Multinational Corporations and his Effect on the Incentives to Invest in Product Innovation by Host Country Firms

By

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Abstract

This paper examines the strategic interaction between a Multinational Corporation (MNC) and a host country firm focused on its effect on product innovation in the host country. To address this issue we analyse the channels through which Multinational corporations affect the incentives to invest in product innovation by host country firms. We consider a market for a vertically differentiated product that consist of a domestic firm, which produce only for domestic consumption, and a MNC, which can reach the local market by exporting or by establishing a subsidiary. They compete over two periods by choosing product quality in the first and prices in the second (Bertrand competition). We also analyse the preferred mode of entry of the foreign firm from the host country’s point of view. The model is then used to determine if there is scope for a domestic R&D policy. In this respect, our analysis suggests that any mechanism that provide an incentive for the domestic to increase its product quality would be welfare improving.

JEL: F2, L1, L5, O3.
Keywords: Foreign Direct Investment, Multinational’s Entry Strategies, Vertical Differentiation, Research and Development.

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1. Introduction

The main factor behind economic growth seems to be technological innovation, which is undertaken mostly in developed countries. In addition to that, an important part of technological innovation follows from R&D investments, where Multinational Corporation (MNC) carries out a major part of the private R&D in the world. On the other hand, empirical evidence strongly supports the existence of international technology transmission from developed to developing countries (see for instance, Coe and Helpman, 1995 and Coe et al. 1997). Within the different channels for this process Foreign Direct Investment (FDI) appears to be one of the principal. Despite FDI is concentrated in developed countries, it is significant and growing in developing countries, especially in countries where local firms undertake themselves R&D investment (UNCTAD-World Investment Report, 2004).

Although there exist significant theoretical literature on the impact of FDI on less developed economies, most of it analyse models where the decision of setting up a subsidiary in the host country has already taken and/or where domestic firms doesn’t invest in R&D (see for instance, Findlay, 1978; Das, 1987; Wang and Blomstrom, 1992). Therefore, the main contribution of this model is that we analyse FDI in less developed countries in which both the mode of foreign expansion and the incentives to innovate are endogenously determined. This chapter try to shed some light on these issues by analysing the impact of the different modes that a foreign firm has to reach a domestic market on the incentives to innovate and on the host country welfare.

We consider a market for a differentiated product that consist of a domestic firm, which produce only for domestic consumption, and a foreign firm, which can reach the local market either by exporting or by establishing a subsidiary. To undertake this task we build and analyse a three stages duopoly model. In the first stage the foreign

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3 Petit and Sanna-Randaccio (2000) develop a model in which these two issues are endogenously determined. Their model, however, is formulated to explain FDI among developed countries. There are also a number of differences in the specific details between their and our model. For instance, they consider process R&D while our model allows both process and product R&D.
firm chooses the mode of serving the domestic market. Then, firms choose simultaneously R&D level in the second stage and prices (Bertrand competition) in the third stage. The effect of R&D investment can be interpreted either as to improve product quality or to reduce production cost. The model is solved backward and the solution concept involved is subgame perfect Nash equilibrium.

Also, in our model we just consider cases of non-cooperative behaviour, which means that firms compete both in R&D investment and in the product market. So, for instance, we do not take into account cases where firms cooperate in the R&D stage by making Research Joint Venture Agreements in any of their different forms. In the following chapter we analyse the case of cooperative behaviour in the R&D stage.

The analysis focuses on the following issues:

1. First, on the impact of the different market structures on the incentives to innovate.
2. Second, on the preferred mode of entry of the foreign firm from the host country’s point of view.
3. Third, on the determinants of the optimal mode of entry of the foreign firm from its point of view.
4. Fourth, to determine if there is scope for a domestic R&D policy

A special feature of our model is that we consider the existence of asymmetric R&D spillovers, which are received by the domestic firm only in the case that the foreign firm reaches the domestic market by setting up a subsidiary. So, we assume that spillovers are geographically localized. The asymmetry follows from the assumption that the foreign firm is on the technology frontier while the domestic firm, which belongs to an emerging economy, is behind it. Also, we include into the analysis the idea that the degree of spillovers received by the domestic firm depends positively on its own R&D effort. Hence, if domestic firm doesn’t invest in R&D it receives no spillovers. So, following Cohen and Levinthal (1989) we consider a dual impact of the R&D effort: it improves technology and also enhances the firm’s capability to absorb information created by other organizations (absorptive capacity).
The structure of our model falls, therefore, into the strategic R&D with spillovers type of model\(^4\). There are two main reasons to choose this type of model. First, because in this type of model the impact of spending resources on R&D is to improve technology gradually, in a non-tournament kind, which is consistent with the stylised view that in most industries “... technological changes take places as a succession of incremental changes, with occasional major shifts and discontinuities.” (De Bondt 1996, pp. 2). Second, since this type of game seems to be more relevant in the context of our analysis: namely, interaction between a domestic firm based in a less developed country, but with the capacity to undertake investment in R&D, and a MNC which is on the technology frontier. Hence, despite the domestic firm is behind the technological frontier it can compete with a technologically more advanced firm\(^5\).

In the following section we discussed the related literature. In section 4.3 we set up the model that we use to analyse the different scenarios. Then, in Section 4.4 we analyse the different modes of serving the host country market and its impact on the incentives to invest in R&D. The first mode arises when the foreign firm serves the domestic market by exporting. The second one, when the foreign firm serves the domestic market by creating a wholly owned subsidiary. In section 4.5 we compare both structures in terms of its impact on the main variables of interest. In particular, in this section we intend to shed some light on the preferred mode of serving the domestic market from the host country’s point of view. Then, in section 4.6 we study the determinants of the optimal mode of operation of the foreign firm. In section 4.7, we intend to answer the following question: Is there a scope for an R&D policy? Finally, section 4.8 provides conclusions and suggestions for further research.

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\(^4\) There are two other main types of models to analyse oligopoly models with R&D spillovers, which are racing games, commitment games.

\(^5\) So, for instance, games in which winners take all seem not relevant in the case of asymmetric firms, where levels of knowledge are significantly different.
2. Literature Review

The model developed in this chapter can be classified into the literature on international oligopolies with strategic R&D and spillovers to the literature on R&D policies in international oligopolies and on the impact of MNC on the host country economy. Also it is related to the literature on strategic R&D with spillovers, which will be surveyed selectively here.

Following to De Bondt (1996), whom summarises the main results obtained in models that analyse spillovers in innovative activities, we can identify three different types of approaches (or games) to analyse R&D activities with spillovers: namely racing games, commitment games and strategic investment games. The model we develop in this chapter belong to the strategic investment game type, which consists of multiple stage R&D investment models with or without R&D spillovers. Earlier seminal papers include Brander and Spencer (1983), Spence (1986) and Katz (1986). This chapter, however, is closer in its structure to the influential paper by D’Aspremont and Jaquemin, 1988 (DJ, from now on), which was extended and complemented in many directions, for example, by Kamien et al (1992), Suzumura (1992), and Kamien and Zang (2000).

In the DJ type of game the structure of the model consists of firms that compete over two periods or stages. In the first stage firms decide simultaneously how much to spend on R&D and then, in the second stage, firms compete in the product market either in a Bertrand or Cournot fashion. R&D investment aims, in most of this literature, to reduce production costs (process R&D). In our model, however, R&D can be interpreted either as product R&D, which aims to improve product quality, or process R&D. As a consequence of this structure when firms decide on price or output they take R&D level as given. This sequence stress the idea that R&D investment is a long run decision, while choosing price or output is a short run one and, therefore, can be modified faster than the R&D level.

Under this strategy of modelation the impact of spending resources on R&D is to improve technology gradually, in a non-tournament kind. So, “there are many
different research paths that firms can follow to improve their production process, so
whatever research path a firm follows, an equivalent amount of R&D spending will
generate an equivalent reduction in production costs or enhancement in demand.
Competitors can not prevent other firms from getting equivalent improvements
through spending equivalent amounts on R&D.” (De Bondt 1996, pp. 9-10)

The imperfect “appropriability” problem of the information (Arrow, 1962) is a
central issue in the literature on R&D with spillovers as in this chapter. We will
consider spillovers as the useful part of the information, regarding process and
product R&D, which is received by a firm with no payment made in return.
Therefore, it is possible to have the case of two firms that share all their
technological information and that, in spite of that, they receive small spillovers. This
could happen, for example, because their products are very differentiated (De Bondt,
1996). The previous example also suggests the idea that the degree of spillovers that
a firm can receive depends on its capacity to absorb information developed by other
firms. There are a number of different channels through which information can be
leaked out to third parties such as patent disclosures, publications or technical
meetings, personal contact with or hiring employees of technologically more
advanced firms, reverse engineering (Mansfield, 1985).

The presence of spillovers also implies that firms, when deciding on R&D
expenditure, take into account that other firms in the same industry can receive part
of the knowledge that they are creating in the form of a positive externality.

So, in summary, there are two central characteristics that this paper shares with the
line of literature on R&D with spillovers that started with D’Aspremont and
Jacquemin (1988):
1. The structure of the model consists of firms that compete over two periods by
   choosing R&D expenditure in the first and price or production in the second.
2. A central characteristic of the market under analysis is the presence of R&D
   spillovers, which means that a part of the R&D effort undertaken by an
   individual firm is appropriated without a payment made in return by other
   firm(s).
The model developed in this chapter, however, differ in the central questions addressed and in some details that will be explained below.

