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The merits of horizontal versus vertical FDI in the presence of uncertainty

Joshua Aizenman[a,*], Nancy Marion[b]

[a] Department of Economics and the NBER, 217 Social Science 1, 1156 High St., University of California, Santa Cruz (UCSC), Santa Cruz, CA, 95064, USA
[b] Economics Department, Dartmouth College, Hanover, NH, 03755, USA

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Abstract

We examine the impact of uncertainty on vertical and horizontal FDI. Our model shows that greater supply uncertainty reduces the expected income from vertical FDI but increases the expected income from horizontal FDI. Greater demand uncertainty adversely affects the expected income under both production modes. Uncertainty about predatory actions by the host country is more costly to the multinational under vertical than under the horizontal mode. We examine sales by foreign affiliates of U.S. parent companies. Conditioning on host-country characteristics thought to influence FDI, we find evidence that volatility and sovereign risk have a greater negative impact on vertical FDI than on horizontal FDI.

Keywords: Horizontal and Vertical FDI; Supply and demand uncertainty; Sovereign risk

JEL classification: F21; F23

1. Introduction

The tremendous growth of foreign direct investment (FDI) over the last decade has received considerable attention. Markusen and Maskus (2001) survey recent studies of FDI that adopt a general-equilibrium trade-theoretic view of the multinational. They also provide a useful overview of a model where firms choose endogenously between vertical and horizontal production structures when investing abroad. A vertical pattern arises when

* Corresponding author. Tel.: +1-831-459-4791; fax: +1-831-459-5900.
E-mail addresses: jaizen@ucsc.edu (J. Aizenman), n.p.marion@dartmouth.edu (N. Marion).

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the multinational firm fragments the production process internationally, locating each stage of production in the country where it can be done at the least cost. A horizontal pattern occurs when the multinational produces the same product or service in multiple countries.

Markusen and Maskus note that the choice between vertical and horizontal production structures depends on country characteristics, such as relative size and relative endowment differences, as well as trade and investment costs. Their review of recent empirical work leads them to conclude that most FDI is of the horizontal type. Since horizontal FDI is most prevalent among countries that are similar in both size and in relative endowments, they argue that "it is similarities between countries rather than differences that generate the most multinational activities" (Markusen and Maskus, 2001, p. 39).

Most of the trade-theoretic FDI literature [including the papers reviewed by Markusen and Maskus (2001)] relies on non-stochastic models.[1] The purpose of this paper is to investigate the role of uncertainty on the relative profitability of horizontal versus vertical production modes. Focusing on uncertainty is important because emerging markets are characterized by much greater uncertainty than the OECD countries.[2] They are also the potential recipients of most vertical FDI since their relative factor endowments and other features differ from those of mature economies where parent firms are based. If greater uncertainty discourages vertical FDI, the observed lack of vertical FDI might be the result of greater uncertainty associated with emerging markets rather than just the weakness of forces encouraging geographic fragmentation of production. Further, a reduction in the uncertainty faced by multinationals engaged in FDI should increase the incidence of vertical investments in emerging markets.

The pattern of FDI between the U.S. and Mexico illustrates the issues involved. As NAFTA increases the economic integration and the mutual dependency of its members, it may also reduce the sovereign risk associated with investment in Mexico and contribute to the observed increase in vertical FDI there.[3] Hence, previous findings reporting the dominance of horizontal FDI may understate the potential scope for vertical FDI.[4]

Understanding the determinants of vertical and horizontal FDI is also important since these two production strategies can have very different implications for the distribution of income both within and across countries. Vertical FDI may compress the skilled–non-skilled wage differential across countries as well as change the income distribution within countries. Horizontal FDI may increase income in each country with minor distributive impact.

[1] See Dunning (1993) for a good overview of the earlier literature. There are a few papers that examine FDI in a stochastic setting. For example, Aizenman (1994) studies the effects of exchange-rate volatility on horizontal FDI. Spiegel (1994) examines the impact of sovereign risk on FDI inflows relative to portfolio investment. Goldberg and Kolstad (1995) study the effects of real exchange-rate uncertainty on FDI under risk aversion and use U.S. bilateral FDI flows to confirm their prediction that higher real exchange rate volatility increases FDI. Wei (2000) identifies the adverse effects of corruption-induced uncertainty on FDI.

