C - d(\alpha) - \frac{(a-c-t)^2}{8} \qquad 30.$$

In this case it can be shown that $SW_{LDC}\big|_{\alpha>\hat{\alpha}}$ is higher than SW_{LDC} at $\alpha = \alpha_1^*$ when government budget is balanced or have a surplus. [15] Thus when government budget is balanced or at surplus at $\alpha = \alpha_1^*$ existence of a fake producer along with foreign firm producing the entire product in the LDC becomes the welfare maximizing equilibrium situation.

Proposition 5 signifies the possibility of two interesting situations. Firstly there may be situations where the foreign direct investment will flow only in the assembly line sectors i.e. the firms are taking fragmented production strategies. Weak IPR restrictions, but low cost of foreign investment leads to a situation where multinationals may shift the assembly line activities in the LDCs. This situation will lead to transfer of embodied technology in the LDC, which does not lead to spill over of knowledge. Secondly Proposition 5 also shows that there may be situations where government is choosing an IPR protection rate that induces the entry of fake firm in the market when the multinational is transferring the entire production process in the LDC. In this situation disembodied technology is transmitted to less developed economies thus leading the situation of knowledge spill over.

5. Concluding Remarks

Our model investigates how foreign firms decision to produce in the LDC market depend on the IPR protection rate, fixed costs of plant installation, market size and transport cost of transferring the finished product to the LDC. The impact of these parameters on the strategic entry decision of a MNC gives some interesting results. Summing up the results we find that the entry decision of the MNC will initially depend upon the plant installation cost of the firm in the LDC. If the plant installation cost is sufficiently high then the firm will find it more profitable to export the finished product to the LDC market. In such a case the Government will find it optimal to exercise no IPR restriction in the form of monitoring mechanism as assumed in the model. Now if the plant

[15] For proof see appendix A3.

installation cost to start off production in the LDC is below the critical value defined in the model then the choice of entry will be restricted between fragmentation or complete LDC production. In this case decision will depend on the probability of entry of the fake producer i.e IPR restrictions enforced by the Government. In case of low probability of entry of the fake producer the foreign firm will undertake complete LDC production. From the Social Welfare consideration the Government will in this case also find it optimal to impose some IPR restrictions. However the underlying assumption made here is that the Government has a balanced or a surplus budget. If he Government runs a budget deficit, as commonly seen in a LDC, then the government will undertake no IPR restriction and its monitoring cost will be zero. In case if the probability of entry of the fake producer is high that is Government imposes no or lenient IPR restriction then the foreign firm will choose fragmented production. The other parameters of the model for instance market size parameter, and transport cost favors fragmented or Complete LDC production over the other modes of production.

The results enumerated briefly above find support from recent policy change undertaken in the Indian Patent Act. Empirical analysis has also shown that Multinational Companies are not willingly to transfer disembodied technology if they face the risk of product imitation in the LDC. Thus in presence of weak Intellectual Property Protection the optimal policy for the MNC will be to transfer embodied technology and FDI will take place in the assembly-line sectors only.

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Appendix A1

First we consider the case where 0<F<F*,and $\alpha^* < \hat{\alpha}$,

At $\alpha = \hat{\alpha}$

$$(SW_{LDC}\big|_{\alpha \le \hat{\alpha}} - SW_{Frag})_{\alpha=\hat{\alpha}}$$

$$= \left[\frac{(a-w)^2}{8} - \frac{(a-w-t)^2}{8}\right] - d(\hat{\alpha})$$

In this case let us make the assumption that government budget is balanced or have a surplus, i.e.

$(1-\alpha)G \ge d(\alpha)$

Then $\left[\frac{(a-w)^2}{8}-\frac{(a-w-t)^2}{8}\right]-d(\hat{\alpha}) \geq \left[\frac{(a-w)^2}{8}-\frac{(a-w-t)^2}{8}\right]-(1-\hat{\alpha})G$

At $\alpha=\hat{\alpha}$ $\frac{\alpha(a-w)^2}{16}-\alpha A-(1-\alpha)G-C=0$.

