Export, foreign direct investment, and joint ventures:

strategic learning and strategic correlation

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We examine the role of uncertainty in a firm's choice between exporting and foreign investment in international oligopoly. Foreign investment elicits two effects, which are absent in exporting. First, locating production within the same country as one's rivals makes the firms face similar shocks and hence make their strategies more closely correlated. Second, propinquity of operations to its rivals increases familiarity between the firms. A joint venture results in further familiarity. A firm's plant location decision depends on the interaction of these two effects, which in turn depend on the type of competition and the substitutability of the firm's products.

JEL: D83, L13
Key words: information, FDI, joint ventures

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[§]We thank Jim Anderson, Carl Davidson, Steve Matusz and participants at the Hitotsubashi Trade Conference (2006) and at a seminar at Kobe University for their comments on preliminary work. We would also like to thank the Department of Economics at Boston College (Creane) and at Hitotsubashi University (Miyagiwa) for their hospitality while working on this paper.

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 spectacular rise in multinational activity has prompted international trade economists to seek reasons why some firms choose foreign investment over exporting. The seminal works of Helpman (1984), Markusen (1984) and Ethier (1986) on the emergence of multinational enterprises, and others that have followed them, have established that market access mode 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]

In this paper we focus on the role of uncertainty in a firm's choice between exporting and foreign investment. The choice determines the propinquity of its operations relative to its rival, which has two effects as a result of uncertainty. First, greater propinquity makes the firms' costs, and hence their strategies, more closely correlated to each other, which we call the correlation effect. For example, having production in the same country mean that the firms now face common country-specific cost shocks, which introduces a correlation in the firms' costs, thereby making their strategies also correlated. The correlation effect could be further intensified when the foreign investment is a joint venture with an indigenous firm.[2]

The second effect greater propinquity has is that it increases familiarity – less uncertainty – between the firms, which we call the learning effect. This appears in two ways. One, because the firms are subject to the same country-specific shocks, the firms learn the rival's country-

[1] For reviews of this extensive literature, see, for example, Caves (1991), and Markusen (1995, 2003).
[2] There is surprisingly little work examining joint production and to the best of our knowledge, the work has emphasized collusive aspects and assumed certainty, see Chen and Ross (2000, 2003) and the discussion and references therein.

specific cost by observing its own. For example, facing a high wage implies that the rival is also facing a high labor cost. Other actions the firms take, e.g., using common suppliers, also facilitate this learning effect. Two, greater propinquity may enable the firms to gain the information about each other's idiosyncratic aspects. Importantly, observe that, unlike the learning of common country-specific cost, a learning of the rival's idiosyncratic cost is purely informational and hence does not directly cause the firms' strategies to be correlated. Hence, by examining idiosyncratic aspects we can disentangle the learning effect that is inherent in shared country shocks.

To fix these ideas, we consider a foreign firm competing with a home firm in the home country, though the results can be applied to other settings.[3] To separate the two effects – learning and correlation – we use the convention that the FDI (locating an independent plant in the foreign country) results in the firms facing a common shock, while with a joint venture (a joint factory with the home firm) the firms also learn each other's idiosyncratic aspects.[4] Specifically, the firms are subject to two types of cost uncertainty. One is country-specific, that is, it depends on where production takes place, independent of which firm, and may reflect

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[3] For example, we could apply the results to a North-South model in which two firms in a developed country choose between exporting and foreign investment in a less developed country that does not have a local firm.

[4] What we primarily examine here is not a joint venture between a multinational from an industrial country and a local firm from a developing country, but rather is a joint venture between firms of similar standings; for example, a joint venture between GM and Toyota, called NUMMI (New United Motor Manufacturing, Inc), in which both firms produce cars under their own names at the Freemont, California, plant. From this GM has learnt a great deal from Toyota regarding quality and efficiency in production (Teresko 2006). Other auto examples include the Flat Rock plant where Ford produces rear-wheel drive vehicles and trucks while Mazda produces front-wheel drive vehicles (Sawyer 2004) and in Poland where Ford shares a factory with Fiat with each producing a different car (PAP 2005). Additional examples include flat screen televisions (Masaki 2006), flash memory (Investor's Business Daily 2000), vegetable juice (where part of the agreement is the use of different suppliers, Smith 2001), silicon wafers (Van Grinsven 2000), steel (Cullison 1989) and beer (e.g., Kirin in the US is brewed at an Anheuser-Busch plant). Additional examples can be found in Morasch (2000). However, it is possible to extend the model to consider asymmetries consistent with such a relationship between a firm from an industrial country and a firm from a developing country by introducing asymmetries into the model.

fluctuations in locally procured input prices or supplies. The other is firm-specific or idiosyncratic cost uncertainty, which reflects fluctuations in product-specific input prices or firm-specific production processes and is independent of plant location.

Broadly, the firms play a three-stage game. First, the foreign firm decides whether to export, or to sell from an independent subsidiary or to set up a joint venture with the home firm, with the home firm's agreement. Then nature chooses cost values and each firm discovers its own costs but not the rival's idiosyncratic costs unless there is a joint venture. Finally, the firms compete in the home market, given the plant location chosen in stage one.