Among the papers on strategic R&D with spillovers, in most of them in the case of cost reducing R&D investment, there are two different ways of introducing knowledge spillovers. The first way, introduced by AJ, is to consider the spillovers as affecting R&D output: this is, the effective reduction in production cost is its own amount of R&D plus an exogenous fraction (which is the spillover parameter) of all other firms’ amount of R&D. The second way, used by Kamien et al. (1992)⁶, is to model knowledge spillovers as affecting R&D expenditure, in other words as an R&D input: this is, the effective firm’s R&D investment is the sum of its own R&D investment plus an exogenous fraction (again representing the spillover parameter) of all others R&D investment. Amir (2000) undertakes a quite complete comparison of these two ways of modelling R&D spillovers within the same framework than in the DJ model. He concludes that from a quantitative point of view the two models are not equivalents and, therefore, there exist conflicts between them with respect to their policy implications. Also, he questions the validity of the DJ model in the case of high degree of spillovers. He also suggests that the Kamien et al. type of model is probably a better way to analyse strategic R&D with spillovers and that it can be applied to a generic industry. In this chapter, we model R&D spillovers as affecting R&D input, but with some differences with the latter case that will be explained below.

Now we will make a selective review of some relevant papers within the DJ type of model. We begin with the DJ seminal paper, in which the authors develop a simple two-stage strategic R&D with spillovers model where firms compete in a Cournot fashion in the second stage. The main contribution is to provide an example in which if firms behave cooperatively in the R&D stage (or in the R&D and product stage) the levels of R&D investment and total output aren’t necessarily lower than the levels obtained for the same variables when firms behave no cooperatively both in R&D and output market. This result requires that the degree of spillovers be big enough. The policy implication is very important because it suggests that if R&D

⁶ This way of modelling technological spillovers was first introduced by Ruff, 1969 (Amir, 2000).
spillovers are big enough welfare can be potentially improved by allowing, at least, R&D agreements.

They analyse three different scenarios:
1. In the first, firms behave no cooperatively both in the R&D and output stages.
2. In the second, firms cooperate in the first (R&D) stage choosing its R&D level to maximise joint profits.
3. Finally, in the third case the authors consider the case of full cooperation, which means that firms cooperate in both stages of the game.

They also find the values of R&D and output that maximise social welfare defined as the sum of consumer’s surplus and producer’s surplus. Then, the authors compare the different equilibrium in relation to the social optimum. They conclude that R&D and output levels obtained in the three cases considered are always lower than the level reached in the social optimum. This result is independent of the degree of spillovers or any other parameter. Also, for a large enough degree of spillovers the second best level of R&D is obtained when there is cooperation in R&D and in output and the lower level is obtained in the case that there is no cooperation at all. Finally, for small spillovers the second best result for R&D is still obtained with full cooperation, but the lower level is reached when there is cooperation only at the R&D stage.

The work by AJ was extended by Kamien et al (1992) to a more general model that consider n symmetric firms that produce a differentiated product and compete in the product stage in either Bertrand or Cournot fashion. The central difference with AJ paper is, however, that they consider a broader range of types of cooperation at the R&D: namely, R&D competition, R&D cartelisation, RJV competition and RJV cartelisation. In the R&D competition case firms behave no cooperatively in both the R&D and product stages. In the R&D cartelisation case firms choose R&D level with the objective of maximizing overall profits. In the RJV cooperation, firms compete in the R&D stage but they share R&D effort and avoid R&D duplication. Finally, in the case of RJV cartelisation firms choose its R&D level with the objective of maximizing overall profits and also they share R&D effort and avoid R&D duplication. In each of these cases, however, firms behave no cooperatively in the product stage. In the RJV cases because firms share information the degree of
spillovers is higher than in the first two cases. Another important difference is that they model knowledge spillovers as affecting R&D expenditure in the way explained above. They compare the outcome of the four cases considered and conclude that the best case is RJV cartelisation because firms obtain the highest profits and product prices are the lowest. Also, they found that the worst case is RJV competition because it generates the lower R&D level and the higher product prices. The central conclusion obtained in the AJ paper that if the degree of spillovers is big enough then R&D coordination lead to a higher level of R&D compared with the case of no cooperation at all can paper is still valid.

Another interesting extension of AJ paper is provided by Suzumura (1989), whom develops a two stage model that includes n symmetric firms, producing a homogenous product and considering more general demand and cost functions. He analyses the effects of cooperative R&D agreements, while keeping oligopolistic competition in the product market. An important modification with respect to the DJ set-up is to utilize the levels of R&D and production obtained from the maximisation of a second best welfare function as the relevant one when comparing the cooperative and no cooperative results with the social optimum. This function measures the total market surplus assuming that the government can enforce optimal R&D levels but keeping the oligopolistic competition in the second stage. The first best welfare function used in DJ, on the other hand, measures the total market surplus assuming that the government can enforce firms to set both optimal levels of R&D and output. The main qualitative results are, however, similar to those obtained in DJ suggesting that they are robust to more general demand and cost function and to a second best welfare functions.

A common feature in the models described above, which is also present in most of the extensions to the DJ type of model, is that they consider the degree of spillovers received by a firm as independent of its own R&D effort. This seems to be in clear opposition with the idea developed by Cohen and Levinthal (1989) which suggests a dual impact of the R&D effort: it not only creates information as in the models discussed above but also enhances the firm’s capability to absorb information created by other organizations. This is, the own R&D also improves the absorptive capacity. Also, it contradicts that “Growing empirical evidence indicates that firms that devote
a large amount of resources to R&D increase their ability to appropriate the knowledge and technology possessed by other firms.” (Grunfeld, 2003, page 1092). Kamien and Zang (2000) propose a way to model R&D spillover that includes the absorptive capacity aspect. In their specification a firm can not receive R&D spillovers without undertaking R&D itself and, also the Kamien et al. (1992) way of modelling R&D spillovers appears as a particular case in which its own R&D doesn’t affects its ability to receive spillovers.

Following Cohen and Levinthal (1989) and Kamien and Zang (2000) we model R&D spillovers as assuming that the firm’s capacity to absorb the knowledge created by other firms depend on its own R&D effort. In other words, the higher is the R&D undertaken by a firm the higher is its ability to receive R&D spillovers. The details of the way in that we introduce the absorptive capacity in to the model are in the section 4.3.

Another common feature to most of the papers discussed above is that firms considered are symmetric. A central advantage of that assumption is that solving the model and undertaking the comparison of the different cases is easier than when firms are asymmetric.

In the next section we develop a model to study the issues in that we are interested. As we mention before a common feature of our model with the literature surveyed in this section is that we build a strategic R&D with spillovers type of game. There are, however, a number of important differences with this literature, where the most important are:

1. Most of this literature focused on oligopolistic firms competing in a single country, which are based in the same country and, therefore market structure is exogenous. In our model the choice of the mode in which the foreign serves the host country economy is endogenous. This type of modelation allows us to shed some light on the determinants of this choice and on the preferred mode from the host country’s point of view. Also, since domestic welfare doesn’t include the foreign firm profits it allows for the analysis of strategic profit shifting policies.
2. In previous models R&D spillovers are received for free. In our model the degree of R&D spillovers received by the domestic firm depend on its absorptive capacity. To the best of our knowledge Kamien and Zang (2000) is the only model that includes it.

3. In summary, the main features that gives novelty to our analysis is that we present the first model with strategic R&D spillovers in that:
   a. Both market structure and R&D level are endogenous.
   b. Analyse the impact of FDI in a less developed economy, in which local firms undertake R&D itself.
   c. There are asymmetric spillovers in a context where to receive R&D spillovers it is necessary to undertake R&D itself.
3. The Model

Consider a duopolistic market located in a small economy, which consists of a domestic firm \((d)\) that produces only for domestic consumption and a foreign firm that can reach the domestic market either by exporting \((e)\) or by establishing a subsidiary \((s)\). These firms manufacture a differentiated good \((q)\) and invest resources in Research and Development \((R)\). Initially we will assume that R&D aims to improve product quality. However, as we will see later investment in R&D can be interpreted as aiming to improve product quality or to reduce production costs.

Another key feature is that the foreign firm decision on how to serve the domestic market is taken endogenously. As a consequence, the firms’ problem is solved as a three stages game. In the first stage, the foreign firm chooses how to expand to the domestic market: by exporting or by setting up a wholly owned subsidiary. Then, firms compete over two periods by choosing R&D in the second and prices (Bertrand competition) in the third. The firms’ problem is solved as a dynamic game of complete but imperfect information, which implies that each firm knows the effects of its decisions on the other firm behaviour in the next period. The imperfect information characteristic follows from the fact that decisions in stages 2 and 3 are taken simultaneously. The solution concept is subgame perfect Nash equilibrium, which implies that equilibrium in each stage is Nash equilibrium. As usual, the model is solved backward.

In our analysis firms behave no cooperatively in each stage of the game. So, we will not consider the possibility of any type of agreement both at the R&D and product stage.

