On strategic vertical foreign investment

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Abstract

We investigate the strategic incentives for vertical foreign direct investment by oligopolistic firms under exchange rate uncertainty. Domestic final good firms meet their input requirements either by investing abroad and producing directly through a subsidiary (intra-firm trade) or by buying from an oligopolistic market abroad (inter-firm trade). Firms undertaking vertical investment can bid up the input price faced by their rivals through strategic purchase. We demonstrate the possibility of vertical foreclosure, multiple equilibria, complementarity and bunching of investment decisions. Increase in the variability of exchange rate has positive effects on foreign direct investment and trade in the intermediate good; an appreciation of investor’s currency has similar effects. © 1998 Elsevier Science B.V. All rights reserved.

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1. Introduction

Foreign direct investment (FDI) has grown dramatically as a major form of international capital transfer over the last few decades. Between 1980 and 1990 world flows of FDI have approximately tripled. The emerging global economy is one increasingly dominated by multinational firms which currently account for

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about one-third of world output. About one-third of world trade takes place in the form of intra-firm trade; intermediates and manufactured goods constitute the major components of such trade flows (UNCTAD, 1994). Therefore, the question of what determines the global expansion and the transboundary investment behaviour of enterprises assumes considerable significance.

One of the important features of FDI is that it is prominent in industries where the classical competitive paradigm fits least well. Old style multinationals populated and continue to dominate oligopolistic natural resource based industries such as oil and aluminium. Modern multinationals thrive in fast moving Schumpetarian sectors such as pharmaceutical and electronics. A large number of empirical studies for several periods and host countries indicate a high correlation between seller concentration in a market and the flow of direct investment abroad.\(^1\) Not surprisingly therefore, a large part of the current literature on FDI has focused on firms’ decisions to set up subsidiaries abroad as an intrinsic element of the competition for market share in oligopolistic industries.

Recent theoretical models have emphasized the role of FDI as an instrument used by exporting firms to protect and improve their market share abroad in the presence of trade barriers.\(^2\) While this covers a very important and growing component of the total flow of actual FDI in the world, there is another important category of foreign investment which is motivated by the desire of firms to acquire direct control over the supply and manufacture of inputs upstream as well as disposal of their output downstream. Such vertical investment enables firms to overcome the market power exercised by enterprises located in the upstream and downstream markets.\(^3\) The effect of such vertical foreign direct investment is not to reduce the volume of trade but rather increase the volume of intra-firm trade at the cost of inter-firm trade.

Historically, international oil and mineral firms have concentrated on developing integrated vertical structures and the tendency has continued to the present day. Thus, U.S. based oil companies remain unwilling to rely upon the upstream market for the bulk of their supplies. In the electronics industry, a large number of U.S. based firms such as IBM and Texas Instruments have chosen to manufacture a considerable part of their labour-intensive component needs directly within their multinational network rather than buy from independent suppliers. In the semiconductor industry, the surge of FDI in South East Asia has largely concentrated on creating offshore assembly plants (Vernon, 1993). In general, the notable tendency among multinationals to increasingly locate various stages of production

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\(^1\)A detailed discussion is contained in Caves (1996).

\(^2\)See, among many others, Smith (1987); Horstmann and Markusen (1987); Motta (1992); Broll and Zilcha (1992) and Goldberg and Kolstad (1995) consider the case of FDI in the presence of exchange rate uncertainty.

\(^3\)They also enable firms to maintain quality of inputs, overcome uncertainties caused by information asymmetry and maintain steady supply of inputs.
in developed and developing countries that are liberalizing their trade (Markusen, 1995), attests to the importance of vertical control and vertical integration as motivations for FDI in the current world.

A fairly well established pattern that has been observed in the past few decades is that rival firms in the same market tend to be bunched in their foreign investment decisions (see Vernon, 1993). Firms are observed to “imitate” decisions of their rival firms to set up production subsidiaries in a particular region. One of the important explanations offered for this has been strategic competition between noncollusive oligopolists. In a pioneering study of FDI by 23 US multinationals over the period 1948–67, Knickerbocker (1973) found that bunching of investment and imitative behaviour increased with seller concentration up to a point and that bunching was most likely to occur in moderately concentrated industries which, in turn, are most likely to exhibit the features of a noncollusive oligopoly. Less bunching occurs in industries where product differentiation and advertisement have reduced the cut and thrust of product market oligopolistic rivalry. These conclusions have been supported by various other statistical and descriptive studies (see among others, Yu and Ito, 1988; Belderbos, 1997).

The natural question which arises from these observations is the nature of conditions under which oligopolistic rivalry leads to bunching of foreign investment decisions and the factors which influence the extent of bunching. In recent years, a number of theoretical models have been developed to study the possibility of bunching or herding in investment decisions of competing firms. In the literature on strategic FDI, the issue has been analyzed in models where FDI is undertaken by exporting firms to jump trade barriers. However, bunching of investment decisions is also observed in industries where foreign investment is geared towards creation of vertical subsidiaries undertaking production upstream or downstream.4

The purpose of this paper is to examine the strategic incentives of oligopolistic firms to undertake upstream vertical FDI and directly produce their own input requirements in the presence of an upstream market from which firms can buy their input at arm’s length prices. We are going to focus on two important factors which influence the incentive of firms to create vertical subsidiaries abroad—the level of existing concentration in the downstream market and the possibility of

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4Following the threat posed by vertical integration of the Saudi and Venezuelan state owned oil companies, U.S. based oil companies have concentrated on creating, repairing and strengthening their upstream links. In the 80’s, new upstream ties were being forged by Gulf Oil, Sun Oil, Citgo and Texaco. Vertical FDI in the semiconductor industry between 1964 and 1972 was characterized by a bunching of investment in offshore assembly plants in South East Asia, essentially driven by the aggressive moves of firms in an increasingly competitive industry to compete on costs (Yoffie, 1993). In the last decade, there has been a huge surge of investment from developing East Asian countries to Thailand and Indonesia setting up subsidiary manufacturing plants whose output is almost entirely exported (Wells, 1993).
strategic vertical foreclosure. The former determines, among other things, the difference between the arm’s length market price and the unit cost of production through a subsidiary. The latter enables firms which undertake vertical FDI to indulge in strategic manipulations of the downstream market which hurt rival firms that rely on the open market for their input needs. The particular form of vertical foreclosure we consider in this model is, in fact, the simplest one—subsidiaries can choose to purchase from the downstream market, if they so wish, thus bidding up the input price faced by rival firms.

The existing literature on vertical integration and foreclosure largely confines attention to outcomes of competition and contracting in vertical markets with a given number of vertically integrated firms. In our model, the number of vertically integrated firms is determined endogenously. This allows us to study the possibility of bunching in vertical investment as a strategic outcome. It is worth emphasizing that there are no externalities, informational or technological, between investing firms. Any complementarity in investment decisions emerges endogenously from strategic interaction in upstream and downstream markets. This distinguishes our work from most of the “macro coordination” literature where technological and/or demand complementarities are assumed to begin with in order to generate complementarity in investment.

