Exporting versus foreign direct investment: Learning through propinquity*

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Abstract

This paper considers the role learning has on foreign direct investments (FDI) when there is both cost and demand uncertainty and firms compete strategically. It is well-known that FDI can have a benefit if it gains the firm information about local demand and costs. However, we find that with cost shocks FDI has a second effect as it correlates the firm's cost with the local rival's cost, which proves harmful in *both* price and quantity competition. Thus, the choice depends on whether the firm faces relatively more demand or cost uncertainty, to what extent inputs are locally procured (so that costs are more correlated) and how differentiated the rival's product is.

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1 Introduction

Over the last quarter-century multinational activity measured by production and sales of foreign affiliates has grown at much faster paces than GDP and trade (Markusen, 2002). The impressive rise in multinational activity has prompted international trade economists to seek reasons why some firms choose foreign direct investment (FDI) over exporting. The seminal works of Caves (1971), Helpman (1984), and Markusen (1984) have established that FDI decisions are influenced by technology characteristics such as firm-level and plant-level scale economies as well as country characteristics such as market sizes, differences in marginal costs, and trade costs.[1] Recent extensions in this strand of literature emphasize what is known as the proximity-concentration trade-off, *i.e.*, FDI is chosen over exporting if the FDI setup cost is cheaper than the transport costs.

A different approach has focused on the informational barriers naturally created by international borders. Some work has considered private information issues for the firm considering FDI,[2] while other has focused on how FDI can be affected by cost or demand uncertainty. Sung and Lapan (2000) show that exchange-rate volatility can motivate a firm to maintain plants in multiple countries so as to produce in the least-cost country. Similarly, Aizenman and Marion (2004) examine how productivity shocks affect the choice between vertical and horizontal FDI. With respect to demand uncertainty, Rob and Vettas (2003) and Kotseva and Vettas (2005) examine how demand learning affects a monopoly firm's timing to switch from exporting to FDI.[3] In related work, Qiu and Zhou (2006) consider how international *merger* can gain a firm demand information about its export market thereby providing one resolution to the "merger paradox" (that mergers are unprofitable in Cournot competition).

[1] Caves (1971) and Markusen (1995, 2002) review the literature.

[2] This approach is pioneered by Ethier (1986), who places internalization at the center of FDI decisions; see also Horstmann and Markusen (1996). More recently, Bagwell and Staiger (2003) examine how FDI can signal a firm's cost to rival firms producing in the consuming country and Katayama and Miyagiwa (2009) examine how FDI can signal a foreign monopoly's product quality.

[3] Demand for a firm's product can change suddenly due to changes in consumer preferences or other economic conditions, especially if a firm sells intermediate goods to downstream firms. In such a case, a firm can respond more quickly by locating in the consuming country, than by producing and shipping the product from its overseas plant.

With the exception of Bagwell and Staiger's (2003) signaling model, these papers examine greenfield FDI decisions in non-strategic environments (greenfield FDI is not an option in Qiu and Zhou's (2006) analysis). However, as Neary (2010) notes, trade is dominated by large firms – oligopolists – and so this environment should also be examined as "whether or not a country hosts any superstar firms is likely to matter for many questions." In this paper, we focus on the role of learning (as opposed to signalling in Bagwell and Staiger 2003) on the FDI decision in strategic environments: the firm choosing between FDI and exporting to a market, faces a local rival in that market. This allows new insights into the way FDI decisions are affected by such factors as the type of competition, the degree of product substitutability and the extent in which FDI requires "local content." It also identifies an important effect of FDI when firms compete strategically hitherto unnoticed in the literature: the correlation of firms' costs, which we describe below.

A second departure of our analysis is that, while the other papers considered either cost or demand uncertainty in isolation, we examine both types of uncertainty, the interplay of which turns out to be critical to the analysis. With demand uncertainty we use a standard simple framework (e.g., Qiu and Zhou 1996) to formalize the idea: a firm can learn more about demand shocks by locating production in the consuming country. That is, the local firm knows more about its country's demand shocks, while the foreign firm gains this additional knowledge only by choosing FDI and producing there. As for cost uncertainty, we assume that costs are distributed independently across countries. Thus, when the foreign firm exports, firms produce in separate countries and face different cost shocks. In contrast, with FDI the foreign firm must procure some of its inputs in the consuming country and hence faces some of the same cost shocks that the rival does and so learns about the rival's cost, which is valuable to the firm when it competes strategically with its rival. For example, as firms employ labor from the common labor market or labor union, seeing wages increase reveals to the foreign firm that its rival is also facing higher labor cost. Other aspects of FDI, *e.g.*, using common local suppliers, enhance this effect.[4] However, this also means that

[4]It is well-known in the "information sharing" literature that duopolists prefer to share private cost information with Cournot competition but prefer to conceal this cost information with price competition

the firms' costs are now more correlated. This is what is meant by "cost correlation," which we show is harmful to firms when they compete strategically.

We now preview our main findings. First, if cost uncertainty is sufficiently larger than demand uncertainty or FDI requires a sufficiently large portion of "local content" so as to correlate costs more, then the foreign firm prefers exporting to FDI. Second, FDI decisions are also influenced by the degree of product differentiability. Specifically, FDI becomes less attractive as the firms produce closer substitutes. This is because as the goods become closer substitutes, demand information becomes less valuable and at the same time the cost correlation effect worsens. Thus, we expect a foreign firm to choose FDI over exporting (i) when rivals produce sufficiently differentiated goods, (ii) when cost uncertainty is small relative to demand uncertainty, and (iii) "local content" is not too large a fraction of the firms production costs. We show that these principal results hold both in quantity and price competition, unlike many results in oligopoly models that depend crucially on the type of competition.[5] In addition, these principal results hold under different information structures regarding the cost uncertainty (*e.g.*, whether a firm learns its rival's cost when exporting is chosen). Finally, these results suggest not only a reason why FDI occurs, but why it has been growing. To the extent that upstream multinationals choose FDI and produce intermediate goods locally, input markets become globalized across countries. As costs become less dependent on local shocks, FDI becomes more attractive to downstream multinationals relative to exporting. Thus, FDI by a multinational producing an input good may be the catalyst for FDI by multinationals using that input.

Turning to the consuming country's welfare we first find that its firm is usually harmed by FDI when the foreign firm finds FDI profitable.[6] The primary reason is that a correlation

(*e.g.*, Gal-or 1986). However, in that literature the characteristic of the distribution from which costs are drawn is fixed, while here firms draw independently with exporting but draw common values with FDI. That is, sharing information about cost does not correlate costs, while FDI does and this is the stronger effect. Thus, our setup is distinct and our results differ from what that literature would suggest.

[5]One exception to this can be found in Etro (2011) who revisits optimal export policy and shows that it is always optimal to subsidize exports when, contrary to previous work, entry is endogenous.

[6]Three conditions must hold simultaneously for the domestic firm actually to benefit: cost uncertainty is sufficiently great (but not too great to prevent the foreign firm from choosing FDI) or local content is sufficiently large; the goods are relatively undifferentiated; and the firms compete in prices. Thus, for

of costs works symmetrically on both firms, harming the local firm as much as it does the foreign firm, but the local firm does not get the benefit of gaining demand information. This finding may help to shed light on evidence that FDI reduces the profitability of local firms (Gorg and Greenaway 2004).