Preferences and Demand

We adapt the demand structure from Dixit (1979). The consumer preferences are represented by a quasilinear utility function.
\[ U(q_d, q_j, m) = u(q_d, q_j) + m, \quad j = e, s \]  

(1)

Where \( m \) is expenditure in other goods (numeraire). This representation of the consumers’ preferences has as an implicit assumption that expenditure on good \( q_i \) represents a small part of the overall economy. As a consequence, income and interindustry substitution effects can be ignored and the system of inverse demand for \( q_i \) can be obtained by equating its price with the marginal utility (MU) of consumption. This specification also will allow us to conduct welfare analysis by comparing the consumer plus producer surplus under different scenarios.

Assume also that \( u(q_d, q_j) \) has a quadratic form:

\[ u(q_d, q_j) = A_d q_d + A_j q_j - \frac{1}{2} [q_d^2 + 2\gamma q_d q_j + q_j^2], \quad j = e, s \]  

(2)

Thus, the inverse demand function system is

\[ p_d = MUq_d = A_d - q_d - \gamma q_j, \quad j = e, s \]  

(3)

\[ p_j = MUq_j = A_j - q_j - \gamma q_d, \quad j = e, s \]  

(4)

The products considered are substitutes, which requires \( \gamma > 0 \). Additionally, by stability condition we need \( \gamma < 1 \). Consequently, \( 0 < \gamma < 1 \).

Given that firm competition is in prices (Bertrand competition) we also need to obtain the demand functions, which are:

\[ q_d = \left[ \frac{1}{1 - \gamma^2} \right] [(A_d - p_d) - \gamma (A_j - p_j)] \quad j = e, s \]  

(5)

\[ q_j = \left[ \frac{1}{1 - \gamma^2} \right] [(A_j - p_j) - \gamma (A_d - p_d)] \quad j = e, s \]  

(6)
The parameter $\gamma$ ($0 < \gamma < 1$) reflects the degree of product differentiation. The lowest degree of product differentiation is reached when $\gamma \to 1$, case in which products become homogeneous. If $\gamma$ decreases then products become more differentiated. The extreme case is when $\gamma \to 0$, case in which products are not related. Evidently, in the latter case demand functions converge to $q_i = [A_i - p_i]$ ($i = d, e$ or $s$) and, therefore, each firm is a monopoly in its own variety.

**Production Technology**

Firm’s production cost functions are given by:

\[
C(q_e) = c_e q_e \quad (7a)
\]
\[
C(q_s) = \bar{C}_s + c_s q_s \quad (7b)
\]
\[
C(q_d) = c_d q_d \quad (8)
\]

We assume that firms have a production technology that implies a constant unit cost of production. However, in case that the foreign firm decides to serve the domestic market by setting up a subsidiary ($s$) this function has two components; a plant level fixed cost ($\bar{C}_s$) and a constant unit cost of production ($c_s$). This fixed cost follows from the cost of setting up a new plant to produce in the domestic market and it is, therefore, a plant specific fixed cost. On the other hand, if the foreign firm serves the domestic market by exporting, then no new production facility is needed and, as a consequence, that mode of serving the local market has no effects on fixed cost at firm or plant level. Therefore, firm e’s production cost function considers just a constant production unit cost ($c_e$).
**Research and Development**

Formally, R&D level increases $A_d$ and $A_e (A_s)$ and hence MU from consumption. More precisely, in equations (3) and (4) $A_d$ and $A_e (A_s)$ are related to R&D level as follows:

\[
\begin{align*}
A_d &= \bar{A}_d + R_d \quad (9a) \\
A_e &= \bar{A}_e + R_e \quad (9b) \\
A_s &= \bar{A}_s + R_s \quad (9c)
\end{align*}
\]

The variable $A_i (i=d,e,s)$, as can be seen from Equations (3) and (4), determines the inverse demand position. It reflects the quality of product $i$ and depends on two variables; the exogenous $\bar{A}_i$, which would be the inverse demand position if firms do not undertake R&D, and the endogenous $R_i$, which is the R&D level undertaken by firm $i$. The variable $\bar{A}_i$ can be interpreted as the stock of knowledge accumulated by firm $i$ before $t=2$ or, in other words, the level of technological competence before the decision about how much invest in R&D is taken. Therefore, the difference $(\bar{A}_e - \bar{A}_d)$ could be interpreted as a measure of the initial technological gap between the MNC and the domestic firm.

It follows from equations 3, 4, 9a, 9b and 9c that, variable $A_i$ can rise only if firms invest in R&D, since it causes an improvement in product quality which increases $A_i$ and, hence the MU of consumption. Therefore, on the demand side the effect of undertaking R&D is that the product’s demand grows up due to an increase in willingness to pay that consumers have for a better quality good. Formally, we have that $(\partial A_i / \partial R_i) > 0$, $i = d, e$ or $s$, where $A_i$ determines the inverse demand position.

Notice that inverse demand functions (equations 3 and 4) suggest that products are horizontally differentiated. However, since the inverse demand position ($A_i$) depends on the R&D levels, then it introduces also some form of vertical differentiation of the products. The reason is that the higher is firm $i$’s R&D level the
higher is the demand for its product and the lower is the demand for the other as can be inferred from demand functions (equations 5 and 6). Hence, the demand system represents products that have embodied a mixture of horizontal and vertical differentiation of the products.

On the other hand, R&D cost functions are assumed to have the following specification:

\[ RC(R_d) = R_d^2 - \alpha_j R_j R_d \quad j = e, s \quad \alpha_e = \alpha = 0 \quad 0 < \alpha_s < 1 \quad (10) \]

\[ RC(R_j) = R_j^2 \quad j = e, s \quad (11) \]

Both (10) and (11) implies increasing costs of R&D. Note that domestic R&D cost function depends on the way in which the foreign firm reaches the domestic market. It is \( R_d^2 \) if the foreign firm reaches the domestic market by exporting or \( (R_d^2 - \alpha_s R_s R_d) \) in the case the foreign firms establishes a subsidiary. As a consequence, the marginal cost of the domestic R&D (MCR\(_d\)) is \( 2R_d \) in the former case and \( (2R_d - \alpha_s R_s) \) in the latter. The latter case introduces the existence of R&D spillovers, which are received by the domestic firm from the foreign firm’s subsidiary. The R&D spillovers, which are assumed to reduce the \( R_d \)’s marginal cost, are modelled as an R&D input: the total cost of a given amount of R&D is lower the higher is the foreign firm R&D level. The parameter \( \alpha_s \) is a measure of the spillovers degree. This specification includes also the idea, first introduced by Cohen and Levinthal (1989), that to receive R&D spillovers the domestic firm needs to undertake R&D itself. In other words, by undertaking R&D the domestic firm increases its capacity to absorb technologies developed by other organizations. In particular, equation (10) tells us that a necessary condition for the domestic firm to be able to receive spillovers is that \( R_d \) be greater than zero.

Applied research suggests that intranational spillovers are higher that international spillovers (see for example Coe and Helpman, 1995). For that reason, we assume that \( \alpha_e < \alpha_s \). We assume, to simplify our analysis, that \( \alpha_e = 0 \), so domestic firm
receive spillovers just in case that the foreign firm establishes a subsidiary in the domestic economy. This also follows from the ‘contagion effect’ hypothesis, first modelled by Findlay (1978).

This basic structure will now be used to analyse the different market structure of the domestic market. The first case emerges when the MNC serves the domestic market through exports. The second case arises when the MNC serves the domestic market by establishing a subsidiary.
4. The Different Modes of Serving the Host Country Market and its Impact on the Incentives to Invest in R&D

In this section we will analyse decisions taken by the domestic and foreign firms in stages 2 and 3 of the game: namely R&D and price level. Later, in section 4.6, we will analyse the decision faced by the foreign firm in the first stage of the game regarding the mode of serving the domestic market.

4.1 First Case: The Foreign Firm Serves the Host Country Market by Exporting

Let us consider first the case in that the foreign firm serves the domestic market by exporting.

Third Stage Firms’ Problem

Given demand functions (equations 5 and 6) the firms’ problem at this stage can be stated as

\[
\max_{p_d} \pi_d = \left[p_d - c_d \left(1 - \frac{1}{\gamma^2}\right)\left[A_d - p_d\right] - \gamma \left[A_e - p_e\right]\right] \quad (12a)
\]

\[
\max_{p_e} \pi_e = \left[p^* - c_e \left(1 - \frac{1}{\gamma^2}\right)\left[A_e - p_e\right] - \gamma \left[A_d - p_d\right]\right] \quad (12b)
\]

where \(p_e = p^* + \tau\), \(p_e\) is price paid by domestic consumer’s for each unit of \(q_e\), \(p^*\) is net price received by the foreign firm for each unit of \(q_e\), and \(\tau\) represents tariff per unit of imports. We could think of \(\tau\) as including not only tariffs but also transport cost per unit of import. So, in more general terms, the parameter \(\tau\) could be considered as the domestic market degree of protection from foreign competition.

first order necessary conditions are:
\[
\frac{d\pi_d}{dp_d} = \left[\frac{1}{1-\gamma^2}\right][A_d - p_d - \gamma(A_e - (p^* + \tau))] - \left[\frac{1}{1-\gamma^2}\right](p_d - c_d) = 0 \quad (13a)
\]

\[
\frac{d\pi_e}{dp^*} = \left[\frac{1}{1-\gamma^2}\right][A_e - (p^* + \tau) - \gamma(A_d - p_d)] - \left[\frac{1}{1-\gamma^2}\right](p^* - c_f) = 0 \quad (13b)
\]

As a consequence, the best response function for firms 1 and 2 are, respectively

\[
p_d = \frac{1}{2}[(A_d + c_d) - \gamma(A_e - (p^* + \tau))]
\]

\[
p^* = \frac{1}{2}[(A_e + c_e - \tau) - \gamma(A_d - p_d)]
\]

Observe that \( dp_i / dp_j = (\gamma / 2) > 0, \quad i = d, e, \quad j = d, e, \quad d \neq e \). So prices are strategic complements. As a stability condition we require that \( |dp_i / dp_j| < 1 \) be satisfied for both firms’ best response functions. These conditions are met because \( 0 < \gamma < 1 \), which implies that \( dp_i / dp_j \) is positive but lower than 1/2. Note that the slope of the best response functions depend on the degree of product differentiation. In particular, \( dp_i / dp_j \rightarrow 0 \) when the product become more differentiated or not related (\( \gamma \rightarrow 0 \)).

