Product Differentiation and the Location of International Production*

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Abstract:

This paper analyses the role of product differentiation in firms' choice between exporting and foreign direct investment as ways to supply overseas markets. When the degree of product differentiation is exogenously fixed, we show that the overseas firm favors exporting at low and high degrees of product differentiation while foreign direct investment is favored at intermediate values: there is a "double switch" in location choice. Moreover, if firms have the same domestic locations, we show that they can be trapped in a prisoners' dilemma in which each firm chooses overseas production although exporting would be more profitable. We then consider a three-stage location/product specification/price game in which the firms choose their product specification. Irrespective of the mode of market serving, there is no symmetric solution to the product specification subgame. One firm chooses a "fighting brand", while the other selects a more passive product specification. The cost disadvantage incurred by an exporting firm translates into a disadvantage in the product specification subgame, with the implication that overseas production is favored if this gives the investing firm the ability to adopt a more aggressive product specification.

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1. Introduction

Some firms sell in their overseas markets by exporting, others set up a factory in the overseas markets. In other words, for a given macroeconomic set of incentives and constraints (regarding such things as the tax regime, the degree of corruption in the administration, the flexibility of labor markets, and so on) some firms are more likely than others to use foreign direct investment (fdi) as a mode for serving their overseas markets. Many factors influence the export/fdi choice. In particular, we know that this choice is affected by the interplay between the *set-up costs of fdi* and the *operational costs of exporting*. Set-up costs of fdi include all outlays that are necessary to establish a subsidiary abroad, such as the cost of building a factory, the extra travel and accommodation expenditure on home management sent to run the factory and so on. Operational costs of exporting are the additional costs of exporting to a country compared to being established in that country, which in turn are given by transportation costs and tariff and other non-tariff trade barriers.

A second important influence is the degree of product market competitiveness. In the vast majority of the industries where fdi occurs, the main determinant of product market competitiveness is the degree of product differentiation. It is, therefore, surprising that product differentiation has received almost no formal attention in the literature. Lyons (1984) and Schmitt (1993, 1995) are among the few analyses that consider product differentiation explicitly. In these papers, however, the issue of whether product differentiation "affects" foreign direct investment is largely unresolved. Our paper aims to fill this important gap by focusing particularly on the direct influence that product differentiation has on the export/fdi choice.

We address two closely related issues. First, we assume that the degree of product differentiation is exogenously fixed, in the sense that firms are unable to affect consumers' perceptions of their products. As might be expected, regardless of market conditions, very high set-up costs rule out fdi, and very low set-up costs make fdi the preferred method of intervention in foreign markets. However, an intriguing feature that emerges from our analysis is that there is a "double switch" in the export/fdi choice. For an intermediate range of values of the parameter measuring set-up costs, a firm chooses to export for high *and* low degrees of product differentiation, and conversely, fdi is chosen only if the degree of product differentiation is neither "too high" nor "too low". An obvious implication of this result is that the degree of substitutability between products is not necessarily a good predictor *of itself* of the way in which firms prefer to serve their overseas markets.

In the second part of the paper (Section 4), we allow firms to choose the degree of substitutability between products. In a world where firms design their products to suit consumers' demand and their competitors' strategies, this is a natural extension. A surprising feature that emerges is that the choice of product characteristics is asymmetric no matter the location configuration chosen by the firms. One firm chooses a very aggressive product specification and makes more profit, while the other opts for a less competitive choice of product characteristics and settles for less profit. This is the case even though our set-up is rigorously symmetric to begin with. In a more realistic world where firms do not, in general, start from a symmetric position, the emergence of asymmetric choices would therefore appear to be the natural outcome to expect.

Market size remains an important influence on the trade/fdi choice when product specification is endogenous. However, in this case less expected and subtler influences emerge. First, an important property of the equilibrium is that, if one firm exports while the other is a local producer (either because it has chosen fdi or because it is a domestic firm), then the cost disadvantage of the exporting firm leads to its choosing the less competitive product specification. This implies that one reason for a foreign firm to prefer fdi is to alter the outcome of the product specification game with the local firm, to create the possibility of switching to an aggressive and more profitable product specification. Secondly, we find that, if the competing firms have domestic operations in the same country, there are situations in which no pure strategy equilibrium location configuration exists. The only equilibrium is in mixed strategies suggesting, again, that the relationship between product differentiation and fdi is at best subtle.

A final introductory remark is worth making. Two separate strands of literature on fdi have developed. On the one hand we have a considerable body of theoretical analysis investigating the trade/fdi choice based on oligopoly models in which firms produce homogeneous products: see, for example, Horstmann and Markusen (1992), Motta (1992), Motta and Norman (1996), Rowthorn (1992), Smith (1987). On the other hand, analyses of fdi based upon, for example, the eclectic framework of Dunning and others (see, for example, Dunning, 1988, 1990) treat product differentiation as a, potentially endogenously determined, ownership-specific advantage that allows overseas firms to break into domestic markets. Our paper can be seen as an attempt to integrate these two bodies of theory.

The remainder of the paper is organized as follows. Our theoretical model is developed in the next section. Section 3 analyzes location choice on the assumption that product specification is symmetric and exogenous to the firms. In section 4 we extend the analysis to allow for endogenous choice of product specification. Our main conclusions are presented in section 5.

2. The Model

We use the standard model in the literature on trade/fdi choice (e.g., Horstman and Markusen. 1987, Motta, 1992, Rowthorn, 1992) with one change to introduce product specification as a potential strategic variable. There are two identical countries, *A* and *B*. These countries are supplied by two firms, 1 and 2, who produce differentiated products; their aim is the maximization of their individual profits from sales in the two countries. Inverse market demand in each country for the two goods is given by

(1)
$$
\begin{aligned}
p_1 &= a - (b - s_1)q_1 - s_2 q_2 \\
p_2 &= a - (b - s_2)q_2 - s_1 q_1
\end{aligned}
$$

where p_i, q_i are price and quantity of good i (i = 1, 2), a and b are general demand parameters. This is a special case of the demand function used in Norman (1983) and De Fraja and Norman (1993); see also Singh and Vives (1984). The parameters s_i give a firm-specific inverse measure of product differentiation.[1] A high value of s_i can be interpreted as encouraging consumers to purchase the product of firm i while at the same time undermining the price-setting ability of firm j. In this sense, we can think of the choice of a high value of s_i as being relatively aggressive, aimed at attracting a wide set of consumers, and the choice of a low value of s_i as being relatively passive, with firm i settling for some kind of niche product.

We assume that firms compete in prices (Bertrand competition). We therefore need to work with the direct demand system in each country:

(2)
$$
\begin{aligned}
q_1 &= \frac{a(b - 2s_2) - (b - s_2)p_1 + s_2 p_2}{b(b - s_1 - s_2)} \\
q_2 &= \frac{a(b - 2s_1) - (b - s_1)p_2 + s_1 p_1}{b(b - s_1 - s_2)}
\end{aligned}
$$

[1] (1) cannot be derived as the demand system of a representative consumer. This is because for an individual consumer's demand function the following must hold: $\partial p_i / \partial q_j = \partial p_j / \partial q_i$. However, by the Sonnenschein-Mantel-Debrue Theorem (Mas-Colell et al 1995, pp 598-602), any demand system which satisfies Walras' law and homogeneity can be derived as the aggregate demand of (sufficiently different) consumers whose individual demand functions obey all standard restrictions derived from utility maximization. An asymmetric industry demand system is fairly standard in the literature, see eg Norman (1983), and has recently been used in econometric estimation of demand Gasmi et al (1992).

It is easy to confirm that $\partial q_i / \partial s_i > 0$ and $\partial q_i / \partial s_j < 0$. This is consistent with our aggressive/passive interpretation: the demand for product *i* is an increasing function of firm *i*'s product specification and a decreasing function of firm *j*'s specification.[2] Marginal production costs for the two firms are assumed to be constant and are normalized to zero. If a firm chooses not to establish direct operations in a country, then it supplies that country by exporting to it. Export costs (including transport, tariff and non-tariff barriers to trade) between the two countries are *t* per unit exported. It is worth noting that the qualitative features of our results are robust to the use of a different specification for the functional forms. The linearity of demand and cost functions is a standard assumption in these types of oligopoly models, and can be interpreted as a linearization around the equilibrium values of non-linear functional forms.

