Foreign Direct Investment as a Signal

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Abstract

This paper models foreign direct investment (FDI) as a signal in a model of incomplete cost information in which two firms compete in two markets. If FDI can serve as a signal, both the probability of FDI and expected aggregate output in each market increase. Firms sort themselves into exporters and multinationals, and they are more likely to undertake FDI because they have an incentive to signal that they operate in the range of low costs (high productivities). Our model thus demonstrates that the proliferation of multinational firms can be explained by the signaling effect if firms are heterogeneous at the outset and costs are private information.

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1 Introduction

Over the last three decades, we have witnessed a proliferation of multinational firms changing the structure of the world economy, and countries have become significantly integrated, especially through foreign direct investment (FDI). In the 1990s, the number of multinational firms producing across borders was estimated at between 17,500 and 20,000, whereas in 2007, there were 79,000 multinational firms operating all over the world through 790,000 foreign affiliates, controlling US$13 trillion in foreign assets, earning US$31 trillion in revenues, and generating 81 million jobs. Since the 1990s, the growth rate of world FDI has been significantly higher than that of both world exports and world GDP. Moreover, developed countries are responsible for most inward and outward FDI, which is mainly of the type horizontal FDI, meaning that firms invest in host countries of similar relative endowments as their home country.

By now, the literature on multinational firm activity and FDI has reached a certain degree of maturity. Starting with the knowledge-capital model by Markusen (1984), it has been shown that multinational firms exist if firm-level economies of scale are larger, and plant-level economies of scale are smaller. Since markets for knowledge do not exist, or are imperfect, firms decide to keep research- and skill-intensive activities within firm boundaries. Antràs (2003) extends these models to a general equilibrium model, including vertical FDI, in which firms face hold-up problems, both within the firm and with an independent partner. He shows that capital-intensive activities are more likely to be organized within the firm. Helpman et al. (2004) extend Melitz’s (2003) heterogeneous firm model, and show that the most productive firms sort themselves into multinationals, whereas less productive firms become exporters, and the least productive firms serve only local markets.

Both strands of the literature, the knowledge-capital models and the heterogeneous firm models, have overlooked the potential signaling effect of FDI. Suppose that the most productive firms undertake FDI, as in Helpman et al. (2004). If a local firm observes the establishment of a subsidiary, and cost structures are not common knowledge, we would expect that this firm would come to the conclusion that it now faces a strong rival. In markets where firms are potentially large, and thus an industry is potentially concentrated, the observation of an investment by a foreign firm will have an effect on

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1 The main motive for horizontal FDI is to avoid trade costs, and to serve consumers in a host country so as to better exploit the host country’s market.

2 See also Horstmann and Markusen (1992), and Markussen and Venables (1998, 2000).

3 A summary of this literature can be found in Markussen (2002) and Navaretti and Venables (2006).
domestic firm behavior. It is this effect we are interested in: what happens if FDI is not neutral in terms of signals, but rather sends the message of high productivity? We explore this issue by comparing the signaling effect of FDI with a benchmark case in which FDI cannot be observed before strategic market decisions are made. The latter case — the conventional view of FDI — may not be empirically the relevant case as FDI activities do not remain secret before firms interact on markets. Nevertheless, it allows us to isolate the signaling effect of FDI, while keeping the incomplete information structure of the model as is.

Empirical evidence suggests that information asymmetries crucially affect firms’ cross-border investment strategies; see, for example, López Duarte and García-Canal (2004), García-Canal et al. (2002), and Shen and Reuer (2005). Surprisingly, not too many papers have explored the strategic effects of FDI in a setting of incomplete information. Long et al. (2012) confine their analysis to trade, and discuss the role of R&D when firms’ costs are private information. Katayama and Miyagiwa (2009) have a model in which product quality is unknown and the FDI mode is used to signal quality to consumers. In the presence of demand uncertainty, and asymmetric information, Moner-Colonques et al. (2007) show that firms may have an additional incentive to undertake FDI, especially when FDI offers more accurate demand information than exporting does. In a model with one-sided asymmetric information — in which the location of production signals a firm’s cost information — Bagwell and Staiger (2003) show that a firm may undertake FDI even just to transmit cost information to foreign rivals, whereas Nastasi and Reverberi (2007) argue that a firm may use FDI as a signaling device also for entry deterrence. In particular, these studies borrow from an extensive industrial organization literature on information sharing, that is, whether a firm has an interest to share information with its

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4 As is rightly argued by Collie and Hviid (1993), in concentrated industries, firms generally have incomplete information about the costs of their rivals, especially from other countries, a typical example of which is the micro-electronics industry where manufacturing experience and some idiosyncratic factors determine firms’ production costs. Incomplete operating cost information is also prevalent in the airline industry; see, for example, Vives (2002).