This implies

$$\left[\frac{(a-w)^2}{8}-\frac{(a-w-t)^2}{8}\right]-(1-\hat{\alpha})G =$$

$$\left[\frac{(a-w)^2}{8}-\frac{(a-w-t)^2}{8}\right]-\frac{\hat{\alpha}(a-w)^2}{16}+\hat{\alpha}A+C$$

$$=\frac{(2-\hat{\alpha})(a-w)^2}{16}-\frac{(a-w-t)^2}{8}+\hat{\alpha}A+C$$

Given the assumption that $\alpha^* < \hat{\alpha}$, from proposition 2 it is clear that profit of the foreign firm is higher under fragmented strategy than that of complete LDC strategy for $\alpha=\hat{\alpha}$. This implies

$$\left[\frac{(a-w)^2(2-\alpha)}{8}\right] \leq \left[\frac{(a-w-t)^2}{4}\right]$$

Thus the sign of $(SW_{LDC}|_{\alpha\leq\hat{\alpha}}-SW_{Frag})_{\alpha=\hat{\alpha}}$ is ambiguous in nature.

Appendix A2

From 28a

$$SW_{LDC}|_{\alpha>\hat{\alpha}}-SW_{Frag}=\left[\frac{\alpha^*(a-w)^2}{16}\right]+\alpha\left[\frac{7(a-w)^2}{32}-A\right]-C-d(\alpha)$$

At $\alpha=\alpha^*$

$$SW_{LDC}|_{\alpha>\hat{\alpha}}-SW_{Frag}=\left[\frac{\alpha^*(a-w)^2}{16}\right]+\alpha^*\left[\frac{7(a-w)^2}{32}-A\right]-C-d(\alpha^*)$$

$$=\left[\frac{9\alpha^*(a-w)^2}{32}\right]-C-d(\alpha^*)-\alpha^* A$$

Given that $\alpha^* > \hat{\alpha}$ we have

$$\pi_{fake}=\frac{\alpha(a-w)^2}{16}-\alpha A-(1-\alpha)G-C\geq 0$$

$$\Rightarrow \frac{\alpha(a-w)^2}{16}\geq \alpha A+(1-\alpha)G+C$$

Thus for $\alpha=\alpha^*$

$$\frac{\alpha^*(a-w)^2}{16} \geq \alpha^* A + (1-\alpha^*)G + C$$

This in turn implies that $\frac{9}{2}\frac{\alpha^*(a-w)^2}{16} > \frac{\alpha^*(a-w)^2}{16} \geq \alpha^* A + (1-\alpha^*)G + C$ as $\frac{9}{2} > 1$

If we assume a balanced or surplus government budget then

$(1-\alpha)G \geq d(\alpha)$

This in turn implies that

$$\frac{9}{2}\frac{\alpha^*(a-w)^2}{16} > \alpha^* A + (1-\alpha^*)d(\alpha^*) + C$$

$SW_{LDC}\big|_{\alpha>\hat{\alpha}} \geq SW_{Frag}$ at $\alpha = \alpha^*$.

If the government budget faces a deficit then $SW_{LDC}\big|_{\alpha>\hat{\alpha}} - SW_{Frag}$ at $\alpha = \alpha^*$ is ambiguous in sign.

Appendix A 3

$$SW_{LDC}\big|_{\alpha>\hat{\alpha}} - SW_{export.}$$

$$= \frac{(a-w)^2(7\alpha+4)}{32} - \alpha A - C - d(\alpha) - \frac{(a-c-t)^2}{8}$$

From (18) at α_1^* the above expression becomes

$$SW_{LDC}\big|_{\alpha>\hat{\alpha}} - SW_{export.} = \left[\frac{9\alpha_1^*(a-w)^2}{32}\right] - C - d(\alpha_1^*) - \alpha_1^* A + F/2$$

At $\alpha = \alpha_1^*$ the fake producer is earning a positive profit as $\alpha_1^* > \hat{\alpha}$. This implies that

$$\pi_{fake} = \frac{\alpha(a-w)^2}{16} - \alpha A - (1-\alpha)G - C \geq 0 \ \ at\ \alpha = \alpha_1^*$$

$$\Rightarrow \frac{\alpha_1^*(a-w)^2}{16} \geq \alpha A + (1-\alpha_1^*)G + C$$

This in turn implies that

$$\frac{9\alpha_1^*(a-w)^2}{32} + F/2 > \frac{\alpha_1^*(a-w)^2}{16} \geq \alpha_1^* A + (1-\alpha_1^*)A + C$$

If we assume a balanced or surplus government budget at $\alpha = \alpha_1^*$ then

$(1-\alpha_1^*)G \geq d(\alpha_1^*)$

Hence we have

$$\frac{9\alpha_1^*(a-w)^2}{32} + F/2 > \alpha_1^* A + d(\alpha_1^*) + C$$

$SW_{LDC}\big|_{\alpha>\hat{\alpha}} > SW_{export.}$ at $\alpha = \alpha_1^*$.

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