Solving (14a) and (14b) we get the Nash-equilibrium in prices:

\[
p_d = \frac{1}{(4 - \gamma^2)}\left\{[(2 - \gamma^2)A_d + 2c_d - \gamma[A_f - (c_f + \tau)]]\right\}
\]

\[
p^* = \frac{1}{(4 - \gamma^2)}\left\{[(2 - \gamma^2)[A_f - \tau] + 2c_f - \gamma(A_d - c_d)]\right\}
\]

Hence, for firm \( i (i=d, e) \) its equilibrium price is higher the higher is its own product quality level (\( A_i \)), its own marginal cost of production (\( c_i \)), the other firm’s marginal cost of production (\( c_j \)) and the lower is the other firm product quality level (\( A_j \)).

\[\text{See Henriques (1990) for details.}\]
Also, it can be observed that the higher is domestic market degree of protection \((\tau)\), then the higher is host country firm price and the lower is foreign firm price. So, tariffs have an asymmetric effect on equilibrium prices. Finally, given the restriction on parameters, for both firms its own R&D increases its own optimal price\(^8\).

So, equilibrium demand functions are
\[
q_d^e = \frac{1}{(1 - \gamma^2)(4 - \gamma^2)} \left\{ (2 - \gamma^2)[A_d - c_d] - \gamma [A_e - (c_e + \tau)] \right\}
\]
and
\[
q_e = \frac{1}{(1 - \gamma^2)(4 - \gamma^2)} \left\{ (2 - \gamma^2)[A_e - (c_e + \tau)] - \gamma [A_d - c_d] \right\}
\]

Let \(\bar{A}_j - c_j = \bar{M}_j\), then \(\bar{A}_j - c_j + R_j = \bar{M}_j + R_j\), where \(\bar{M}_j\) is firm \(j\)'s basic market size, which would be the market faced by firm \(j\) if it conducted no R&D.

Also, this basic market is higher the higher is initial firm’s product quality and the lower is the firm’s initial unit production cost. Therefore, we can interpret that the effects of successful R&D by firm \(j\) is to increase its market size, either by improving product quality \((A_i)\) or by reducing marginal cost \((c_i)\). There is no particular need to differentiate between the two.

Therefore, demand functions can be stated as
\[
q_d^e = \frac{1}{(1 - \gamma^2)(4 - \gamma^2)} \left\{ (2 - \gamma^2)[\bar{M}_d + R_d] - \gamma [\bar{M}_e + R_e] \right\} \tag{16a}
\]
and
\[
q_e = \frac{1}{(1 - \gamma^2)(4 - \gamma^2)} \left\{ (2 - \gamma^2)[\bar{M}_e + R_e] - \gamma [\bar{M}_d + R_d] \right\} \tag{16b}
\]

Thus, firm \(j\)'s demand is higher the higher its basic market and R&D level are and the lower the other firm’s basic market and R&D level are. Also, the negative effect

---

\(^8\) In particular, \(\frac{dp_j}{dR_i} = \frac{(2 - \gamma^2)}{(4 - \gamma^2)} R_i\), expression that is bigger than zero given the restriction on \(\gamma\).
of other firm’s basic market and R&D level is lower the lower is the degree of product substitutability.

By using the previous definition and from equations (15a) and (15b) we can obtain that

\[
(p_d - c_d) = \frac{1}{(4 - \gamma^2)} \left[ \left(2 - \gamma^2\right)(M_d + R_d) - \gamma[M_e + R_e] \right] \tag{17a}
\]

\[
(p^* - c_e) = \frac{1}{(4 - \gamma^2)} \left[ \left(2 - \gamma^2\right)[M_e + R_e] - \gamma(M_d + R_d) \right] \tag{17b}
\]

Hence, in the optimum \[\frac{1}{1-\gamma^2}(p_i - c_i) = q_i \quad i = d, e, \] which implies that

\[
\pi_i = \left[ \frac{1}{1-\gamma^2} \left( p_d - c_d \right)^2 - (1-\gamma^2)[q_i]^2 \right] \tag{18}
\]

**Second Stage Firms’ Problem**

By introducing Nash equilibrium prices into equation (18), the firms’ second stage maximisation problem become

\[
Max_{R_i} \quad TP^d = \frac{1}{(1-\gamma^2)(4 - \gamma^2)^2} \left[ \left(2 - \gamma^2\right)(M_d + R_d) \right] - R_d^2
\]

\[
Max_{R_i} \quad TP^e = \frac{1}{(1-\gamma^2)(4 - \gamma^2)^2} \left[ \left(2 - \gamma^2\right)[M_e + R_e] \right] - R_e^2
\]

which give the following best response functions\(^9\)

\[
R_d = \frac{1}{D} \left( (2 - \gamma^2)^2 M_d - \gamma(2 - \gamma^2)M_e - \gamma(2 - \gamma^2)R_e \right) \tag{19a}
\]

\[
R_e = \frac{1}{D} \left( (2 - \gamma^2)^2 M_e - \gamma(2 - \gamma^2)M_d - \gamma(2 - \gamma^2)R_d \right) \tag{19b}
\]

\(^9\) Second order condition requires \((1 - \gamma^2)(4 - \gamma^2)^2 - (2 - \gamma^2)^2 > 0\)
where, \( D = [1 - \gamma^2][4 - \gamma^2]^2 - [2 - \gamma^2]^2 \), which need to be positive to have that both R&D levels are positive and is met since it is the second order condition. By using numerical methods we find that \( D > 0 \) requires \( \gamma \leq 0.93 \). Hence, what we require is that products can’t be too homogenous.

Equilibrium is stable and unique if \( \left| \frac{dR_i}{dR_j} \right| < 1 \), which implies \( D > \gamma(2 - \gamma^2) \). This condition is more stringent than the second order condition. By using numerical methods we get that this condition is met for \( \gamma \leq 0.86 \), so stability and uniqueness require products can’t be too homogeneous, even less than to satisfy the second order condition.

The two best response functions can now be solved for the equilibrium R&D levels, which are

\[
R^e_i = \frac{(2 - \gamma^2)}{[D^2 - \gamma^2(2 - \gamma^2)^2]} \left[ \frac{(2 - \gamma^2)[D + \gamma^2][\overline{M}_d]}{-\gamma[D + (2 - \gamma^2)^2][\overline{M}_e]} \right] \quad (20a)
\]

\[
R^e_\epsilon = \frac{(2 - \gamma^2)}{[D^2 - \gamma^2(2 - \gamma^2)^2]} \left[ \frac{(2 - \gamma^2)[D + \gamma^2][\overline{M}_\epsilon]}{-\gamma[D + (2 - \gamma^2)^2][\overline{M}_d]} \right] \quad (20b)
\]

Hence, the key determinants of R&D levels are the basic market size. Firm \( j \)'s R&D level increases with its basic market and decreases with other firm’s basic market. Alternatively, we can interpret equations 20a and 20b as that firm \( i \)'s R&D equilibrium level increases with its initial competence level \( (\overline{A}_i) \), the other firm unit production cost \( (c_\epsilon) \). Also, it decreases with other firm competence level \( (\overline{A}_j) \), its own unit cost of production \( (c_i) \). On the other hand, the protection degree of the domestic market \( (\tau) \) exerts an asymmetric effect on the optimal R&D level: positive on domestic firm R&D and negative on foreign firm R&D.
4.2 Second Case: The Foreign Firm Serves the Host Country Market by Establishing a Subsidiary

In this section we analyse the case in that the foreign firm sells in the domestic country by establishing a wholly owned subsidiary ($s$), which produces $q_s$ and undertakes R&D ($R_s$) in the host country.

This mode of serving the domestic market has a number of implications both on the foreign and domestic firm. In first place, it changes the profit function of the foreign firm because in this case the subsidiary’s product can be sell in the domestic market without having to pay tariffs. Also, the foreign firm has to incur in the fixed costs associated to a new production plant ($C_s$). So, export implies higher marginal cost but lower fixed cost, while FDI implies the opposite. Therefore, as a necessary condition for the foreign firm to set up the subsidiary is $c_s < c_f + \tau$. Otherwise, the foreign firm, by producing in the host economy, would face not just a plant specific fixed cost but also a higher variable production cost. Also, the subsidiary undertakes R&D investment ($R_s$), which in addition to increase its market size it allows to transfer technology from the parent firm and to adapt its product to the local conditions.