[2] See Hausmann and Gavin (1995).

[3] In fact, the formation of NAFTA has affected many determinants of FDI. See Feenstra and Hanson (1997) for a detailed analysis of the impact of NAFTA on FDI and relative wages.

[4] Hanson et al. (2002) argue that vertical FDI is more common than previous research suggested.

In order to explore the role of uncertainty on vertical and horizontal FDI, we develop a model where the multinational making investment decisions faces productivity and demand shocks. Productivity shocks are shown to increase the expected profits of horizontal FDI because the multinational has the incentive to reallocate production and employment from less productive plants to more productive ones, even if it is risk neutral. In contrast, productivity shocks reduce the expected profits from vertical FDI since, with limited substitutability, low realized productivity in a plant that is part of a vertical chain increases the demand for labor in that plant in order to compensate for the productivity shortfall. Had the plant been part of a horizontal structure, it would have experienced a fall in the demand for labor as output shifted to more productive plants. Demand shocks are shown to affect adversely both production modes.

Horizontal production also entails lower exposure to sovereign risk than does a vertical production structure. Suppose that the host country reverses its attitude towards multinationals and tries to force the multinational to renegotiate rents by threatening nationalization, production disruptions or similar actions. We show that limited substitutability across geographically separated production stages under a vertical structure grants more bargaining clout to the host country than if the FDI had been horizontal in nature. Hence, predatory behavior by the host country is more costly to the multinational engaged in vertical FDI.[5]

Finally, we use data on U.S. multinational firms to examine whether volatility and views about sovereign risk differentially impact horizontal and vertical FDI. We focus on sales by foreign affiliates of U.S. parent companies and characterize vertical and horizontal FDI by the destination market for those sales. Conditioning on host-country characteristics thought to influence FDI, we find evidence that volatility and sovereign risk have a greater negative impact on vertical FDI than on horizontal FDI.

The rest of the paper is organized as follows. Section 2 lays out the stochastic model, specifying the two feasible modes of FDI-horizontal and vertical. Section 3 examines the impact of supply and demand shocks on the profits of each type of FDI. Section 4 evaluates the impact of sovereign risk on profits when the host country has bargaining power. Section 5 examines some empirical evidence on whether volatility and sovereign risk concerns have a differential impact on horizontal and vertical FDI. Section 6 concludes.

2. The model

We consider a global economy composed of two countries, Home (H) and Foreign (F), each consuming two final goods, Y and Z. Asterisks signify foreign (country

[5] We assume that the multinational faces only two options—vertical and horizontal investment. This imposed limitation on the firm's choice set might arise from its desire to control the use of knowledge-capital and marketing, or because of contracting and enforcement problems. Our analysis thus sidesteps some important elements of firm organization. See Grossman and Helpman (2001) for a model of the endogenous organization of the firm in the open economy. See Markusen and Venables (1998, 2000) for a trade model combining the Heckscher-Ohlin structure, monopolistic competition, transport costs, and multinational corporations. Their framework demonstrates how the mix of national and multinational firms operating in equilibrium depends on technology and on the division of the world endowment between countries.

F) variables. The utility of H consumers is a semi-additive function of the two goods

$$U = Z + \frac{A}{\delta}[Y]^{\delta}, \qquad 0 < \delta < 1. \tag{1}$$

Identical preferences characterize consumers in country F.

The supply of labor in each country is inelastic and given by

$$L^s = \bar{L}; \quad L^{s*} = \bar{L}^* \tag{2}$$

Good Z is produced in both countries using a simple Ricardian technology. In H, this technology is

$$Z = L_z. \tag{3}$$

so the real wage is one in the competitive equilibrium. We normalize the price of good Z to one.

In country F, the technology is:

$$Z^* = a^* L_z^*, \tag{4}$$

where the parameter a^* is the productivity of foreign labor and the real wage is $w^* = a^*$.