5 In the international trade literature, there is a number of studies scrutinizing strategic trade policy under incomplete information. For example, by employing a model à la Brander and Spencer (1985), (i) Creane and Miyagiwa (2008) show that when subsidizing exporters, governments want to learn about firms’ private demand and cost information, irrespective of the type of competition, although firms have an incentive to disclose such information only if they compete by quantities, (ii) Collie and Hviid (1993) show that a fully-informed government may use export subsidies to signal the foreign firm that the domestic firm has low costs, in which case the optimal subsidy rate is larger than that under complete information, although (iii) Wright (1998) shows that the optimal subsidy under incomplete cost information is smaller than that under complete information, especially when the government does not know about the domestic firm’s costs.

6 Bagwell and Staiger (2003) focus on firm entry in a single country, whereas Nastasi and Reverberi (2007) employ a sequential game in which counter-entry by a foreign firm — following a domestic firm’s entry mode choice in a foreign country — is possible.
rivals. The information-sharing literature shows that when firms produce a homogeneous good and compete by quantities, and when firms’ constant marginal costs are private information, then firms’ have an incentive to share their private information with which they increase their profits; see, for example, Shapiro (1986) and Li (1985). In this paper, however, we do not endogenize whether a signal will be sent or not. We are interested in the additional effect of FDI as a signal, and we find that FDI as a signal increases both the probability of FDI and aggregate output in a market. Thus, we can identify another channel by which we can explain the dominant role of multinational firms. We employ a model of horizontal FDI because horizontal FDI is still dominant and does not rely on factor price differences, so all our results will be driven only by the signaling effect.

The remainder of this paper is organized as follows. Section 2 sets up the model and explains the role of FDI under incomplete information. Section 3 extends this model to the case that FDI is a signal. Section 4 demonstrates the signaling effect of FDI, and Section 5 concludes the paper.

2 FDI under incomplete information

Our paper employs a model of two countries and two firms, each located in one country. The country $i$-based firm $i$ competes against country $j$-based firm $j$ by quantities, in both country $i$ and country $j$, so this is a model of reciprocal dumping à la Brander and Krugman (1983) in case of trade, or a model of reciprocal FDI à la De Santis and Stähler (2004) in case of FDI. The difference is that there is no firm heterogeneity in these models, and thus costs are common knowledge. In our model, the firms’ marginal production costs, $c$, are private information, and firms draw their costs from the uniform distribution, $\Phi(c) = (c - \alpha) / (\beta - \alpha)$, where $\beta$ and $\alpha$ are the upper and lower bound, respectively. Thus, our model features firm heterogeneity and can include the strategic effects of private cost information.

We keep the demand side of our model as simple as possible. In each country inverse demand is given by $p^k = A - (q^k_i + q^k_j)$, where $k = d$, or $f$, is the country indicator, such that $d$ and $f$ stand for domestic and foreign, respectively, and the two markets are segmented. The trade-off between serving the foreign market via exports or via FDI

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7A change in the specifications of the model (e.g., substitute vs complement products, demand vs cost uncertainty, common-value vs private-value information, or quantity vs price competition, or fixed market structure vs free entry) may generate a different result; see, for example, Vives (1984, 2002), and Gal-Or (1985, 1986, 1988).

8In symmetric models of complete information, the assumption of segmented markets is innocuous because equilibrium prices are identical, so there is no reason for arbitrage, or for cross-border shopping.
is the same as in Markusen-type models: if a firm decides for exports, there is a trade cost, \( t \), it has to cover; if it decides for FDI, it saves this trade cost by making greenfield investment which requires an investment with fixed costs of size \( F \). In this respect, we follow the standard literature implying the well-known, usual, proximity-concentration trade-off. Both the trade cost, \( t \), and the fixed cost, \( F \), are common knowledge. It goes without saying that all our results remain valid if exporting involves a fixed cost as well, insofar as the fixed costs of FDI are larger than the fixed costs of exports. For the ease of exposition, we focus only on fixed FDI costs; an alternative interpretation would be that this is the difference between the fixed costs of FDI and the fixed costs of exporting.

We are now ready to scrutinize the behavior of these two firms and the scope for FDI under incomplete information. We first consider a one-stage game in which FDI cannot serve as a signal: both firms decide on exports versus FDI at the same time when they decide on their outputs/capacities for both the domestic and the foreign market. This is then a one-stage Bayesian game, that is, when deciding on output levels, firms do not know each other’s mode of supply, which is either trade or FDI, nor do they know each other’s cost level. In any case, each firm will maximize its expected profits and will form expectations on its rival’s costs. These expectations must be rational, that is, each firm knows which type of firms will select itself into which international business mode. For now, we will assume that (i) an interior solution exists such that different types will choose different strategies, and that (ii) lower-cost (higher-cost) types will choose FDI (exports). We will later on show that this self-selection is confirmed in equilibrium, and we will also discuss possible corner solutions.