An important factor affecting firms’ foreign investment decisions is volatility in the major currencies of the world as illustrated by the behaviour of the U.S. dollar in the 80’s and the 90’s. Such fluctuations give rise to both “level” and “risk” effects. Exchange rate movements affect the relative cost of import of intermediate goods obtained through inter-firm trade vis-a-vis intra-firm trade. This draws attention to the pricing policies of producers (exchange rate pass-through) in vertically related markets and investment decisions in response to exchange rate movements. Further, long term investment is clearly affected by the future variability of exchange rate shocks. Central to the issue, here, is the popular conjecture that the floating exchange rate regime has led to a decrease in the volume of FDI by multinational firms. This view has been repeatedly put forward by various international organizations and governments (see for example, UN-

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1In addition to these factors, the literature refers to the role of informational asymmetry and externalities as important factors which make firms invest downstream when their rivals do.

2The literature contains numerous references to threats of other kinds of vertical foreclosure as being important to the foreign investment decisions of firms e.g. cutting off or creating impediments to sources of supply through direct vertical restraints and contracts. See, among others, Rosengren and Meehan (1994) and Mullin and Mullin (1996) for recent case studies of vertical foreclosure and antitrust complaints.

3See, among others, Grossman and Hart (1986); Salinger (1988); Hart and Tirole (1990); Ordover et al. (1990); Bolton and Whinston (1991); Schrader and Martin (1995).

4See, for example, Murphy et al. (1989) and the survey by Matsuyama (1995).

5A related issue is the conjectured negative effect of exchange rate variability on international trade flows. The numerous empirical investigations into this issue have, on the whole, yielded no conclusive evidence about such relationship. Recent theoretical models have offered several explanations for this empirical ambiguity (see, for example, Dellas and Zilberfarb, 1993, and references contained therein).
The specific model we analyze is as follows. There is a given number of firms which operate in an oligopolistic downstream (or final good) market and meet their intermediate good requirements through import. These firms have the option of either investing abroad (by incurring a fixed cost) and importing their inputs through intra-firm trade at transfer prices, or of not investing and importing their input requirements at arm's length prices. In both cases, they are affected by exchange rate movements. The market for the intermediate good abroad is also an oligopoly. Firms investing upstream can bid up the input price faced by their rivals which do not invest, through strategic purchase. We assume that the market demand for the final good is linear and that production technology at both final and intermediate stages exhibit constant returns. All firms are risk-neutral expected profit maximizers. After investment decisions are made, exchange rate uncertainty is resolved and the firms strategically determine their net supply in each market they participate in.

The main result of this paper is that, for a large class of environments, the strategic incentive to invest may increase as more and more rival firms invest; in other words, vertical investment decisions may exhibit strategic complementarity. This is a consequence of strategic purchase by investing firms in order to raise the input price faced by their rivals thus magnifying the relative disadvantage of not investing. This motivation for strategic investment becomes dominant when the intermediate market is more “competitive” in terms of the number of foreign producers active in the market. In such situations, there are typically multiple equilibria: some equilibria involve many firms investing and others involve very few firms investing, sometimes, all or none. In other words, we can observe bunching in investment decisions; competing firms invest upstream because their rivals do. A small decrease in the fixed cost of investment can trigger a big jump in the volume of investment.

Another interesting result we derive is that the reduced form expected gain from investment is a strictly convex function of the uncertain exchange rate. Therefore, an increase in foreign exchange variability (more precisely, a second-order decrease in the distribution of the exchange rate) has a positive effect on vertical foreign direct investment and the flow of international trade. To the extent that strategic control of vertical production is a motive for foreign investment, our results indicate there is a theoretical basis for increased volatility of exchange rates having a positive effect on FDI. As for the effect of a change in the level of exchange rate, a depreciation of the investor’s currency increases both the effective arm’s length price at which a unit of the intermediate good can be bought in the market and the unit cost of producing the good directly through a subsidiary; however, demand for the input also changes which affects the arm’s length price. We show that the net effect is always a reduction in the incentive to undertake FDI.

The paper is organized as follows. In Section 2, we lay out the general
framework, describe the extensive form of the game as well as the solution concept. In Section 3, we derive the equilibrium in the final and intermediate good markets following any profile of investment decisions by domestic firms. In Section 4, we consider the reduced form foreign investment game where firms simultaneously decide whether or not to invest, prior to the resolution of exchange rate uncertainty, and characterize the equilibria of this game. In particular, we derive our main results about the strategic incentive to invest and analyze the effects of decline in investment barriers. In Section 5, we outline the effects of change in exchange rate level and volatility on investment. We conclude in Section 6. Appendix A contains a glossary of symbols.

2. The model

We analyze the issue of vertical foreign investment in the context of markets in two countries—which we shall call “domestic” and “foreign”. A homogenous final good is produced by $N$ firms ($N \geq 1$) in the domestic economy by using a homogenous intermediate good as input. The demand curve for the final good is linear; in particular, the inverse demand function is given by:

$$p = a - bQ, \; a > 0, \; b > 0, \; Q < (a/b)$$

$$= 0, \; Q \geq (a/b) \tag{1}$$

where $p$ denotes the price and $Q$ is the total output/quantity demanded in the final good market. We assume that the input must be imported by domestic firms from the foreign economy and that the final good is produced and consumed in the domestic market only. Further, apart from the domestic final good producers mentioned above, there are no other firms which demand the intermediate good produced in the foreign market. Assume that production of one unit of the final good requires only one unit of the imported intermediate good. There are $m^*$ existing foreign firms (indexed by $k$) which produce the intermediate good abroad at a unit foreign currency cost $c^*$. Final good firms have the option of making vertical foreign investment in order

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10This could reflect a situation where production of the input requires some foreign country specific factor which is nontradeable or, more simply, the unit cost of producing the input domestically is relatively very high (for example higher than the largest possible domestic currency cost of importing it at monopoly price from abroad).

11Allowing export of final output would make the revenue side subject to exchange rate variability; in this paper we wish to confine ourselves to the effect of exchange rate fluctuations on the import/input supply side.

12This is a simplifying assumption which is representative of the technology of trading houses, for example, but can be easily generalized to any constant factor requirement technology. Allowing for possibility of factor substitution would complicate the analysis without adding to the basic story.
to set up subsidiary units in the foreign economy which can directly produce the intermediate good for own use or for sale to other users. Let \( f > 0 \) denote the fixed cost of setting up such a subsidiary unit, measured in domestic currency. The domestic resource cost of importing the intermediate good, whether from own subsidiary or from other suppliers, depends on the exchange rate, defined as domestic price of the foreign currency and denoted by \( \hat{e} \). Final good firms face uncertainty about \( \hat{e} \) when they make vertical investment decisions. All firms are risk-neutral, maximize expected net profit and have rational expectations.

The market evolves in two stages; decisions made in the first stage being irreversible and fully observable in the second stage. First, \( N \) domestic final good firms decide simultaneously on whether or not to make vertical foreign investments in intermediate production. Once firms have decided on vertical investment, uncertainty about the exchange rate is resolved. In the second stage, firms operating in both domestic final good as well as foreign intermediate good markets make their supply decisions rationally. Producers of the intermediate good, consisting of the preexisting \( m^* \) foreign firms as well as newly set-up subsidiaries, anticipate the derived demand for the intermediate good and determine their net supply. Each of them holds Cournot conjecture about the decisions of other producers in the intermediate good market. Subsidiaries of investing firms can bid up the market price of the intermediate good by actually buying some amount of the intermediate good, even though they can produce it at a unit cost less than the market price. This has the effect of raising the input cost of rival noninvesting firms.\(^{13}\) The derived demand for intermediates from the final good market emanates entirely from noninvesting domestic firms and these firms act as price-taking buyers in the intermediate good market. The net supply decisions of the foreign firms and the subsidiaries, together with the derived demand function, determine the market price for the intermediate good. This price is anticipated by firms in the final good market where, again, each firm determines its final output holding Cournot conjecture about the behaviour of the other firms in the same market. Firms from each country evaluate their net profit in terms of their own currency. A final good firm which invests and its subsidiary maximize the sum of their profits in both markets (evaluated in domestic currency).