Good Y is produced by a monopoly using two possible production modes: vertical or horizontal. Our modeling strategy is designed to highlight in the simplest way how the choice of production mode affects profitability under uncertainty. Hence, we abstract from various considerations. For example, capital does not enter directly into the production process and so cannot alter labor productivity by changing the capital–labor ratio. We do not allow for heterogeneous tastes, transportation costs, and so forth. In Section 3, we review possible extensions of the basic model.

2.1. Vertical production of good Y

The vertical mode implies that production is fragmented geographically. Suppose the final production stage uses intermediate inputs produced abroad at an earlier stage. Specifically, assume that an intermediate input, M, is produced in the foreign country using a Cobb–Douglas production technology

$$M = (1 + \varepsilon^*) b^* \sqrt{L_M^*} \tag{5}$$

where L_M^* is the labor employed, b^* is labor productivity in the foreign intermediate-good sector, and ε^* is a mean zero foreign productivity shock that is uncorrelated with any domestic shock. The final production stage combines intermediate input M and domestic labor using a Leontief technology to produce Y^f, where

$$Y^f = min\left[M;\ (1 + \varepsilon) b \sqrt{L_Y}\right]; \qquad E(\varepsilon) = 0,\ \text{cov}(\varepsilon, \varepsilon^*) = 0. \tag{6}$$

The fragmented production process requires the multinational to invest in two plants, resulting in a total set-up cost of C_f.

2.2. Horizontal production of good Y

Alternatively, the multinational can follow a horizontal strategy, producing Y in both markets according to the following technology

$$Y = (1+\varepsilon)a\sqrt{L_Y}; \quad Y^* = (1+\varepsilon^*)a^*\sqrt{L_Y^*}. \tag{7}$$

where L_Y (L_Y^*) is the labor employed in producing good Y in country H (F), and ε, ε^* are uncorrelated productivity shocks with zero means. The horizontal production process also requires the multinational to invest in two plants, resulting in a total set-up cost of C_h.

In order to focus on the impact of uncertainty, we assume zero transportation costs. Hence, proximity to the consumer does not play a role in determining production patterns.[6] The main differences between vertical and the horizontal production strategies lie in the time sequencing and the substitutability. With horizontal production, global demand is met by production in both countries. The various plants produce perfect substitutes. With vertical production, the intermediate good is produced before the final good. There is very limited substitutability between the outputs produced in the various production stages.

The monopoly must pre-commit to a horizontal or vertical investment strategy prior to the realization of shocks. The monopoly is risk neutral and chooses the production strategy that maximizes its expected profit.

We now calculate the expected profit of vertical and horizontal investments. From Eq. (1), we observe that the demand elasticity for good Y faced by the monopoly is $\eta=1/(1-\delta)$. In Appendix A, we show that the expected profit associated with vertical production is

$$E[\Pi_f] = k_f E\left\{[\theta_f(1+\varepsilon)^{-2} + \theta_f^*(1+\varepsilon^*)^{-2}]^{-\frac{\eta-1}{\eta+1}}\right\} - C_f; \tag{8}$$

where k_f, θ_f, θ_f^* are constants and $\theta_f + \theta_f^* = 1$. The weights θ_f, θ_f^* reflect the effective productivities of the two countries and are determined by real wages and the productivity coefficients b, b^*.[7]

The expected profit associated with horizontal production is

$$E[\Pi_h] = k_h E\left\{[\theta_h(1+\varepsilon)^{2} + \theta_h^*(1+\varepsilon^*)^{2}]^{\frac{\eta-1}{\eta+1}}\right\} - C_h; \tag{9}$$

where k_h, θ_h, θ_h^* are constants and $\theta_h + \theta_h^* = 1$. The weights θ_h, θ_h^* reflect the effective productivities of the two countries and are now determined by real wages and the

[6] We revisit the correlation between transportation costs, measured by distance, and production patterns in the empirical section of the paper. Note that if markets are segmented, horizontal FDI will be motivated by tariff jumping, and the volatility of domestic demand becomes important. Substantial declines in effective protection may reduce the attractiveness of horizontal FDI.