As for consumers, we find that the effect of FDI on consumer surplus – unlike our previous results – depends on whether the firms compete in prices or quantities. With quantity competition, consumers benefit from FDI because the foreign firm responds to high demand by expanding output. While the opposite holds when demand is low, consumers' marginal value is lower, so the loss from reduced consumer surplus when demand is low is dominated by the gain in consumer surplus from an output expansion at high demand. However, in price competition this effect is reversed because a firm raises its price when demand is high. As a result, FDI benefits consumers when the firms compete in quantities but harms them when firms compete in prices.

While it may affect consumers and the consuming country's firm differently, FDI almost always decreases the consuming country's welfare. The exception occurs only when all three of the following conditions hold: the goods are highly differentiated (so there is little strategic interaction); demand uncertainty is large relative to cost uncertainty or there is sufficiently small "local content" of inputs; and the firms compete in quantities. A high degree of product differentiation implies that the local firm is little affected by the foreign firm's access mode (production location) and that cost learning also has little or no effect on consumers. Thus, when these three conditions are met, FDI affects the consuming country's welfare primarily through demand learning, which is positive with quantity competition. Otherwise, the consuming country is harmed.

The remainder of the paper is organized in four sections. In the next section we present the main modeling assumptions. We then examine the outcomes when the firms compete in quantities (Section 3) and then prices (Section 4). Section 5 concludes and briefly considers

example, even if the firms compete in prices and the goods are of any degree of product differentiation, if the demand and cost uncertainty are of the same magnitude, then the local firm is always harmed when the foreign firm prefers FDI.

additional extensions.

2 Environment

A foreign firm (firm f) competes with a home firm (firm h) in the home market producing differentiated goods in quantities q_f and q_h, respectively. The home firm always produces at home but the foreign firm can locate in the foreign country (F) or the home country (H). The production costs are linear and partially depend on the location of production, but also on the extent that input supply is internationally integrated (so not dependent on location) or that there are "local content" laws. Let x represent the fraction of costs from internationally integrated inputs and $(1-x)$ from local inputs, which to focus on the issue at hand we will take as being the same fraction regardless where production is located. Let $c_{j,N}$, $j = f, h; N = F, H$, denote the location-specific marginal cost for firm j and c_I denote the internationally integrated marginal cost. Alternatively, $(1-x)$ can be interpreted the extent production is susceptible to local shocks and implies the extent cost between firms are correlated by location. Although the home country marginal cost is the same for both firms (*i.e.*, $c_{f,H} = c_{h,H}$), we will keep the firm subscript to make clearer the source of different effects. Thus, the home firm's marginal cost is $xc_I + (1-x)c_{h,H}$ whereas the foreign firm's marginal cost equals $xc_I + (1-x)c_{f,N}$, depending on the choice of production location.

Consumers in the home market are modeled, following Vives' (1984) model of learning in strategic competition, as a continuum of identical agents with separable, linear utility in the numeraire good and quadratic preferences for the differentiated goods:

$$U(q_f, q_h) = \alpha(q_f + q_h) - (1/2)(q_f^2 + 2\delta q_f q_h + q_h^2), \alpha > 0, 1 \geq \delta > 0,$$

where $\delta \in [0, 1]$ is a measure of product substitutability. Given prices p_f and p_h, the consumer chooses q_f and q_h to maximize

$$\alpha(q_f + q_h) - (1/2)(q_f^2 + 2\delta q_f q_h + q_h^2) - p_f q_f - p_h q_h. \tag{1}$$

There is a random element to the home preferences α with $E[\alpha] = \overline{\alpha}$ and $Var[\alpha] = \sigma_\alpha^2$.[7]

We model the interaction between the firms in three stages. In stage one the foreign firm chooses where to build a plant to serve home country consumers. The home firm has a plant in the home country. In stage two, nature draws values for preferences, α, and costs, $c_{j,H}$, $c_{j,F}$ and c_I, and reveals them to the home firm regardless of the foreign firm's location choice. Nature also reveals all four values to the foreign firm only if it locates in the home country; otherwise only the values of $c_{j,F}$ and c_I are disclosed. This is all common knowledge. In stage three, given the foreign firm's location and the values revealed, the firms compete in quantities or prices in the home market.

Notice that we take the foreign firm's cost realization to be always observed by both firms. This is purposely done so as to maximize the amount of information the foreign firm learns with FDI, making FDI informationally most attractive relative to exporting. That is, we try to bias our model to make FDI as attractive as possible and yet we can show that the foreign firm may not choose FDI due to the correlation of costs.[8] However, this information structure is not critical to our results because the cost correlation effect swamps the information effect. We outline how the results under alternative informational assumptions are qualitatively the same in Section 3.5 after the presentation of our main results.[9]

To focus on the issue at hand we will make some assumptions to simplify the exposition. First, to prevent asymmetry in expected marginal costs from driving the results, we assume that country-specific costs are drawn independently from some common distribution, so that they have identical expected value and variance, *i.e.*, $E[c_j, N] = E[c_I] = \overline{c}$ and $Var[c_j, N] = \sigma_c^2$. However, in our presentation we will keep subscripts to make clear the source of different effects. In addition, since the international content is independent of location, to simplify notation we assume that $Var[c_I] = 0$, *i.e.*, the value of c_I is fixed. Once our main results are

[7]Implicitly it is assumed that α has finite support and the lower limit of the support is sufficiently large so that all firms have positive output. (The same implicit assumption will apply to the cost uncertainty assumed below.)

[8]As discussed in the introduction (cf. footnote 4) this also allows us to emphasize how our model and results are different (and at times contradictory) to those in the information sharing literature.

[9]If the domestic rival did not learn the foreign firm's cost with exporting, then some of our results would be related to the information sharing literature (see, *e.g.*, Vives 1990). Then FDI would be equivalent to the foreign firm forcing both firms to share information.

presented, relaxing this assumption on variance is straightforward and the implications are immediate. Likewise, we could introduce other "world" shocks as well, but so long as they are not dependent on location our results would not change and to the extent they would depend on location this would just emphasize our point. Second, we assume that the foreign firm incurs the same plant setup cost regardless of its location choice, and that export requires no transport cost while FDI involves no additional fixed costs. This eliminates the standard proximity-concentration trade-off familiar in the literature, making FDI and exporting equally attractive to the foreign firm (and to the home firm) in the absence of uncertainty.

3 Quantity Competition

To derive the equilibrium we first characterize the third stage depending on the foreign firm's location decision, and then work back to each previous stage.

3.1 Third stage

In the third stage, the foreign firm has already made its location choice (exporting or FDI) and the demand and the cost shocks have been realized. From consumers maximizing their utility (the first-order conditions on (1)), firm j faces inverse demand $p_j = \alpha - q_j - \delta q_k, j \neq k$. There are two subgames to consider, depending on the foreign firm's choice of access mode (production location).