Our analysis shows that whether the foreign firm exports or chooses between FDI and a joint venture hinges crucially on the interactions of the correlation and the learning effect, which in turn depend on the type of competition (price or quantity) as well as the substitutability of the products the firms produce. We find, for example, that, if the firms compete in quantities and produce substitute goods, the correlation effect is negative, making foreign investment a less attractive option than exporting. This result reverses itself, however, if the goods are complements. On the other hand, the learning effect is always positive, thereby making a joint venture a more attractive choice relative to FDI, whether the goods are substitutes or not. Price competition leaves the correlation effect intact but turns the learning effect to being negative, giving FDI a chance.

We also examine the effect on home country welfare. The home country's most preferred option can differ from the foreign firm's choice, in which case the home government has incentive to intervene so as to influence the foreign firm's decision. Thus, our analysis can throw new light on the formation of host country policy towards foreign investment. This is perhaps best seen by considering the standard model of the trade literature: Cournot competition

with a homogeneous good. In this case, the correlation effect is negative, making exporting more profitable than FDI, but as we show below the learning effect dominates the correlation effect, making a joint venture more profitable than exporting. Thus, firms choose a joint venture over exporting, but the home country consumers prefer exporting to either a joint venture or FDI, and home country welfare is also greatest with exporting. Thus, counter to the politically favorite choice, the home country government would want to ban joint ventures to ensure that firms choose exporting.

Finally, to explain a firm's access mode decision much of the literature introduces some asymmetries in country or firm characteristics; for example, it is typically assumed that a firm incurs transport cost when exporting, and setup or fixed cost with foreign investment (FDI).[5] To prevent such asymmetries from driving our results, we assume away any trade cost or setup cost, and assume equal variances for each type of cost uncertainty, so that in the absence of uncertainty the firms are completely indifferent among the three options we consider. The symmetry we impose on our model has additional benefits. First, it is straightforward to introduce asymmetries into the uncertainty from which additional results can be obtained. Second, the symmetry allows us to readily apply our model to other settings and examine other issues; for example, it is straightforward to extend the model to a two-country setting to offer an explanation as to why the bulk of foreign investment today flows between high-income economies instead of from the rich to the poor countries (Markusen, 1995 and 2002, chapter 1), or why similar firms in a developed country may chose differing plant locations when selling in a new market.

The remainder of the paper is organized in five sections. Section 2 sets up the model.

[5] See, e.g., Helpman, Melitz and Yeaple (2004), Horstmann and Markusen (1992), Motta (1992) and Horn and Persson (2001).

Section 3 compares expected profits and host-country welfare from exporting, FDI and a joint venture for quantity competition. Section 4 does the same with price competition. Section 5 discusses additional results that asymmetric cost variances can bring. Section 6 concludes.

2. Environment

Suppose that a foreign firm (firm 1) competes with a home firm (firm 2) in market 2 (home market). Firm *i* faces inverse demand $p_i = \alpha - q_i - \delta q_k$. Assume $\delta \in [-1, 1]$ so both substitutes and complements are considered. The case in which $\delta = 1$ corresponds to the classic Cournot model. Firm 2 always produces in country 2, but firm 1 is footloose; it may export from country 1 or produce in country 2. Production costs are linear and separable between a country-specific component and a firm-specific component: $c_i(q) = (c_{i,N} + c_{i,F})q_i$, where the subscript N indicates country- or nation-specific cost and F indicates firm-specific or idiosyncratic cost. To prevent asymmetry from driving the results, the characteristics of the distribution from which each cost component is drawn, are assumed identical: G(c) with $E[c_{iK}] = c_e$ and $Var[c_{iK}] = \sigma^2$, while the effect asymmetries can have will be examined in section 5. Assume that exporting requires no transport cost and FDI and a joint venture involve no setup or additional fixed costs. These symmetry assumptions imply that in the absence of uncertainty, firm 1 is completely indifferent among the three options it faces, as is firm 2 to firm 1's choice.

We model the interaction between the firms in three stages. In stage one firm 1 chooses a mode of access to country 2 buyers among exporting, FDI and a joint venture. In stage two, nature moves and draws values for the costs, and each firm learns its own country-specific and firm-specific cost realizations. In addition, depending on the plant location choice made in the first stage as discussed below, the firm may learn its competitor's cost realization(s). In stage

three the firms compete in the product market, given the choice from stage one.

If exporting is chosen, production takes place in separate countries, and hence neither firm learns about the rival's cost realizations. Thus, the stage-three game is one of incomplete information as regards country-specific and firm-specific costs. With FDI, the firms learn the common country-specific shock but are ignorant of each other's idiosyncratic cost, so they play a game of incomplete information regarding only idiosyncratic costs. Finally, with a joint venture the firms learn about each other's idiosyncratic cost, as well, and so they play a game of complete information. We begin with quantity competition.

3. Quantity competition (strategic substitutes)

In this section we assume that the firms compete in quantities, which are strategic substitutes. To derive the equilibrium we first characterize the third stage for all possible outcomes and then work back to each previous stage.