[7] Eq. (8) assumes that the production of M takes place after the realizations of productivity shocks in both locations. If the production of M takes place before the realization of the domestic productivity shock, the expected profit is $E[\Pi_f] = k_f E\{[E[\theta_f(1+\varepsilon)^{-2} + \theta_f^*(1+\varepsilon^*)^{-2}]^{-(\eta-1)/(\eta+1)} - C_f$. The main results hold for either case.

productivity coefficients, a, a^*. We assume that fixed costs C_h, C_f are large enough so that it is never profitable to set up more than two plants.[8]

3. Profitability in the face of productivity and demand shocks

We first compare the effects of stochastic productivity changes on expected profits from horizontal and vertical investment strategies. The outcome will depend on the concavity/convexity of the profit functions specified in (8) and (9). In the Appendix we show that

Proposition 1: *Higher volatility of supply shocks increases the expected profit associated with horizontal FDI but reduces the expected profit associated with vertical FDI.*

Suppose that the multinational is indifferent between the two production modes in the absence of uncertainty. Proposition 1 implies that uncertainty will bias production patterns towards horizontal FDI. The reason is that volatility induces the multinational engaged in horizontal FDI to reallocate production and employment from less productive plants to more productive ones. Such behavior is optimal even if the multinational is risk neutral. This reallocation increases the expected profit of horizontal FDI. With vertical FDI, there is more limited substitutability among outputs, so a low realized productivity in one plant actually increases the demand for labor in that plant in order to compensate for the productivity shortfall. Consequently, more volatile shocks reduce the expected profit of vertical FDI.[9]

The first-order conditions that give the optimal employment allocation under uncertainty for each type of investment strategy illustrate the point:

$$\begin{aligned} &\text{(a) Vertical} \qquad \frac{L_Y}{L_M^*} = \frac{[b^*(1+\varepsilon^*)]^2}{[b(1+\varepsilon)]^2} \\ &\text{(b) Horizontal} \quad \frac{L_Y}{L_Y^*} = \frac{[a(1+\varepsilon)]^2}{[a^*(1+\varepsilon^*)/w^*]^2} \end{aligned} \tag{10}$$

Inspection of Eq. (10) reveals that the employment responses to increased uncertainty are completely opposite for the two modes of production. The different employment responses lead directly to the different profitability outcomes.

So far we have assumed stable demand conditions. We turn now to the other polar case, where supply conditions are stable and shocks originate on the demand

[8] This assumption allows us to exclude mixed horizontal and vertical production patterns [such as the case where M is produced in both countries and the final good is produced at home]. In practice, if there are a large number of countries and the fixed costs are not prohibitive, mixed production modes may be useful in diversifying country-specific risk or reducing the incidence of predatory behavior.

[9] See Aizenman and Marion (2001) for a detailed graphical analysis of the propositions advanced in this paper.

side. The utility function specified in Eq. (1) implies a constant elasticity of demand for Y,

$$Y^d = (A/P_y)^\eta; \qquad \eta = \frac{1}{1-\delta} > 1. \tag{1'}$$

We model demand shocks as random fluctuations in A. Specifically, we consider a transformation of A such that:

$$A = \begin{cases} (1+v)^{1/\eta} A_0 & \text{country H} \\ (1+v^*)^{1/\eta} A_0 & \text{country F} \end{cases},$$

where A_0 is a positive scale constant and v, v^* are country-specific, i.i.d. demand shocks with mean zero. It is easy to confirm that the modified demands for good Y in countries H and F are $Y_{\rm H}^d=(1+v)[A_0/P_y]^\eta$; $Y_{\rm F}^d=(1+v^*)[A_0/P_y]^\eta$, respectively. Aggregate demand facing the multinational is subject to a multiplicative demand shock, the sum of the two country-specific shocks:

$$Y_{\rm H}^d + Y_{\rm F}^d = 2[1 + 0.5(v + v^*)][A_0/P_y]^\eta.$$

Suppose that supply shocks are zero, $\varepsilon = \varepsilon^* = 0$. Then in both production modes, the demand disturbance induces a movement along the marginal productivity of labor curve. The impact of demand uncertainty is summarized by the following proposition:

Proposition 2: *Higher volatility of demand shocks reduces the expected profit associated with both horizontal FDI and vertical FDI.*