Let \( \Pi_X(c) \) (\( \Pi_{FDI}(c) \)) denote the expected profits of a firm of type \( c \) when it chooses exports (FDI). An interior solution requires that there exists a type \( \delta \) with \( \delta \in [\alpha, \beta] \) that is indifferent between trade and FDI such that \( \Pi_X(c = \delta) = \Pi_{FDI}(c = \delta) \). Consider first foreign firm \( j \) that forms expectations about its rival \( i \)'s costs in the domestic market. This rival does not face any trade costs in serving her domestic market, and hence firm \( j \)'s expectation of firm \( i \)'s costs in country \( i \) is simply the expectation of the marginal costs:

\[
E_j(c^d_i) = \int_\alpha^\beta c \frac{1}{\beta - \alpha} dc = (\beta + \alpha)/2.
\]

Now consider domestic firm \( i \) when forming expectations on the expected cost of its rival \( j \) in the domestic market. If this rival serves this market by exports, then it will have to

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In our model, ex-ante symmetry does not imply identical prices in both markets ex post. If we allowed for arbitrage, we would have taken into account the probability that both prices differ by more than the trade cost, \( t \).
bear an additional trade cost, \( t \). Given the uniform distribution, this will happen with probability \( (\beta - \delta)/(\beta - \alpha) \). However, if the rival will go for FDI, then the relevant cost for production does not include \( F \), as it is a fixed cost, nor does it include \( t \), as it is saved by FDI. That will happen with probability \( (\delta - \alpha)/(\beta - \alpha) \). Consequently, firm \( i \)'s expectation of firm \( j \)'s production costs in country \( i \) is equal to

\[
E_i(c^j_f) = \int_\alpha^\delta c \frac{1}{\beta - \alpha} dc + \int_\delta^\beta (c + t) \frac{1}{\beta - \alpha} dc = (\beta + \alpha)/2 + t(\beta - \delta)/(\beta - \alpha)
\]

By symmetry, firm \( i \)'s expectation of firm \( j \)'s production costs in country \( j \) is equal to

\[
E_i(c^d_j) = \int_\alpha^\delta c \frac{1}{\beta - \alpha} dc = (\beta + \alpha)/2,
\]

and firm \( j \)'s expectation of firm \( i \)'s production costs in country \( j \) is equal to

\[
E_j(c^f_i) = \int_\alpha^\delta c \frac{1}{\beta - \alpha} dc + \int_\delta^\beta (c + t) \frac{1}{\beta - \alpha} dc = (\beta + \alpha)/2 + t(\beta - \delta)/(\beta - \alpha).
\]

We now turn to the optimal output decisions of firms. For this purpose, it will be convenient to introduce

**Definition 1** \( \Delta = 2A + (\beta + \alpha)/2 \), and \( M = (\beta - \alpha) \).

Each firm maximizes its profits, \( \Pi_X(c) \) or \( \Pi_{FDI}(c) \), w.r.t. its outputs when it serves the foreign market by exports or FDI, respectively, taking into account the rival’s expected cost. From the first-order conditions, we find that production in country \( i \) is given by

\[
q^d_i = \frac{\Delta + 2t (\frac{\beta - \delta}{M}) - 3c_i}{6},
\]

\[
q^f_i = \frac{\Delta - t (\frac{\beta - \delta}{M}) - 3c^f_i}{6},
\]

where the subscript denotes the location of a firm’s headquarters and the superscript denotes the target market. The relevant cost \( c^f_j \) is equal to \( (c_j + t) \) if firm \( j \) serves country \( i \) by exports, or it is \( c_j \) if it undertakes FDI in country \( i \). Similarly, production in country \( j \) is equal to

\[
q^d_j = \frac{\Delta + 2t (\frac{\beta - \delta}{M}) - 3c_j}{6},
\]

\[
q^f_j = \frac{\Delta - t (\frac{\beta - \delta}{M}) - 3c^f_j}{6},
\]

where \( c^f_i \) is equal to \( (c_i + t) \) if firm \( i \) serves country \( j \) by exports, or it is \( c_i \) if it undertakes FDI in country \( j \). In order to focus on the export-FDI trade-off, we assume that all
outputs are positive throughout the paper. Otherwise, some types of firms would not produce at all, and this would not change our results except for making our exposition more complicated.

Given the optimal outputs in this Bayesian game, we can now compute the maximized profits of the exporting firm, and of the firm undertaking FDI, which are respectively given as

\[ \Pi_X = \frac{(\Delta - t\left(\frac{\beta - \delta}{M}\right) - 3(c + t))^2}{36}, \]
\[ \Pi_{FDI} = \frac{(\Delta - t\left(\frac{\beta - \delta}{M}\right) - 3c)^2}{36} - F. \]  

A firm prefers FDI over trade if \( \Pi_{FDI} > \Pi_X \), that is, FDI is the preferred mode of supply when fixed FDI costs are sufficiently small such that

\[ F < \frac{t}{12} \left(2\Delta - 6c - 2t\left(\frac{\beta - \delta}{M}\right) - 3t\right). \]