3.1.1 Foreign firm exports

If it exports, the foreign firm learns neither the home market demand intercept (α) nor the rival's cost realization ($c_{h,H}$). Thus, it chooses q_f to maximize the expected profit

$$E[\alpha - q_f - \delta q_h(\alpha, c_{h,H}) - (xc_I + (1-x)c_{f,F})]q_f$$

yielding from the first-order condition

$$q_f(c_{f,F}) = E[\alpha - (xc_I + (1-x)c_{f,F}) - \delta q_h(\alpha, c_{h,H})]/2. \tag{2}$$

In contrast, having complete information, the home firm chooses q_h to maximize

$$[\alpha - q_h - \delta q_f(\alpha, c_{f,F}) - (xc_I + (1-x)c_{h,H})]q_h.$$

yielding from the first-order condition

$$q_h(\alpha, c_{h,H}) = [\alpha - (xc_I + (1-x)c_{h,H}) - \delta q_f(c_{f,F})]/2. \tag{3}$$

From (2) and (3) and taking the foreign firm's expectation of the home firm's choice (3), we obtain the following Bayesian-Nash equilibrium outputs (with superscript X to indicate the exporting decision):

$$q_f^X = \frac{\overline{\alpha}(2-\delta) - 2(xc_I + (1-x)c_{f,F}) + \delta(xc_I + (1-x)\overline{c}_{h,H})}{4-\delta^2}$$

$$q_h^X = \frac{\alpha(2-\delta) - 2(xc_I + (1-x)c_{h,H}) + \delta(xc_I + (1-x)c_{f,F})}{4-\delta^2} + \frac{\delta^2}{2}\frac{\alpha - \overline{\alpha} + (1-x)(c_{h,H} - \overline{c}_{h,H})}{4-\delta^2}$$

Third-stage equilibrium profits then are

$$\pi_f^X = (\alpha - q_f^X - \delta q_h^X - (xc_I + (1-x)c_{f,F}))q_f^X$$
$$\pi_h^X = (\alpha - q_h^X - \delta q_f^X - (xc_I + (1-x)c_{h,H}))q_h^X$$

Note that the foreign firm's profit is linear in demand intercept and the home firm's cost shocks since they do not enter q_f^X.

3.1.2 Foreign firm chooses FDI

If the foreign firm chooses FDI, both firms know the demand and (now common) cost shocks and hence play a game of complete information. Letting c_H denote the common home marginal cost, *i.e.*, $c_{f,H} = c_{h,H} \equiv c_H$, the usual calculus yields the following symmetric Nash equilibrium outputs:

$$q_j^{FDI} = \frac{\alpha(2-\delta) - 2(xc_I + (1-x)c_{j,H}) + \delta(xc_I + (1-x)c_{k,H})}{4-\delta^2} = \frac{\alpha - (xc_I + (1-x)c_H)}{2+\delta}.$$

Firm j's third-stage equilibrium profit is given by

$$\pi_j^{FDI} = (\alpha - q_j^{FDI} - \delta q_k^{FDI} - (xc_I + (1-x)c_{j,H}))q_j^{FDI}.$$

With these calculations the two possible third-stage games have been characterized. In stage two Nature moves, revealing information to the firms according to the foreign firm's mode selection. We now proceed to the first stage.

3.2 First stage

To simplify exposition it is useful to exploit the fact that, as the shocks enter linearly, in the first stage the expected output is the same across access mode (production location) decisions; that is, $E[q_j^{FDI}] = E[q_j^X]$. Define this mean output as

$$\overline{q}_j^{(\cdot)} \equiv \frac{\overline{a}(2-\delta) - 2(x\overline{c}_I + (1-x)\overline{c}_{j,N}) + \delta(x\overline{c}_I + (1-x)\overline{c}_{k,N})}{4-\delta^2}.$$

Note that $\overline{q}_j^{(\cdot)}$ is also a firm's output if it did not learn any of the shocks. Further, since expected marginal costs are equal, expected outputs are the same across firms; that is, $\overline{q}_j^{(\cdot)} = \overline{q}_k^{(\cdot)} \equiv \overline{q}$. It follows from the definitions of profits in Section 3.1 that the profit evaluated at the expected cost are also equal across access mode decisions and firms: $\pi_j^X = \pi_j^{FDI}$.[10]

[10] See Qiu (1994) for a clear demonstration and intuition of these results.

Denote this common profit by:

$$\overline{\pi}_j \equiv (\overline{\alpha} - \overline{q}_j - \delta\overline{q}_k - (x\overline{c}_I + (1-x)\overline{c}_{j,N}))\overline{q}_j.$$

Note that this also is the firm's expected profit if it did not learn any of the shocks.

We now compute the expected profits. If the foreign firm exports, then, taking the expectation of π_f^X, yields

$$E[\pi_f^X] = \overline{\pi} + \frac{4(1-x)^2}{(4-\delta^2)^2}\sigma_{f,F}^2. \tag{4}$$

The first term in (4) is the foreign firm's expected profit when it does not learn (and would have set output $\overline{q}_f$). The second term reflects the value to the firm from learning its cost. Two effects determine the coefficient on variance. The first is the classic value from learning: because the foreign firm adjusts its output upon learning its cost shock, its profit, given that cost realization, is greater than when the firm does not learn (and so cannot adjust its output from $\overline{q}_f$). Hence, its expected profit with learning is greater than expected profit without learning ($\overline{\pi}$).

The second effect is subtler and is due to the fact that the home firm also learns the foreign firm's cost shock and reacts to it. To understand this effect, suppose, for example, that the foreign firm draws a lower-than-average cost. From the envelope theorem, the direct effect is to increase the foreign firm's profit margin, $(\alpha - q_f - \delta q_h - (xc_I + (1-x)c_{f,F}))$, by $(1-x)dc_{f,F}$ given the home firm's output. However, there is a second effect: observing the foreign firm having low cost, the home firm contracts its output, which further increases the foreign firm's profit margin. Thus, the home firm's reaction amplifies the effect of drawing a lower cost. The same logic applies when the foreign firm draws a higher-than-average cost; the foreign firm's profit margin decreases more when the home firm reacts. Thus, the home firm's reactions to the foreign firm's cost realization generate an effect akin to a mean-preserving spread on the cost distribution of the foreign firm, which is beneficial because its profit is convex in cost.[11]

[11]The total effect of a unit cost change to the foreign firm (*i.e.*, both the foreign firm's cost change and the

Observe however that the second effect diminishes as δ diminishes; that is, as the goods become more differentiated, the home firm's output response generates less variability in the foreign firm's profit margin, decreasing the foreign firm's expected profit. Note also that, since the foreign firm does not learn demand or the home firm's cost realization, those shocks do not introduce variance into the foreign firm's expected profit expression in (4).

Consider now the case in which the foreign firm chooses FDI. Then, since both firms know home demand and face the same cost shock specific to the home country, they have the identical expected profit:

$$E[\pi_i^{FDI}] = \overline{\pi} + \frac{(2-\delta)^2}{(4-\delta^2)^2}\sigma_\alpha^2 + \frac{(1-x)^2(2-\delta)^2}{(4-\delta^2)^2}\sigma_H^2, \tag{5}$$

where the firm indication on the cost variance has been dropped as $\sigma_{f,H}^2 = \sigma_{h,H}^2 \equiv \sigma_H^2$.

For the foreign firm, its profit with exporting (4) differs from its profit with FDI (5) in two respects. First, since the foreign firm can now adjust to demand shocks, its profit is convex in the demand intercept, implying that it values demand information. This is reflected by the positive coefficient on σ_α^2 in (5).