With exogenous product specification, we have a two-stage location/price game. Before the beginning of the game, each firm already has a production operation in its "home" location. In the first stage each firm chooses whether to set up a (second) production operation in the foreign country. This incurs a set-up cost *f*. In the second stage the firms choose their prices in each country. We do not require that each firm sets the same price in the two countries.

When product specification is endogenous, we have a three-stage location/product specification/price game. In the second stage each firm chooses the product specification that it will adopt for each country and we allow for the possibility that a firm does not wish to adopt the same product specification in both countries.[3] We consider two cases for each treatment of the product specification parameters. In the first, the firms have their domestic bases in different countries while in the second their domestic bases are in the same countries.

In all these cases the equilibrium concept adopted is that of subgame perfect equilibrium. Our assumptions on production cost and product specification rule out feedback effects between countries, allowing us to treat each country separately. This implies that maximization of a firm's aggregate profits from supplying the two countries is achieved by maximizing profits in each country separately.

[2] Note that for quantities to be non-negative, (2) implies that the product-specification parameters must satisfy the constraints $s_i < 1/2$. We do not impose an explicit non-negativity constraint on q_1 and q_2, but verify that at any equilibrium quantities are indeed at least zero.

[3] Lambertini and Rossini (1998) focus on the number of specifications, and introduce a fixed cost per specification, θ. This is unnecessary in our set-up.

3. The Export/FDI Choice with Exogenous Product Specification

We consider first the case in which product specification is exogenous and symmetric as in De Fraja and Norman (1993) with $s_1 = s_2 = s < b/2$. As we noted above, two cases must be distinguished. In the first, the two firms have their domestic operations in different countries, in which case our constant marginal production cost assumption results in there being no strategic interaction in the firms' location choices. Each firm chooses the profit-maximizing mode of market serving, correctly anticipating the outcome of the price subgame. In the second case, we assume that the firms have their domestic operations in the same country, as a result of which there are strategic considerations of the type first considered by Knickerbocker (1973). Firms may be trapped in a prisoner's dilemma, choosing fdi as a market-serving mode even though their joint profits would be higher if they each exported.

3.1 Firms have Domestic Operations in Different Countries

Assume that firm 1 has its domestic operations in country *A* and firm 2 in country *B*. We can confine our attention to the export/fdi choice of firm 1: because of the absence of feed-back from the foreign to the domestic market symmetric results apply to firm 2. The presentation of the results becomes simpler with the following normalization (as in Rowthorn 1992): $\alpha = a/t$, $\sigma = s/b$ and $\phi = bf/t^2$.

3.1.1 Firm 1 Establishes Direct Production in Country B

When firm 1 adopts fdi to supply country *B* standard calculations give the equilibrium price for each firm as:

(3) $$p_i^f(\sigma) = \frac{a(1-2\sigma)}{2-3\sigma}.$$

Substituting these prices into the profit function gives the profit to firm 1 from fdi in country *B* of

(4) $$\pi_i^f(\sigma) = a^2\mu(\sigma)/b - f$$

where $\mu(\sigma) = \frac{(1-\sigma)(1-2\sigma)}{(2-3\sigma)^2}$. It follows that for fdi to be feasible we must have

(5) $$\mu(\sigma) > bf/a^2 = \phi/\alpha^2 .$$

Since $\mu'(\sigma) \le 0$ and $\mu''(\sigma) < 0$, (5) is more likely to be satisfied when the degree of product differentiation is "high" (σ is "small"). We also have the familiar result that fdi is more likely to be feasible when the consumer reservation price is high and set-up costs of the overseas facility are low. The impact of market size is, however, ambiguous. Profit falls with an increase in *b* (which is an *inverse* measure of market size) provided that $\sigma < 0.3735$

but increases with *b* for $\sigma > 0.3735$ (note that as *b* varies so does σ). This reflects a tension between two forces. On the one hand, an increase in *b* while holding *s* constant indicates a reduction in market size and so should give rise to a reduction in profits from fdi. On the other hand, it also indicates an increase in product differentiation and so should give rise to an increase in profits from fdi. When $\sigma < 0.3735$ the degree of product differentiation is already high and the size effect dominates. By contrast, when $\sigma > 0.3735$ the product differentiation effect dominates.

3.1.2 Firm 1 Exports to Country B

When firm 1 exports to country *B* the equilibrium prices are:

(6) $$p_1^e(\sigma) = t \cdot \frac{\alpha(1-2\sigma)(2-\sigma) + 2(1-\sigma)^2}{(2-3\sigma)(2-\sigma)}; \; p_2^e(\sigma) = t \cdot \frac{\alpha(1-2\sigma)(2-\sigma) + \sigma(1-\sigma)}{(2-3\sigma)(2-\sigma)}.$$

Both prices are decreasing functions of σ. Also, we have $p_1^e(\sigma) > p_2^e(\sigma)$: the exporting firm sets a higher price than the domestic firm, as we would expect given the cost disadvantage of the exporting firm.

Substituting (6) into the profit equations and simplifying gives the profits to the two firms

(7) $$\pi_1^e(\sigma) = \mu(\sigma)(\alpha - \varepsilon(\sigma))^2 \frac{t^2}{b}; \; \pi_2^e(\sigma) = \mu(\sigma)(\alpha + (\varepsilon(\sigma) - 1))^2 \frac{t^2}{b}$$

where $\varepsilon(\sigma) = \frac{2 - 4\sigma + \sigma^2}{(1-2\sigma)(2-\sigma)} > 1$. The domestic firm's cost advantage translates into higher profits.

Since $\varepsilon'(\sigma) > 0$ there is an upper limit on the product differentiation parameter σ above which exporting is not feasible, given by the solution to the equation $\varepsilon(\sigma) = \alpha$. We denote this value of σ as $\hat{\sigma}(\alpha)$. Profit to firm 1 from exporting is a decreasing function of σ and an increasing function of the consumer reservation price α for σ within the range $[0, \hat{\sigma}(\alpha)]$.

3.1.3 The First-Stage Location Game

From equations (4) and (7) we know that firm 1 prefers fdi to exporting as a means of supplying consumers in country *B* provided that

(8) $$\phi < \mu(\sigma)\alpha^2 - \mu(\sigma)(\alpha - \varepsilon(\sigma))^2 = \mu(\sigma)\varepsilon(\sigma)(2\alpha - \varepsilon(\sigma)) = \Delta\pi(\sigma, \alpha)$$

$\Delta\pi(\sigma, \alpha) - \phi$ is increasing in α so that our model is consistent with the familiar result that fdi is more likely the higher is the consumer reservation price relative to the barriers to exports. There is, however, no such simple relationship between the degree of product differentiation and the relative profitability of fdi over exporting.

It is easy to confirm that $\Delta\pi_\sigma(\sigma,\alpha)\big|_{\sigma=0} > 0$, $\Delta\pi_\sigma(\sigma,\alpha)\big|_{\sigma=\hat{\sigma}(\alpha)} < 0$ and that both $\Delta\pi(\sigma,\alpha)$ and $\Delta\pi_\sigma(\sigma,\alpha)$ are continuous for σ in the interval [0, $\hat{\sigma}(\alpha)$]. It follows that $\Delta\pi(\sigma,\alpha)$ has at least one turning point in this interval. $\Delta\pi(\sigma,\alpha)$ is not necessarily concave in the interval [0, $\hat{\sigma}(\alpha)$] and we have not been able to prove analytically that its turning point is unique. However, extensive numerical grid search suggests that this is, indeed, the case. Let this turning point be denoted by $\overline{\sigma}(\alpha)$. Further analysis also confirms that $\Delta\pi(0,\alpha) > \Delta\pi(\hat{\sigma}(\alpha),\alpha)$. As a result, we have the following proposition:

Proposition 1: Assume that product specification is exogenous and symmetric and that the two firms have domestic operations in different countries. The mode by which each firm chooses to serve its overseas market is determined as follows:

i) *for* $\phi < \Delta\pi(\hat{\sigma}(\alpha),\alpha)$ *firms choose foreign direct investment;*

ii) *for* $\Delta\pi(\hat{\sigma}(\alpha),\alpha) < \phi < \Delta\pi(0,\alpha) = (2\alpha - 1)/4$ *there is a critical value* $\sigma^u(\alpha)$ *such that firms choose to export if* $\sigma >$ $\sigma^u(\alpha)$ *and choose foreign direct investment if* $\sigma <$ $\sigma^u(\alpha)$.

iii) *for* $\Delta\pi(0,\alpha) < \phi < \Delta\pi(\overline{\sigma}(\alpha),\alpha)$ *there are critical values* $\sigma^l(\alpha)$ *and* $\sigma^h(\alpha)$ *such that firms choose to export if* $\sigma <$ $\sigma^l(\alpha)$ *or if* $\sigma >$ $\sigma^h(\alpha)$ *and choose foreign direct investment if* $\sigma^l(\alpha) < \sigma < \sigma^h(\alpha)$.

iv) *for* $\Delta\pi(\overline{\sigma}(\alpha),\alpha) < \phi$ *firms choose to export.*

Figure 1 illustrates a typical curve $\phi = \Delta\pi(\sigma,\alpha)$: below it both firms choose fdi, above both export (the curve shifts upwards if α increases). Numerical analysis confirms that σ^u, σ^h and $\overline{\sigma}$ are increasing and σ^l is decreasing in α. In other words, the range of values of σ for which fdi is the preferred mode is an increasing function of the transport-cost adjusted consumer reservation price.

(Figure 1 near here)

The intuition underlying parts i) ii) and iv) of proposition 1 is straightforward. Since prices are strategic complements, the choice of foreign direct investment by firm 1 reduces its operating cost disadvantage but makes it a tougher competitor in the overseas market, leading to a reduction in the equilibrium prices charged by the two firms (Bulow *et al.* 1985). After all, as equation (6) indicates, firm 1 as an exporter is able to pass on more than 50 per cent of its export costs to consumers in the overseas market. So for fdi to be preferred the operating cost advantages of local production must more than offset its fixed cost penalty and the increased intensity of price competition to which it gives rise.

Therefore, if set-up costs of fdi are low, or trade barriers are high, or market size is large (ϕ is less than $\Delta\pi(\hat{\sigma}(\alpha),\alpha)$) fdi dominates the trade/fdi choice at any degree of product differentiation, part i), or vice versa, part iv). Similar considerations arise for "intermediate" values of ϕ, between $\Delta\pi(\hat{\sigma}(\alpha),\alpha)$ and $\Delta\pi(0,\alpha)$. Fdi leads to tougher price competition, but provided that the products are sufficiently different ($\sigma < \sigma^u(\alpha)$), this does not offset the operating costs advantages of being a local producer. The desire to soften price competition, and so the commitment to exporting rather than fdi, applies only when the competing products are "very alike" since this is when the rewards from softer price competition are likely to be greatest.

These results accord with intuition. The counterintuitive result in proposition 1 is iii). For values of ϕ between $\Delta\pi(0,\alpha)$ and $\Delta\pi(\overline{\sigma}(\alpha),\alpha)$ such as ϕ_1 in Figure 1, we have a double switch in the trade/fdi choice by firm 1. Exporting is preferred to fdi at low *and* at high degrees of product differentiation. We have already seen why exporting should be preferred for low differentiation. Now consider the situation when the products are highly differentiated. For iii) to apply it is necessary that ϕ be sufficiently high that firm 1 would choose to export if it were a monopolist, i.e. if $\sigma = 0$. Now consider a reduction in the degree of product differentiation: this decreases profits both from exporting, since firm 1 has a cost disadvantage, and from fdi, because price competition becomes tougher. At such high degrees of product differentiation, the "toughening" effect of fdi on price competition is relatively weak, with the result that the cost effect has a sharper impact on profit than the competition effect. As a consequence, for $\sigma > \sigma^l(\alpha)$ (but less than $\sigma^u(\alpha)$) the operating cost advantage of fdi is sufficiently strong to offset the set-up cost disadvantage of fdi.

To summarize, our analysis indicates that the relationship between the degree of product differentiation and the trade/fdi choice is far from straightforward. In industries characterized by relatively low set-up costs (adjusted for market size and trade barriers), we are more likely to see exporting if the degree of product differentiation is relatively low. By contrast, where set-up costs are relatively high, exporting is likely to be prevalent in industries characterized by the highest as well as the lowest degrees of product differentiation.

3.2 Firms have Domestic Operations in the Same Country[4]

Assume that both firms have their domestic operations in country *A* and choose how they supply consumers in country *B*.

3.2.1 The Second-Stage Price Subgame

Consider first the case in which both firms invest in country *B*. Then the equilibrium prices are given by equation (3) and the profits to each firm are given by

$$(9)\qquad \pi_i^{ff}(\sigma,\alpha)=\left(\frac{\alpha^2(1-\sigma)(1-2\sigma)}{(2-3\sigma)^2}-\phi\right)\frac{t^2}{b}=\left(\alpha^2\mu(\sigma)-\phi\right)\frac{t^2}{b}\ .$$

If firm 1 exports to *B* and firm 2 invests in local production in *B*, the equilibrium prices are given by (6) and the firms' profits are, from (7):

$$(10)\qquad \pi_1^{ef}(\sigma,\alpha)=\left(\mu(\sigma)(\alpha-\varepsilon(\sigma))^2\right)\frac{t^2}{b};\pi_2^{ef}(\sigma,\alpha)=\left(\mu(\sigma)(\alpha+(\varepsilon(\sigma)-1))^2-\phi\right)\frac{t^2}{b}\ .$$

Symmetric prices and profits are obtained if firm 1 invests in and firm 2 exports to *B*.

Finally, if both firms export to *B* the equilibrium prices are

$$(11)\qquad p_i^{ee}=t\cdot\frac{\alpha(1-2\sigma)+(1-\sigma)}{2-3\sigma}\qquad (i=1,2)$$

These give profits to each firm of

$$(12)\qquad \pi_i^{ee}(\sigma,\alpha)=\mu(\sigma)(\alpha-1)^2\,\frac{t^2}{b}\qquad (i=1,2).$$

3.2.2 The First-Stage Location Game

The solution to the price subgame gives us the pay-off matrix of Table 1, where for convenience we have omitted the common multiple t^2/b. We then have the following as a description of the subgame perfect equilibrium for the two firms' location choices:

(Table 1 near here)

Proposition 2: Assume that product specification is exogenous and symmetric and that the two firms have domestic operations in the same country. The mode by which the firms choose to serve their overseas market is determined as follows:

[4] The analysis in this section also applies if the two firms have domestic operations in different countries but are considering the trade/fdi choice with respect to a third country that they both supply.

i) *for* $\phi > \mu(\sigma)\left((\alpha+\varepsilon(\sigma)-1)^2 - (\alpha-1)^2\right)$ *both firms export;*

ii) *for* $\mu(\sigma)\left((\alpha+\varepsilon(\sigma)-1)^2 - (\alpha-1)^2\right) > \phi > \mu(\sigma)\left(\alpha^2 - (\alpha-\varepsilon(\sigma))^2\right)$ *one firm exports and the other uses fdi;*

iii) *for* $\mu(\sigma)\left(\alpha^2 - (\alpha-\varepsilon(\sigma))^2\right) > \phi$ *both firms use fdi.*

This proposition is illustrated in figure 2. This figure is similar to figure 1 (note that the AC curve is precisely the same as the boundary between Export and FDI in figure 1 discussed in section 3.1), but has the added possibility of asymmetric equilibria. Between AB and AC one firm exports and the other uses fdi, for parameter combinations above the locus AB both firms export, while for parameter combinations below AC both firms use fdi. Furthermore, the location equilibrium (Export, Export) is a Nash equilibrium only if $\phi > \Delta\pi(0,\alpha) = (2\alpha-1)/4$.