3.A The third stage

In the third stage each firm simultaneously sets output. Firm *i* maximizes expected profit

$$E[(\alpha - q_i - \delta q_k - (c_{i,N} + c_{i,F}))q_i].$$

From the first order condition firm *i*'s best response is

$$q_i = [\alpha - (c_{i,N} + c_{i,F}) - \delta E(q_k)]/2. \qquad (1)$$

Note that firm *i*'s output is linear in firm *k*'s choice and its own costs. To ease calculation of equilibrium outputs, it is useful to first calculate the outcome as if there were no uncertainty, i.e., each cost parameter equals its mean. In such a case, the Cournot-Nash equilibrium output is

$$q_{ei} = [\alpha(2-\delta) - 2(c_{ei,N} + c_{ei,F}) + \delta(c_{ek,N} + c_{ek,F})]/\Delta \qquad (2)$$

where $\Delta \equiv 4 - \delta^2$ and the subscript *ei* indicates the expected for firm *i*.

With this preliminary calculation made, we derive the equilibrium outputs and profits for exporting, FDI and a joint venture. With firm 1 choosing to produce in country 1, firms learn neither a rival's country-specific nor firm-specific cost shocks and so they play a game of incomplete information. Noting that firm *i*'s expectation of firm *k*'s output equals q_{ek}, the Bayesian-Nash equilibrium outputs and profits are straightforward to derive from (1) and (2):

$$q_i^X = [\alpha(2-\delta) - 2(c_{i,N} + c_{i,F}) + \delta(c_e + c_e)]/\Delta + \delta^2[(c_{i,N} - c_e) + (c_{iF} - c_e)]/2\Delta$$

where the superscript X represents firm 1 choosing to produce and export from country 1. Firm *i*, after setting its output, expects its third stage profits to be (i.e., conditioned on its observation $\{c_{i,N}, c_{i,F}\}$)

$$E_{c_i}[\pi_i^X] = [\alpha - q_i^X - \delta E_{c_i}[q_k^X] - (c_{i,N} + c_{i,F})]\, q_i^X = [q_i^X]^2 .$$

With FDI, firm 1 produces at an independent plant in country 2, by which the firms learn common country-specific cost shocks but not each other's idiosyncratic cost shocks. Using (1) and modifying (2) in this setting yields the equilibrium levels of output of:

$$q_i^{FDI} = [\alpha(2-\delta) - 2(c_{2,N} + c_{i,F}) + \delta(c_{2,N} + c_e)]/\Delta + \delta^2(c_{i,F} - c_e))/2\Delta.$$

Firm *i*, after setting its output, expects its third stage profits to be

$$E_{c_i}[\pi_i^{FDI}] = [\alpha - q_i^{FDI} - \delta E_{c_i}[q_k^{FDI}] - (c_{i,N} + c_{i,F})]\, q_i^{FDI} = [q_i^{FDI}]^2 .$$

Finally, with a joint venture, in addition to country-specific costs, the joint factory results in firm-specific aspects of costs also being revealed to the rival. The firms thus play a game of complete information, so the usual calculus yields equilibrium outputs and profits. Outputs are

$$q_i^J = [\alpha(2-\delta) - 2(c_{2,N} + c_{i,F}) + \delta(c_{2,N} + c_{k,F})]/\Delta,$$

where J indicates joint venture. With complete information firm *i* knows at the beginning of the third stage what its profits will be

$$\pi_i^J = [\alpha - q_i^J - \delta q_k^J - (c_{i,N} + c_{i,F})] q_i^J = [q_i^J]^2 .$$

Now all the third-stage games have been characterized. In stage two Nature moves, revealing relevant information to the firms. We are ready to proceed to the first stage.

3.B The access mode decision

The first thing to note is that in the first stage the expected output is the same independent of the firm's access mode decision. That is, from the definitions above of q_i^X, q_i^{FDI}, and q_i^J we can see that in stage one (before costs are realized) their expectations are equal: $E[q_i^X] = E[q_i^{FDI}] = E[q_i^J]$. It is convenient to define this "mean" output as $\bar{q}$. Note that $\bar{q}_1 = \bar{q}_2$ by symmetry. It follows from the definitions of profits in section 3.A that the profit evaluated at the expected cost are also equal across access model decisions and firms: $\pi_i^X(c_e) = \pi_i^{FDI}(c_e) = \pi_i^J(c_e)$ for i = 1, 2, which allows us to focus on a representative firm. In particular, it is useful to define this common profit by: $\bar{\pi}$.

We can now write the stage-one expectation of the profits in a useful manner. When firm 1 chooses exporting, each firm observes its own costs but not the competitor's, so neither firm responds to the competitor's cost realizations. Hence, the competitor's cost cannot introduce variance into the firm's profits as it only enters linearly. Firm *i*'s expected profits are

$$E[\pi_i^X] = \bar{\pi} + \sigma^2/4 + \sigma^2/4 \qquad (3)$$

where the first variance term corresponds to firm *i*'s idiosyncratic cost term and the second to its country-specific cost term.

With FDI, taking the expectation yields

$$E[\pi_i^{FDI}] = \bar{\pi} + \sigma^2/4 + \sigma^2/(2+\delta)^2. \qquad (4)$$

Here again the first term is the variance representing the firm's idiosyncratic cost shock and is

identical to that with exporting. The second variance term, reflecting the country-specific cost uncertainty, differs from its counterpart with exporting, now that both firms face the same country specific shock. This difference is what we termed the correlation effect. Using (3) and (4), we state our first result (Q indicates quantity competition).