Second, the coefficient of cost variance σ_H^2 in (5) differs from that of $\sigma_{f,F}^2$ in (4) because of the correlation of costs alluded to earlier: by locating in the home country the foreign firm learns the home firm's cost, but also faces the same cost shocks that the home firm does.[12] To understand this, compare what occurs now with FDI when the foreign firm draws a lower-than-average cost ($dc_{f,H}$) to when the firm exports. In both cases, the direct effect of this lower cost is to, fixing the home firm's output, increase the foreign firm's profit margin ($\alpha - q_f - \delta q_h - (xc_I + (1-x)c_{f,H})$ by $(1-x)dc_{f,H}$. With FDI however, the second effect changes as compared to when it exports: the home firm also has drawn a lower cost and expands its output, which decreases the foreign firm's profit margin, given the cost shock

change in the home firm's output) on the foreign firm's profits therefore equals $-[1+(\delta^2/(4-\delta^2)](1-x) = -4(1-x)/(4-\delta^2)$ which is greater in magnitude than $-(1-x)$, so the coefficient of the variance term is $4(1-x)^2/(4-\delta^2)^2$. This is the reason why Cournot firms agree to information sharing contracts on cost (see, *e.g.*, Gal-Or 1986).

[12] Or, to put it another way, the information has gone from being private valued to being common valued.

(with exporting, the home firm would have, instead, *contracted* its output). Calculations show that the latter decreases the foreign firm's profit margin by $(\delta(1-x)/(2+\delta))dc_{f,H}$. In net, these two effects change the profit margin by $(2(1-x)/(2+\delta))dc_{f,H}$, which is smaller in magnitude as compared to the export case.[13] Similarly, when the firms draw a higher-than-average cost, the foreign firm's profit margin decreases by a smaller amount than in the exporting case. Thus, correlation of cost shocks generates an effect similar to a mean-preserving contraction on the cost distribution, which is harmful, given convexity of profit.

3.3 The access mode decision for the foreign firm

We are now in a position to address our main issue. The foreign firm chooses FDI whenever it is more profitable than exporting or if:

$$E[\pi_f^{FDI}] - E[\pi_f^X] = \frac{(2-\delta)^2}{(4-\delta^2)^2}\sigma_\alpha^2 + \frac{(1-x)^2(2-\delta)^2}{(4-\delta^2)^2}\sigma_H^2 - \frac{4(1-x)^2}{(4-\delta^2)^2}\sigma_{f,F}^2 > 0. \tag{6}$$

The second and third terms sum to less than zero under the assumption that the variances on the country-specific shocks are identical; $\sigma_H^2 = \sigma_{f,F}^2$ (recall that $\sigma_{i,F}^2 = \sigma_c^2$). Thus, the foreign firm's decision depends on whether the value from learning about the market demand is relatively greater than the harm from correlating costs. Using the common cost variance σ_c^2 in (6), we obtain:

Proposition 1 *When firms compete in quantities, FDI is the more profitable than exporting for the foreign firm if the demand uncertainty is sufficiently greater than the cost uncertainty or the goods are sufficiently differentiated or production costs are not too locally dependent:*

$$\sigma_\alpha^2 \geq \frac{(1-x)^2\delta(4-\delta)}{(2-\delta)^2}\sigma_c^2. \tag{7}$$

When the goods are perfect substitutes ($\delta = 1$) the condition in Proposition 1 becomes $\sigma_\alpha^2 \geq 3(1-x)^2\sigma_c^2$. As the goods become more differentiated (or δ decreases), the RHS of

[13] Since its cost shock effect is -1, the net effect of a unit cost change (home firm response plus the direct cost change) equals $\delta/(2+\delta) - 1 = -2/(2+\delta)$, which is smaller in magnitude than -1. As $-2/(2+\delta) = -2(2-\delta)/(4-\delta^2)$ we have the coefficient of $(2-\delta)^2/(4-\delta^2)^2$ on the variance term.

(7) decreases: FDI becomes more attractive. This has both a demand-side and a cost-side explanation. On the demand side, a higher-than-average demand induces the home firm to expand output q_h, dampening the net increase in the foreign firm's price-cost margin $(\alpha - q_f - \delta q_h - (xc_I + (1-x)c_{f,H}))$. However, as this expression makes clear, a smaller δ mitigates the dampening effect. The same logic applies for lower-than-average demand, yielding a result akin to a mean-preserving spread on the demand distribution as the goods become more differentiated (smaller δ), which benefits the foreign firm. Thus, demand information is more valuable the more differentiated the goods. The logic on the cost-side works similarly. As the discussion following (5) indicates, a decrease in δ mitigates the effect of a mean-preserving contraction in the cost distribution, making FDI more attractive. Thus, both on the demand and the cost side a decrease in δ makes FDI more profitable to the foreign firm.

Turning to the extent that cost are location dependent, as cost becomes more location dependent (a decrease in x), the correlation effect worsens, making FDI less attractive. In other words, as input markets become more internationally integrated or globalized (an increase in x; input costs less dependent on the production location), FDI becomes more attractive to a firm. Thus, as the world becomes more globally integrated (partly because of FDI), the correlation effect diminishes encouraging more FDI, perhaps helping to explain why FDI has been growing at a greater rate than GDP and trade.

3.4 Home country welfare

We next examine the effect of FDI on home firm profit, consumer surplus and home country welfare (home firm profits plus consumer surplus). The focus is on when the foreign firm's and the home-country government's preferred plant location choices diverge, and what type of government interventions can be inferred from it. In addition, the producer and consumer surplus effects can shed light on the political pressure the home government might face.

We begin with home firm profit. Since the home firm always learns and responds to demand and cost realizations when the foreign firm exports, these three shocks introduce

variance into the home firm's expected profit:

$$E[\pi_h^X] = \overline{\pi} + \frac{1}{4}\sigma_\alpha^2 + \frac{(1-x)^2}{4}\sigma_{h,H}^2 + \frac{(1-x)^2\delta^2}{(4-\delta^2)^2}\sigma_{f,F}^2.$$

Though we assume that $\sigma_{h,H}^2 = \sigma_{f,F}^2$ we have kept the subscripts to clarify the role of various cost shocks in the location decision.

When the foreign firm chooses FDI, profits are identical across firms, so (5) also represents the home firm's expected profit. Then the relative effect of FDI on home profits is given by

$$\begin{aligned} E[\pi_h^{FDI}] - E[\pi_h^X] = &- \frac{\delta(4+\delta)(2-\delta)^2}{4(4-\delta^2)^2}\sigma_\alpha^2 \\ &- \frac{\delta(1-x)^2(4+\delta)(2-\delta)^2}{4(4-\delta^2)^2}\sigma_H^2 - \frac{4(1-x)^2\delta^2}{4(4-\delta^2)^2}\sigma_{f,F}^2. \end{aligned} \tag{8}$$

All the terms in (8) are negative, and hence when the foreign firm would choose FDI over exporting the home firm is made worse off.