As shown in Appendix A, when demand elasticity exceeds one, demand uncertainty reduces expected profits under both production modes. Since a monopolist operates on that part of the demand curve where demand is elastic, it follows that demand uncertainty reduces expected profits under *both* production modes.[10]

We close this section with some discussion about the robustness of our results. Our model characterizes the risk-neutral multinational with access to a well-functioning capital market and the ability to finance investment at the risk-free interest rate. The model implies that volatility induced by demand shocks discourages both vertical and horizontal FDI, while volatility induced by supply shocks discourages vertical FDI but promotes horizontal FDI. Consequently, in the presence of both supply and demand shocks, our model predicts that volatility has more adverse consequences on the profitability of vertical FDI than on horizontal FDI.

[10] A positive demand shock induces a price rise. With elastic demand, a higher price dampens the increase in profits, implying that the net increase in profits falls short of the demand shock. Similarly, a negative demand shock leads to a drop in the price, mitigating the decline in profits. Profits are thus concave with respect to the demand shock. In Appendix A we show that the magnitude of this adverse effect is identical for both horizontal and vertical FDI if we assume that the elasticity of supply with respect to labor input is the same [one-half] in both production modes. For general values of the labor supply elasticities, as long as labor is subject to diminishing marginal productivity, demand uncertainty adversely affects both horizontal and vertical FDI, but the magnitudes of these adverse effects depend on the precise values of the labor supply elasticities.

The result that volatility arising from supply shocks promotes horizontal FDI but discourages vertical FDI follows from the observation that the profit function is convex in the shock when FDI is horizontal but concave in the shock when it is vertical. It is important to note that changes in economic structure can modify the curvature of the profit function. For example, capital–market imperfections, financing constraints or risk aversion reduce the convexity—or increase the concavity—of the profit function and dampen the positive response of horizontal investment to volatility induced by the supply shocks. If these forces are strong enough, they can even reverse the result of a positive correlation between volatility and horizontal investment induced by supply shocks. In that case, volatility might not have a significantly more adverse effect on vertical FDI.

One can also extend the theoretical framework to a 'hybrid' model where multinationals diversify the production of intermediate products by investing in several emerging markets. Our earlier results continue to hold. From the perspective of a single emerging market, higher volatility reduces the inflow of vertical FDI. From the multinational's perspective, however, higher volatility in one market leads to a reallocation of vertical FDI that may increase total vertical FDI (see Aizenman (2003)).

Our model can also be extended to consider the implications of segmented markets. Such an extension would allow uncertainty to operate through additional channels and strengthen its differential effects on horizontal and vertical FDI.[11]

4. Exposure to sovereign risk and the pattern of production

Though FDI has been less subject to nationalization by sovereign states in the last 20 years, the risk of at least partial confiscation is ever present. It can be shown that a multinational engaged in vertical FDI is exposed to higher sovereign risk than one involved in horizontal FDI. To simplify the argument, we keep all our previous assumptions and focus on the case where productivity and demand shocks are absent.

Suppose that the host country forces a new division of the surplus associated with FDI by threatening to stop production in the absence of agreement. We use the Nash bargaining solution to infer the outcome for the case where both parties have equal bargaining power.[12]

[11] For example, domestic competitors of horizontal producers in a given market are likely to be affected by the same country-specific shocks, whereas competitors of vertical producers selling in export markets are less likely to be affected by the same shocks. [We thank an anonymous referee for making this point.] In our empirical work we take an eclectic approach and employ standard controls such as host country income and transport costs that are important when markets are segmented.

[12] To simplify matters, we ignore other policies that might supplement or respond to the act of nationalization. The locations of the final demand for good Y would be important if policies such as commercial policies were added. Our analysis is related to the industrial organization literature on the endogenous determination of flexibility in production. Flexibility serves several purposes. It may hedge against uncertainty about future market conditions, providing a real option (see Sheshinski and Dreze, 1976; Milgrom and Roberts, 1990; Pyndyck, 1988). It may serve strategic goals, influencing the behavior of market participants (see Tirole, 1988 for further discussion). The strategic use of excess capacity as a countervailing threat in the presence of tax competition was highlighted by Janeba (2000). For strategic FDI in the presence of exchange-rate uncertainty, see Lapan and Sung (2000).