We solve the model by backward induction. First, we consider the final and intermediate good markets and determine the equilibrium in these markets for any given profile of investment decisions and for any specific realization of the exchange rate. This allows us to determine the expected net profit for each final good firm corresponding to any profile of investment decisions across the \( N \) firms. Next, we consider the reduced form game where each firm decides whether or not to make vertical foreign investment; the payoff to each firm is its expected profit.

\(^{13}\)The literature on vertical foreclosure contains models where such input cost raising is pursued by oligopolistic vertically integrated downstream firms (see Salop and Scheffman, 1983, 1987; Schrader and Martin, 1995).
net of any fixed cost of investment. The Nash equilibrium of this reduced form game determines the solution of the model; in particular, the number of investing firms.

Suppose that firms have made their vertical investment decisions and that a particular value of \( \tilde{e} \) is realized. Let \( m \) denote the number of final good firms (indexed by \( i \)) which invest, \( 0 \leq m \leq N \). Thus there are \((N-m)\) noninvesting firms (indexed by \( j \)). In the next section, we work out the market equilibrium for each value of \( m = 0, 1, ..., N \) and each possible realization of \( \tilde{e} \).

3. Equilibrium in goods markets

Let \( e \) denote a specific realization of \( \tilde{e} \). Fix \( e \) and \( m \). We now proceed to derive the equilibrium outcome in stage 2. Let \( q_i \) and \( r_j \) be respectively (investing) firm \( i \)'s and (noninvesting) firm \( j \)'s final good production, so that:

\[
\sum_{i=1}^{m} q_i + \sum_{j=1}^{N-m} r_j = Q
\]

Let \( p^* \) denote the anticipated market price of the intermediate good in foreign currency. The anticipated profit (in domestic currency) of a final good firm \( j \) which produces output \( r_j \), is given by:

\[
\Pi_j = r_j(a - bQ - ep^*) \quad j = 1, 2, ..., N - m
\]  

(2)

On the other hand, an investing firm \( i \) has to take into account its revenues and costs in both the final and the intermediate good markets. As stated in the previous section, such a firm and its subsidiary have identical objective functions. Let \( x_i \) denote the net purchase of the intermediate good by a subsidiary of firm \( i \). Its anticipated domestic currency profit from combined participation in the downstream and upstream markets is given by:

\[
\Pi_i = q_i(a - bQ - ec^*) - x_i(ep^* - ec^*) \quad i = 1, 2, ..., m; \ m \geq 1
\]  

(3)

When \( x_i \) is positive, the subsidiary of firm \( i \) actually buys a strictly positive amount of the intermediate good in the foreign market. Then, out of the total input need \( q_i \), which is imported from its subsidiary, a quantity \((q_i - x_i)\geq0\) is internally produced by the subsidiary (and imported at transfer price \( ec^* \) in terms of domestic currency), while an amount \( x_i \) is bought by the subsidiary from the intermediate good market at price \( p^* \) (imported at arm’s length price \( ep^* \) in terms of domestic currency). Being a net buyer of the intermediate good, the investing firm (or, equivalently, its subsidiary) earns a negative profit upstream in order to

\footnote{It can be checked that \( x_i \) never exceeds \( q_i \) in equilibrium.}
gain strategic advantage by pushing up the market price of the intermediate good faced by its noninvesting rivals. When \( x_i \) is negative, firm \( i \)'s subsidiary actually sells on the intermediate good market and its total production is \( (q_i - x_i) > q_i \).

Lastly, a foreign intermediate good firm \( k \) produces output \( q_k^* \) which leads to anticipated profit (in foreign currency):

\[
\Pi_k^* = q_k^* [p^* - c^*], \quad k = 1,...,m^*
\]

The expressions (2)--(4) define the profit for each type of firm.

In the final good market, firms \( i \) and \( j \) simultaneously choose \( q_i \) and \( r_j \) (for given anticipated \( p^* \)). Imposing symmetry within each group of domestic firms (\( q_i = q, \forall i; r_j = r, \forall j \)), we obtain the Cournot–Nash equilibrium:

\[
q = \frac{1}{b(N + 1)} \left[ a - ec^* + (N - m)(ep^* - ec^*) \right]
\]

\[
r = \frac{1}{b(N + 1)} \left[ a - ec^* - (m + 1)(ep^* - ec^*) \right]
\]

with final good price:

\[
p = \frac{1}{(N + 1)} (a + (N - m)ep^* + mec^*)
\]

It is clear from (7) that an increase in \( m \) is always associated with a decrease in \( p \) and, hence, from (1) with an increase in \( Q \). This is because, as more firms invest upstream, these final good firms are able to produce their output at lower marginal cost. As in other standard Cournot competition models (Dornbusch, 1987), the decline in the weighted marginal cost of production across the industry is passed on to consumers in the form of lower price, greater consumption and increased consumer surplus. Increase in the final good output implies a direct increase in the volume of international trade of the intermediate good.\(^{15}\) Profits are given by:

\[
\Pi_i = bq^2 - x_i(ep^* - ec^*)
\]

\[
\Pi_j = br^2
\]

Now, consider the intermediate good market abroad. As assumed earlier, the market demand for intermediate good is generated by noninvesting firms, which act as price-taking buyers in this market. Premultiplying (6) by \((N - m)\), we can

\(^{15}\)Vertical foreign investment also changes the composition of trade. Trade in the intermediate good is equal to \( Q = m(q - x) + (m + (N - m)r) \) for \( x \geq 0 \); it is equal to \( Q = mq + (N - m)r \) for \( x < 0 \). In both expressions, the first term reflects intra-firm trade, the second arm's length trade. Hence, besides increasing \( Q \), an increase in \( m \) increases the proportion of the former at the expense of the latter.
obtain the total derived demand for the intermediate good. The inverse demand for the intermediate good is then given by:

\[ p^* = c^* + \frac{1}{e(m + 1)} \left[ a - ec^* - \frac{b(N + 1)Q^*}{(N - m)} \right] \]  

where \( Q^* \) is the total quantity of the intermediate good demanded. Given this, foreign producers of intermediates and investing domestic firms simultaneously choose their actions: foreign firms choose the quantity \( q_k^* \) they wish to supply and the subsidiaries of investing firms decide on \( x_i \). The total output available for satisfaction of intermediate good demand (by noninvesting final good firms) is:

\[ Q^* = \sum_{k=1}^{m} q_k^* - \sum_{i=1}^{m} x_i \]  