Proposition 2 *Profitable FDI for the foreign firm harms the home firm.*

The intuition behind Proposition 2 is straightforward. If the foreign firm chooses FDI, the home firm loses its advantage in demand information and is also harmed by having correlated cost. However, a key aspect is that even if the home firm had no informational advantage on demand, it would still be opposed to FDI because of the correlation of costs. Of course, non-profitable FDI would also harm the home firm, but the foreign firm would not choose it unless subsidized in some manner. Finally, note that no matter how internationally integrated the input markets become (an increase in x), the home firm is still harmed by FDI because of the loss of the demand advantage.

Turning to consumers, substituting the derived demands into consumer surplus (1) yields

$$\frac{q_f^2}{2} + \delta q_f q_h + \frac{q_h^2}{2}. \tag{9}$$

Note that because consumers make purchases *after* observing prices, the consumer is able to

adjust their consumption between the two goods the firms produce and the numeraire good: when the price is high for a good, the harm is mitigated as the consumer substitutes away from it to the other goods, and when the price is low they can buy more of it.[14] As a result, consumer surplus is convex in the firms' output, that is, consumer surplus is increasing in output variability.

Using equilibrium quantities in the third stage, we can calculate expected consumer surplus under the two regimes (exporting and FDI).[15] Since expected outputs are the same with either mode, mean consumer surplus (that is, consumer surplus evaluated at expected cost and demand) is the same. Denote this mean consumer surplus $\overline{CS}$. Substituting the equilibrium outputs q_i^X into (9) and taking the expectation yields expected consumer surplus when the foreign firm exports:

$$E[CS^X] = \overline{CS} + \frac{1}{8}\sigma_\alpha^2 + \frac{(1-x)^2}{8}\sigma_{h,H}^2 + \frac{(1-x)^2(4-3\delta^2)}{2(4-\delta^2)^2}\sigma_{f,F}^2.$$

If instead the foreign firm chooses FDI, then there is only one variance term for the cost shock, subscripted H: $\sigma_{f,H}^2 = \sigma_{h,H}^2 = \sigma_H^2$. Using q_i^{FDI} in (9) and taking the expectation yields expected consumer surplus with FDI:

$$E[CS^{FDI}] = \overline{CS} + \frac{1+\delta}{(2+\delta)^2}\sigma_\alpha^2 + \frac{(1-x)^2(1+\delta)}{(2+\delta)^2}\sigma_H^2.$$

Then the effect of FDI on consumer surplus is

$$\begin{aligned} E[CS^{FDI}] - E[CS^X] =& \frac{(4+4\delta-\delta^2)(2-\delta)^2}{8(4-\delta^2)^2}\sigma_\alpha^2 + \frac{(1-x)^2(4+4\delta-\delta^2)(2-\delta)^2}{8(4-\delta^2)^2}\sigma_H^2 \\ & - \frac{4(1-x)^2(4-3\delta^2)}{8(4-\delta^2)^2}\sigma_{f,F}^2. \end{aligned} \tag{10}$$

Analyzing (10) we see that home consumers can potentially be harmed by FDI, but if the goods are sufficiently close substitutes, then they always benefit. Specifically, if $\delta \geq$

[14] Recall that the Walrasian auctioneer in the Cournot model sets the prices to clear the market given the firms' output, i.e. the prices so that the consumer consumes the total amount brought to market.

[15] See Schlee (2008) for analysis of expected consumer surplus under other assumptions on preferences.

$2(2-3^{1/2}) \approx (1/2)$ then the sum of the last two terms on the RHS of (10) is positive, so (10) is positive: consumers always benefit from FDI. That is, a necessary but not sufficient condition for consumers to be harmed by FDI is that $\delta < 2(2-3^{1/2})$. To understand how consumers can be harmed first note that the only negative term in (10) come from lost variability from the foreign cost shocks when the foreign firm locates in the home country. The intuition here is that when the foreign firm chooses FDI consumers no longer have the opportunity to buy more of the foreign good when foreign cost is low. As the goods become closer substitutes (δ increases) this harm becomes relatively smaller because the correlated effect on costs becomes relatively larger (the middle term) and when $\delta \geq 2(2-3^{1/2})$ the coefficient on σ_H^2 becomes greater than the coefficient on $\sigma_{f,F}^2$. On the other hand, a benefit of FDI is that the foreign firm better responds to demand conditions: producing more output when the consumers value the product more (high demand) and less output when they value it less. As the goods are closer substitutes (δ increases) this benefit is stronger. Thus, FDI could harm consumers if demand uncertainty is small relative to cost uncertainty. Finally, as the world becomes more integrated (x increases), consumers are more likely to benefit from FDI.

Although the effect on home consumers from FDI is ambiguous, the effect on home consumers when the foreign firm would *choose* FDI is clear: FDI that is profitable to the foreign firm always increases home consumer welfare.

Proposition 3 *Profitable FDI for the foreign firm increases expected home consumer surplus.*

Proof. From (10) FDI increases consumer surplus whenever

$$\sigma_\alpha^2 \geq \frac{\delta^2(1-x)^2(4-8\delta+\delta^2)}{(2-\delta)^2(4+4\delta-\delta^2)}\sigma_c^2 \tag{11}$$

As

$$\frac{\delta(4-\delta)}{(2-\delta)^2} \geq \frac{\delta^2(4-8\delta+\delta^2)}{(2-\delta)^2(4+4\delta-\delta^2)}$$

then the condition for FDI to be profitable (7) implies that FDI increases home welfare:

$$\sigma_\alpha^2 \geq \frac{\delta(1-x)^2(4-\delta)}{(2-\delta)^2}\sigma_c^2 \geq \frac{\delta^2(1-x)^2(4-8\delta+\delta^2)}{(2-\delta)^2(4+4\delta-\delta^2)},$$

and so if FDI is profitable to the foreign firm, home consumer surplus increases with FDI. ■

FDI could harm consumers when demand uncertainty is relatively small. However, by Proposition 1 this is exactly when the foreign firm would prefer exporting over FDI. In fact, it is even possible that the foreign firm would prefer to choose exporting even though consumers prefer FDI. On the other hand, subsidies that induce the foreign firm to choose FDI when exporting is more profitable could result in consumer surplus reducing FDI. Finally, notice that the result does not depend on how internationally integrated the input market is (x).

We turn next to consider the effect of FDI on home welfare, which comprises home profit and consumer surplus: $W \equiv \pi_h + CS$. The effect is not immediate since when it is profitable for the foreign firm to choose FDI home consumers benefit while the home firm is harmed. Combining (8) and (10) the welfare impact of FDI (that is, home welfare with FDI less home welfare with exporting) is expressed as:

$$E[W^{FDI}] - E[W^X] = \frac{(2-3\delta)(2-\delta)}{8(4-\delta^2)}\sigma_\alpha^2 + \frac{(1-x)^2(2-3\delta)(2-\delta)}{8(4-\delta^2)}\sigma_H^2 - \frac{4(1-x)^2}{8(4-\delta^2)}\sigma_{f,F}^2. \quad (12)$$

Examination of (12) shows that unless the goods are sufficiently differentiated and either demand uncertainty is relatively large or local production sufficiently small, home welfare is harmed by FDI that is profitable for the foreign firm. First, if the goods are close enough substitutes, *i.e.*, $\delta > 2/3$, then (12) is clearly negative, so FDI yields lower welfare than exporting. Second, if $\delta < 2/3$, the first two terms on the right-hand side of (9) are positive while the third is negative. Then demand uncertainty needs to be relatively small for (12) to be negative. However, if the demand uncertainty is too small the foreign firm does not choose FDI (7). However, straightforward algebraic manipulations of (12) yields that there is still a range of uncertainty when $\delta < 2/3$ that results in profitable FDI that harms the

home country.