In the absence of agreement, the gross profit of the multinational engaged in vertical FDI is zero. (We assume the host country's income is not affected by the absence of agreement.) Since the symmetric Nash bargaining solution requires a division of the surplus that maximizes the product of the gains from the agreement, it follows that bargaining leads to an equal division of the gross profits (k_f) between the host country and the multinational. Hence, the multinational's net profit in the bargaining regime is

$$0.5k_f - C_f \tag{11}$$

(see Appendix A for details). In this case, a switch to the bargaining outcome when FDI is vertically structured reduces the multinational's gross profit by 50%.

With horizontal FDI, the perfect substitutability of outputs produced in the two countries reduces the bargaining clout of the host country. In Appendix A we show that a switch to the bargaining outcome reduces profit from horizontal FDI by:

$$0.5[1 - (\theta_h)^{2\frac{\eta-1}{\eta+1}}] \tag{12}$$

The ability to diversify production when FDI is horizontal cuts the exposure to the political risk induced by the threat of nationalization or production stoppage.

5. Empirical evidence

To discover whether volatility and sovereign risk have different effects on horizontal and vertical FDI, we focus on the foreign operations of U.S. multinationals since 1989 (U.S. Bureau of Economic Analysis).

Our categorization of vertical and horizontal FDI output by the destination market for affiliate sales is admittedly less precise than we would like. Analysis (BEA) collects data on the sales of majority-owned, non-bank affiliates of U.S.-headquartered corporations. These sales data are disaggregated by destination market and by industry but do not provide information on whether the affiliates are structured along horizontal or vertical lines. We shall use the destination market for the sales of these affiliates to distinguish between vertical and horizontal FDI.

Following Hanson et al. (2002), we measure the output of vertical investment either as affiliate exports back to the U.S. or, more broadly, affiliate exports to the U.S. and to other foreign countries. The assumption is that these affiliate exports represent intermediate goods requiring further processing in the parent country or some third country. We measure the output of horizontal investment by affiliate sales in the local market where the affiliate resides. The assumption is that these are sales of final goods. The goods are produced locally because the cost to the parent company of exporting to the local market is higher. It seems reasonable that some affiliate sales back to the U.S. or to third countries represent sales of final products and should more appropriately be designated horizontal FDI. It is also likely that some affiliate sales to the local market that we label horizontal FDI are later exported to the U.S. or some other foreign market for further processing. Nevertheless, given the data limitations, the destination market seems a reasonable metric for dividing FDI into horizontal and vertical components.

The BEA conducts more extensive surveys on U.S. multinationals in certain benchmark years, and we shall use data from those surveys for our analysis. For the 1990s, the benchmark years are 1994 and 1999. We also include information from the benchmark year 1989.

Table 1 provides information about the location of U.S.-owned foreign affiliates. It shows the real dollar value of affiliate sales and share of sales by region for 1989,1994 and 1999. Table 1 shows that affiliate sales are concentrated in high-income countries—in Europe, Canada and Japan. It also shows that Latin America and Asia have attracted an increasing share of U.S.-directed FDI during the 1990s. Latin America's share of affiliate sales has grown from 8.5% to 11.2% between 1989 and 1999, while Asia's share has grown from 15.8% to 19.4% over the same period.

Table 2 reports by region the share of total affiliate sales that are exported back to the U.S. and to other foreign countries, our broad measure of vertical FDI, as well as the share of total sales exported just to the U.S., a narrower measure of vertical FDI. Table 2 reveals that about 34% of affiliate sales were exported back to the U.S. or to third countries in 1999. Only a third of these exports, or 10.7%, were exported back to the U.S. In some countries, such as Japan and Korea, exports account for a modest share of affiliate sales. In other countries, such as Ireland, Switzerland, Malaysia and Singapore, most affiliate sales are exported. According to our broader classification scheme, these latter countries had relatively high concentrations of vertical FDI in 1999. If we classify vertical FDI more narrowly as affiliate exports back to the U.S. alone, then countries such as Malaysia, Mexico, Singapore and Canada had relatively high concentrations of vertical FDI in 1999.