A foreign producer \( k \) sets \( q_k^* \) so as to maximize its foreign currency profit given by (4), while the subsidiary of investing firm \( i \) sets \( x_i \) so as to maximize its reduced form profit given by (3). Using (10) and (11), the best response of firm \( k \) satisfies:

\[ a - ec^* + \frac{b(N + 1)}{(N - m)} (mx - (m + 1)q^*) = 0 \]  

where symmetry is imposed (\( q_k^* = q^*, \forall k; x_i = x, \forall i \)). From (9), (10) and (11), we can calculate the net reduced profit of firm \( i \) from any choice of \( x_i \). The best response for firm \( i \) satisfies (imposing symmetry of actions chosen):

\[ \left[ \frac{2}{(m + 1)} (a - ec^* + bm^* q^*) \right] \\
- \left[ a - ec^* + \frac{b(N + 1)}{(N - m)} (m + 1)x - m^*q^* \right] = 0 \]  

The first expression in square brackets represents the marginal effect on firm \( i \)'s profits derived from the sales of the final good as a result of raising rivals’ costs. The symmetric best response \( x \) must be such that this marginal gain is just offset by the additional resources lost in buying the intermediate good at a higher price \( p^* \) (compared to its own constant marginal cost \( c^* \)). The Nash equilibrium values of \( x \) and \( q \) are readily obtained from (12) and (13):

\[ q^* = \alpha(m)(a - ec^*) \]  

\[ x = \beta(m)(a - ec^*) \]  

and total output \( Q^* \) available for noninvesting firms is given by:

\[ Q^* = m^*q^* - mx = (N - m)r = \gamma(m)(a - ec^*) \]  

where the terms \( \alpha(m), \beta(m) \) and \( \gamma(m) \) are given by:
\[
\alpha(m) = \frac{(N-m)(N+2m+1)(m+1)}{b(N+1)[(m+1)^2 + (N-m)(m^2 + 1) + (m+1)^2 + (N-m)(m+1)]m^*}
\]

\[
\beta(m) = \frac{\alpha(m)b m^*[m+1] + (N-m)(m-1) - (N-m)(m-1)}{b[(m+1)^2 + (N-m)(m^2 + 1)]}
\]

\[
\gamma(m) = m^* \alpha(m) - m\beta(m)
\]

for \(m=0, 1, \ldots, N-1\). Note that \(\alpha(m), \beta(m)\) and \(\gamma(m)\) are independent of \(e\). It can be checked that \(\alpha(m)\) and \(\gamma(m)\) are strictly positive for all values of \(m<N\), while \(\beta(m)\) can be positive or negative which suggests that \(x\) may take positive or negative values in equilibrium. If all firms invest that is, \(m=N\), the intermediate good market disappears. We then set \(\alpha(N) = \beta(N) = \gamma(N) = 0\) and the game reduces to a \(N\)-firm symmetric Cournot game where the marginal cost of each firm is given by \(\hat{ec^*}\). From (10) and (16):

\[
ep^* = ec^* + \frac{1}{m+1} \left[ 1 - \frac{(N+1)b \gamma(m)}{(N-m)} \right] (a - ec^*) \geq 0
\]

Using (6), (9) and (17), the profit of firm \(j\) from the reduced form game in the second stage (with \(m\) investing firms and given \(e\)) is:

\[
\Pi_j(m|e) = \frac{(\gamma(m))^2}{(N-m)^2} (a - ec^*)^2 > 0
\]

Using (5), (8), (15) and (17), the reduced form profit of firm \(i\) is:

\[
\Pi_i(m|e) = \Omega(m) (a - ec^*)^2 > 0
\]

where \(\Omega(m)\) is given by:

\[
\Omega(m) = \left[ \frac{1}{b(m+1)} \right] \left[ \frac{(1 - b \gamma(m))^2}{(m+1)} - b \beta(m) \left( 1 - \frac{b \gamma(m)(N+1)}{(N-m)} \right) \right]
\]

for \(m = 1, \ldots, N\). Note that \(\Omega(m)\) is independent of \(e\) and it can be checked that \(\Omega(m)\) is strictly positive. If \(m=0\) that is, no firm invests, then the profit of an investing firm is not defined. This completes our derivation of the equilibrium in stage 2.

Before concluding this section, we wish to make certain points about the extent of exchange rate pass-through in our model, in particular, about the effect of exchange rate movement on the domestic currency price of intermediate goods \(ep^*\), as well as the final good price \(p\). Taking the partial derivative of (17) with respect to \(e\) and multiplying by \((e/ep^*)\) gives the elasticity of \(ep^*\) with respect to \(e\):
Similarly, substituting (17) into (7) we can derive the elasticity of $p$ with respect to $e$:

$$
\eta_1 = \frac{c^*}{p^*} \left[ 1 - \frac{1}{(m + 1)} + \frac{b(N + 1)\gamma(m)}{(m + 1)(N - m)} \right]
$$

The above expressions indicate that there are three main determinants of the pass-through coefficients: the relative number of investing firms, the number of foreign producers of the intermediate good and the ratio of actual marginal cost to price. Of course, both $p$ and $p^*$ are endogenously determined in the model and so the elasticity captures local response of the equilibrium values to exchange rate changes. As the expressions turn out to be large, we solve numerically for the two elasticities for different values of $m$ and $m^*$, while fixing the other parameters. Figs. 1 and 2 plot the relationship between $m$ and the pass-through elasticities, for alternative values of $m^*$ when $N=10$, $a=100$, $b=1$, $c^*=1$ and $\bar{e}$ is taken to be deterministic with value equal to 1. We observe that given $m^*$, as $m$ increases (for
example, in response to a reduction in $f$ as discussed below) the pass-through elasticities increase as the input market becomes increasingly competitive. Similarly, increase in $m^*$ also increases the pass-through elasticities. It is worth noting that the absolute values of pass-through elasticities are quite small. To see why, let us go through the following sequential reasoning. An increase in $e$ leads to an increase in the realized cost structure of final good producers which in turn, depresses the derived demand for the intermediate good by noninvesting firms. The latter has a depressing effect on the intermediate good price so that the net effect on $e p^*$ of a movement in $e$ tends to be small. This also means that the net effect on final good price $p$ is small.

4. Equilibrium of reduced form investment game

In this section, we analyze the strategic foreign investment decisions of the $N$ final good firms, where the payoff from each profile of investment decisions is the expected profit from stage 2 equilibrium, as derived in the previous section, net of investment cost. At the point of time in which the $N$ domestic final good firms make their investment decisions, exchange rate uncertainty is not yet resolved.
Suppose that \( \tilde{m} \) \((0 \leq \tilde{m} < N)\) firms invest. Then, using (19), the payoff to the investing firms \( i = 1, 2,...,\tilde{m} \) denoted by \( R_i(\tilde{m}) \) is given by:

\[
R_i(\tilde{m}) = E\Pi(\tilde{m}|\tilde{e}) - f = \Omega(\tilde{m})E[(a - \tilde{e}c^*)^2] - f \tag{20}
\]

where \( E \) is the expectation operator with respect to the uncertainty caused by exchange rate \( \tilde{e} \). Using (18), the payoff to a noninvesting firm \( j = 1, 2,...,N-\tilde{m} \), denoted by \( R_j(\tilde{m}) \), is given by:

\[
R_j(\tilde{m}) = E\Pi(\tilde{m}|\tilde{e}) = \frac{(\gamma(\tilde{m}))^2}{(N-\tilde{m})^2}E[(a - \tilde{e}c^*)^2] \tag{21}
\]

If \( \tilde{m} = N \), that is, all firms invest, then the payoff to each firm \( i \) is also obtained from (20). If \( \tilde{m} = 0 \), that is, no firm invests, the payoff to each firm \( j \) is given by (21).