We also see clearly from eq.(1) that the exporting firm’s maximized profits decrease less with an increase in \( c \) than the maximized FDI profits, that is, \( \partial \Pi_{FDI}/\partial c < \partial \Pi_X/\partial c < 0 \), which confirms our assumption that, if an interior solution exists, then it will be the low-cost firms opting for FDI, while the high-cost firms will prefer exporting. We can solve for the indifferent type \( c = \delta \) which is defined by

\[ \tilde{F}(\delta) = \frac{t}{12} \left(2\Delta - 6\delta - 2t\left(\frac{\beta - \delta}{M}\right) - 3t\right). \]  

We want to impose stability for our model, and thus we require that \( \tilde{F}(\delta) \) should decline with \( \delta \), that is, if fixed costs are reduced, then more firms will undertake FDI. This is guaranteed by

**Assumption 1** \( t < 3M \),

which implies \( d\tilde{F}(\delta)/d\delta < 0 \). We can also demonstrate that the co-existence of exporters

\[ 9 \] If there was a positive relationship between \( \tilde{F}(\delta) \) and \( \delta \), then an increase in \( \delta \) would lead to a huge profit increase, especially for those firms undertaking FDI, and this could be stopped only by an increase in \( F \). Consequently, there could be no co-existence of exporters and multinational firms if Assumption was violated.
and multinational firms is no knife-edge case, simply by scrutinizing the corner solutions. All firms will prefer trade over FDI when fixed FDI costs are sufficiently large. Let $F'$ denote the lowest level of fixed costs which makes all firms become exporters. Thus, $F'$ is set such that the lowest-cost firm is indifferent between trade and FDI ($c = \delta = \alpha$):

$$F' = \frac{t}{12} (2\Delta - 6\alpha - 5t).$$

Similarly, we can show that all firms prefer FDI over trade when fixed FDI costs are sufficiently small. Let $F''$ denote the highest level of fixed costs which makes all firms become multinational firms. Thus, $F''$ is set such that the highest-cost firm is indifferent between trade and FDI ($c = \delta = \beta$):

$$F'' = \frac{t}{12} (2\Delta - 6\beta - 3t).$$

Since

$$(F' - F'') = t \left( \frac{3M - t}{6} \right) > 0$$

due to Assumption 1, we see that a range of fixed costs exists such that different types will choose different international business strategies (trade vs FDI). Which role does firm heterogeneity play for the co-existence of exporters and multinational firms? We can measure an increase in firm heterogeneity by a mean-preserving spread of the probability distribution $\Phi(c)$. We find that

**Lemma 1 (Mean-Preserving Spread I)** An increase in firm heterogeneity makes different responses more likely because $\partial(F' - F'')/\partial M = t/2 > 0$.

Thus, firm heterogeneity is the key for the co-existence of exporters and multinational firms. We conclude that the same ranking of firms in terms of their productivity prevails in a model of incomplete information: more efficient firms undertake FDI, whereas less efficient firms sort themselves into exporters, and if the industry under consideration is characterized by a large degree of firm heterogeneity, then different international business strategies are more likely.

### 3 FDI as a conspicuous activity

In the preceding section, we have assumed that FDI does not serve as a cost signal. In this section, we will explore how firms behave when FDI is a conspicuous activity
which precedes output decisions. We thus now employ a two-stage game in which firms simultaneously decide on the FDI or export mode in the first stage, and on their outputs for the two markets in the second stage. This is now a game in which we look for a perfect Bayesian Nash equilibrium in which FDI serves as a binary signal. Depending on the signal, firms will use this information to update their beliefs about the rival’s costs, and in equilibrium this update must be consistent with the self-selection into exporting and multinational firms. In the first stage, however, the foreign entry decision must be made without knowing the rival’s decision, and thus each will now form expectations not only about the rival’s type but also about the rival’s international business decision.

Each firm will consider different outcomes of the decision on the foreign market entry. Let \( \delta_s \) denote the type of the firm that is indifferent between trade and FDI, in this setting. Should both firms undertake FDI, both firms signal that their production costs are in the range \((\alpha, \delta_s)\), and thus the mutual expectation about the rival’s cost is equal to

\[
E_i(c^f_j) = E_i(c^d_j) = E_j(c^f_i) = E_j(c^d_i) = \int_{\alpha}^{\delta_s} c \frac{dc}{\delta_s - \alpha} = \frac{\delta_s + \alpha}{2}.
\]

Accordingly, production in country \( i \) is given by

\[
q^d_i = \Delta - \left( \frac{\beta - \delta_s}{2} \right) - 3c_i,
\]

\[
q^f_i = \Delta - \left( \frac{\beta - \delta_s}{2} \right) - 3c_j,
\]

where the sub- and superscripts have the same meaning as in the preceding section. Due to symmetry, production in country \( j \) is given by

\[
q^d_j = \Delta - \left( \frac{\beta - \delta_s}{2} \right) - 3c_j,
\]

\[
q^f_j = \Delta - \left( \frac{\beta - \delta_s}{2} \right) - 3c_j.
\]

Note carefully that both firms use the mutual FDI signal to update their beliefs about the range of production costs that the other firm operates in. If both firms opt for FDI, then they both signal that they are low-cost firms, and this changes the nature of competition in the product market.