Proposition 4 *Profitable FDI for the foreign firm reduces expected home welfare when either the goods are close enough substitutes, or, demand uncertainty is not too large relative to cost uncertainty and production costs are sufficiently locally dependent:*

1. $\delta > \frac{2}{3}$
2. $\delta < \frac{2}{3}$ *and* $\sigma_\alpha^2 \in \left(\delta\frac{(1-x)^2(4-\delta)}{(2-\delta)^2}\sigma_c^2, \delta\frac{(1-x)^2(8-3\delta)}{(2-\delta)(2-3\delta)}\sigma_c^2\right)$.

In the first case ($\delta > 2/3$), as the goods become closer substitutes home firm profits decrease as it loses more of its informational advantage from FDI. At the same time the gain to home consumers from the foreign firm learning demand decreases because of the strategic response of the home firm (*e.g.*, when demand is high the home firm's increase in output reduces the magnitude of the foreign firm's increase in output). Similarly, as the goods are closer substitutes the home firm is harmed more by the correlation of its cost with the foreign firm's cost. In the second case ($\delta < 2/3$) when the goods are, instead, more differentiated, the logic is reversed and home welfare increases, unless cost uncertainty is sufficiently large so that home consumer gain very little (Proposition 3), but not too large that the foreign firm would not choose FDI (Proposition 1). Note that in the extreme case of independent goods ($\delta = 0$, so the empty set for σ_α^2), the home firm is not harmed by the foreign firm learning home demand while consumers benefit from the latter.

3.5 Other information structures

In the preceding analysis we assumed that the home firm always observes the foreign firm's cost, while the foreign firm does not observed the home firm's cost when it exports. As discussed in Section 2, this assumption enabled us to seemingly make FDI as attractive as possible to the foreign firm by maximizing the amount of information acquired. However, there are two other information structures that are also quite plausible:

1. No firms observe the rival's cost when exporting is chosen.

2. Both firms know each other's cost realizations regardless of the mode selection.

These alternatives however produce only secondary effects so our results are qualitatively unaffected. That is, the correlation effect is significantly greater than any informational effect and so changes in the information structure has little if any impact. For example, if the goods are perfect substitutes ($\delta = 1$), then the foreign firm will still choose FDI only if the demand uncertainty is greater than the cost uncertainty. Likewise, in both of these alternative structures the home firm is still harmed by FDI, FDI that is profitable to the foreign firm makes home consumers better off and the home country prefers exporting unless δ is sufficiently low (for the case of equal variances the critical δ is almost identical).

4 Price Competition

Oftentimes in models of strategic competition the results critically turn on the type of competition. Therefore, in this section we check the robustness of our results by extending our analysis to price competition. The main finding is that, surprisingly enough, almost all of the principal results from quantity competition carry over to price competition almost intact; namely, the incentive to choose FDI and the likelihood that the home firm is harmed by FDI is only slightly weakened while the likelihood the home country is harmed is strengthened (*i.e.*, it is harmed for a greater range of parameter values).

The derivations of these results follow the outline of Section 3. Using again the first-order conditions on (1), but now inverting, firm j faces the following demand

$$q_j = \frac{\alpha}{1 = \delta} - \frac{p_j}{1 - \delta^2} + \frac{\delta p_k}{1 - \delta^2}, \delta \in (0, 1), j \neq k.^{16} \tag{13}$$

[16]Note that demand is not defined with perfect substitutes ($\delta = 1$). However, this approach allows the most direct comparison between price and quantity competition (see Vives (1984)).

4.1 Third stage

In the third stage each firm simultaneously sets price. Using (13), firm j chooses p_j to maximize

$$E\left[\frac{\alpha(1-\delta)-p_j+\delta p_k}{1-\delta^2}(p_j-(xc_I+(1-x)c_{j,N}))\right] \tag{14}$$

From the first-order condition firm j's best response is

$$p_j=\frac{1}{2}(E[\alpha](1-\delta)+\delta p_k+(xc_I+(1-x)c_{j,N}))$$

where the expectation of α depends on the firm's information. For reference it is again useful to first calculate the outcome when there is no uncertainty, i.e., each parameter equals its mean. In such a case, the Nash equilibrium price is

$$\overline{p}_j\equiv\frac{\overline{\alpha}(2-\delta-\delta^2)+2(x\overline{c}_I+(1-x)\overline{c}_{j,N})+\delta(x\overline{c}_I+(1-x)\overline{c}_{k,N})}{4-\delta^2}$$

This also is the firm's price if it did not learn any of the shocks. As the remainder of the derivations closely follows the steps from the previous section, the intermediate steps are omitted.

Suppose that the foreign firm exports. Then in stage three firms play a game of (asymmetric) incomplete information. Calculations yield the Bayesian-Nash equilibrium prices:

$$p_f^X=\frac{\alpha(2-\delta-\delta^2)+2(xc_I+(1-x)c_{f,F})+\delta(x\overline{c}_I+(1-x)\overline{c}_{h,H})}{4-\delta^2}$$

$$p_h^X=\frac{\alpha(2-\delta-\delta^2)+2(xc_I+(1-x)c_{h,H})+\delta(xc_I+(1-x)c_{f,F})}{4-\delta^2}$$
$$-\frac{\delta}{2}\frac{(\alpha-\overline{\alpha})(2-\delta-\delta^2)+\delta(1-x)(c_{h,H}-\overline{c}_{h,H})}{4-\delta^2}.$$

In contrast, if the foreign firm chooses FDI, then firms have complete information in stage three. As a result, equilibrium prices are

$$p_j^{FDI}=\frac{\alpha(2-\delta-\delta^2)+(2+\delta)(xc_I+(1-x)c_{h,H})}{4-\delta^2}$$

From (13) we calculate the quantity demanded of each good in the third stage for given demand shocks and equilibrium prices, and then realized profits and consumer surplus. With these calculations we can now derive the expected profits, etc. in the first stage.

4.2 First stage

Analogous to when the firms compete in quantities, in the first stage the expected price is the same regardless of the firm's access mode decision because cost and demand shocks are linear and the expected cost are assumed equal across firms and access mode. That is, in stage one (before costs are realized), $E[p_j^X] = E[p_j^{FDI}]$, which also equals the equilibrium price evaluated at mean demand intercept (α) and cost (c). As with quantity competition, it is notationally convenient to define this "mean" price as $\overline{p}_j$. As outputs evaluated at the expected cost also are equal across access modes and firms, so too are profits, denoted $\overline{\pi}$.