A Nash equilibrium of this game where exactly \( \tilde{m} \) firms, \( \tilde{m} = 1, 2,...,N-1 \), undertake foreign investment exists if and only if, given the investment decisions of other firms, two conditions hold:

(a) a firm which invests cannot gain by deviating, that is, not investing (in which case there would be only \( \tilde{m} - 1 \) investing firms):

\[
R_i(\tilde{m}) \geq R_i(\tilde{m} - 1) \tag{22}
\]

(b) a firm which does not invest cannot gain by deviating, that is, by undertaking to invest (in which case there would be \( \tilde{m} + 1 \) investing firms):

\[
R_j(\tilde{m}) \geq R_j(\tilde{m} + 1) \tag{23}
\]

An equilibrium where all \( N \) firms invest exists if and only if (22) holds at \( \tilde{m} = N \). An equilibrium where no firm invests exists if and only if (23) holds at \( \tilde{m} = 0 \).

For \( m = 0, 1,...,N-1 \), let \( \phi(m) \) denote the “gain from investment” that is, the increase in expected profit (gross of the fixed cost of investment) of a firm which changes its decision from “no investment” to “investment”, in a situation where there are exactly \( m \) other investing firms. More formally:

\[
\phi(m) = E(\Pi(m+1|\tilde{e})) - E(\Pi(m|\tilde{e})) \tag{24}
\]

which, using (18) and (19), implies:

\[
\phi(m) = \left[ \Omega(m+1) - \frac{(\gamma(m))^2}{(N-m)^2} \right] E[(a - \tilde{e}c^*)^2] \tag{25}
\]

It can be verified that \( \phi(m) \) is strictly positive for \( m = 0, 1,...,N-1 \). The necessary and sufficient conditions (22) and (23) for Nash equilibrium can now be rewritten in terms of a relation between the gain from investment \( \phi(m) \) and the fixed cost of investment \( f \):
Proposition 1. In a Nash equilibrium of the reduced form investment game, exactly \( m \) firms, \( m = 1, 2, \ldots, N - 1 \), undertake foreign investment if and only if:

\[
\phi(m) \leq f \leq \phi(m - 1)
\]  

(26)

There exists an equilibrium where all firms invest (\( m = N \)) if and only if:

\[
f \leq \phi(N - 1)
\]

(27)

There exists an equilibrium where no firm invests (\( m = 0 \)) if and only if:

\[
f \geq \phi(0)
\]

(28)

In our model, the number of firms which invest in equilibrium reflects the flow of vertical foreign investment. The fixed cost of investment, in part, reflects barriers to foreign direct investment.

It is of interest to see how one can characterize the flow of foreign investment as a function of the level of fixed cost \( f \), given the function \( \phi(m) \). Note that if \( \phi(m - 1) < \phi(m) \) for some \( m \), then (26) cannot hold at \( m = m \), for any level of \( f \). This means that there is no equilibrium with exactly \( m \) firms investing. In such situation, what can we say about the amount of investment if we know that \( f \) exceeds or lies below \( \phi(m) \) for a certain \( m \)? The following result is useful in this context:

Proposition 2. (i) For \( m = 1, 2, \ldots, N \), if \( f \geq \phi(m - 1) \), then there exists at least one equilibrium where strictly less than \( m \) firms invest;

(ii) For, \( m = 0, 1, 2, \ldots, N - 1 \), if \( f \leq \phi(m) \), then there exists at least one equilibrium where strictly greater than \( m \) firms invest.

Proof: (i) If \( f \geq \phi(0) = \phi(1 - 1) \), then \( m = 0 \) is an equilibrium which proves the proposition. So consider the case where \( f < \phi(0) \) and suppose that, contrary to the proposition, there is no equilibrium with \( m = 0, 1, 2, \ldots, m - 1 \). Using Proposition 1, as (26) does not hold for \( m = 1, 2, \ldots, m - 1 \), one can show by induction (starting from \( f < \phi(0) \)), that \( f < \phi(m - 1) \), \( m = 1, 2, \ldots, m \) which, in particular, implies that \( f < \phi(m - 1) \), a contradiction.

(ii) If \( f \leq \phi(N - 1) \), then \( m = N \) is an equilibrium which proves the proposition. So consider the case where \( \phi(N - 1) < f \leq \phi(m) \) for some \( m < N - 1 \) and suppose that, contrary to the proposition, there is no equilibrium with \( m = m + 1, m + 2, \ldots, N \). Using Proposition 1, as (26) does not hold for \( m = m + 1, \ldots, N \), it follows by induction (start from \( f > \phi(N - 1) \)), that \( f > \phi(m) \), \( m = N - 1, N - 2, \ldots, m \), a contradiction.

The intuition behind Proposition 2 is simple. As we have said earlier, \( \phi(m - 1) \), \( m = 1, 2, \ldots, N \), reflects the additional gain from becoming an investor when \( (m - 1) \) firms are already investing. If \( f \) exceeds this additional gain, it appears reasonable
that in equilibrium less than \( m \) firms should be investing. On the other hand, if \( f \)
falls below this level, more than \((m-1)\) firms should be investing. It therefore
stands to reason that as the barriers to investment go down, the flow of investment
should increase. One has to be a bit careful in stating this however, as equilibrium
is not necessarily unique. For \( f > 0 \), let \( M(f) \) be the set defined by:

\[
M(f) = \{ \tilde{m} : \text{\tilde{m} firms undertaking foreign investment is an equilibrium, given } f \}
\]

**Proposition 3.** If \( f_1 < f_2 \), then

(i) if \( m_1 \in M(f_1) \), then there exists \( m_2 \in M(f_2) \) such that \( m_2 \leq m_1 \);

(ii) if \( m_2 \in M(f_2) \), then there exists \( m_1 \in M(f_1) \) such that \( m_1 \geq m_2 \);

**Proof.** (i) If \( m_1 = N \), then the statement holds by definition. So consider the case
where \( m_1 < N \). From Proposition 1, (26) and (28) imply that \( f_2 \geq f_1 \geq \phi(m_1) \). Using
Proposition 2, we obtain that there exists at least one equilibrium at \( f = f_2 \), where
less than \( m_1 \) firms invest.

(ii) If \( m_2 = 0 \), the statement holds by definition. So consider the case where
\( m_2 > 0 \). From Proposition (1), (26) and (27), it follows that \( f_1 < f_2 \leq \phi(m_2 - 1) \).
Using Proposition 2, \( f_1 < \phi(m_2 - 1) \) implies that there exists at least one equilib-
rium at \( f = f_1 \), where more than \( m_2 \) firms invest.

One of the implications of Proposition 3 is that the maximum and the minimum
number of firms which invest in equilibrium at any level of \( f \), decreases as \( f \)
increases. Further, if equilibrium is unique at \( f_1 \) and \( f_2 \), the number of firms
investing at \( f_1 \) is always at least as large as the number of firms investing at \( f_2 \); for
values of \( f \) close to certain critical values, an increase in \( f \) can lead to a strict
decline in the number of firms investing.