Lemma 1Q: ***With quantity competition the correlation effect is negative (positive) if the firm's products are substitutes (complements).***

To gain an intuitive understanding of the correlation effect, suppose that firm 2 has a higher-than-average country-specific shock and contracts its output. If the goods are substitutes ($\delta > 0$), then this benefits firm 1. However, with FDI firm 1 also faces the same high cost and contracts its output as well – the correlation effect.[6] In contrast, with exporting the firm's costs are uncorrelated and firm 1 is ignorant of firm 2 having high cost, so this has no effect on firm 1's output. Thus, if the goods are substitutes, the correlation effect makes profits less convex, and hence is negative, implying that firm 1 is better off with exporting than with FDI. By symmetry firm 2 also prefers exporting to FDI. Note, however, that this logic reverses itself when the goods are complements, and as a result the country-specific variance term (the second term) is greater with FDI than with exporting; that is, the correlation effect is positive. Finally, observe that due to the symmetry both firms have exactly the same preference between the two access modes firm 1 chooses.

Turning to a joint venture, the first-stage expected profits are calculated to be

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[6] Notice the presence of a learning aspect here as well, albeit of secondary nature: since the firm by knowing that its rival faced the same shock will expand its output in response. That is, we could decompose the two aspects by considering how correlation affects expected profits if neither firm knew that shocks were correlated. In such a case, output would be lower. Thus, the learning aspect raises output. However, it is secondary; the correlation aspect dominates and so the equilibrium effect is a reduction in output. This learning aspect is isolated when we examine a joint venture.

$$E[\pi_i^J] = \bar{\pi} + 4\sigma^2/(4-\delta^2)^2 + \sigma^2/(2+\delta)^2 + \sigma^2\delta^2/(4-\delta^2)^2. \quad (5)$$

The middle variance term is the same as with FDI and reflects the correlation effect discussed above. With a joint venture, however, the first variance term, which reflects the firm's idiosyncratic uncertainty, differs from its counterpart under exporting or FDI. Furthermore, there also appears a third variance term, $\sigma^2\delta^2/(4-\delta^2)^2$. These differences between FDI and a joint venture capture the learning effect. Using (4) and (5) we obtain

Lemma 2Q: ***With quantity competition the learning effect is positive.***

To intuitively understand the nature of the learning effect, consider first the third variance term in (5). This is the variance in the rival's idiosyncratic cost. Suppose that firm 2 draws a higher-than-average firm-specific cost. Then, firm 2's best-response function shifts down, which benefits firm 1 at any output level it produces. But if it knows that firm 2 has a high cost, firm 1 can increase output and earn an even greater profit. By the same logic, if firm 2 has a low cost, it is bad for firm 1, but firm 1 could minimize the damage by contracting its output if it knew firm 2 has a high cost. Thus, knowing firm 2's idiosyncratic cost shocks allows firm 1 to react optimally and raises expected profits to firm 1.

Turning now to the first variance term in (5), we see that the own firm-specific cost variance also is larger than with FDI. The intuition is similar to the previous intuition. If firm 1 has a lower-than-average cost, it can capture a larger market share if firm 2 is informed and contracts output than if firm 2 does not respond. Although by the same logic firm 1 is hurt more when it has a higher cost and firm 2 responds, the benefit from being able to expand output when

its cost is low more than offsets the harm when its cost is high.[7] In sum, the learning effect is positive, as a comparison of (5) with (4) shows, implying the firms always prefer a joint venture to FDI regardless of whether the products are complements or substitutes.

The accompanying table organizes the principal results. Signs under C (signifying correlation effect) indicate changes in profit that arises from switching from exporting to FDI: (+) means positive change and (–) negative change. Similarly, signs under L (signifying learning effect) indicate changes in profit arising from switching from FDI to a joint venture.

	Quantity competition		
	C	L	C+L
Substitutes	–	+	?
Complements	+	+	+

We can now examine location choice so as to characterize the trade-offs between the two effects. First note that for complements both the correlation effect and the learning effect work in the same direction, giving an unambiguous increase in expected profit as the firm switches from exporting to FDI or a joint venture, and from an FDI to a joint venture.

Proposition 1Q: ***With quantity competition and complements, a joint venture is more profitable than FDI, which is more profitable than exporting.***

Turning to substitutes, since the correlation effect and learning effect have opposite signs,

[7] This is a well-know feature of the models analyzing similar issues; see, e.g, Qiu (1994) and Creane and Miyagiwa (2005).

the choice between exporting and a joint venture depends on which effect dominates. Intuitively, the more substitutable the products, the more convex the profits are, and hence the greater the learning effect – the first and third variance terms in (5). On the other hand, starting from independent products ($\delta = 0$), as the substitutability δ increases, the correlation effect intensifies, reducing expected profits. As a result, there is a range of positive δ in which exporting is preferred to a joint venture. Denote this critical δ by δ^*, which is defined as the unique root of $\{\delta^3 - 12\delta^2 + 8 = 0\}$ on the interval [0,1] ($\delta^* \approx 0.7$). By an explicit comparison of (3) and (5) we can now characterize

Proposition 2Q*: With quantity competition and substitutes;*

(a) FDI is less profitable than either exporting or a joint venture.

(b) A joint venture is the most profitable strategy if $\delta > \delta^*$; Exporting is the most profitable strategy otherwise.