On the other hand, in this case we allow for the existence of R&D spillovers. In particular, the domestic firm R&D cost function become

$$RC(R_d) = R_d^2 - \alpha R_s R_d$$

As we explained above applied research suggests that intranational spillovers are higher that international spillovers. We consider the extreme case in that spillover arise just in the case that the foreign firm establishes a subsidiary in the domestic economy. Also, we assume that spillovers are asymmetric: namely, the foreign firm doesn’t receive R&D spillovers from the domestic firm. The implicit assumption behind this is that the domestic firm is behind the technology frontier and, as a consequence, no useful information is received by the foreign firm. To be consistent
with this assumption we also need to assume that $\bar{A}_e > \bar{A}_d$, it is the initial level of knowledge of the foreign firm is higher than for the domestic firm.

Therefore, the relevant profit function (net from the cost of R&D investment) for the foreign firm become

$$\pi_s = \left[\frac{1}{1 - \gamma} \right] \left[ (A_s - p_s) - \gamma (A_d - p_d) \right] [p_s - c_s] - \bar{C}_s$$

On the other hand, the way in that we introduce $R_s$ into the model is determined by the following two equations:

$$A_s = \bar{A}_e + R_s \quad (21)$$

$$C(R_s) = \frac{R_s^2}{2} \quad (22)$$

Equation (21) indicates that all the initial foreign firm stock of knowledge can be fully transferred to the subsidiary$^{10}$. This could reflect the idea that the knowledge is basically embodied in the product rather than in the production process. As in the previous case, that stock can be increased if the subsidiary undertakes R&D investment itself.

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$^{10}$ An alternative to this modelation could be to assume that not all the foreign firm’s initial level of knowledge can be transferred to its subsidiary. The main reasons being that transferring technology is a process that involves the use of resources and that the newer is the technology the more expensive is this process. This could happen, for instance, due to the fact that part of the knowledge is embodied in the workers in the parent firm. There is significant empirical research that support this idea (see for instance Teece, 1977). This assumption would make our analysis more realistic but it would not change the qualitative results of our model.
Third Stage Firms’ Problem

As usual, we begin by analysing the problem faced by both firms in the last stage of the game, which is

\[
\begin{align*}
    \text{Max}_{p_d} & \quad \pi_d = [p_d - c_d] \left[ \frac{1}{1 - \gamma^2} \right] \left[ [A_d - p_d] - \gamma [A_s - p_s] \right] \\
    \text{Max}_{p_s} & \quad \pi_s = [p_s - c_s] \left[ \frac{1}{1 - \gamma^2} \right] \left[ [A_s - p_s] - \gamma [A_d - p_d] \right] - C_s
\end{align*}
\] (23a) (23b)

first order necessary conditions are:

\[
\begin{align*}
    \frac{d\pi_d}{dp_d} &= \left[ \frac{1}{1 - \gamma^2} \right] (A_d - p_d) - \gamma (A_s - p_s) - \left[ \frac{1}{1 - \gamma^2} \right] (p_d - c_d) = 0 \\
    \frac{d\pi_s}{dp_s} &= \left[ \frac{1}{1 - \gamma^2} \right] (A_s - p_s) - \gamma (A_d - p_d) - \left[ \frac{1}{1 - \gamma^2} \right] (p_s - c_s) = 0
\end{align*}
\] (24a) (24b)

which imply the following reaction functions:

\[
\begin{align*}
    p_d &= \frac{1}{2} [(A_d + c_d) - \gamma (A_s - p_s)] \\
    p_s &= \frac{1}{2} [(A_s + c_s) - \gamma (A_d - p_d)]
\end{align*}
\] (25a) (25b)

Note that, as in case 1, \( dp_i / dp_j = \gamma / 2 \) so prices are strategic complements. Also, since the absolute value of \( dp_j / dp_j \) is lower than 1, then the Nash equilibrium in prices is both stable and unique. The Nash equilibrium in prices, which is found by solving both best response functions, is

\[
\begin{align*}
    p_d &= \left[ \frac{1}{4 - \gamma^2} \right] \left\{ (2 - \gamma^2) [A_d + R_d] + 2c_d \right\} \\
    p_s &= \left[ \frac{1}{4 - \gamma^2} \right] \left\{ - \gamma (A_s - c_s + R_s) \right\}
\end{align*}
\] (26a)
\[ p_s = \left[ \frac{1}{4 - \gamma^2} \right] \left\{ (2 - \gamma^2)(\overline{A}_s + R_s) + 2c_s \right\} \] 

(26b)

therefore, equilibrium demand functions are

\[ q_d^* = \left[ \frac{1}{(1 - \gamma^2)(4 - \gamma^2)} \right] \left\{ (2 - \gamma^2)[\overline{M}_d + R_d] - \gamma(\overline{M}_s + R_s) \right\} \] 

(27a)

\[ q_s = \left[ \frac{1}{(1 - \gamma^2)(4 - \gamma^2)} \right] \left\{ (2 - \gamma^2)[\overline{M}_s + R_s] - \gamma(\overline{M}_d + R_d) \right\} \] 

(27b)

As in the previous case firm j’s demand is higher the higher its basic market and R&D level are, and the lower the other firm’s basic market and R&D level are. Also, the negative effect of the other firm’s basic market and R&D level is lower the lower is the degree of product substitutability. The difference, however, is that in this case the basic market of the foreign firm increases since \((c_e + \tau) > c_s\).

**Second Stage Firms’ Problem**

We are now in a position to find the R&D level Nash equilibrium. By introducing the price Nash equilibrium into total profit functions, the firms’ second stage maximisation problem become

\[
\text{Max}_{R_j} \quad TP^d = \frac{1}{(1 - \gamma^2)(4 - \gamma^2)^2} \left[ \left\{ (2 - \gamma^2)(\overline{M}_d + R_d) \right\} \right]^2 - \overline{R}_d^2 - \alpha_s R_s R_d
\]

\[
\text{Max}_{R_s} \quad TP^s = \frac{1}{(1 - \gamma^2)(4 - \gamma^2)^2} \left[ \left\{ (2 - \gamma^2)(\overline{M}_s + R_s) \right\} \right]^2 - \overline{c}_s^2 - R_s^2
\]

from the first order necessary conditions we obtain the reaction functions, which are
\[ R_d = \left[ \frac{1}{2D} \right] \left\{ 2(2 - \gamma^2)\left[ \bar{M}_d \right] - 2\gamma(2 - \gamma^2)(\bar{M}_s) + D_iR_s \right\} \]  \hspace{1cm} (28a)

\[ R_s = \left[ \frac{1}{D} \right] \left\{ (2 - \gamma^2)^2\left[ \bar{M}_s \right] - \gamma(2 - \gamma^2)(\bar{M}_d) - \gamma(2 - \gamma^2)R_d \right\} \]  \hspace{1cm} (28b)

where

\[ D_i = \alpha(1 - \gamma^2)(4 - \gamma^2)^2 - 2\gamma(2 - \gamma^2) \]

As we know, equilibrium is stable and unique if \( |dR_i / dR_s| < 1 \). For the foreign firm the condition doesn’t change in relation to case 1. For the domestic firm, however, it is different due to the existence of R&D spillovers. The condition for the domestic firm is now \( |D_i / 2D| < 1 \). Notice that if \( \alpha = 0 \), then the condition is the same than in case 1. If \( \alpha > 0 \) then the numerator of the condition increases and if

\[ \alpha > \frac{2\gamma(2 - \gamma^2)}{(1 - \gamma^2)(4 - \gamma^2)^2} \]  \hspace{1cm} (28c)

then the numerator become positive and, therefore, \( (dR_d / dR_s) > 0 \), making the R&D levels strategic complements from the host country firm’s point of view. The degree of spillovers required for this to happen is higher the higher is \( \gamma \). If R&D level become strategic complements then the stability condition is met since for any degree of product substitutability \( (dR_d / dR_s) < 1 \). So, stability condition is met provided, as in case 1, that products are not too homogeneous \( (\gamma \leq 0.88) \), since the relevant restriction is the condition for the foreign firm.

Notice also that in the presence of R&D spillovers the effect of the subsidiary’s R&D on the domestic firm incentives to invest in R&D exerts two effects. First, a negative effect since the higher is subsidiary’s R&D the lower is the marginal benefit of domestic R&D. If only this effect is present, then R&D levels are strategic substitutes. This is the effect present in case 1, and the reason why en case 2 R&D levels are strategic substitutes from the subsidiary’s point of view. Second, if there are R&D spillovers, then the marginal cost of domestic R&D decreases and therefore it increases the incentives to invest in R&D faced by the domestic firm. So, there are
two opposite effects of the subsidiary’s R&D on domestic R&D. The final effect depends on the degree of spillovers and the degree of product substitutability according to condition 28c. For instance, if $\gamma = 0$, then a sufficient condition for the R&D levels to be strategic complements is $\alpha > 0$. On the other hand, if $\gamma > 0$, then the critical value for $\alpha$ increases and is higher the higher is $\gamma$.