Consider the behaviour of the function \( \phi(m) \). Suppose that the function \( \phi \) is
decreasing over integer values of \( m \) going from 0 to \((N-1)\), that is

\[
\phi(0) \geq \phi(1) \geq \ldots \geq \phi(N-1)
\]

As more and more other firms invest, the additional gain from becoming an
investor, decreases. In this case, the correspondence \( M(f) \) is very well behaved.
The range of possible values of \( f \) can be divided into a finite chain of intervals \{[0, \phi(N-1)], [\phi(N-1), \phi(N-2)], \ldots, [\phi(1), \phi(0)], [\phi(0), \infty)\}, nonintersecting except
at end points. The equilibrium number of firms is unique in the interior of each interval.
As the value of \( f \) moves from a higher to a consecutive lower interval, the
number of firms investing in Nash equilibrium goes up by exactly one.

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Note that in this case, for any \( \tilde{m} = 0, 1, \ldots, N \), there is always a nonempty interval such that if \( f \)
lies in this interval, it is an equilibrium for exactly \( \tilde{m} \) firms to invest. This is not necessarily so if \( \phi \) is
not decreasing in \( m \).
However, \( \phi(m) \) is not necessarily decreasing; it can also be increasing in \( m \) over a subset of the possible values of \( m \). The behaviour of \( \phi(m) \) depends on the expected profit from the product market accruing to investors and noninvestors corresponding to various configurations of investment. If \( \phi(m) \) is monotonic decreasing as in (29), then the market profits are such that investment by firms are strategic substitutes; more other firms invest, the less worthwhile it is for a noninvestor to invest. This is actually something one would normally expect. On the other hand, \( \phi(m) \) increasing over a range of values of \( m \) implies that there is strategic complementarity between investment decisions of firms. As the number of firms which invest goes up, there might actually be greater incentive for a noninvestor to become an investor. The reason behind this is that the strategic actions of the investing firms in the upstream market designed to raise the intermediate good price might become more damaging as the number of investing firms increases, so that the relative disadvantage of being a noninvestor increases.17

There are two interesting features of foreign investment flows that can occur as a consequence of strategic complementarity of investment that is, of \( \phi \) increasing in \( m \). The first feature is that there can be a relatively large increase in the amount of foreign investment when \( \phi \) falls just below a critical level. To see this, suppose \( \phi \) exhibits the following nonmonotonic behaviour:

\[
\phi(N - 1) < \phi(N - 2) < \ldots < \phi(m) < \phi(m - 1) > \phi(m - 2) > \cdots > \phi(0) \quad (30)
\]

For \( f > \phi(m - 1) \), the only equilibrium is that no firm invests. However, if \( f \) is reduced to a level just below \( \phi(m - 1) \), there is an equilibrium where the number of firms investing is \( m \) which implies a jump in the flow of foreign investment, the size of the jump depending on how large \( m \) is. The second interesting consequence of strategic complementarity is the possibility of multiple equilibria. In the situation described by (30), one can easily check (using Proposition 1) that for \( f \in [\phi(0), \phi(m - 1)] \), there are two equilibria, one in which no firm invests and the other in which at least \( m \) firms invest. The fact that there can be multiple equilibria, some with large investment flows and others with little or none, brings out the importance of coordination devices as an instrument of securing a boost in foreign direct investment. This also illustrates the so-called bandwagon effect or herding in investment behaviour; firms invest when many others decide to do so, but would rather refrain from investing otherwise. If investment decisions exhibit strategic complementarity globally that is, the function \( \phi(m) \) is always increasing in \( m \): 

\[
\phi(0) \leq \phi(1) \leq \ldots \leq \phi(N - 1) \quad (31)
\]

then we have an extreme form of herding. There are just two possible equilibrium

\footnote{If our model is modified such that investing firms are not allowed to make strategic purchase upstream in order to raise noninvesting rivals’ costs, that is, we put an exogenous constraint \( x_i \leq 0 \), then it can be shown that \( \phi(m) \) is always decreasing in \( m \).}
outcomes viz., either all firms invest or no firm invests. For \( f > \phi(0) \), the only outcome is that no firm invests whereas for \( f \leq \phi(0) \), \( \tilde{m} = 0 \) and \( \tilde{m} = N \) are the two equilibrium outcomes. This implies that as \( f \) just falls below \( \phi(0) \), there can be a really big jump in investment. However, there is a coordination problem. Firms will invest only if they think all their rivals will do so.

Figs. 3–5 illustrate the function \( \phi(m) \) for different parameter configurations. In all three figures \( N = 10, a = 100, b = 1, c^* = 1 \) and \( \tilde{e} \) is taken to be deterministic with value equal to 1. Fig. 3 depicts the situation when \( m^* = 5 \). Here \( \phi(m) \) is decreasing in \( m \) everywhere as in (29) and investment decisions are strategic substitutes. Fig. 4 depicts the case where \( m^* = 23 \). In this case, \( \phi(m) \) is increasing for small values of \( m \) and decreasing thereafter, as in (30). Fig. 5 depicts the situation where \( m^* = 30 \). In this case, \( \phi(m) \) is strictly increasing in \( m \) everywhere so that investment decisions are strategic complements globally.

For the case where \( N = 2 \), it is easy to verify that \( \phi(0) \leq \phi(1) \) i.e. the situation depicted in (31) obtains for any configuration of parameter values if \( m^* > 4 \), while at \( m^* = 1 \), it is always the case that \( \phi(0) \geq \phi(1) \) i.e. the situation depicted in (29) obtains. The general conclusion obtained by plotting the function \( \phi(m) \) for various alternative parameter configurations is that, other things being equal, for low values of \( m^* \) investment decisions are strategic substitutes while for \( m^* \) large enough, they are strategic complements.

Thus, the extent to which firms may engage in foreign investment hinges on a
Fig. 4. Investment decisions exhibit strategic complementarity when \( m \) is small: \( \phi(m) \) is initially increasing in \( m \).

crucial factor: the degree of concentration in the intermediate good market. Low concentration in this market leads to a conventional result viz., the larger the number of final good firms which invest abroad vertically, the less is the incentive for an individual firm to undertake foreign investment. On the other hand, with a high level of concentration in the foreign intermediate good market, an increase in the number of final good firms undertaking investment can increase the incentive to invest abroad for an individual firm leading to herding in investment decisions, multiple equilibria and a positive role for coordination activities. The reason is that when the number of foreign producers in the intermediate good market is small, the market price is relatively high. This implies that not many producers of the final good will purchase inputs from the market and those that do, will produce a relatively smaller output as they will have a relatively high marginal cost compared to investing firms. Then, a final good firm’s incentive to “raise rivals cost” by strategic purchase is likely to be very low and the incremental gain from investing comes mostly from the conventional cost reducing aspect i.e., purchasing input at lower “marginal price”. The more the number of rival firms which invest, the lower is the increase in profit from the final good market achieved through the lower cost resulting from investment. On the other hand, when there is a very large number of foreign producers in the intermediate good market, the equilibrium market price of the intermediate good tends to be low which means a lot of final
good firms will find it attractive to rely on the market to procure the intermediate good. This, in turn, means that strategic purchase by investing firms can have a significantly large effect on their Cournot profit by raising the rivals’ costs and as the market price of the intermediate good is low, it is not very costly to indulge in such strategic purchase. This means that a significant part of the gain from incremental investment comes from the ability to raise rivals cost which it confers on investing firms. The more the number of noninvesting final good firms, the greater is the effect of strategic purchase designed to raise their cost in the final good market and hence, the greater the increase in profit resulting from investment by an individual final good firm.  