(Figure 2 near here)

One issue raised by the payoff matrix of Table 1 is whether there are prisoners' dilemma aspects to the equilibrium (FDI, FDI) (as in Knickerbocker, 1973). Would both firms be better off continuing to export? For this to be the case two conditions must be satisfied. It is necessary first, that (FDI, FDI) is a Nash equilibrium and secondly, that the individual firm's profit in this equilibrium, $(\mu(\sigma)\alpha^2 - \phi)t^2/b$, is less than the profit when both firms export, $(\mu(\sigma)(\alpha-1)^2)t^2/b$. The first condition holds for all parameter combinations below AC and the second holds for $\phi > \mu(\sigma)(\alpha^2 - (\alpha-1)^2)$, which is true for parameter combinations above AD. Thus, all parameter combinations in the region $(F, F)_{PD}$ bounded by loci AC and AD in Figure 2 give rise to a prisoners' dilemma.

No matter the degree of product differentiation, an increase in set-up costs ϕ has the expected effect: it increases the likelihood that firms serve their external markets by exporting to them. The converse is not true: the impact of increased product differentiation on the trade/fdi choice changes dramatically depending upon the relationship between $\Delta\pi(0,\alpha)$ and ϕ.

i) $\phi < (2\alpha-1)/4$: A reduction in the degree of product differentiation reduces fdi. In this region set-up costs are sufficiently low that both firms choose fdi provided that the products are not "too alike". At low degrees of product differentiation, however, we see the same forces as we discussed in section 3.1. One of the firms chooses to export rather than to invest in order to soften price competition, even though the exporting firm suffers a cost disadvantage.

ii) $\phi > \Delta\pi(0,\alpha) = (2\alpha - 1)/4$: In this region set-up costs are sufficiently high that both firms choose to export if their products are highly differentiated. However, the curve AB defining the boundary between (Export, Export) and (Export, FDI) is upward sloping, while the boundary between (Export, FDI) and (FDI, FDI) is non-monotonic. What this implies is that there is a non-monotonic relationship between the degree of product differentiation and the trade/fdi choice. Both firms choose to export at *high* degrees of product differentiation, while at least one of the firms choose fdi at *low* degrees of product differentiation. For $\Delta\pi(0,\alpha) < \phi < \Delta\pi(\overline{\sigma}(\alpha),\alpha)$ a decrease in the degree of product differentiation initially increases but then decreases fdi.

While counter-intuitive, there is a relatively simple intuition underlying this outcome. When the firms have domestic operations in the same country and both are exporters, the decision by one of them to switch to fdi leads to tougher competition in the export market, but it also gives the investing firm an operating cost advantage. Naturally, this cost advantage of fdi is more likely to outweigh the tougher price competition it generates when the degree of product differentiation is low. Moreover, despite the relatively high set-up costs of fdi, the operating cost *disadvantage* of being an exporter can lead to a situation in which *both* firms choose fdi even though in this parameter region the equilibrium (FDI, FDI) is always less profitable than (Export, Export).

Once again we find that there is no simple relationship between the degree of product differentiation and the decision by firms to adopt fdi as a means of supplying their overseas markets. In industries where set-up costs are relatively low, exporting can be expected to be associated with low degrees of product differentiation. However, where set-up costs are relatively high, the reverse is true.

4. The Trade/FDI Choice with Endogenous Product Specification

We now extend the analysis by allowing each firm to choose the specification of its product, giving us a three-stage location/product specification/price game. This is the natural ordering for the three stages: price can be modified more rapidly than product specification, which, in turn, can be adjusted more quickly than location. We normalize the model as above, defining $\sigma_i = s_i/b$ and noting that $0 \leq \sigma_i < 1/2$. In section 4.1 we study the case in which the two firms have domestic operations in different countries. We need to solve the product differentiation subgame for both the choices available to firm *i* (fdi in section 4.1.4. and export, in 4.1.2). A common feature of these two sections is the asymmetry in the choice of product specification. Section 4.2 corresponds to 3.2: firms have their domestic operations in the same country. In this case we show that the wealth of possible subgame perfect equilibria found in 3.2. is maintained (proposition 5).

4.1 The Two Firms have Domestic Operations in Different Countries

4.1.1 Firm 1 Establishes Direct Production in Country B

We begin by analyzing the subgame where both firms are located in the same country. Standard techniques give the equilibrium prices of

(13) $$p_i = \frac{a\left(2(1-\sigma_i) - \sigma_j(3-2\sigma_i)\right)}{4(1-\sigma_i) - \sigma_j(4-3\sigma_i)} \qquad (i = 1,2 \quad i \neq j).$$

Substituting this into the profit functions for the two firms gives the profit function for firm i, ignoring the set-up costs associated with fdi and product specification:

(14) $$\pi_i^f(\sigma_i, \sigma_j, \alpha) = \frac{\alpha^2 (1-\sigma_j)\left(2(1-\sigma_j) - \sigma_i(3-2\sigma_j)\right)^2}{(1-\sigma_i-\sigma_j)\left(4(1-\sigma_j) - \sigma_i(4-3\sigma_j)\right)^2} \cdot \frac{t^2}{b}.$$

The equilibrium for the second-stage product specification subgame is defined as the pair of product specifications $\left(\sigma_1^{f*}, \sigma_2^{f*}\right)$ such that

(15) $$\pi_i^f\left(\sigma_i^{f*}, \sigma_j^{f*}, \alpha\right) \geq \pi_i^f\left(\sigma_i^f, \sigma_j^{f*}, \alpha\right) \text{ for all } \sigma_i^f \in [0, 0.5]. \qquad (i = 1,2).$$

In order to identify this equilibrium we need first to identify the product specification best reply functions for the two firms. Consider firm 1: the best reply function for firm 2 is symmetric. Equation (14) indicates that the equilibrium product specification for each firm is independent of the parameters α and t: the best reply by firm 1 to firm 2's choice of product specification σ_2 is a function solely of σ_2. The profit functions (14) have the following characteristics:

(i) $\pi_1^f(\sigma_1, \sigma_2, \alpha)$ is monotonic increasing in σ_1 for $\sigma_2 < 0.463205$;

(ii) $\pi_1^f(\sigma_1, \sigma_2, \alpha)$ has a local maximum at $\sigma_1 = \dfrac{16 - 19\sigma_2(2-\sigma_2) - \sigma_2\sqrt{48\sigma_2^3 - 183\sigma_2^2 + 204\sigma_2 - 60}}{4(2-3\sigma_2)(2-\sigma_2)}$, but a global maximum at $\sigma_1 = 0.5$ for $0.463205 < \sigma_2 \leq 0.46812$;

(iii) $\pi_1^f(\sigma_1, \sigma_2, \alpha)$ has a global maximum at $\sigma_1 = \dfrac{16 - 19\sigma_2(2-\sigma_2) - \sigma_2\sqrt{48\sigma_2^3 - 183\sigma_2^2 + 204\sigma_2 - 60}}{4(2-3\sigma_2)(2-\sigma_2)}$ for $\sigma_2 > 0.46812$.

An immediate implication is that the product specification best reply function for firm i is discontinuous at $\sigma_j = 0.46812$. We state this formally as follows.

Lemma 1: Assume that the two firms have domestic operations in different countries, that product specification is endogenous and that firm i uses fdi to supply its overseas market. The product specification best reply function for firm i is:

(i) $\sigma_i = 0.5$ *for* $\sigma_j \le 0.46812$;

(ii) $$\sigma_i = \frac{16 - 19\sigma_j(2-\sigma_j) - \sigma_j\sqrt{48\sigma_j^3 - 183\sigma_j^2 + 204\sigma_j - 60}}{4(2-3\sigma_j)(2-\sigma_j)}$$ *for* $\sigma_j > 0.46812$.

The product specification best reply functions of firm 1 and firm 2 are illustrated in Figure 3. They intersect twice, identifying two pure strategy equilibria to the product specification subgame.

Proposition 3: Assume that the two firms have domestic operations in different countries, that product specification is endogenous and that firm i uses fdi to supply its overseas market. There are two pure strategy equilibria to the product specification subgame for this case: (0.2, 0.5) *or* (0.5, 0.2).