For reference to the literature, consider the classic Cournot model of homogeneous goods. In this case the firms prefer a joint venture to exporting, and exporting to FDI. More generally, for both substitutes and complements a joint venture is more profitable than FDI, and unless the products are sufficiently unrelated, a joint venture is the most profitable strategy.

3.C. Host country policy

We next examine the effect on country 2 welfare, given by the sum of consumer surplus and profit to firm 2. The main focus is when the firms' and the host-country (country 2) government's plant location choices diverge, and what type of government interventions can be

inferred from it. To make welfare comparisons possible we introduce preferences that would generate the demand specified in the previous subsections. Assume that there is a continuum of identical consumers with separable, linear utility in the numeraire good and quadratic preferences for the differentiated goods. For the demand specified in quantity competition this implies that utility is represented by the quadratic function

$$U(q_1,q_2) = \alpha(q_1 + q_2) - (1/2)(q_1^2 + 2\delta q_1 q_2 + q_2^2),\ \alpha > 0,\ \beta \geq |\delta| > 0.$$

Hence, welfare is

$$W(q_1,q_2) = U(q_1,q_2) - p_1 q_1 - p_2 q_2 + \pi_2.$$

As firm 2's profits have already been derived in (3) – (5), we need only derive the expected consumer surplus for each access mode choice, using q_i^X, q_i^{FDI}, q_i^J. Again, given the certainty equivalence of these outputs, we need only calculate the variance in stage one for each of the three options, letting $\overline{CS}_2$ denote consumer surplus evaluated at the expected costs.

If firm 1 exports, consumers are subject to all shocks, two country-specific and two firm-specific shocks, which are all uncorrelated. Thus, expected consumer surplus is

$$E[CS_2^X] = \overline{CS}_2 + \sigma^2/8 + \sigma^2/8 + \sigma^2/8 + \sigma^2/8 \qquad (11)$$

where the convention remains the same on the variance terms: the first is firm 1's idiosyncratic noise, the second is the variance on country 1's noise, the third is firm 2's idiosyncratic variance and the last is country 2's country-specific variance.

With FDI, country 2 consumers are no longer unaffected by country 1 specific noise but are subject to the correlation of strategies. Thus, expected consumer surplus is

$$E[CS_2^{FDI}] = \overline{CS}_2 + \sigma^2/8 + \sigma^2(1+\delta)/(2+\delta)^2 + \sigma^2/8 \qquad (12)$$

where the middle term is the variance arising from country 2's noise, reflecting the correlation of strategies. Correlated strategies under FDI reduce price variability, making consumer surplus

less convex, which reduces the opportunity to diversify, and harms consumers.

With a joint venture, expected consumer surplus is

$$E[CS_2^J] = \overline{CS}_2 + \sigma^2(4-3\delta^2)/2(4-\delta^2)^2 + \sigma^2(1+\delta)/(2+\delta)^2 + \sigma^2(4-3\delta^2)/2(4-\delta^2)^2. \quad (13)$$

Comparing (13) with (12) we find that expected consumer surplus is greater with FDI than with a joint venture. The following then summarizes consumers' preferences.

Proposition 3Q: ***With quantity competition, country 2 consumers always prefer exporting to FDI, and FDI to a joint venture.***

Turning to host country (country 2) welfare, if the goods are substitutes, the correlation effect is negative, so country 2 consumers' and firm 2's preferences align, implying that welfare is greater with exporting than with FDI. Comparing welfare with FDI and that with a joint venture, recall that the learning effect is positive, meaning the firm's expected profit is greater with a joint venture than with FDI. However, it is consumers' preference ranking that dictates the welfare ranking because the consumers always gain more than the firms when prices vary more. Thus,

Proposition 4Q*: *With quantity competition

(a) and complements, country 2 welfare is greater with a joint venture than with FDI, which is greater than with exporting.

(b) and substitutes, country 2 welfare is greater with exporting than with joint ventures, which is greater than FDI.

Thus, the product characteristics are key in determining the welfare ordering.

It is clear that there can be conflict between country 2 and firm 1. For example, if the firms produce strong substitutes ($\delta > \delta^*$), or more specifically, if they produce homogenous goods, firm 1 would prefer a joint venture to exporting (Proposition 2Q), while country 2 would prefer exporting (proposition 4Q). In such a case, the country 2 government may want to ban or tax foreign investment so as to encourage exporting. On the other hand, if the products are complements the firms' and country 2's preferences align on a joint venture. This renders support to casual observations that foreign investment for complementary products are typically more welcomed than for substitutes. Furthermore, if it cannot, perhaps for political reasons, stop the foreign firm from investing, then the host country government would encourage a joint venture over an independent plant. This result holds whether the goods are substitutes or complements. While other work has attempted to explain these host country government policy choices through asymmetry, i.e. assuming that the home firm acquires knowledge that the foreign firm has, here no asymmetry has been imposed.

4. Price competition/strategic complements.

Although we considered both physical complements and substitutes in the preceding section, the effects of firms that compete in strategic substitutes may differ because costs enter into the profit expression differently. Thus, we can deepen our analysis by considering firms that compete in strategic complements.