Finally, by solving the best response functions we find the R&D Nash equilibrium levels, which are

$$R^s_d = \frac{2(2 - \gamma^2)D - \gamma D_1}{2D^2 + \gamma(2 - \gamma^2)D_1} \left\{ \frac{2(2 - \gamma^2)(D + \gamma^2)}{2\gamma D + (2 - \gamma^2)} \right\} (29a)$$

$$R^s_j = \frac{2(2 - \gamma^2)}{2D^2 + \gamma(2 - \gamma^2)D_1} \left\{ \frac{2(2 - \gamma^2)(D + \gamma^2)}{2\gamma D + (2 - \gamma^2)} \right\} (29b)$$

So, the key determinants of R&D levels are the basic markets and the degree of product differentiation. In particular, each firm equilibrium R&D level depends positively on its basic market and negatively on the other firm basic market. The relative effect of basic markets also depends on the degree of product substitutability.
4.5 Impact of the Different Modes of Serving the Host Country Market on the Main Variables

In this section we analyse the model developed and solved in section 4.4. We compare, under the two modes in that the foreign firm can serve the host country, the behaviour of the main variables of interest: namely, R&D and production levels, domestic consumers’ welfare and domestic firm profits. Our final aim is to shed some light on the preferred mode of operation of the foreign firm from the host country’s point of view.

**Proposition 1**: Provided the degree of spillovers is small enough, when the foreign firm moves from reaching the domestic market by exporting (case 1) to setting up a subsidiary (case 2), then

1. Domestic firm R&D, output and profits decrease
2. Foreign firm R&D and output increases

**Proof:**

Let us first consider the case with no R&D spillovers. In this case \( \alpha = 0 \), which implies \( D_1 = -2\gamma(2 - \gamma^2) \) and therefore R&D equilibrium levels in case 2 (equations 29a and 29b) converge to the same functional form obtained in case 1 (equations 20a and 20b). Then in this case,

\[
\Delta R_d = R_d^S - R_d^E = \phi(\gamma) \left\{ \left( 2 - \gamma^2 \right) \left[ D + \gamma^2 \right] \left[ M_d - \overline{M}_d \right] \right\} - \left\{ \left[ \gamma \left( D + \left( 2 - \gamma^2 \right)^2 \right) \right] \left[ \overline{M}_s - \overline{M}_r \right] \right\}
\]  

(30)

where \( \phi(\gamma) = \frac{(2 - \gamma^2)}{D^2 + \gamma^2 (2 - \gamma^2)^2} \)

Before making sense of equation 30, notice that when we move from case 1 to case 2 and there are no R&D spillovers, then the domestic R&D level changes due to the
fact that foreign firm’s basic market size increases. This is, $\bar{M}_d > \bar{M}_e$ since $c_e < (c_e + \tau)$. Therefore, equation 30 become

$$\Delta R_d = R_d - R_d^F = -\phi(\gamma)\left\{c(D + (2 - \gamma^2))\left[\bar{M}_d - \bar{M}_e\right]\right\} < 0$$

(31a)

With the same reasoning we have

$$\Delta R_s = R_s - R_s^F = \phi(\gamma)\left\{2 - \gamma^2\right\}[D + \gamma^2]\left[\bar{M}_s - \bar{M}_e\right] > 0$$

(31b)

Hence, if $\alpha = 0$, then foreign firm R&D level increases when we move from case 1 to case 2. The reason is that in case 2 the market size faced by the subsidiary increases and, as a consequence, improve incentives to undertake R&D. Simultaneously, this reduce the incentives faced by the domestic firm to undertake R&D. Evidently, the higher is the degree of market protection ($\tau$) then the higher is the reduction in domestic firm R&D and increase in foreign firm R&D.

Figure 1 shows the effect on the R&Ds equilibrium level when the market moves from equilibrium in case 1 (E1) to case 2 (E2).

![Figure 1: Equilibrium in case 1 and 2 with no R&D Spillovers](image)

Also, from the best response functions 19a and 19b we can verify that
\[
\frac{dR_d}{d\tau} = \frac{(2 - \gamma^2)}{D} \gamma > 0 \quad \text{and} \quad \frac{dR_s}{d\tau} = -\frac{(2 - \gamma^2)}{D} (2 - \gamma^2) < 0
\]

and therefore when \( \tau \) decreases, then the best response function of the host and foreign country firms move inward and forward, respectively, which explain the movement of the best response functions in figure 1. Also, we can observe that the absolute value of the movement of the best response functions is bigger for the foreign firm, since \( (2 - \gamma^2) > \gamma \).

Let us see now what happen with equilibrium if we allow for R&D spillovers. In this case the slope of the host country firm’s best response function become steeper. The best response function of the subsidiary, however, doesn’t change.

![Figure 2: Movement in Equilibrium in case 2 when the parameter of R&D Spillovers Increases](image)

Therefore, if \( \alpha > 0 \), then the negative effect exerted by the increase in the basic foreign firm market on the domestic R&D level is offset by the effect of the spillover. The presence of spillovers exerts an opposite effect on the incentives faced by the foreign firm to undertake R&D. However, if \( \alpha \) is small enough then the foreign basic market effect predominates.

Also, we can infer that when \( \alpha > 0 \) the equilibrium move from the point E2 to the right on the foreign firm best response function. Hence, since \( \left| \frac{dR_s}{dR_d} \right| < 1 \) due to
stability condition, then the increase in domestic R&D level is higher than decrease in subsidiary R&D level. Therefore, total R&D level increases in relation to the level reached in the equilibrium E2 (without R&D spillovers).

**Effect on outputs**

Also, from expressions (16a), (16b), (27a) and (27b) we have

\[
q_d^S - q_d^E = -\frac{1}{(1-\gamma^2)(4-\gamma^2)^2} \left[ \left( 2-\gamma^2 \right)[R_d^S - R_d^E] - \gamma\left( M_s - M_s \right) + (R_s - R_s) \right]
\]

and

\[
q_s - q_e = \frac{1}{(1-\gamma^2)(4-\gamma^2)^2} \left[ \left( 2-\gamma^2 \right)[M_s - M_s] + (R_s - R_s) \right]
\]

Also, we know that \( M_s > M_e \) and that if R&D spillovers are small enough \( R_d^S < R_d^E \) and \( R_s > R_e \).

Therefore, under these conditions we can conclude that

- \( q_d^S - q_d^E < 0 \)
- \( q_s - q_e > 0 \)

In summary, provided R&D spillovers are small enough, when equilibrium market moves from case 1 to case 2, then domestic output level decreases and foreign firm output increases.

**Effect on profits**

As we know domestic and subsidiary profits can be stated as

\[
TP_d = (1-\gamma^2)[q_d]\left[ -\frac{R_d^2}{2} - \alpha R_d \right] = (p_d - c_d)q_d - \frac{R_d^2}{2} - \alpha R_d
\]
So, profits depend on the output of each firm since it reflects the both the margin price-marginal cost of production and output level. Therefore, under the conditions stated, since domestic output decrease in case 2, then so do domestic profits. On the other hand, subsidiary’s output increases, which imply that profits net from plant specific cost also do. So, if foreign firm prefer to serve the domestic firm through FDI it is a necessary condition that increase in the later profits must be higher than the cost of the plant cost. So, we can conclude that subsidiary’s profits increases.

**Proposition 2:** For any value of the degree of spillovers, when the foreign firm moves from reaching the domestic market by exporting to setting up a subsidiary, then

1. Total R&D increases
2. Total production level increases

Proof:
Let us first consider the case with no R&D spillovers. Also, let us define the total R&D level undertaking by the domestic and foreign firms in cases 1 and 2 as $R^E_d = R^E_d + R^E$ and $R^S_d = R^S_d + R^S$, respectively.

Therefore,

$$R^S_d - R^E_d = (R^S_d - R^E_d) + (R^E_d - R^E) = \Delta R_d + \Delta R^E$$ \hspace{1cm} (32)

Then, by substituting equations 31a and 31b into equation 32, we obtain

$$R^S_d - R^E_d = \phi(\gamma)[(2 - \gamma^2 - \gamma)(D - \gamma(2 - \gamma^2))]\{\bar{M}_s - \bar{M}_e\}$$ \hspace{1cm} (33)

Since $\{\bar{M}_s - \bar{M}_e\} > 0$ the sign of the right hand expression depends on the sign of
\[[2 - \gamma^2 - \gamma](D - \gamma(2 - \gamma^2))\], which is positive due to the stability condition \((D > \gamma(2 - \gamma^2))\) and the restriction on the parameter \(\gamma\), positive but lower than 1.

So, total R&D level increases when the equilibrium market moves from case 1 to case 2.

Consider now the case with R&D spillovers \((\alpha > 0)\). As we explain above, in that case the equilibrium R&D levels moves to the right on the foreign firm best response function. Also, since \(\left|\frac{dR_s}{dR^E_s}\right| < 1\) due to stability condition, then the increase in domestic R&D level is higher than decrease in subsidiary R&D level. Therefore, total R&D level increases in relation to the level reached in the equilibrium E2 (without R&D spillovers). So, with R&D spillover total R&D level increase even more than in the case with no R&D spillovers.

With respect to the effect on total output, let us first define total output in case 1 and 2 as \(Q^E_r = q^E_d + q^E_s\) and \(Q^S_r = q^S_d + q^S_s\), respectively.