The case of mutual FDI is only one out of four possible outcomes which have to be antici-
pated. If firm \( i \) undertakes FDI, but firm \( j \) exports, then we have an asymmetric outcome. In this case, firm \( i \) signals that its production costs are in the range \((\alpha, \delta_s)\), whereas firm \( j \) signals that its production costs are in the range \((\delta_s, \beta)\), leading to expectations

\[
E_j(c_d^i) = E_j(c_f^j) = \int_{\alpha}^{\delta_s} \frac{dc}{\delta_s - \alpha} = \frac{\delta_s + \alpha}{2},
\]

\[
E_i(c_d^j) = \int_{\delta_s}^{\beta} \frac{dc}{\beta - \delta_s} = \frac{\beta + \delta_s}{2},
\]

\[
E_i(c_f^j) = \int_{\delta_s}^{\beta} (c + t) \frac{dc}{\beta - \delta_s} = \frac{\beta + \delta_s}{2} + t.
\]

In this case, firm \( i \) is regarded as the firm operating in the low-cost range, and since it is a multinational firm, the expectation of its rival does not depend on the location of the market. In contrast, firm \( j \) has signaled that it is operating in the high-cost range, and since this makes firm \( j \) an exporter, it will be expected to be at a further disadvantage in firm \( i \)'s home market due to trade costs. Thus, the no-FDI signal has two implications for firm \( i \): (i) it learns that the rival is relatively weak because it is in the high-cost range, and (ii) the rival is even weaker in the home market of firm \( i \) due to trade costs. It goes without saying that this outcome would be most favorable for firm \( i \). We find for production in country \( i \):

\[
q_d^i = \frac{\Delta + \left(\frac{\beta - \delta_s}{2}\right) + (\delta_s - \alpha) + 2t - 3c_i}{6},
\]

\[
q_f^j = \frac{\Delta - \left(\frac{\delta_s - \alpha}{2}\right) - (\beta - \delta_s) - 4t - 3c_j}{6},
\]

and for production in country \( j \):

\[
q_f^i = \frac{\Delta + \left(\frac{\beta - \delta_s}{2}\right) + (\delta_s - \alpha) - 3c_i}{6},
\]

\[
q_d^j = \frac{\Delta - \left(\frac{\delta_s - \alpha}{2}\right) - (\beta - \delta_s) - 3c_j}{6}.
\]

If we have the opposite case, that is, if firm \( i \) exports, and firm \( j \) undertakes FDI, then firm \( i \) signals that its production costs are in the range \((\delta_s, \beta)\), whereas firm \( j \) signals that
its production costs are in the range \((\alpha, \delta_s)\), leading to expectations

\[
E_i(c^d_j) = E_i(c^f_j) = \int_{\alpha}^{\delta_s} \frac{dc}{\delta_s - \alpha} = \frac{\delta_s + \alpha}{2},
\]

\[
E_j(c^d_i) = \int_{\delta_s}^{\beta} \frac{dc}{\beta - \delta_s} = \frac{\beta + \delta_s}{2},
\]

\[
E_j(c^f_i) = \int_{\delta_s}^{\beta} (c + t) \frac{dc}{\beta - \delta_s} = \frac{\beta + \delta_s}{2} + t,
\]

and to production levels in country \(i\)

\[
q^d_i = \frac{\Delta - (\delta_s - \alpha)}{6} - (\beta - \delta_s) - 3c_i,
\]

\[
q^f_i = \frac{\Delta + (\beta - \delta_s)}{6} - (\delta_s - \alpha) - 3c_j,
\]

and to production levels in country \(j\)

\[
q^f_j = \frac{\Delta - (\delta_s - \alpha)}{6} - (\beta - \delta_s) - 4t - 3c_i,
\]

\[
q^d_j = \frac{\Delta + (\beta - \delta_s)}{6} + (\delta_s - \alpha) + 2t - 3c_j.
\]

Finally, both firms could decide not to undertake FDI, but to export, that is, both firms signal that their production costs are in the high-cost range \((\delta_s, \beta)\), leading to expectations

\[
E_i(c^d_j) = E_i(c^f_j) = \int_{\delta_s}^{\beta} \frac{dc}{\beta - \delta_s} = \frac{\beta + \delta_s}{2},
\]

\[
E_i(c^f_j) = E_j(c^d_i) = \int_{\delta_s}^{\beta} (c + t) \frac{dc}{\beta - \delta_s} = \frac{\beta + \delta_s}{2} + t,
\]

and to production levels in country \(i\)
\[
q_i^d = \Delta + \frac{(\frac{\delta_s - \alpha}{2}) + 2t - 3c_i}{6},
\]
\[
q_j^f = \Delta + \frac{(\frac{\delta_s - \alpha}{2}) - 4t - 3c_j}{6},
\]

and to production levels in country \( j \)

\[
q_i^f = \Delta + \frac{(\frac{\delta_s - \alpha}{2}) - 4t - 3c_i}{6},
\]
\[
q_j^d = \Delta + \frac{(\frac{\delta_s - \alpha}{2}) + 2t - 3c_j}{6}.
\]