With exporting, substituting the expressions for p_h^X and p_f^X into the profit expression (14) and taking the expectation yields the foreign and home firm's expected profit

$$\begin{aligned} E[\pi_f^X] &= \overline{\pi} + \frac{(1-x)^2(2-\delta^2)^2}{(4-\delta^2)^2(1-\delta^2)}\sigma_{f,F}^2 \\ E[\pi_h^X] &= \overline{\pi} + \frac{(1-\delta)^2}{4(1-\delta^2)}\sigma_\alpha^2 + \frac{(1-x)^2}{4(1-\delta^2)}\sigma_{h,H}^2 + \frac{(1-x)^2\delta^2(1-x)^2}{(4-\delta^2)^2(1-\delta^2)}\sigma_{f,F}^2 \end{aligned} \tag{15}$$

With FDI, using the expression for p_j^{FDI} and taking the expectation of (13), yields

$$E[\pi_j^{FDI}] = \overline{\pi} + \frac{(1-\delta)^2}{(2-\delta^2)(1-\delta^2)}\sigma_\alpha^2 + \frac{(1-x)^2(1-\delta)^2}{(2-\delta^2)(1-\delta^2)}\sigma_H^2 \tag{16}$$

Again, as the firms are facing the same cost shock with FDI there is only one variance term for the cost shock, subscripted with H.

4.3 The access mode decision for the foreign firm

From (15) and (16), the foreign firm chooses FDI whenever FDI is more profitable than exporting or

$$E[\pi_f^{FDI}] - E[\pi_f^X] = \frac{(2+\delta)^2(1-\delta)^2}{(4-\delta^2)^2(1-\delta)^2}\sigma_\alpha^2 + \frac{(1-x)^2(2+\delta)^2(1-\delta)^2}{(4-\delta^2)^2(1-\delta)^2}\sigma_H^2 - \frac{(1-x)^2(2-\delta^2)^2}{(4-\delta^2)^2(1-\delta)^2}\sigma_{f,F}^2 > 0. \tag{17}$$

Learning the home country demand still is valuable to the foreign firm when it competes in prices instead of quantities as shown by the first term on the RHS of (17). Similarly, the correlating of cost shocks is still harmful to the foreign firm because the second and third terms on the right sum to less than zero under the assumption of equal cost variance across countries. Indeed, comparing (17) with (6) shows that the coefficients are quantitatively very similar (and exactly equal if $\delta = 0$) to those in quantity competition. As a result, we obtain a similar condition as we did with quantity competition:

Proposition 5 *When firms compete in prices, FDI is more profitable than exporting for the foreign firm if the demand uncertainty is sufficiently greater than the cost uncertainty or the goods are sufficiently differentiated or production costs are not too locally dependent:*

$$\sigma_\alpha^2 \geq \delta\frac{(1-x)^2(4-\delta-2\delta^2)}{(2+\delta)^2(1-\delta)^2}\sigma_c^2. \tag{18}$$

Examination of (18) reveals that the forces behind the foreign firm's choice of FDI in price competition are the same as in quantity competition. The inequality above holds only if demand variance is just slightly larger than is needed in quantity competition. For example, if $\delta = 3/4$, then the above condition is approximately $\sigma_\alpha \geq 1.8(1-x)\sigma_c$, while with quantity competition the condition is approximately $\sigma_\alpha \geq 1.3(1-x)\sigma_c$. Further, both for price and quantity competition, the value from learning demand information decreases as the goods become closer substitutes (δ increases).[17] For example, in the case of equal variance and

[17]The reason for this with price competition differs though. As is well known, in Bertrand competition (perfect substitutes) with constant marginal cost the equilibrium is determined by the marginal cost (so long

all local content ($x = 0$), the maximum δ at which FDI is preferred is just slightly lower (approximately one-half) with price competition than with quantity competition.

4.4 Home country welfare

We begin examining home country welfare by considering the effect of FDI on the home firm first. Using (15) and (16) we have

$$E[\pi_h^{FDI}] - E[\pi_h^X] = \frac{\delta(4-\delta)(1-\delta)^2}{4(1-\delta^2)(2-\delta)^2}\sigma_\alpha^2 - \frac{\delta(1-x)^2(4-3\delta)}{4(1-\delta^2)(2-\delta)^2}\sigma_H^2 - \frac{\delta^2(1-x)^2}{4(4-\delta^2)^2(2-\delta)^2}\sigma_{f,F}^2. \tag{19}$$

Here price competition has a different qualitative effect on demand learning: the home firm benefits from the foreign firm learning the home demand intercept, whereas it was harmed in quantity competition. This is because in price competition a rival's response to demand information amplifies the demand shock: when there is a high (low) demand intercept, a rival responds with a higher (lower) price, which is equivalent to an even greater (smaller) demand intercept for the firm (see Equation 14). This is akin to a mean-preserving spread in the distribution of the demand intercept.[18] In contrast, in quantity competition when there is high (low) demand, the rival increases (decreases) output, which is akin to dampening the change in the demand intercept. Despite this difference in demand learning, the home firm can still be harmed by FDI because the demand effect is indirect and so is small relative to the loss from correlating the cost. As a result, unless the demand uncertainty is much greater than the cost uncertainty or local content is sufficiently small (large x), the home firm is harmed by FDI that is profitable for the foreign firm. From (18) and (19) we have

Proposition 6 *When firms compete in prices, profitable FDI for the foreign firm harms the home firm if demand uncertainty is not too large relative to cost uncertainty and production*

as marginal cost is less than the demand intercept) and so learning the exact demand intercept has no value. Thus, as the goods become closer substitutes the value of learning the demand intercept decreases

[18]This effect also exists for the foreign firm, but it is secondary because the size of the price changes from a change in α decreases faster in δ.

costs are sufficiently locally dependent:

$$\sigma_\alpha^2 \in \left(\delta \frac{(1-x)^2(4-\delta-2\delta^2)}{(2+\delta)^2(1-\delta)^2}\sigma_c^2, \frac{(1-x)^2(16+8\delta-8\delta^2-3\delta^3)}{(2+\delta)^2(1-\delta)^2(4-\delta)}\sigma_c^2 \right) \tag{20}$$

When all production is local ($x = 0$), the coefficient on σ_c^2 on the upper bound in (20) is greater than one and at least three times greater than the lower bound coefficient (which reflects the profitability condition for the foreign firm). As the goods become more differentiated the range in (20) increases reflecting that the home firm's gain from the foreign firm learning home demand is secondary and decreasing as the goods become more differentiated. For example, if $\delta = 1/4$ and $x = 0$, then the upper bound is over five times greater than the lower bound.

Consider next home consumer welfare. If the foreign firm exports, substituting the equilibrium prices and quantities into (1) and taking the expectation yields

$$E[CS^X] = \overline{CS} + \frac{(1-\delta)(5+3\delta)}{8(1-\delta^2)}\sigma_\alpha^2 + \frac{(1-x)^2}{8(1-\delta^2)}\sigma_{h,H}^2 + \frac{(1-x)^2(4-3\delta^2)}{2(4-\delta^2)^2(1-\delta^2)}\sigma_{f,F}^2.$$

If the foreign firm chooses FDI, then expected consumer surplus is

$$E[CS^{FDI}] = \overline{CS} + \frac{1}{(1+\delta)(2-\delta)^2}\sigma_\alpha^2 + \frac{(1-x)^2}{(1+\delta)(2-\delta)^2}\sigma_H^2.$$

The effect of FDI on home consumer surplus is

$$\begin{aligned} E[CS^{FDI}] - E[CS^X] = -\frac{(1-\delta)^2(12+4\delta-3\delta^2)}{8(1-\delta^2)(2-\delta)^2}\sigma_\alpha^2 + \frac{(1-x)^2(4-4\delta-\delta^2)}{8(1-\delta^2)(2-\delta)^2}\sigma_H^2 \\ - \frac{(1-x)^2(4-3\delta^2)}{8(1-\delta^2)(2-\delta)^2}\sigma_{f,F}^2. \end{aligned} \tag{21}$$