Following the strategic trade literature (e.g., Eaton and Grossman 1986), assume that price-setting firms produce differentiated goods and, by the appropriate choice of units, write

demand for good *i* as

$$q_i = A - p_i + dp_k,$$

where $d \in (-1,1)$ measures the degree of product differentiation between the two goods. Thus, profits are

$$(A - p_i + dp_k)(p_i - (c_{1,N} + c_{1,F})).^{8}$$

The remainder of the analysis closely follows the steps from the previous section.

4.A The third stage

Firms simultaneously set their price. From the maximization of profits, firm *i*'s best response is

$$P_i = [A + (c_{i,N} + c_{i,F}) + d \cdot E(p_k)]/2. \quad (6)$$

Note that as with output competition firm *i*'s price is linear in firm *k*'s choice and its own costs. As a result, it is again useful to calculate the equilibrium prices when there is no uncertainty, i.e., each cost parameter equals its mean. In such a case, the equilibrium prices are

$$p_{ei} = [2(A + c_{ei,N} + c_{ei,F}) + d(A + c_{ek,N} + c_{ek,F})]/\Delta \quad (7)$$

where $\Delta \equiv 4 - d^2$ and the subscript *ei* indicates the expected cost for firm *i*.

When firm 1 exports, neither firm learns a rival's cost. Following the analysis from section 3.A, the Nash equilibrium prices are:

$$p_i^X = [A(2 + d) + 2(c_{i,N} + c_{i,F}) + d(c_e + c_e)]/\Delta - d^2[(c_{i,N} - c_e) + (c_{i,F} - c_e))/2\Delta.$$

Firm *i,* after setting its price, expects its third-stage profits to be (i.e., conditioned on its observation $\{c_{i,N}, c_{i,F}\}$)

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[8] Alternatively, we could invert the inverse demands from the previous section to derive the demands for this section. The results would not change. However, there would be significantly more notation.

$$E_{c_i}[\pi_i^X(p)] = (A - p_i^X + d\,E_{c_i}[p_k^X])(p_i^X - (c_{i,N} + c_{i,F})) = [q_i^X(p)]^2$$

where q(*p*) is to indicate outputs when firms compete in prices.

With FDI the equilibrium prices are

$$p_i^{FDI} = [A(2 + d) + 2(c_{2,N} + c_{i,F}) + d(c_{2,N} + c_e)]/\Delta - d^2(c_{i,F} - c_e))/2\Delta.$$

Firm *i*, after setting its price expects its third stage profits to be

$$E_{c_i}[\pi_i^{FDI}(p)] = (A - p_i^{FDI} + d\,E_{c_i}[p_k^{FDI}])(p_i^{FDI} - (c_{i,N} + c_{i,F})) = [q_i^{FDI}(p)]^2 .$$

Finally, if the firms engage in a joint venture, prices are

$$p_i^J = [2(A + c_{2,N} + c_{i,F}) + d(A + c_{2,N} + c_{k,F})]/\Delta.$$

With complete information firm *i* knows at the beginning of the third stage that its profits will be

$$\pi_i^J(p) = (A - p_i^J + d\,E_{c_i}[p_k^J])(p_i^J - (c_{i,N} + c_{i,F})) = [q_i^J(p)]^2 .$$

We can now proceed to the first stage and the firm's access mode decision.

4.B The access mode decision

As with quantity competition, in the first stage the expected output is the same across access modes. That is, from the definitions above, outputs in expectation are equal: $E[q_i^X(p)] = E[q_{i1}^{FDI}(p)] = E[q_i^J(p)] \equiv \bar{q}_i(p)$. Given the definitions for profits it follows that the profits evaluated at the expected cost are also equal across access modes and firms. Let $\bar{\pi}$ denote this common profit.

If the firm 1 exports, then firm *i*'s expected profits are

$$E[\pi_i^X(p)] = \bar{\pi} + \sigma^2/4 + \sigma^2/4. \qquad (8)$$

This is the same as (3) from the previous section. With FDI, taking the expectation yields

$$E[\pi_i^{FDI}(p)] = \bar{\pi} + \sigma^2/4 + \sigma^2(1-d)^2/(2-d)^2. \qquad (9)$$

This again is analogous to (4), its quantity competition counterpart. Although the correlation effect manifests itself differently in (4) and (9), the condition remains the same as with quantity competition; the correlation effect does not depend on the type of strategic competition. That is, a comparison of (8) with (9) shows that the results with quantity competition (lemma 1Q) hold with price competition as well. We denote results that hold in both quantity and price competition with a star, and so

Lemma 1*: ***With quantity or price competition the correlation effect is negative (positive) if the firms' products are substitutes (complements).***

Turning to a joint investment, the first-stage profits are

$$E[\pi_i^J(p)] = \bar{\pi} + \sigma^2(d^2-2)^2/(4-d^2)^2 + \sigma^2(1-d)^2/(2-d)^2 + \sigma^2 d^2/(4-d^2)^2. \qquad (10)$$

As in quantity competition, the learning effect represents a change in profits between a joint venture and FDI. However, in this case a comparison between (9) and (10) shows that in contrast to the result with quantity competition

Lemma 2P: ***With price competition the learning effect is negative.***

To understand the intuition behind this result, consider a change in the firm's idiosyncratic cost, the first variance term. If firm 1 draws a low cost, and lowers the price, firm 2 would also lower its price if it knew firm 1's cost is low, which reduces profits to firm 1. Although by the same logic profit to firm 1 is greater if it draws a high cost and firm 2 also raises its price, the inability to expand when the price is low harms firm 1; that is, learning under a joint venture reduces the

size of variance in idiosyncratic cost, and makes expected profit less convex. Further, although the third variance term, which reflects variance of firm 2's idiosyncratic cost and has a similar interpretation, adds to expected profit, given symmetry, it is insufficient to reverse the outcome. As a result, with price competition the learning effect is negative, whether products are substitutes or complements, making FDI a more attractive choice than a joint venture.