We are now prepared to develop the expected profits of a firm, especially dependent on its international business strategy. Whether or not the firm does undertake FDI, it will always face two different possible responses by the other firm: with probability \((\delta_s - \alpha)/M\), the rival firm will become multinational, and with the complementary probability \((\beta - \delta_s)/M\), it will be an exporter. Given the production levels above, we can now compute firm \( i \)'s expected total profits, denoted by \( \Pi_X \), when firm \( i \) decides to serve country \( j \) by exporting:

\[
\Pi_X = \frac{(\delta_s - \alpha)}{M} \left( \frac{\left(\Delta + \frac{(\frac{\delta_s - \alpha}{2}) - 3c_i}{M} \right)^2}{36} \text{ Profits from country } i \right) + \frac{(\beta - \delta_s)}{M} \left( \frac{\left(\Delta + \frac{(\frac{\delta_s - \alpha}{2}) - 4t - 3c_j}{M} \right)^2}{36} \text{ Profits from country } j \right)
\]

Similarly, firm \( i \)'s expected total profits, denoted by \( \Pi_{FDI} \), when its mode of supply in country \( j \) is FDI, are given by eq.(4), in which we use a different notation, \( F_s \), for the fixed costs of FDI in case FDI may serve as a signal:
Firm \( i \) prefers FDI over trade if \( \Pi_{FDI} > \Pi_X \), that is, FDI is the preferred mode of supply when fixed FDI costs are sufficiently small such that,

\[
F_s < \frac{M(4\Delta + \beta - 2\delta_s + \alpha) + 4t(4\Delta + \beta - 3\delta_s + 2\alpha - 8t) - 12\delta_s(4t + M)}{72}.
\]

Once again, we have to check whether our initial assumption about the firm behavior across cost ranges is true. We observe from eq.(3) and eq.(4) that the exporting firm’s maximized profits decrease less with an increase in \( c \) than the maximized FDI profits, that is, \( \frac{\partial \Pi_{FDI}}{\partial c} < \frac{\partial \Pi_X}{\partial c} < 0 \), which confirms our assumption that, if an interior solution exists, then it will be the low-cost firms opting for FDI, while the high-cost firms will prefer exporting.

We can solve for the indifferent type \( c = \delta_s \),

\[
\tilde{F}_s(\delta) = \frac{M(4\Delta + \beta - 2\delta_s + \alpha) + 4t(4\Delta + \beta - 3\delta_s + 2\alpha - 8t) - 12\delta_s(4t + M)}{72}, \tag{5}
\]

and show that, in this case, stability is guaranteed because \( d\tilde{F}_s/d\delta < 0 \), irrespective of the size of \( t \). Let us also consider the scope for co-existence. All firms prefer trade over FDI when fixed FDI costs are sufficiently large. Let \( F'_s \) denote the lowest level of fixed costs such that the lowest-cost firm is indifferent between trade and FDI, that is, \( c = \delta_s = \alpha \):

\[
F'_s = \frac{M(4\Delta + M - 12\alpha) + 4t(4\Delta + M - 12\alpha - 8t)}{72}.
\]

Similarly, all firms prefer FDI over trade when fixed FDI costs are sufficiently small. Let \( F''_s \) denote the smallest level of fixed costs such that the highest-cost firm is indifferent between trade and FDI, that is \( c = \delta_s = \beta \):
\[ F'_s = \frac{M(4\Delta - 12\beta - M) + 8t(2\Delta - 6\beta - M - 4t)}{72}. \]

Since
\[ (F'_s - F''_s) = \frac{M(30t + 7M)}{36} > 0, \]
a range of fixed costs exists such that different types will choose different international business strategies (trade vs FDI). Firm heterogeneity plays qualitatively a similar role:

**Lemma 2 (Mean-preserving spread II)** An increase in firm heterogeneity makes different responses more likely because \( \partial(F'_s - F''_s)/\partial M = (15t + 7M)/18 > 0. \)

Thus, we find that although FDI serves as a signal, it does not completely turn things upside down because also in this case (i) co-existence of exporters and multinational firms is possible, and (ii) the scope for co-existence increases with an increase in the degree of firm heterogeneity. However, we also find that these results do not depend on the size of trade costs, whereas an upper bound was warranted for stability, especially in the case that FDI cannot serve as a signal. In the next section, we will explore the differences between the two cases.