5. Effect of change in exchange rate

The expected profits of final good firms resulting from any given investment profile (contained in (20) and (21)) depend on the random exchange rate. We have assumed that firms are ex ante risk neutral, that is, maximize expected profits. The expression for expected profit (gross of the fixed cost of investment) of any final good firm, whether or not the firm invests, is multiplicatively separable into two

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\( \text{We thank an anonymous referee for this explanation.} \)
terms—one of which is positive and independent of $\tilde{e}$ and the other is $E[(a - \tilde{e}c^*)^2]$. Observe that $[(a - \tilde{e}c^*)^2]$ is a strictly convex function of $\tilde{e}$. Therefore, $E[(a - \tilde{e}c^*)^2]$, and hence the expected profit, increases whenever, ceteris paribus, there is a second-order stochastic decrease (for example, an increase in the mean-preserving spread) of the distribution of the exchange rate. A second order stochastic decrease is equivalent to an increase in risk (see Rothschild and Stiglitz, 1970). It follows that if the forward exchange rate market is unbiased (forward rate is equal to the expected value of $\tilde{e}$), final good firms will prefer not to hedge against the exchange rate risk. To summarize:

**Proposition 4.** Given any profile of investment decisions, an increase in exchange rate risk (a second order decrease in the distribution of exchange rate) leads to an increase in the expected profit for both investing as well as noninvesting domestic firms. If a forward market exists and is unbiased, final good firms will not hedge against the exchange rate risk.

The basic intuition behind Proposition 4 is that with an increase in the spread of the exchange rate, the profitability of production increases when there is a favourable realization of the exchange rate and this increase is stronger than the decrease in profitability in case of relatively unfavourable realizations of the exchange rate.

Now, an increase in exchange rate variability increases the expected net profit of both investing as well as noninvesting firms. Therefore, it is not immediately clear what the net effect on the equilibrium investment profile is. Obviously, the relevant consideration here is the gain in expected profit when a noninvestor becomes an investor, which means that we should be looking at the effect of increase in exchange rate risk on the function $\phi(m)$. To look at $\phi$ as a function of both $m$ and $\tilde{e}$, we can rewrite (25):

$$\phi(m, \tilde{e}) = \left[ O(m + 1) - \frac{(\gamma(m))^2}{(N - m)^2} \right] E[(a - \tilde{e}c^*)^2]$$

(32)

Note that exchange rate uncertainty enters the gain from investment only through the term $E[(a - \tilde{e}c^*)^2]$. As the expression enclosed in square brackets in (32) is strictly positive, for any $m < N$ the gain from undertaking foreign investment $\phi(m)$ increases with any increase in exchange rate variability.\(^9\) More specifically, consider two possible exchange rate situations and let $\tilde{e}_h$ denote the random

\(^9\)In a model of hysteresis involving entry and exit costs by final goods producers, Dixit (1989) has shown the existence of a zone of inaction by firms and that this zone is increasing with the degree of exchange rate uncertainty. In our model, despite the absence of exit sunk costs, exchange rate uncertainty increases both the gain from investment (see (32)) and the interval of inaction defined by (26).
exchange rate in these situations \((h=1, 2)\). Assume that the distribution of the exchange rate in situation 1 has a second-order stochastic dominance over that in situation 2. Situation 2 is one of greater exchange rate risk. Then,

\[
\phi(m, \tilde{\epsilon}) \leq \phi(m, \tilde{\epsilon}_2), \quad m = 0, 1, ..., N - 1.
\] (33)

It follows intuitively that the equilibrium number of firms investing in situation 2 should be at least as large as that in situation 1, for any given level of \(f\). As our model contains possibility of multiple equilibria, the exact sense in which the equilibrium number of firms goes up must be carefully specified. Recall that we used the notation \(M(f)\) to denote the set of equilibrium outcomes (in terms of the number of firms that undertake investment) when fixed cost of investment equals \(f\). To bring in the effect of exchange rate variability, let us now denote it by \(M(f, \tilde{\epsilon})\). We want to see how, for any given \(f\), the sets \(M(f, \tilde{\epsilon}_1)\) and \(M(f, \tilde{\epsilon}_2)\) compare.

**Proposition 5.** Suppose \(\tilde{\epsilon}_1\) has a second order stochastic dominance over \(\tilde{\epsilon}_2\). Then,

(i) for any \(\mu_1 \in M(f, \tilde{\epsilon}_1)\), there exists \(\mu_2 \in M(f, \tilde{\epsilon}_2)\) such that \(\mu_2 \geq \mu_1\); 
(ii) for any \(\mu_2 \in M(f, \tilde{\epsilon}_2)\), there exists \(\mu_1 \in M(f, \tilde{\epsilon}_1)\) such that \(\mu_2 \geq \mu_1\).

**Proof.** (i) Suppose \(\mu_1 \in M(f, \tilde{\epsilon}_1)\). If \(\mu_1 = 0\), then it is clear that there must be some \(\mu_2 \in M(f, \tilde{\epsilon}_2)\), such that \(\mu_2 \geq \mu_1\). If \(\mu_1 > 0\), then it follows from (26) and (27) that:

\[
f \leq \phi(\mu_1 - 1, \tilde{\epsilon}_1)
\]
(34)

which, using (33), implies that

\[
f \leq \phi(\mu_1 - 1, \tilde{\epsilon}_2)
\]
(35)

Proposition 2 implies then that there exists an equilibrium in situation 2 where at least \(\mu_1\) firms invest. (ii) Suppose \(\mu_2 \in M(f, \tilde{\epsilon}_2)\). If \(\mu_2 = N\), then it is clear that there must be some \(\mu_1 \in M(f, \tilde{\epsilon}_1)\), such that \(\mu_2 \geq \mu_1\). If \(\mu_2 < N\), then it follows from (26) and (27) that:

\[
f \geq \phi(\mu_2 - 1, \tilde{\epsilon}_2)
\]
(36)

which, using (33), implies that

\[
f \geq \phi(\mu_2 - 1, \tilde{\epsilon}_1)
\]
(37)

Proposition 2 implies that there is an equilibrium in situation 1 where less than \(\mu_2\) firms invest.

One of the implications of Proposition 5 is that for any given \(f\), both the maximum as well as the minimum number of firms which invest in equilibrium is nondecreasing in exchange rate risk.
If $\tilde{e}_1$ has a strict second order dominance over $\tilde{e}_2$, then (using the fact that $(a-\tilde{e}e)^2$ is strictly convex in $\tilde{e}$) from (32):

$$\phi(m, \tilde{e}_1) < \phi(m, \tilde{e}_2), \quad m = 0, 1, \ldots, N - 1$$  \hspace{1cm} (38)

This implies that, compared to situation 1, there is a strictly greater incentive to invest in situation 2 in terms of the additional gain from investment at any given level of $m$. It is intuitive, therefore, that for certain intervals of values of $f$, there will be strictly greater foreign investment under situation 2.

**Proposition 6.** Suppose $\tilde{e}_1$ has a strict second order stochastic dominance over $\tilde{e}_2$. Then, for $m = 0, 1, 2, \ldots, N-1$ and $f \in \{\phi(m, \tilde{e}_1), \phi(m, \tilde{e}_2)\}$, there always exist $\mu_1, \mu_2$ where $\mu_1 \leq m < \mu_2$, $\mu_1 \in M(f, \tilde{e}_1)$ and $\mu_2 \in M(f, \tilde{e}_2)$, that is, one can always select a pair of equilibria, one for each exchange rate situation, such that not more than $m$ firms invest in the equilibrium in situation 1 and strictly greater than $m$ firms invest in the equilibrium pertaining to situation 2.