(Figure 3 hear here)

There is no symmetric pure strategy equilibrium to the product specification subgame when the outside firm adopts fdi.[5] The intuition underlying this outcome can be given with reference to the profit function (14). Suppose that firm 2 chooses a "low" value for the product specification parameter σ_2. Then even if firm 1 chooses the same low value for σ_1 the products are highly differentiated, leading to relatively soft price competition between the two firms. In these circumstances, firm 1 always gains by adopting a more aggressive product specification since this attracts consumers from firm 2, as a result of which it sets $\sigma_1 = ½$. At higher, but not "very high" values for σ_2 a countervailing force sets in. Firm 1's profit increases with σ_1 initially for the reasons just discussed. But now the price competition between the two products becomes more intense as their product specifications become more alike since they are less differentiated: if they had the same product specification this would be nearer to the no-differentiation limit of ½. As a result, beyond some point firm 1's profit falls as σ_1 approaches σ_2. Nevertheless, in this range of values for σ_2 it remains the case that firm 2 leaves enough room for firm 1 to have the incentive to adopt the most aggressive product specification $\sigma_1 = ½$. It is only when σ_2 is "very high" – in our model greater than 0.46812 – that price competition between the two firms is sufficiently intense for this aggressive response by firm 1 to be unprofitable. Even if firm 1 were to choose $\sigma_1 = ½$ the two products would be "very alike" with the result that price competition between them would be intense. In these circumstances, firm 1 earns greater profits by adopting a relatively passive product specification. Again, while the specific values of the equilibrium depend on the formulation of the model, the qualitative nature of the results would be robust to perturbations in the functional forms.

With the equilibrium product specifications of Proposition 3 the equilibrium prices and profits are:[6]

$$(16)\qquad \begin{aligned} &p_i^{*f} = \frac{2a}{5} \text{ if } \sigma_i^* = 0.5 \text{ and } \frac{a}{5} \text{ if } \sigma_i^* = 0.2 \\ &\pi_1^{*f}(0.5, 0.2, \alpha) = \frac{32\alpha^2}{75}\cdot\frac{t^2}{b} - f \;\; ; \pi_1^{*f}(0.2, 0.5, \alpha) = \frac{5\alpha^2}{75}\cdot\frac{t^2}{b} - f \end{aligned} .$$

Firm 1 is the investing firm. Profits for the domestic firm do not of course include the set-up cost. Both price and profit are higher for the firm with the more aggressive product specification.

4.1.2 Firm 1 Exports to Country B

Assume that firm 1 exports to country *B*, while firm 2 has its domestic operations there.[7] The equilibrium prices in Country B are now

$$(17)\quad p_1(\sigma) = t\cdot\frac{\alpha(2(1-\sigma_1)-\sigma_2(3-2\sigma_1)) + 2(1-\sigma_1)(1-\sigma_2)}{4(1-\sigma_1)-\sigma_2(4-3\sigma_1)};\;\; p_2(\sigma) = t\cdot\frac{\alpha(2(1-\sigma_2)-\sigma_1(3-2\sigma_2)) + \sigma_1(1-\sigma_2)}{4(1-\sigma_1)-\sigma_2(4-3\sigma_1)}$$

These allow us to identify the profit functions for the two firms

$$(18)\qquad \begin{aligned} &\pi_1^e(\sigma_1,\sigma_2,\alpha) = \frac{(1-\sigma_2)(\alpha(2(1-\sigma_1)-\sigma_2(3-2\sigma_1)) - 2(1-\sigma_1) + \sigma_2(2-\sigma_1))^2}{(1-\sigma_1-\sigma_2)(4(1-\sigma_1)-\sigma_2(4-3\sigma_1))^2}\cdot\frac{t^2}{b} \\ &\pi_2^e(\sigma_1,\sigma_2,\alpha) = \frac{(1-\sigma_1)(\alpha(2(1-\sigma_2)-\sigma_1(3-2\sigma_2)) + \sigma_1(1-\sigma_2))^2}{(1-\sigma_1-\sigma_2)(4(1-\sigma_1)-\sigma_2(4-3\sigma_1))^2}\cdot\frac{t^2}{b} \end{aligned} .$$

Equilibrium for the second-stage product specification subgame is defined as above to be the product specification σ_i^{e*} chosen by firm *i* such that

$$(19)\qquad \pi_i^e\left(\sigma_i^{e*}, \sigma_j^{e*}, \alpha\right) \geq \pi_i^e\left(\sigma_i^e, \sigma_j^{e*}, \alpha\right) \text{ for all } \sigma_i^e \in [0, 0.5].$$

By contrast with the case in which firm 1 establishes production in country *B*, now the product specification equilibrium is affected by the demand parameter α. We have the following result:[8]

[5] There are of course symmetric mixed strategy equilibria, but, given the applied viewpoint of the paper, it seems preferable to concentrate on the pure strategy equilibria.

[6] We give the profits for firm 1, the investing firm. Profits for firm 2 are $\pi_2^{*f}(\;) = \pi_1^{*f}(\;) + f$.

[7] We show in the Mathematical Appendix that firm 2 cannot exclude firm 1's exports through its choice of product specification.

Proposition 4: Assume that the firms are located in different countries and that firm 1 exports to Country B. The equilibrium to the product specification subgame is $\left(\sigma_1^{e*}, \sigma_2^{e*}\right) = \left(\sigma_1^{e*}(\alpha), 0.5\right)$ *where*:

$$\sigma_1^{e*}(\alpha) = \begin{cases} 0 & \textit{for } \alpha \le 6 \\ \dfrac{7\alpha - 18 - \sqrt{3(\alpha+6)(3\alpha-2)}}{10(2\alpha-3)} & \textit{otherwise.} \end{cases}$$

The cost advantage enjoyed by the domestic firm leads to an equilibrium in which it always chooses the most aggressive product specification. The exporting firm, by contrast, adopts a very passive specification: $\sigma_1^{e*}(\alpha)$ = 0 when $\alpha \le 6$, is increasing in α and tends to 0.2 as α increases without bound. In other words, the choice of exporting by the outside firm leads to its choosing a product specification that is even more passive than the most passive specification it might choose with fdi. Moreover, this product specification is a decreasing function of the cost disadvantage *t* to which the exporting firm is subject.

An immediate implication of proposition 4 is that the aggressive pursuit of trade policy by an importing country may well benefit domestic firms not just because it increases the costs of overseas rivals, making them less competitive. When firms can choose their product specifications, aggressive trade policy may well also force outside firms to choose passive, niche specifications for their export products, allowing the domestic firms to control their domestic market by adopting more aggressive product specifications. This cannot be pushed too far, of course, as we note in the next section. The exporting firm always has the option of switching to fdi if trade barriers are set very high.

4.1.3 The First-Stage Location Game

Firm 1's choice of mode by which to supply consumers in Country *B* is determined by the relationship between the demand parameter α and set-up costs ϕ: firm 1 prefers fdi to exporting provided that $\Delta\pi(\alpha) = \pi_1^f\left(\sigma_1^{f*}, \sigma_2^{f*}, \alpha\right) - \pi_1^e\left(\sigma_1^{e*}(\alpha), 0.5, \alpha\right) > \phi$. In other words, $\Delta\pi(\alpha)$ identifies an upper bound on ϕ below which fdi is the preferred mode for supplying the overseas market. The first point to note is that $d\Delta\pi(\alpha)/d\alpha > 0$. It follows naturally, therefore, that there is always a value for the demand parameter α above which, or a value of the set-up cost parameter ϕ below which fdi is preferred to exporting. Secondly, the critical value of α (ϕ) above

[8] Proofs of this and other results are outlined in the Mathematical Appendix.

(below) which fdi is the equilibrium supply mode is affected by the product specification that firm 1 adopts with fdi: both are lower if $\sigma_1^{f*} = 0.5$ than if $\sigma_1^{f*} = 0.2$.

Thirdly, our analysis implies that when the firms can choose their product specifications, there is a further force pushing firms to adopt fdi. As we have noted, if the outside firm exports, the cost disadvantage under which it operates manifests itself in its having to adopt a passive product specification while the domestic rival can control the domestic market through its more aggressive product specification. Fdi, by contrast, has the potential for allowing the investing firm to turn the tables on the domestic rival since there is now the possibility that the investing firm can adopt the aggressive product specification.

4.2 The Two Firms have Domestic Operations in the Same Country

The final case we consider is that in which the two firms have domestic operations in the same country and are considering how best to serve the overseas market.