Then, by substituting equations 16a, 16b, 27a and 27b into the previous definition we obtain,

\[Q^E_r = \phi(\gamma)(2 - \gamma^2 - \gamma)\left\{\bar{M}_d + \bar{M}_s + R^E_d + R^E_s\right\}\]

and

\[Q^S_r = \phi(\gamma)(2 - \gamma^2 - \gamma)\left\{\bar{M}_d + \bar{M}_s + R^S_d + R^S_s\right\}\]

and, therefore

\[Q^S_r - Q^E_r = \phi(\gamma)(2 - \gamma^2 - \gamma)\left[(\bar{M}_s - \bar{M}_d) + (R^S_d + R^S_s) - (R^E_d + R^E_s)\right]\] \hspace{1cm} (34)

In the previous section we show that when the market move from case 1 to case 2, then both the foreign firm basic market and total R&D level increase. So, expression to the right in equation 34 is positive and, therefore, total output increases \((Q^S_r > Q^E_r)\). In other words, despite domestic production decreases, the foreign firm production increases more, so that total output increases.
Effect on Domestic Consumer’s Welfare

In this section we study the effect on domestic consumer’s surplus when market equilibrium moves from case 1 to case 2.

Let us first define $\lambda = q_j / q_d$ as the proportion of the foreign firm output in relation to the domestic firm output. The central result is stated in the following proposition.

**Proposition 4:** Provided $\lambda \geq 1$ when the foreign firm moves from reaching the domestic market by exporting (case 1) to setting up a subsidiary (case 2), then total domestic consumer’s surplus grows. On the other hand, if $\lambda < 1$, then the effect on total consumer’s welfare depends on the level of import tariff ($\tau$) and degree of product substitutability ($\gamma$).

Proof:

Total domestic consumers’ surplus can be stated as

$$CS = \frac{(A_d - \gamma q_j - p_d) * q_d}{2} + \frac{(A_e - \gamma q_d - p_j) * q_j}{2} \quad j = e, s$$

(35)

Also, from inverse demand functions we know that $(A_d - \gamma q_j - p_d) = q_d$ and $(A_j - \gamma q_d - p_j) = q_j$ with $j = e, s$.

So, domestic consumer’s surplus become:

$$CS(M_d, R_d, M_j, R_j) = \frac{q_d^2(M_d, M_j)}{2} + \frac{q_j^2(M_d, M_j)}{2}$$

(36)

where, as we established before, equilibrium outputs depend on basic market sizes.

Let us consider the case with no R&D spillovers. As we know, in that case when market move from case 1 to case 2 equilibrium outputs change due to the basic
foreign firm market increases. Thus, the effect on consumer’s surplus can be stated as

\[
\frac{dCS}{dM_j} = q_d \frac{dq_d}{dM_j} + q_j \frac{dq_j}{dM_j} = q_d \left[ \frac{dq_d}{dM_j} + \lambda \frac{dq_j}{dM_j} \right]
\]

but we know (see equation 34) that \( \left[ \frac{dq_d}{dM_j} + \frac{dq_j}{dM_j} \right] > 0 \), since domestic output decreases less than the foreign output increases. So, if \( \lambda \geq 1 \) then \( \left[ \frac{dq_d}{dM_j} + \lambda \frac{dq_j}{dM_j} \right] > 0 \).

Thus, in this case total consumer’s surplus increases. The intuition behind this result is that by moving from case 1 to case 2 the foreign firm basic market increases and therefore so do the incentives faced by the foreign firm to undertake R&D. Simultaneously, domestic firm output decreases, but less than the amount in that foreign firm output grows. Also, from equilibrium prices we have that

\[
\frac{dp_i}{dR_i} = \frac{(2 - \gamma^2)}{(4 - \gamma^2)}
\]

which is positive but lower than 0.5. This tells us that when firms increase its R&D level they transfer a fraction lower than one of the product improvement to the price paid by consumers. Also, for each unit of increment in \( R_i \) consumer’s willingness to pay increase in one unit. Therefore, when product quality increases then the extra surplus is shared both by the firm and consumers. The firm receives a higher margin price-marginal cost of production and consumers receive a higher surplus per unit of consumption. Finally, since \( q_j > q_d \) the additional surplus obtained by the foreign product consumers is higher than the surplus lost by the domestic product consumers.

In case there are R&D spillovers this result is still valid, since as we will see in next section a necessary condition for the foreign firm to move from exporting to FDI is that its output level increases.
If $\lambda < 1$, then $\left[ \frac{dq_d}{dM_j} + \frac{dq_j}{dM_j} \right]$ can be higher or lower than zero. In this case, the sign of this expression depends on the increase in the foreign firm basic market and the degree of product substitutability. In particular, if $\gamma = 0$ then consumer’s surplus rise because in that case $dq_d / dM_j = 0$ and, as a consequence, there is just a positive effect on foreign product consumer’s surplus. If $\gamma$ increases then the negative effect on domestic consumers also do. So the higher is $\gamma$ the more likely is that total consumers surplus decreases. Finally, the higher is increment in basic foreign market (the higher is $\tau$) then the higher is the positive impact on the foreign firm output and therefore makes it more likely that total consumers surplus increases.

As a final consideration, if $(\bar{A}_d - c_d) < (\bar{A}_e - [c_e + \tau])$ then $\lambda > 1$ and, as a consequence, total consumer’s surplus goes up when the market equilibrium moves from case 1 to case 2. Also, by assumption $\bar{A}_d < \bar{A}_e$, so a sufficient condition to consumer’s surplus increases is $([c_e + \tau] - c_d) < (\bar{A}_e - \bar{A}_d)$. In words, the initial technology gap is higher than the difference between the foreign unit cost of production including import tariff and the domestic unit cost of production.

**Effect on domestic welfare**

Finally it follows from the previous analysis that when market moves from case 1 to case 2 the effect on domestic welfare is ambiguous since consumers’ surplus increases while domestic firm profits decreases. However, if the degree of spillovers increases it can be possible that domestic welfare increases, but also it could induce the foreign firm to choose exporting as we will see in the next section. On the other hand, if the degree of product substitutability falls then it makes more likely than domestic welfare increases. In the extreme case that $\gamma = 0$ and $\alpha > 0$ then domestic welfare increases and therefore the preferred mode of entry from the host country point of view is FDI.
In summary, if the foreign firm moves from serving the local market by exporting to setting up a subsidiary and R&D spillovers are low enough, then domestic firm output and R&D level decrease. Simultaneously, foreign firm output and R&D level rise. On the other hand, consumers’ surplus increase provided the output of the foreign firm is higher than the output of the local firm. If the degree of spillovers increases then, compared with the level reached when there are no R&D spillovers, domestic firm’s output, R&D level and profits rise and, eventually, they could be higher than in the exporting equilibrium case. Finally, independent of the degree of spillovers total output and R&D level is higher in the subsidiary equilibrium case, the reason being that total basic market available to both firm increases.
6. Determinants of the Optimal Mode of Operation of the Foreign Firm

Now we will analyse the problem faced by the foreign firm in the first stage of the game developed in this chapter, namely the optimal mode of serving the local market.

As we know, the foreign firm profit function in case 2 is

\[ TP^S = (1 - \gamma^2)\left[ q_s \right]^2 - \frac{R^2}{2} \]

Let us define

\[ \Delta q_s = q_s - q_e \]
\[ \Delta R_s = R_s - R_d \]
\[ \Delta C_s = C_s - 0 \]

Thus, by using these definitions foreign firm profit function can be expressed as

\[ TP^S = (1 - \gamma^2)\left[ q_e + \Delta q_s \right]^2 - \Delta C_s - \frac{(R_s + \Delta R_s)^2}{2} \]  

(37)

Notice that if \( \Delta q_s = \Delta R_s = \Delta C_s = 0 \), then we get the foreign firm profits in case 1, which is

\[ TP^E = (1 - \gamma^2\left[ q_e \right]^2 - \frac{R^2}{2} \]

So, we can conclude that a necessary condition for the foreign firm to prefer serving the domestic market a necessary condition is \( \Delta q_s > 0 \), since as we see above \( \Delta C_s > 0 \). The reason is that by setting up a subsidiary the foreign firm can save variable costs, since it can avoid tariff (\( \tau \)), but it has to incur in a plant specific fixed cost (\( C_s \)).
By developing eq. 37 we have that a necessary and sufficient condition for the foreign firm to choose mode 2 to serve the domestic market is

\[(1 - \gamma^2)\left[2q_s \Delta q_s + (\Delta q_s)^2\right] > \Delta C_s + R_s \Delta R_s + \frac{(\Delta R_s)^2}{2}\]

As a consequence, the variables that determine the choice of the foreign firm are:

1. Level of protection of the domestic market (\(\tau\)). This is due to the fact that the higher is the degree of protection of the domestic market the higher is expansion of the foreign firm basic market when it moves from case 1 to case 2.

2. Level of the plant specific fixed cost (\(C_s\)), since the higher is this cost the higher is the required expansion of the subsidiary’s production to make it profitable to change the mode of serving the domestic market.

3. Degree of product differentiation (\(\gamma\)), since the lower is the degree of product substitutability, then the higher are the incentives for the foreign firm to increase output and R&D.