### 4 The signaling effect of FDI

The objective of this section is to discuss to what extent the two cases differ. We trust more in the case that FDI is a conspicuous activity, for the reasons outlined in Section 1. However, it is important to understand the additional effects implied by FDI as a conspicuous activity, so we use the results of Section 2 as a benchmark and compare them with the results of Section 3. By this comparison, we are able to isolate the signaling effect of FDI. Let us start with the comparison of the threshold levels of fixed costs, such that

\begin{align*}
F'_s - F' &= \frac{M(4\Delta - 12\alpha + 4t + M) + t(2\Delta - 6\alpha - t)}{72} > 0, \quad (6) \\
F''_s - F'' &= \frac{M(4\Delta - 12\beta - 8t - M)}{72} + \frac{t(2\Delta - 6\beta - 7t)}{36} > 0, \\
(F'_s - F''_s) - (F' - F'') &= \frac{(7M^2 + 6t^2 + 12Mt)}{36} > 0.
\end{align*}
Eq. (6) shows that the signaling effect of FDI shifts both thresholds up, and leads to a larger range of fixed costs in which we have co-existence of exporters and multinational firms. Figure 1 illustrates this result, and shows the indifferent types as a function of fixed costs.

![Figure 1: Indifferent types with and without signaling](image)

Below $F''_s$ (in case FDI is a conspicuous activity) and $F''$ (in the benchmark case), all types opt for FDI; above $F'_s$ (in case FDI is a conspicuous activity) and $F'$ (in the benchmark case), all types prefer exporting, which leads to the horizontal lines in Figure 1. As is clear from the comparison of the threshold levels of fixed costs, given by eq. (6), the signaling effect of FDI makes FDI more likely, both in levels, and in the size of the range. Furthermore, the change of the indifferent type with the critical fixed FDI costs is smaller in absolute terms in the case of signaling, as can easily be seen from differentiating and comparing eq. (2) and eq. (5).

We summarize this finding in
Proposition 1 (Comparing the threshold fixed costs) The probability of FDI is larger if FDI can serve as a signal. An increase in heterogeneity makes the difference between the two sets of fixed costs in which different types will choose different international business strategies larger.

Proof: The first part follows immediately from eq. (6) and Figure 1, whereas the second part follows from \[ \frac{\partial (F'_s - F''_s) - (F'_F - F''_F)}{\partial M} = \frac{(6t + 7M)}{18} > 0. \]

Since the indifferent type and the critical fixed FDI costs are inversely related, a direct implication of Proposition 1 and Figure 1 is that more firms undertake FDI if FDI can serve as a signal because \( \delta_s \geq \delta \) for any given fixed FDI costs (see Figure 1).

The clear result in terms of the FDI probability already indicates that consumers are likely to benefit from the signaling effect of FDI. The details of the computation of expected outputs are cumbersome and tedious, in particular for FDI as a signal. For FDI as a signal, we must go through all possible cases, that is, both firms may undertake FDI or may export, or the two asymmetric cases (i.e., one firm may undertake FDI, while the other firm may export). If FDI is not a signal, the computation of expected outputs is easier because the expected output of a firm in this local market does not depend on its international business strategy. You find the details of the computations in Appendix A.1 where \( E[Q^*_k](E[Q_k]) \) denotes the aggregate expected output if FDI can (cannot) be a signal. As for the difference, we find

\[
E[Q^*_k] - E[Q_k] = \left( \frac{2\Delta - 3(\beta + \alpha) - \frac{2t(\beta - \delta)}{M}}{6} \right) - \left( \frac{2\Delta - 3(\beta + \alpha) - \frac{2t(\beta - \delta)}{M}}{6} \right) = \frac{t(\delta_s - \delta)}{3M} \geq 0, \quad \text{as } \delta_s \geq \delta, \text{ for a given } F \text{ (see Figure 1)},
\]

which leads immediately to

Proposition 2 Aggregate expected output in each country is larger if FDI can serve as a signal.

As the model is symmetric, this result coincides with the change in expected total firm output, that is in particular, that expected total firm output is larger by \( \frac{t(\delta_s - \delta)}{3M} \) if FDI can serve as a signal. We are also able to decompose this output change into the two markets each firm operates in. We find that the signaling effect of FDI makes each firm win market share in the foreign market and lose market share in the local market.
**Proposition 3** FDI as a signal reduces both firms’ expected output levels in their respective home markets by $t(\delta - \bar{\delta})/3M$, but increases their expected output levels in the foreign markets by $2t(\delta - \bar{\delta})/3M$.

Proposition 3 demonstrates the signaling effects of FDI. The FDI probability increases because not undertaking FDI is a bad signal: a firm loses market share not only in the foreign country due to trade costs, but also in both countries due to signaling high marginal costs. Thus, firms are willing more to undertake FDI when FDI is a signal. A higher probability of FDI means that competition becomes more intense in both countries, and therefore firms win market share abroad, while losing it at home. Can we say anything about the welfare effects of FDI as a signal? Consumers will always benefit from FDI as it will reduce the variable production costs. However, it is well known from duopoly models without firm heterogeneity that an FDI option can lead to a prisoners’ dilemma for both firms: while profits are larger with exports, each firm has an individual incentive to become multinational. The profit decrease can even be larger than the consumer gain.