From (21) we find the second difference between price and quantity competition. With price competition consumers do not like the firms learning demand. The reason is that when consumers value the product more, the firm raises its price, and when they value the product less the firm lowers the price (while with quantity competition, when consumers value the

product more, the firm produces more). Combined with their harm from the correlation of costs, consumers are harmed when the foreign firm chooses FDI. From (21) (recalling that $\sigma_H^2 = \sigma_{i,N}^2 = \sigma_c^2$) we obtain:

Proposition 7 *When the firms compete in prices, profitable FDI for the foreign firm reduces expected home consumer surplus.*

Turning to home country welfare from (19) and (21) we have

$$E[W^{FDI}] - E[W^X] = -\frac{(1-\delta)^2(12+8\delta+\delta^2)}{8(1-\delta^2)(4-\delta^2)}\sigma_\alpha^2 + \frac{(1-x)^2(4-8\delta-5\delta^2)}{8(1-\delta^2)(4-\delta^2)}\sigma_H^2 - \frac{4(1-x)^2}{8(1-\delta^2)(4-\delta^2)}\sigma_{f,F}^2. \tag{22}$$

From (21) we know that consumers are harmed by profitable FDI. The home firm could benefit from profitable FDI, however only if demand uncertainty is far greater than cost uncertainty, but in that case consumers are harmed even more. The net result, as is clear from (22) is that the home country is made worse off.

Proposition 8 *Profitable FDI for the foreign firm reduces expected home country welfare.*

Recall from Proposition 4 that in quantity competition FDI usually is home welfare-reducing except when goods are sufficiently independent and at the same time demand uncertainty is sufficiently greater than cost uncertainty or production cost are not too locally dependent. As Proposition 8 shows, in price competition these exceptions do not exist. The only key difference the type of competition has is on consumers (who benefit from FDI in price but not quantity competition), but as that effect is secondary, the overall welfare effect is qualitatively the same: profitable FDI harms home welfare.

5 Conclusion

We consider information-based FDI decisions under demand and cost uncertainty when a foreign firm competes strategically with a home firm in the home market. FDI allows the

foreign firm to learn home demand and cost, which by itself would increase its expected profit. However, FDI also means buying labor and other inputs from the same national market as does the home firm, which correlates the firms' costs. We find that this correlation of costs reduces the value from learning cost information and can make FDI unprofitable. Intuitively, the harm arises because a correlation of costs reduces a firm's ability to exploit the cost information. For example, if a firm learns it has low cost it exploits this information by expanding its output. However, with correlated cost the rival too would expand its output, mitigating the benefit from the information. This effect, like the demand effect, exists in both price and quantity competition. Thus, FDI decision hinges on the balance of the benefit from learning demand shocks against the harm from correlation of costs. A key insight is that if cost uncertainty is too great or there is too much "local content" so as to correlate costs more, then the foreign firm does not choose FDI even though it gains information. This suggest (but not modeled here) that FDI may beget more FDI: to the extent that FDI globalizes the input market to reduce the significance of local cost shocks, it may encourage other firms in the future to opt for FDI over exporting. Another implication is that when choosing FDI firms may act to reduce the cost correlation, for example by choosing a production location different from its rivals or non-unionized workers when the home firm has unionized workers as has been done with Japanese automakers in the US.

Our second finding is that the FDI decision also depends on the substitutability between the goods the firms produce. Somewhat counter-intuitively, the more homogeneous the goods, the less valuable the demand information acquisition is to the foreign firm in *both* price and quantity competition, though for different reasons. In quantity competition, this is because a firm's ability to exploit the information is mitigated by the rival's reaction to this same information. For example, a firm reacts to the news that demand is stronger than expected by expanding its output. However, the rival also expands its output, lowering the market price for the firm. The more substitutable the goods firms produce, the greater this effect, and hence the less valuable the demand information. In price competition the rival's

response does benefit the firm.[19] Yet, as the goods become closer substitutes, information about the demand intercept becomes less important for the equilibrium prices; indeed, with Bertrand competition (*i.e.*, perfect substitutes) the equilibrium price is determined by cost. The upshot is our second insight: the more substitutable the goods the firms produce, the less valuable the demand information is and hence the more likely that the foreign firm chooses exporting over FDI in *both* price and quantity competition.

Turning to home welfare analysis, we find that the home firm is generally harmed by FDI that is profitable to the foreign firm. The exception to this occurs when (i) the goods are relatively differentiated; (ii) demand uncertainty is greater than cost uncertainty or there is sufficiently little local content in production; and (iii) the firms compete in prices. This is because differentiated goods dampens the harm from the cost correlation and in price competition the home firm benefits from its rival learning demand. Home consumers benefit from FDI if the firms compete in quantities because the firms increase production when consumers have a high marginal value, which consumers are willing to trade-off for less production when they have low demand (that is, little value for the product). Despite the beneficial effect on consumers, FDI that is profitable to a foreign firm in quantity competition is usually harmful to the home country as a whole. In price competition the effect on consumers is reversed because consumers see higher prices exactly when their marginal values are high and so are worse off from FDI. Thus, the negative welfare effect of FDI is exacerbated when firms compete in prices. In conclusion, FDI that is profitable to the foreign firm is likely to decrease home country welfare in the model. The exception to this conclusion occurs if all three of the following conditions are met: (i) the goods are sufficiently differentiated; (ii) demand uncertainty is sufficiently greater than cost uncertainty or there is sufficiently little local content; and (iii) the firms compete in quantities. The first two reduce the harm from the cost correlation and the third means that home consumers benefit.

Our results shed light on other work examining similar issues. For example, consider the Qiu and Zhou (2006) analysis of international merger mentioned earlier; while merger is

[19]For example, when the firm learns that demand is stronger than expected, it raises its price and the rival raises its price to the firm's benefit.

unprofitable in Cournot oligopoly, there is a case for international merger when demand is uncertain, because the foreign firm, learning home market demand through merger, may be able to compensate the partner for the loss of profit from the merger (Salant, et al. 1983) and from the information loss. There is however an unasked question here: if the foreign firm can choose FDI instead of merger, it can capture the information rent without compensating the home partner for the loss of profit. Thus, in the Qiu and Zhou (2006) environment FDI may dominate merger. While sufficiently high set-up cost may provide one reason the foreign firm chooses merger instead of FDI, our model provides another: if cost uncertainty is also present in their environment FDI may be less profitable than merger, and also gives the foreign firm a better threat point when negotiating with a domestic rival over a merger.

Our analysis suggests several directions in future research. One would be to consider other types of learning. For example, propinquity of production allows firms to gain specific information regarding the rivals, including firm-specific demand information (as opposed to common demand examined here) and firm-specific cost information. A second possibility is to relax our assumption regarding equal cost variances, which would change the relative value of learning the country specific costs. The implication though is relatively straightforward, e.g., greater home cost uncertainty would make FDI relatively more attractive. A third way in which to extend the results would be to have more than one foreign or home firm as this can affect the welfare implications. These possible extensions are left for future research.

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