We now turn to regression analysis to examine whether volatility and perceptions about sovereign risk have more negative effects on vertical FDI than on horizontal FDI, conditioning on standard host-country characteristics believed to influence FDI.

In the empirical literature, researchers have shown that *total* affiliate sales are influenced by host-country characteristics such as host-country GDP, host-country distance from the U.S., linguistic ties with the U.S., host-country corporate tax rates, the skill differential with the U.S., and trade and investment barriers. (For examples, see Carr et al., 2001; Blonigen and Davies, 2001; Brainard, 1997; Wei, 2000.) Total affiliate sales tend to increase with

Table 1
Affiliate sales by region

	1989		1994		1999	
	Bil 95$	Share	Bil 95$	Share	Bil 95$	Share
World	1201.7		1467.2		2057.9	
Canada	204.1	17.0	198.2	13.5	263.1	12.8
Latin America	102.5	8.5	137.7	9.4	230.2	11.2
of which Mexico	19.4	1.6	40.3	2.7	74.4	3.6
Europe	675.4	56.2	814.2	55.5	1126.3	54.7
Africa	13.6	1.1	15.2	1.0	22.4	1.1
Middle East	9.4	0.8	8.2	0.6	12.8	0.6
Asia and Pacific	190.4	15.8	287.2	19.6	398.7	19.4
of which China	0.3	0.03	3.3	0.2	18.8	0.9
of which Japan	68.8	5.7	99.7	6.8	117.2	5.7

Sales data deflated by U.S. GDP deflator.

Table 2
Affiliate exports

	Exports to U.S. and others (1995 bil$)	Share	Exports to US (1995 bil$)	Share
1989				
All	388.1	32.3	135.2	11.2
Canada	54.2	26.5	48.1	23.6
Latin America	36.5	35.6	21.7	21.2
Mexico	6.2	31.9	5.1	26.6
Europe	230.7	34.2	32.7	4.8
Ireland	8.9	66.0	0.9	6.4
Switzerland	30.9	72.3	3.3	7.7
Africa	5.9	43.5	3.8	27.7
Middle East	3.6	38.3	2.3	24.0
Asia	54.2	28.5	23.4	12.3
China	0.0	5.4	0.0	0.4
Japan	10.2	14.9	4.0	5.8
Korea	0.9	32.0	0.7	24.2
Malaysia	3.2	49.5	1.5	23.7
Singapore	13.1	73.7	6.8	38.1
1994				
All	482.4	32.9	150.6	10.3
Canada	61.1	30.8	55.9	28.2
Latin America	43.9	31.9	25.4	18.5
Mexico	12.7	31.5	11.4	28.4
Europe	286.2	35.1	31.9	3.9
Ireland	14.2	72.9	1.4	7.4
Switzerland	35.6	69.9	4.1	8.0
Africa	5.5	36.2	3.9	25.7
Middle East	3.5	41.9	0.9	11.4
Asia	78.5	27.3	28.6	10.0
China	0.7	21.9	0.2	6.8
Japan	9.5	9.6	4.2	4.2
Korea	0.7	12.1	0.4	6.4
Malaysia	5.0	42.1	2.3	19.0
Singapore	29.7	62.0	12.3	25.6
1999				
All	695.6	33.8	219.8	10.7
Canada	78.9	30.0	73.3	27.9
Latin America	78.8	34.2	40.2	17.5
Mexico	26.8	36.0	20.4	27.4
Europe	406.0	36.0	52.8	4.7
Ireland	40.5	74.9	6.9	12.8
Switzerland	46.5	70.4	2.7	4.1
Africa	8.4	37.7	4.2	18.6
Middle East	5.6	43.6	3.3	25.7
Asia	116.2	29.1	44.3	11.1
China	5.8	31.0	2.5	13.5
Japan	9.5	8.1	3.9	3.3
Korea	1.0	9.6	0.4	3.9
Malaysia	13.4	65.4	6.3	30.5
Singapore	42.9	58.7	17.2	23.5

host-country GDP, a linguistic tie with the U.S., the size of the skill differential between the U.S. and the host country, and host-country trade barriers. Affiliates sales tend to decrease with the host's corporate income tax rate, its distance from the U.S., and investment barriers. Conditioning on some of these same variables, we examine how volatility and sovereign risk influence our three variables of interest-affiliate exports (vertical FDI), affiliate local sales (horizontal FDI), and the ratio of affiliate exports relative to local sales (vertical relative to horizontal FDI).