4. Degree of spillovers, because the higher it is the lower is both output and R&D level of the foreign firm, which can induce to change to exporting.

If in addition we allow the existence of R&D spillovers, then the gains of setting up a subsidiary decrease since both the subsidiary’s optimal R&D and output level decrease and so do subsidiary’s profits. As a consequence, the higher the level of R&D spillovers the lower is the probability that the foreign firm serves the domestic firm through FDI.
7. Is there an Scope for an R&D Policy?

In this section we ask if there is an scope for an R&D policy. We don’t derive the optimal R&D policy, we just ask if the domestic R&D level is the optimal from a social point of view. To do that we evaluate, at the equilibrium, the effect of a marginal increase in domestic R&D level on domestic welfare.

Let us define the social welfare in case 2 as

\[
W = \frac{(A_d - \gamma q_s - p_d) \cdot q_d}{2} + \frac{(A_s - \gamma q_d - p_s) \cdot q_s}{2} + TP^S_d
\]  

(38)

These expressions summarize the different channels through which \( R_d \) can affect domestic welfare: domestic product consumer surplus, foreign product consumer surplus, and domestic firm profits.

Also, from inverse demand functions we know that \((A_d - \gamma q_s - p_d) = q_d \) and \((A_s - \gamma q_d - p_s) = q_s \).

So, welfare function can be stated as

\[
W(R_d, R_s) = \frac{q_d^2(R_d, R_s)}{2} + \frac{q_d^2(R_d, R_s)}{2} + TP^S_d(R_d, R_s)
\]  

(39)

We now evaluate the marginal effect of R&D on Welfare in the market equilibrium reached in case 2. The marginal effect is given by:

\[
\frac{dW}{dR_d} = q_d \left\{ \frac{\partial q_d}{\partial R_d} + \frac{\partial q_d}{\partial p_d} \frac{\partial p_d}{\partial R_d} \right\} + q_s \left\{ \frac{\partial q_s}{\partial R_d} + \frac{\partial q_s}{\partial p_s} \frac{\partial p_s}{\partial R_d} \right\} + \frac{\partial TP^S_d}{\partial R_d} \frac{\partial R_d}{\partial R_d} + \frac{\partial TP^S_d}{\partial R_d} \frac{\partial R_d}{\partial R_d}
\]  

(40)
Because we are evaluating welfare in the optimum we have that \( \frac{\partial TP^S_d}{\partial R_d} = 0 \), then

\[
\frac{dW}{dR_d} = q_d \left\{ \frac{\partial q_d}{\partial R_d} + \frac{\partial q_d}{\partial R_s} \frac{\partial R_s}{\partial R_d} \right\} + q_s \left\{ \frac{\partial q_s}{\partial R_d} + \frac{\partial q_s}{\partial R_s} \frac{\partial R_s}{\partial R_d} \right\} + \frac{\partial TP^S_d}{\partial R_s} \frac{\partial R_s}{\partial R_d}
\]

(41)

Last term represents the profit shifting strategic effect of domestic R&D. The other terms show the effect on surplus that domestic consumers derive from consumption of the domestic and foreign product. So, there are three basic channels through which domestic welfare can be affected with a marginal increases in domestic R&D.

Also, by using \( \lambda = q_s / q_d \) eq. 44 become

\[
\frac{dW}{dR_d} = q_d \left\{ \frac{\partial q_d}{\partial R_d} + \frac{\partial q_d}{\partial R_s} \frac{\partial R_s}{\partial R_d} \right\} + \lambda \left\{ \frac{\partial q_s}{\partial R_d} + \frac{\partial q_s}{\partial R_s} \frac{\partial R_s}{\partial R_d} \right\} + \frac{\partial TP^S_d}{\partial R_s} \frac{\partial R_s}{\partial R_d}
\]

(42)

Note that

\[
\frac{\partial TP^S_d}{\partial R_s} = -(1 - \gamma^2)2q_d \left\{ \frac{\gamma}{(1 - \gamma^2)(4 - \gamma^2)} \right\} + \alpha R_d \geq 0 < 0
\]

\[
\frac{\partial R_s}{\partial R_d} = -\frac{\gamma(2 - \gamma^2)}{D} < 0
\]

\[
\frac{\partial q_d}{\partial R_d} = \frac{(2 - \gamma^2)}{(1 - \gamma^2)(4 - \gamma^2)} > 0
\]

\[
\frac{\partial q_d}{\partial R_s} = -\frac{\gamma}{(1 - \gamma^2)(4 - \gamma^2)} < 0
\]

\[
\frac{\partial q_s}{\partial R_d} = -\frac{\gamma}{(1 - \gamma^2)(4 - \gamma^2)} < 0
\]

\[
\frac{\partial q_s}{\partial R_s} = \frac{(2 - \gamma^2)}{(1 - \gamma^2)(4 - \gamma^2)} > 0
\]

In summary, first term is in equation 41 is positive since domestic product consumer’s surplus increase, second term is negative since subsidiary product consumer’s surplus decrease and, as a consequence, the relative magnitude of these
two effects depend on the degree of product differentiation and the relative size of domestic and subsidiary product market size. On the other hand, the last term is can be positive or negative, since depend on the relative effect of the subsidiary’s R&D on domestic firm profits, which implies that the profit shifting can call either for a subsidy or a tax on domestic R&D.

All these partial effects decrease when the degree of product differentiation. In particular, if $\gamma \to 0$ then $\frac{\partial R}{\partial R_d} = 0$ and $\frac{dW}{dR_d} \to q_d \left\{ \frac{1}{2} \right\} > 0$. So, if products are not related a marginal increase in domestic R&D is welfare improving. On the other hand, if $\gamma > 0$ in addition to the positive effect on the domestic product surplus we have a negative effect on the subsidiary’s product consumer surplus so become relevant to the evaluation the relative size market of both products. The higher is the relative size of the subsidiary’s market then the lower is increase in overall consumer’s surplus. Also, we have a positive effect on domestic firm profits.

In summary, the net effect depends on the relative size of domestic and subsidiary markets, the degree of product differentiation and the magnitude of the rent shifting profits motive. This analysis must be taken as a preliminary step toward a more complete analysis of the policy implications of the model developed in this chapter. However, results in this section suggest that the optimal level of R&D chosen by the domestic firm couldn’t be optimal. Hence, it suggests that it could exist space for an R&D policy. Further research should analyse the optimal policy within the context of this model.
8. Main Conclusions and Suggestions for Further Research

In this chapter we analyse FDI in less developed countries in which both the mode of foreign expansion and the incentives to innovate are endogenously determined. This is the main contribution of the model developed in this chapter since, to the best of our knowledge, it is the first model that analyse FDI in developing countries with a model of these characteristics. Our main objective is to shed some light on the impact of the different modes that a foreign firm has to reach a domestic market on the incentives to innovate and on the host country welfare.

We analyse a three stages game in which the foreign firm chooses in the first stage the mode of serving the domestic market. Then in stages two and three firms choose simultaneously R&D and price level, respectively.

Some key features of our analysis are:

- We consider asymmetric R&D spillovers, which are received by the domestic firm from the MNC when it decides to serve the domestic market by creating a wholly owned subsidiary and undertakes R&D in the host economy. So spillovers are geographically localized.
- Also, we include into the analysis the idea that the degree of spillovers received by the domestic firm depends positively on its own R&D effort, which incorporates the idea that the degree of R&D spillovers depend on the absorptive capacity of the firm that receive them.
- R&D investment can be interpreted both as aimed to improve product quality or to reduce production cost.

The main issues and results are:

1) First, on the impact of the different market structures on the incentives to innovate. We have shown that:

   a) Provided the degree of spillovers is small enough, when the foreign firm moves from exporting to FDI, domestic and foreign firm R&D level decreases and increases, respectively.
b) Independent on the degree of spillovers total R&D increases. If the degree of spillovers rises, then total R&D increases further.

2) Second, on the preferred mode of entry of the foreign firm from the host country’s point of view.
   a) If the foreign firm chooses FDI, provided the relation between foreign and domestic output is bigger than one, consumers welfare increases while domestic output drop. If the degree of spillovers increases it can be possible that domestic welfare increases, but also it could induce the foreign firm to choose exporting. On the other hand, if the degree of product substitutability falls then it makes more likely than domestic welfare increase. In the extreme case that \( \gamma = 0 \) and \( \alpha > 0 \) then domestic welfare increases and therefore the preferred mode of entry from the host country point of view is FDI.

3) Third, on the determinants of the optimal mode of entry of the foreign firm from its point of view.
   a) The key determinant on the optimal mode of serving the host economy are: the level protection of the domestic market, the degree of product substitutability, the level of the plant specific cost and the degree of spillovers. The higher is the first determinant and the lower the other three, then the more likely is that the foreign firm would choose setting up a subsidiary.

4) Fourth, to determine if there is scope for a domestic R&D policy
   a) Ours results suggest that there is space or a domestic R&D policy. The optimal policy however requires further research.

Some policy implications are:
1. A policy implication of this model is that host country governments must pay attention to domestic firms if they want to improve benefits received from FDI.
2. To improve benefits of R&D we require to strength absorptive capacity.

Finally, further research should aimed to find the optimal policy from the host country’s point of view.