The next table summarizes the analysis so far where C indicates correlation effect and L the learning effect.

	Price competition		
	C	L	C+L
Substitutes	–	–	–
Complements	+	–	+

From the column, note that, unlike with quantity competition, the correlation and the learning effect work in the same direction for substitutes, but not for complements. While this makes the combined effect (C + L) appear ambiguous for the case of complements, a direct computation shows that the correlation effect dominates the learning effect, making a joint venture more profitable than exporting as indicated in the table. The next proposition then follows from the table.

Proposition 1P. ***With price competition and complements, FDI is more profitable than a joint venture, which is more profitable than exporting***

In contrast, with quantity competition a joint venture is more profitable than FDI which is more

profitable than exporting (Proposition 1Q).

With substitutes both the correlation effect and the learning effect work in the same direction, giving an unambiguous increase in expected profit as the firm switches from exporting to FDI or a joint venture, and from an FDI to a joint venture:

Proposition 2P. ***With price competition and substitutes, exporting is more profitable than FDI, which is more profitable than a joint venture.***

Thus, while a joint venture is more attractive an option than FDI under quantity competition and substitutes (proposition 2Q), it is reversed under price competition.

Finally, while the type of competition is critical to the optimal mode of access, in comparing across propositions 2Q and 2P, we see that some results are independent of the type of competition. In particular, because of the correlation effect, exporting is always more profitable than FDI, and if the products are sufficiently weak substitutes, then exporting is the most profitable mode of access.

4. C Host country policy

The demand specified in the price competition setting implies that utility is represented by the quadratic function $U(q_1,q_2) = A(q_1 + q_2)/(1-d) - (1/2)(q_1^2 + 2\delta q_1 q_2 + q_2^2)/(1-d^2)$, $A > 0$, $1 > |d| > 0$. Otherwise, the derivations follow the previous section and so are omitted.

With firm 1 exporting, country 2's expected consumer surplus is

$$E[CS_2^X(p)] = \overline{CS}_2 + \sigma^2/8 + \sigma^2/8 + \sigma^2/8 + \sigma^2/8 \qquad (14)$$

which is identical to is quantity counterpart, (11). With FDI, it is

$$E[CS_2^{FDI}(p)] = \overline{CS}_2 + \sigma^2/8 + \sigma^2(1-d)/(2-d)^2 + \sigma^2/8 \qquad (15)$$

where now the middle term is the variance arising from country 2's noise, and with a joint venture it is

$$E[CS_2^{J}(p)] = \overline{CS}_2 + \sigma^2(4-3d^2)/2(4-d^2)^2 + \sigma^2(1-d)/(2-d)^2 + \sigma^2(4-3d^2)/2(4-d^2)^2 \qquad (16)$$

Note that the idiosyncratic variance and the country-specific variance terms once again look similar to those with quantity competition. Algebraic manipulation of (8-10) and (14-16) reveals that while the firms' preferences depend critically on the type of competition, consumers' preferences do not:

Proposition 3*: ***With quantity and price competition, country 2 consumers prefer exporting to FDI, and FDI to a joint venture.***

Turning to welfare we can also use (8-10) and (14-16) to obtain:

Proposition 4P: ***With price competition***

(a) and complements, country 2 welfare is greater with FDI than with a joint venture, which is greater than with exporting.

(b) and substitutes, country 2 welfare is greater with exporting than with FDI, which is greater than with a joint venture.

Although the type of competition is once again critical to the welfare rankings, there are still pair wise comparisons that are independent of the type of competition. In particular, note that

country 2 always prefers FDI over a joint venture.

Finally, using propositions 4Q and 4P, we can compare across price and quantity competition to obtain welfare results that are independent of the type of strategic competition.

Proposition 4*: ***Both with quantity and price competition, country 2 welfare is***

(a) greatest with exporting if the products are substitutes.

(b) worst with exporting if the products are complements.

5. Extensions

As we discussed in the introduction, the specific, symmetric structure we imposed on our model helps make the effects transparent. A second benefit of this structure is that there are straightforward extensions and applications that can be made. As the strategic effects of the access model is driven by the uncertainty, in this section we focus on the effects of relaxing the symmetry imposed on the cost distribution. To save space, we will not consider the entire nomenclature of cases, but limit ourselves to quantity competition.