We cannot rule out that similar effects could be at work in our setup.

## 5 Conclusions

Our paper has shown that the literature on multinational enterprises and FDI may have underestimated the role FDI can play in a strategic setting with firm heterogeneity. If FDI is a conspicuous activity, a further driving force of FDI is the incentive not to signal a low productivity. Therefore, either assuming homogeneous firms as in the standard proximity-concentration trade-off models, or assuming firm heterogeneity in a non-strategic (monopolistic competition) setup may only partially explain the significant role multinational firms play. We could clearly show that the signaling effect of FDI will lead to a higher probability of FDI, and larger expected aggregate outputs. We have developed our results in a duopoly model of two firms, each located in a different country. An extension to endogenizing market entry should be straightforward. With FDI as a signal, expected operating profits will be smaller, and this should lead to a reduction in market entry. Furthermore, we have assumed that firms compete in quantities. An extension to price competition would require a model with imperfect substitutes, because pure price competition would lead to a winner-takes-it-all result. However, we expect similar results with price competition because firms will still have an incentive not to report low productivities. We leave these extensions to future research.

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\[10\] This result depends crucially on the assumption that market entry is not endogenous. With endogeneous market entry, the welfare effects of FDI are unambiguously positive (see De Santis and Stähler, 2004).
References


Appendix

A.1 Aggregate expected outputs

Aggregate expected output in country $k = \{i, j\}$ if FDI serves as a signal is denoted by $E[Q^*_k]$, and given by

\[
\frac{(\delta_s - \alpha)}{M} \left( \frac{\beta - \delta_s}{M} \right) \left( \int_{\alpha}^{\delta_s} \frac{\Delta - \left(\frac{\beta - \delta_s}{2}\right) + M + 2t - 3c}{6} \, dc \right) \delta_s - \alpha + \frac{(\delta_s - \alpha)}{M} \left( \int_{\delta_s}^{\beta} \frac{\Delta + \left(\frac{\beta - \delta_s}{2}\right) - M - 4t - 3c}{6} \, dc \right) \beta - \delta_s
\]

\[
\text{Domestic (firm i’s) production}
\]

\[
\frac{(\delta_s - \alpha)}{M} \left( \frac{\beta - \delta_s}{M} \right) \left( \int_{\alpha}^{\delta_s} \frac{\Delta + \left(\frac{\beta - \delta_s}{2}\right) - M - 3c}{6} \, dc \right) \delta_s - \alpha + \frac{(\delta_s - \alpha)}{M} \left( \int_{\delta_s}^{\beta} \frac{\Delta + \left(\frac{\beta - \delta_s}{2}\right) - 4t - 3c}{6} \, dc \right) \beta - \delta_s
\]

\[
\text{Foreign (firm j’s) production}
\]

\[
\frac{(\delta_s - \alpha)}{M} \left( \frac{\beta - \delta_s}{M} \right) \left( \int_{\alpha}^{\delta_s} \frac{\Delta - \left(\frac{\beta - \delta_s}{2}\right) + M + 2t - 3c}{6} \, dc \right) \delta_s - \alpha + \frac{(\delta_s - \alpha)}{M} \left( \int_{\delta_s}^{\beta} \frac{\Delta + \left(\frac{\beta - \delta_s}{2}\right) - M - 4t - 3c}{6} \, dc \right) \beta - \delta_s
\]

\[
\text{Domestic (firm i’s) production}
\]

\[
\frac{(\delta_s - \alpha)}{M} \left( \frac{\beta - \delta_s}{M} \right) \left( \int_{\alpha}^{\delta_s} \frac{\Delta + \left(\frac{\beta - \delta_s}{2}\right) - M - 3c}{6} \, dc \right) \delta_s - \alpha + \frac{(\delta_s - \alpha)}{M} \left( \int_{\delta_s}^{\beta} \frac{\Delta + \left(\frac{\beta - \delta_s}{2}\right) - 4t - 3c}{6} \, dc \right) \beta - \delta_s
\]

\[
\text{Foreign (firm j’s) production}
\]

\[
\text{Domestic (firm i’s) and foreign (firm j’s) production}
\]

Aggregate expected output in country $k = \{i, j\}$ if FDI cannot be a signal is denoted by $E[Q_k]$, and given by

\[
\int_{\alpha}^{\delta_s} \frac{\Delta - t \left(\frac{\beta - \delta_s}{M}\right) - 3c}{6} \, dc + \int_{\delta_s}^{\beta} \frac{\Delta - t \left(\frac{\beta - \delta_s}{M}\right) - 3(c + t)}{6} \, dc + \int_{\alpha}^{\beta} \frac{\Delta + 2t \left(\frac{\beta - \delta_s}{M}\right) - 3c}{6} \, dc.
\]

\[
\text{Foreign (firm j’s) production}
\]

\[
\text{Domestic (firm i’s) production}
\]

Subtracting this expression from the preceding one leads to eq. (7).