When both firms invest in the overseas market, equilibrium for the product specification and price subgames is as in section 4.1.1, Lemma 1 and Proposition 3. This gives the equilibrium prices and profits for both firms of equation (16). Similarly, when one firm exports and the other invests, equilibrium is determined by Proposition 4. The only case we need to consider explicitly, therefore, is where both firms export. We show in the Mathematical Appendix that the product specification best reply functions for the two firms are characterized by Lemma 1, as a result of which the equilibrium product specifications are given by Proposition 3. One firm adopts the aggressive product specification $\sigma_i = 0.5$ and the other the passive specification $\sigma_j = 0.2$. The only difference between this case and the (FDI, FDI) case is in the equilibrium prices and profits. These are

$$\tag{20} \begin{aligned} & p_i^{ee} = \frac{2a+3t}{5} \text{ if } \sigma_i^* = 0.5 \text{ and } \frac{a+4t}{5} \text{ if } \sigma_i^{e*} = 0.2 \\ & \pi_1^{ee}(0.5, 0.2, \alpha) = \frac{32(\alpha-1)^2}{75} \cdot \frac{t^2}{b} \; ; \pi_1^{ee}(0.2, 0.5, \alpha) = \frac{5(\alpha-1)^2}{75} \cdot \frac{t^2}{b} \end{aligned} .$$

In order to describe the resulting equilibrium location configurations we first define the following critical values of ϕ:

$$(21)\qquad \begin{cases} \phi_1(\alpha) = \alpha^2/15 - \gamma_1\left(\sigma_1^{e*}(\alpha), \alpha\right) \\ \phi_2(\alpha) = \gamma_2\left(\sigma_1^{e*}(\alpha), \alpha\right) - 32(\alpha-1)^2/75 \\ \phi_3(\alpha) = 32\alpha^2/75 - \gamma_1\left(\sigma_1^{e*}(\alpha), \alpha\right) \\ \phi_4(\alpha) = \gamma_2\left(\sigma_1^{e*}(\alpha), \alpha\right) - (\alpha-1)^2/15 \end{cases}$$

where $\gamma_1(\sigma,\alpha) = \dfrac{(2-3\sigma+\alpha(1-2\sigma))^2}{(1-2\sigma)(4-5\sigma)^2}$, $\gamma_2(\sigma,\alpha) = \dfrac{2(1-\sigma)(2\alpha(1-2\sigma)+\sigma)^2}{(1-2\sigma)(4-5\sigma)^2}$ and $\phi_1(\alpha) < \phi_2(\alpha) < \phi_3(\alpha) < \phi_4(\alpha)$.

We suppose that there is consistency in the product specification equilibria: in the location configurations (FDI, FDI) and (Export, Export) we assume that the product specification equilibrium is (0.2, 0.5) i.e. firm 1 has the passive product specification in both situations. Of course, with the asymmetric location configurations (FDI, Export) and (Export, FDI) the investing firm has a production cost advantage and so it adopts the aggressive product specification 0.5 while the exporting firm chooses $\sigma_i = \sigma_1^{e*}(\alpha)$. We then have the following [9]:

Proposition 5: Assume that the two firms have domestic operations in the same country. If in the location configurations (FDI, FDI) and (Export, Export) firm 1 *has product specification* $\sigma_1 = 0.2$ *then the pure strategy equilibrium location configurations in supplying the overseas market are:*

(i) *(FDI, FDI) for* $\phi \le \phi_1(\alpha)$;

(ii) *(Export, FDI) for* $\phi_1(\alpha) \le \phi \le \phi_2(\alpha)$;

(iii) *(FDI, Export) for* $\phi_3(\alpha) \le \phi \le \phi_4(\alpha)$;

(iv) *(Export, Export) for* $\phi_4(\alpha) < \phi$.

For $\phi_2(\alpha) < \phi < \phi_3(\alpha)$ *there is no pure strategy equilibrium location configuration: the equilibrium location configuration is in mixed strategies and given by:*

$$e_1(\phi) = (\phi_3(\alpha) - \phi)/(\phi_3(\alpha) - \phi_2(\alpha)),\ e_2(\phi) = (\phi - \phi_1(\alpha))/(\phi_4(\alpha) - \phi_1(\alpha))$$

where firm i exports with probability $e_i(\phi)$ i=1,2.

Each of the four location configurations is an equilibrium for some range of values of ϕ as illustrated in Figure 4 but there is also a relatively large parameter range in which there is no pure strategy equilibrium in location

9 The calculations underlying propositions 4 and 5 are sketched in the Mathematical Appendix. Further details can be obtained from the authors on request.

configurations.[10] In addition, $e_1(\phi)$ is a decreasing and $e_2(\phi)$ an increasing function of ϕ. In other words, the probability that firm 1 - with the passive product specification - chooses to export is an increasing function of the set-up costs ϕ. By contrast, the probability that firm 2 - with the aggressive product specification – chooses to export is a decreasing function of set-up costs. This might be interpreted as a positive connection between product differentiation and fdi. We would suggest, however, that the fact that there is a relatively wide parameter range in which there exists no pure strategy equilibrium in location configurations should be taken as evidence, yet again, that there is no clear-cut relationship between the export/fdi choice and the degree of product differentiation.

(Figure 4 near here)

5. Conclusions

It has often been claimed that product differentiation can be expected to lead firms to choose fdi rather than exporting as a method for serving their overseas markets but the empirical evidence supporting this claim is at best ambiguous. This paper has developed a formal model of trade and foreign direct investment when firms produce differentiated products from which we are able to identify theoretically the source of this ambiguity, and so can provide a guide to future empirical work in this important area. We have analyzed a number of possible cases. When the degree of product differentiation is outside the control of the firms, we have shown that a direct link between fdi and product differentiation can indeed be expected to hold provided that the set-up costs associated with fdi are not "too high". In industries characterized by high set-up costs, however, we find an ambiguous relationship. Exporting is the preferred mode of market serving at low *and* high degrees of product differentiation, fdi at intermediate degrees.

We also find that the connection between product differentiation and trade/fdi is affected in important ways depending upon whether the competing firms have their domestic production bases in different or in the same countries. In particular, if the firms have their domestic operations in the same country and have relatively high set-up costs, we have shown that fdi is more likely at *low* degrees of product differentiation. The intuition behind this surprising result is simple enough: a switch from exporting to fdi gives the investing firm a significant competitive advantage over its rival(s) that is particularly valuable when the competing products are "very alike".

[10] If we did not have consistency in product specifications, i.e. if in the location configuration (FDI, FDI) the product specification equilibrium is (0.2, 0.5) whereas with (Export, Export) it is (0.5, 0.2) then (FDI, Export) cannot be an equilibrium. The additional profit that firm 2 earns from its aggressive product specification with (FDI, FDI) more than offsets the set-up costs of fdi.

When the firms can exercise strategic choice over the degree of product differentiation, we have shown that they do *not* choose identical product specifications despite the symmetric nature of the underlying model. Rather, one of the firms adopts an aggressive product specification and the other a passive, niche specification. If the two firms adopt the same method of market serving, it is uncertain which of the rival firms will adopt the aggressive specification. However, when one firm exports and the other produces locally, the operating cost disadvantage suffered by the exporting firm leads it to adopt the passive specification. This implies that a possible motive for fdi is to give the investing firm the potential to make its product specification more aggressive, increasing its profits while significantly reducing the market share of its domestic rival.

In this case also, we find that the locations of the domestic production bases of the rival firms are important determinants of the equilibrium location configuration that is likely to emerge. In particular, suppose that the firms have domestic operations in the same country and that there is some degree of consistency in product specifications when both firms export and when they both invest. Then there is a potentially large parameter range in which there is no pure strategy equilibrium in location choice. There is, of course, a mixed strategy equilibrium but once again we have the indication that the connection between product specification or product differentiation and fdi is weak at best. Indeed, there is the suggestion that the direction of causation may well go the other way. A firm prefers foreign direct investment because this allows it to opt for an aggressive product specification that would not be possible should the firm continue to export.

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Mathematical Appendix

Section 4.1.2 We first check that firm 2 cannot exclude the exports of firms 1 by a sufficiently aggressive choice of product specification. It is simple to confirm the following:

Lemma 2: Assume that the firms are located in different countries and that firm 1 exports to Country B. There will always be a sufficiently low value of s_1 such that firm 1 has positive exports provided that the demand parameter $\alpha > 2$.