**Proof.** Consider $m < N$ and $f \in \{\phi(m, \tilde{e}_1), \phi(m, \tilde{e}_2)\}$. From Proposition 2, we can see that as $f \geq \phi(m, \tilde{e}_1) = \phi(m+1, \tilde{e}_1)$, there exists an equilibrium at fixed cost level $f$ in situation 1 where strictly less than $m+1$ firms invest. Thus there exists $\mu_1 \in M(f, \tilde{e}_1)$ where $\mu_1 \leq m$. Similarly, as $f \leq \phi(m, \tilde{e}_2)$, from Proposition 2 we have that there exists $\mu_2 \in M(f, \tilde{e}_2)$ where $\mu_2 > m$. \hspace{1cm} \Box

Proposition 5 states that an increase in exchange rate volatility does not decrease the total volume of vertical foreign investment. Proposition 6 indicates that for certain intervals of values for the level of fixed cost, there is a strict increase in the level of foreign investment following a strict increase in exchange rate risk. Using (7), one can observe that an increase in exchange rate variability by affecting $m$ positively leads to a fall in expected domestic final good price $p$ and as a resultant an increase in the total output sold in the final good market which, in our model, is exactly the total volume of trade. While domestic consumer surplus is positively affected as a result, the effect on net social surplus is ambiguous as it is influenced (somewhat arbitrarily) by the level of fixed cost of investment.

The empirical literature has provided mixed answers concerning the link between exchange rate uncertainty and direct investment. While a large class of empirical studies have dealt with horizontal direct investment, their results are not fully comparable to those of Propositions 5 and 6 derived in the context of vertical investment. In a direct test of the model by Dixit (1989), Campa (1993) finds exchange rate volatility to be negatively correlated with entry events that occurred in 61 U.S. wholesale industries. In a different context, Goldberg and Kolstad (1995) show that the effect of short-term exchange rate volatility is to increase the share of production activity that is located offshore. Empirical work concerning exchange rate uncertainty and vertical direct investment is rare. An exception is
case III of Cushman (1985) that assumes, as in our paper, the use of an intermediate good which is imported from a foreign subsidiary. The results support the hypothesis that increases in exchange rate risk consistently raise direct investment. In addition, Cushman found that foreign subsidiaries have also increased exports of intermediates to the home country.

5.1. Change in the level of exchange rate

In order to study the effect of a change in the level of exchange rate, assume that there is no exchange rate uncertainty that is, \( \hat{e} = e \), where

\[
0 < e < (a/c^*)
\]

is a deterministic number. Note that ceteris paribus, an increase in \( e \) increases the domestic currency equivalent of the arm’s length price \( (ep^*) \) as well as that of the unit cost of producing directly through a subsidiary \( (ec^*) \). Further, the consequent changes in demand for the intermediate good leads to changes in \( p^* \). So, the net effect on the relative profitability of direct production vis-a-vis purchase from the market is not obvious. However, our earlier analysis of exchange rate pass-through in Section 3 indicates that the elasticity of domestic currency price of intermediate good with respect to a change in \( e(\eta) \) is quite low (see Fig. 1). Therefore, one would expect that an increase in \( e \) would make purchase from the market more attractive than direct production. This is precisely what we show:

**Proposition 7.** A depreciation of the investor’s home currency (increase in \( e \)) always leads to a decrease in the strategic incentive to invest; the gain from investment for a firm (given the investment decisions of rival firms) decreases.

This result follows directly from (32); for any \( m \geq (N-1) \), \( \phi(m, e) \) is strictly decreasing in \( e \). Thus, when \( e \) increases, the incentive to undertake direct investment (and replace inter-firm trade by intra-firm trade) decreases. Thus, our model provides another explanation of the effect of change in exchange rate level on FDI as observed empirically (see, for example, Cushman, 1988; Caves, 1989).

6. Conclusion

We have shown that the strategic incentive to undertake vertical foreign investment by oligopolistic downstream firms may increase as more firms invest,

\( ^2 \)The mechanism through which change in exchange rate level affects FDI in our model is different from those found in the existing literature. For example, currency movements can affect the relative wealth of firms across countries and therefore the relative ability to undertake mergers or acquisitions (see, Froot and Stein, 1991; Klein and Rosengren, 1994).
leading to possibility of herding in foreign investment decisions. A small decline in the fixed cost of investment can lead to a big jump in the flow of investment. There can be multiple equilibria some involving lot of firms investing and others, very few, thus opening up room for coordination efforts. We have also shown that, contrary to popular conjectures advocated by governments and various international organizations, an increase in exchange rate volatility has a positive effect on vertical foreign investment and on trade in intermediate goods. An appreciation of the investor’s currency also has a similar effect.

Our results are derived for the specific case of linear demand and cost functions. Under more general demand and cost structures, the effect of exchange rate uncertainty could be ambiguous or even reversed. In addition, our model does not capture barriers to vertical foreign investment due to entry deterring activities by incumbents in the intermediate good market abroad. Alternative models of vertical foreign investment could therefore be used to study questions similar to those raised in our model. It is our understanding that qualitatively similar results can be derived in a model where intermediate good firms invest upstream. If, instead of domestic firms setting up their own subsidiaries, we allowed for vertical mergers, then the input-price-raising effect of vertical investment would be even sharper as the total number of firms willing to supply positive quantity in the input market would be smaller. Another interesting extension of our model would be one which allows for two-way strategic vertical investments by international oligopolistic firms, located upstream as well as downstream.

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Appendix A

Glossary of Symbols

\(N\) = number of firms in the final good market
\(m\) = number of investing firms (subscript \(i\))
\[ N - m = \text{number of noninvesting firms (subscript } j) \]
\[ m^* = \text{number of foreign producers of the intermediate good (subscript } k) \]
\[ \tilde{c} = \text{exchange rate (domestic price of foreign currency)} \]
\[ p = \text{domestic price of the final good} \]
\[ p^* = \text{foreign currency price of the intermediate good} \]
\[ c^* = \text{foreign currency marginal cost of producing one unit of intermediate} \]
\[ q_i = \text{final good output of investing firm } i \]
\[ r_j = \text{final good output of noninvesting firm } j \]
\[ Q = \text{aggregate output of the final good} \]
\[ x_i = \text{firm } i's \text{ net purchase of the intermediate good} \]
\[ q_k^* = \text{output of foreign intermediate good by firm } k \]
\[ Q^* = \text{aggregate output of the intermediate good} \]
\[ \Pi_i = \text{gross profit of investing firm } i \]
\[ R_i = \text{net payoff of investing firm } i \]
\[ \Pi_j = \text{profit of noninvesting firm } j \]
\[ R_j = \text{profit of noninvesting firm } j \]
\[ \Pi_k^* = \text{gross profit of intermediate producer } k \]
\[ f = \text{fixed cost of vertical investment} \]
\[ M(f, \tilde{c}) = \text{set of equilibrium outcomes in terms of the number of firms investing (also denoted by } M(f)) \]
\[ \phi(m) = \text{expected gain from investment (reduced form), gross of the fixed cost of investment, when } m \text{ rival firms invest.} \]

References