6.A Role of differing country-specific costs shocks

Suppose first that the country-specific costs no longer have the identical variance. Let $\text{Var}[c_{1,N}] = \sigma_{1,N}^2$ and $\text{Var}[c_{2,N}] = \sigma_{2,N}^2$. Since firm 2 always produces in country 2, this change in assumption does not change its expected profits, whether firm 1 chooses exporting or FDI. Thus, proposition 1 holds for firm 2. Turning to firm 1, profit with exporting is

$$E[\pi_1^X] = \bar{\pi} + \sigma^2/4 + \sigma_1^2/4 \qquad (3')$$

while profit with FDI is now

$$E[\pi_1^{FDI}] = \bar{\pi} + \sigma^2/4 + \sigma_2^2/(\delta+2)^2. \qquad (4')$$

If $\sigma_2^2 > \sigma_1^2$, then FDI increases the size of country-specific variance for firm 1, affecting the correlation effect. This can reverse some of our early results. For example, with equal variance, if the goods are substitutes, then the correlation effect is negative and so FDI is less profitable. Now, if σ_2^2 is sufficiently greater than σ_1^2 FDI becomes more profitable to firm 1 because the very act of locating a plant in country 2 makes expected profit more convex to firm 1; compare (3′) with (4′). Thus, we can generalize parts of proposition 1Q to

Proposition 1Q′: ***With quantity competition firm 1 prefers FDI to exporting, if and only if $\delta < 2(\sigma_{2,N}^2 - \sigma_{1,N}^2)/\sigma_{1,N}^2$ ($\sigma_{2,N}^2$ is the variance of country-2 specific uncertainty).***

For example, if $\delta = 1$; i.e., the goods are perfect substitutes, the inequality in proposition 1Q′ is satisfied if $\sigma_{2,N} > 3\sigma_{1,N}/2$. In such cases, firm 1 prefers FDI, but firm 2's profits are still greater if firm 1 chooses exporting. Interestingly, then, firm 2 would want to block FDI.

As the above example illustrates, asymmetries in variance of the country-specific costs can alter the correlation effect. However, that is not the case with idiosyncratic costs variances, because they are independent of plant locations. Thus, an asymmetry in the size of variance of firm-specific costs would not change the firms' preferences between exporting and FDI; see (3) and (4). Similarly, the learning effect is unaffected; therefore, a joint venture remains more profitable to both firms than FDI; compare (4) and (5).[9]

6.B Role of differing distributions on the cost shocks

[9] With price competition an asymmetry can affect the learning effect, which was negative under symmetry. If the rival's variance is greater, the firm can increase convexity of profit if it sets up a joint venture. But since the rival is harmed, it would not agree to a joint venture.

We now consider what results when all four variances could differ. Any new results we might obtain however would depend primarily on the size of the country-specific cost variance relative to that of the firm-specific cost variance. From the analysis of the previous subsection, there is thus no loss of generality by holding the firm-specific cost variances equal.[10] Further, by inspecting (3) and (4) we see that asymmetries in the size of variances between country-specific and firm-specific costs do not affect the firms' preference rankings between exporting and FDI, so we focus on the preference orderings involving a joint venture.

First, comparing (3) and (5), we see that, if variances of the country-specific costs are sufficiently small relative to those of the idiosyncratic costs, then a joint venture is preferred to exporting for all $\delta \in [-1,1]$, partially reversing the results in proposition 2Q. The underlying intuition is straightforward: if country-specific variance is trivial, the decision is driven by the learning effect, which is positive and so the firms prefer a joint venture to exporting.

In the reverse case; i.e., if the firm-specific variances are sufficiently small, then the correlation effect dominates. Since the correlation is negative if the goods are substitutes, the firms would prefer separate countries of production. Thus, for all $\delta \in [-1,1]$ exporting is more profitable than a joint venture, given that the country-specific variances are equal. If the firm-specific variances are sufficiently small but the country-specific variances differ, the correlation effect is affected as described in the previous section. For example, if σ_2^2 is sufficiently larger than σ_1^2, firm 1 would choose a joint venture or FDI over exporting. But then firm 2 would be worse off and object to a joint venture so firm 1 would choose FDI.

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[10] Recall from the previous subsection that asymmetries in variance of firm-specific costs have no effect on our results.

6. Conclusions

A remarkable rise in multinational activity has spawned a growing interest in explaining why some firms choose foreign investment over exporting. Most of the literature explains the choice, exploiting asymmetries in firm and country characteristics. In this model, we focus on what we believe to the best of our knowledge are two new effects that drive our results: the correlation and the learning effect. While the propositions summarize our main findings, it is useful to apply them to the standard model of homogenous-good Cournot duopoly. In this archetypal case, we find that the correlation effect is negative, making exporting more profitable than FDI, but that the learning effect dominates the correlation effect, making a joint venture more profitable than exporting. Thus, firms choose a joint venture over exporting, (proposition 2Q), while the host country consumers prefer exporting to a joint venture or FDI and home country welfare is also greatest with exporting (proposition 4Q). This implies that the home country government has incentives to ban joint ventures to ensure that firms choose exporting.

These results are obtained using a symmetric model. Incorporating the usual asymmetry assumptions such as trade cost or investment setup costs is a straightforward extension with predictable results. On the other hand, introducing asymmetries in the variance of the cost shocks can introduce new results. For example, if there is greater country-specific uncertainty in the host country, then paradoxically, FDI may become more profitable than exporting for the foreign firm (proposition 1Q′). As the last case demonstrates, introducing asymmetries may produce other interesting results. Due to the consideration of space, such extensions are not considered here but are left for future research.

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