Proof:

When firm 1 exports and firm 2 is a local producer the exports of firm 1 are:

$$q_1^e(\sigma_1, \sigma_2, \alpha) = \frac{(1-\sigma_2)(\alpha((2-2\sigma_1)-\sigma_2(3-2\sigma_1))-(2-2\sigma 1)+\sigma_2(2-\sigma_1))}{(1-\sigma_1-\sigma_2)(4(1-\sigma_1)-\sigma_2(4-3\sigma_1))} \cdot \frac{1}{b}$$

If firm 2 adopts a very aggressive product specification, $\sigma_2 = 1/2$ we have:

$$q_1^e(\sigma_1, 1/2, \alpha) = \frac{\alpha + \sigma_1(3-2\alpha)-2}{(1-2\sigma_1)(4-5\sigma_1)} \cdot \frac{1}{b}.$$

This is positive at $\sigma_1 = 0$ for $\alpha > 2$.

Now assume that firm 2 chooses σ_2 to exclude firm 1. This requires

$$\sigma_2(\sigma_1, \alpha) = \frac{2(1-\sigma_1)(\alpha-1)}{\alpha(3-2\sigma_1)-(2-\sigma_1)}.$$

This is increasing in σ_1 and $\sigma_2(0,\alpha) = 2(\alpha - 1)/(3\alpha - 2)$. Further, $\sigma_2(0,\alpha) \geq 1/2$ for $\alpha \geq 2$. It is impossible for firm 2 to exclude firm 1 from the market by choosing an aggressive product specification for demand parameters greater than $\alpha = 2$.

Proposition 4: Define $\sigma_2^{\max}(\sigma_1, \alpha) = \max\left\{\frac{2(1-\sigma_1)(\alpha-1)}{\alpha(3-2\sigma_1)-(2-\sigma_1)}, 0.5\right\}$ as the maximum value for σ_2 for which it is feasible for firm 1 to export to country *B*.

1. Numerical analysis confirms that $\pi_2^e(\sigma_1, \sigma_2, \alpha)$ in (18) is unambiguously increasing in α for $2 < \alpha \leq 6$.
2. $\pi_2^e(\sigma_1, \sigma_2, \alpha)$ has a local maximum at $\sigma_2 < 0.5$ for $\alpha > 6$. Denote this as $\overline{\sigma}_2^e(\sigma_1, \alpha)$. However, $\pi_2^e(\sigma_1, \overline{\sigma}_2^e(\sigma_1, \alpha), \alpha) < \pi_2^e(\sigma_1, \sigma_2^{\max}(\sigma_1, \alpha), \alpha)$ for $6 < \alpha \leq 10.75$. As a result, the dominant strategy is for firm 2 to set $\sigma_2 = 0.5$ in this range of α.
3. For $\alpha > 10.75$ there is a range of values of σ_1, which we can denote $\overline{\sigma}_1(\sigma_2, \alpha)$, which is such that $\pi_2^e(\overline{\sigma}_1(\alpha), \overline{\sigma}_2^e(\overline{\sigma}_1, \alpha), \alpha) > \pi_2^e(\sigma_1, \sigma_2^{\max}(\sigma_1, \alpha), \alpha)$ so that $\pi_2^e(\sigma_1, \sigma_2, \alpha)$ has a global maximum at $\overline{\sigma}_2^e(\sigma_1, \alpha)$. Define $\sigma_1^{\max}(\sigma_2, \alpha) = \frac{\alpha(2-3\sigma_2)-(2-\sigma_2)}{2\alpha(1-\sigma_2)-(2-\sigma_2)}$. For $\sigma_1 > \sigma_1^{\max}(\sigma_2, \alpha)$ firm 1 is not able to export to country *B*, in that these values of σ_1 allow firm 2 to exclude firm 1 as an exporter to country *B*. Hence firm 2 can act as a local monopolist, and set $\sigma_2 = 0.5$.

   Hence firm 2's product specification best reply function for $\alpha > 10.75$ is:

i) $\sigma_2 = 0.5$ for $\sigma_1 < \bar{\sigma}_1(\sigma_2, \alpha)$;

ii) $\sigma_2 = \bar{\sigma}_2^e(\sigma_1, \alpha)$ for $\bar{\sigma}_1(\sigma_2, \alpha) < \sigma_1 \leq \sigma_1^{\max}(\sigma_2, \alpha)$;

iii) $\sigma_2 = 0.5$ for $\sigma_1 > \sigma_1^{\max}(\sigma_2, \alpha)$.

4. Firm 1's product specification best reply function has a discontinuity at $\tilde{\sigma}_2(\sigma_1, \alpha)$. Furthermore, $\tilde{\sigma}_2(\sigma_1, \alpha) > \bar{\sigma}_2^e(\sigma_1, \alpha)$. Figure A.1 illustrates a typical pair of product specification best reply functions for $\alpha > 10.75$, leading to proposition 4.

(Figure A.1 near here)

Product Specification Best Reply Functions when Both Firms Export:

The profit functions for the two firms when they have domestic operations in the same country and both export are:

$$\pi_1^{ee}(\sigma_1, \sigma_2, \alpha) = \frac{(1-\sigma_2)(\alpha(2(1-\sigma_1)-\sigma_2(3-2\sigma_1)) - 2(1-\sigma_1)+\sigma_2(3-2\sigma_1))^2}{(1-\sigma_1-\sigma_2)(4(1-\sigma_1)-\sigma_2(4-3\sigma_1))^2} \cdot \frac{t^2}{b}$$

$$\pi_2^{e}(\sigma_1, \sigma_2, \alpha) = \frac{(1-\sigma_1)(\alpha(2(1-\sigma_2)-\sigma_1(3-2\sigma_2)) - 2(1-\sigma_2)+\sigma_1(3-2\sigma_2))^2}{(1-\sigma_1-\sigma_2)(4(1-\sigma_1)-\sigma_2(4-3\sigma_1))^2} \cdot \frac{t^2}{b}$$

Differentiating these profit functions assuming that there is an internal solution, gives the product specification best reply functions:

$$s_i = \frac{16 - 19\sigma_j(2-\sigma_j) - \sigma_j\sqrt{48\sigma_j^3 - 183\sigma_j^2 + 204\sigma_j - 60}}{4(2-3\sigma_j)(2-\sigma_j)}.$$

This is identical to the (FDI, FDI) case. As a result, the product specification best reply functions are identical to the (FDI, FDI) case, as are the subgame perfect equilibria to the product specification subgame: (0.2, 0.5) or (0.5, 0.2). Substituting these values into the profit functions gives equation (20).

Proposition 5: If the product specifications are (0.2, 0.5) in the location configurations (FDI, FDI) and (Export, Export) then the pay-off matrix for the first-stage location game is as in Table A.1. In this Table, γ_1 and γ_2 are obtained by substituting σ_2 = ½ and σ_1 = ½ respectively into the relevant profit equations. The conditions determining the pure strategy equilibria follow immediately.

Now consider the mixed strategy equilibrium. Assume that firm i exports with probability e_i and adopts fdi with probability $(1 - e_i)$. The expected profit to firm 1 from exporting is:

$$E(\pi_1^e) = e_2\frac{(\alpha-1)^2}{15} + (1-e_2)\gamma_1(\cdot)$$

while the expected profit from fdi is:

$$E(\pi_1^f) = e_2(\gamma_2(\cdot) - \phi) + (1-e_2)\left(\frac{\alpha^2}{15} - \phi\right).$$

Equating these expected profits and solving for e_2 gives $e_2(\phi)$. Similar calculations give $e_1(\phi)$.

(Table A.1 near here)

Proposition 6: The pay-off matrix is obtained from Table A.1 by switching the pay-offs for (Export, Export). The proposition then follows immediately.

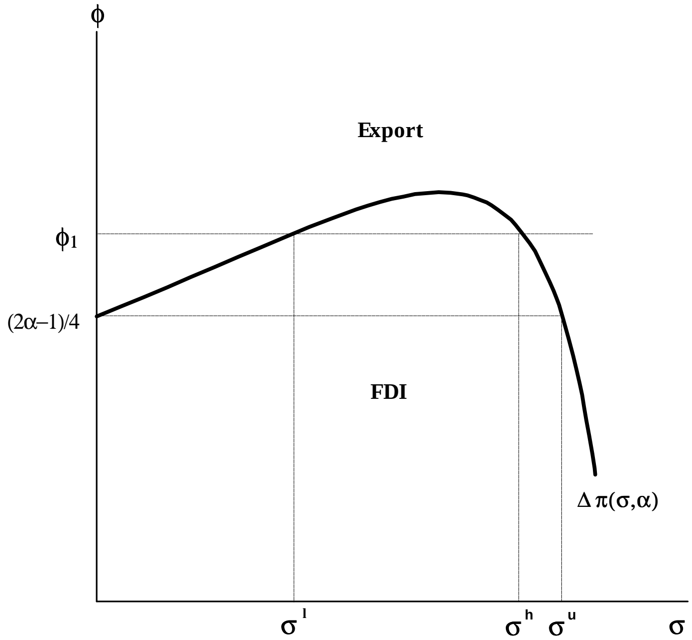

Figure 1: The Export/FDI Choice – firms located in different countries

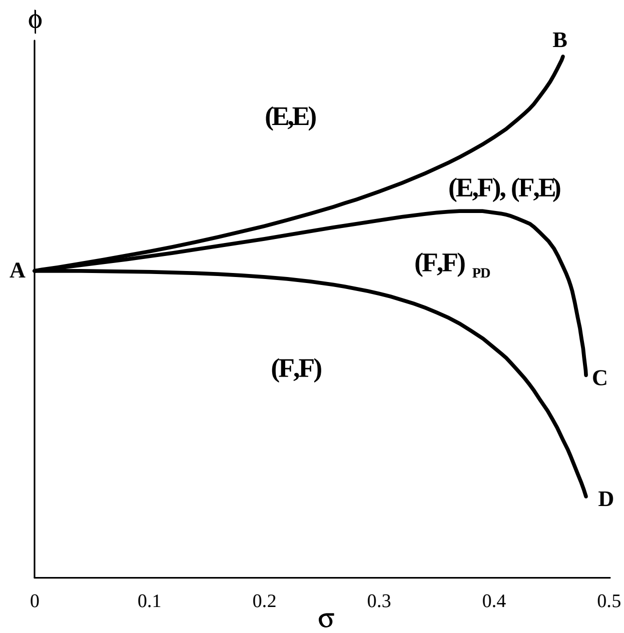

Figure 2: The Export/FDI Choice – firms located in the same country

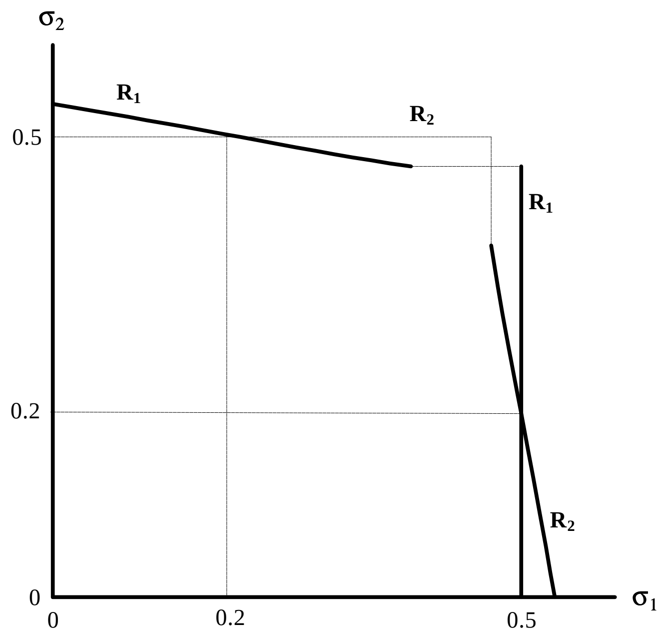

Figure 3: Product Specification Best Reply Functions when both Firms adopt FDI

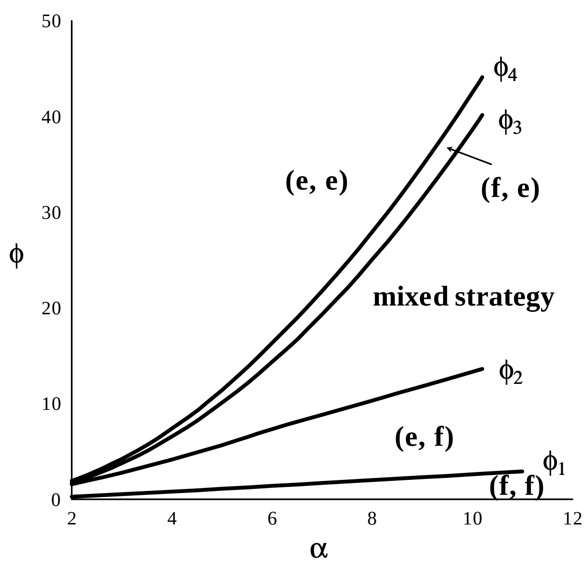

Figure 4: Equilibrium Location Configuration when the Firms have Domestic Operations in the Same Country

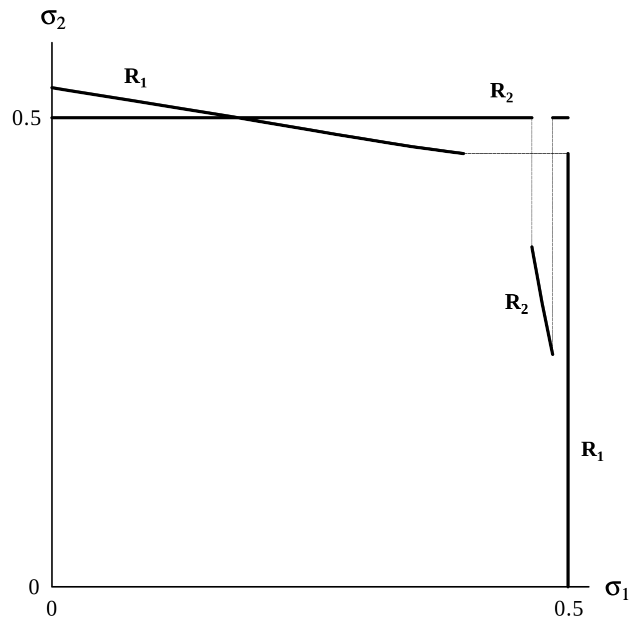

Figure A.1: Product Specification Best Reply Functions with Firm 1 Exporting and Firm 2 a Domestic Producer: $\alpha > 10.75$

Table 1: Pay-Off Matrix with Symmetric Product Specification

		Firm 2	
		Export	FDI
Firm 1	Export	$\mu(\sigma)(\alpha-1)^2;\ \mu(\sigma)(\alpha-1)^2$	$\mu(\sigma)(\alpha-\varepsilon(\sigma))^2;\mu(\sigma)(\alpha+\varepsilon(\sigma)-1)^2-\phi$
	FDI	$\mu(\sigma)(\alpha+\varepsilon(\sigma)-1)^2-\phi;\mu(\sigma)(\alpha-\varepsilon(\sigma))^2$	$\mu(\sigma)\alpha^2-\phi;\ \mu(\sigma)\alpha^2-\phi$

Table A.1: Pay-Off Matrix with Endogenous Product Specification: $\sigma_1^{ff}=\sigma_1^{ee}=0.2$

		Firm 2	
		Export	FDI
Firm 1	Export	$\frac{(\alpha-1)^2}{15}-\theta;\frac{32(\alpha-1)^2}{75}$	$\gamma_1\left(\sigma_1^{e*}(\alpha),0.5\right);\gamma_2\left(\sigma_1^{e*}(\alpha),0.5\right)-\phi$
	FDI	$\gamma_2\left(\sigma_1^{e*}(\alpha),0.5\right)-\phi;\gamma_1\left(\sigma_1^{e*}(\alpha),0.5\right)$	$\frac{\alpha^2}{15}-\phi;\frac{32\alpha^2}{75}-\phi$