We propose estimating the following specification using affiliate sales data for *i* countries over *t* benchmark years:

$$\ln Z_{it} = \beta_0 + \beta_1 \ln \mathrm{RGDP}_{it} + \beta_2 \ln \mathrm{DIST}_i + \beta_3\ \mathrm{ENG}_i + \beta_4 \ln(1 - \mathrm{TAX}_{it}) + \beta_5\ \mathrm{SKILL}_{it} + \beta_6 \ln \mathrm{VOL}_{it} + \beta_7\ \mathrm{RISK}_{it} + \varepsilon_{it} \qquad (13)$$

In Eq. (13), *Z* can represent either the real value of affiliate exports, the real value of affiliate local sales, or the ratio of affiliate exports to local sales. RGDP is the host country's real GDP, DIST is the distance between the host country and the U.S., ENG is a dummy variable that takes the value of one if the host country is English-speaking, TAX is the host country's effective corporate income tax rate on foreign firms, and SKILL is the skill differential between the U.S. and the host country.

VOL measures the volatility of a particular host-country macroeconomic variable, such as GDP per worker—a partial proxy for productivity shocks—CPI inflation, or the terms of trade. The latter two volatility measures can be thought of as demand-side shocks or a mix of demand and supply shocks. The volatility measures vary over time.

RISK is a measure of sovereign risk.[13] Our sovereign risk measure comes from Political Risk Services, a firm that provides assessments of risk to international investors. Their *International Country Risk Guide* (ICRG) rates over 100 countries according to various economic and political indicators each month. The *investment profile* indicator assesses the risk of investing in a country by evaluating contract viability/expropriation, profits repatriation, and payment delays. We use this measure as our indicator of sovereign risk.[14] We also consider two other measures. One is the ICRG's *law and order* indicator that assesses the strength and impartiality of the legal system and popular observance of the law. The other is a measure of *institutional quality* constructed in the manner of Knack and Keefer (1995) and Hall and Jones (1999). It is the average of four indicators from the

[13] Volatility and sovereign risk measures are often highly correlated, precluding their simultaneous use in some specifications.

[14] In 1997, the *International Country Risk Guide* discontinued the category "expropriation risk" and began providing an assessment of a country's "investment profile", backdating the new measure to 1984. We use this new measure in our empirical work. Hall and Jones (1999) and Acemoglu et al. (2001) used the previous category "expropriation risk" in their investigations of cross-country growth regressions. We do not instrument this variable since we consider it to be exogenous with respect to decisions of U.S. multinationals, whereas the exogeneity assumption is more problematic for cross-section growth regressions. In addition, satisfactory instruments for expropriation risk—settler mortality in Acemoglu et al (2001), or the extent to which the primary languages of Western Europe are spoken as first languages today in Hall and Jones (1999)—are time-invariant and thus inappropriate for our panel regression.

ICRG—the investment profile, law and order, bureaucratic quality, and corruption. A description of all data and data sources is provided in Appendix A.

To estimate Eq. (13) we have data for about 45 countries for each of the benchmark years 1989, 1994 and 1999. Missing data on corporate tax rates reduces the sample to about 115 observations for 42 countries. Because the volatility and sovereign risk measures are much less correlated when 1999 data are excluded, we start by estimating Eq. (13) over just the benchmark years 1989 and 1994, enabling us to examine the effects of supply-side volatility, demand-side volatility and sovereign risk simultaneously.

Table 3 presents estimates for the determinants of vertical FDI, horizontal FDI and vertical relative to horizontal FDI when supply-side uncertainty is (partially) measured by the volatility of output per worker, demand-side uncertainty is (partially) measured by the volatility of the terms of trade, and sovereign risk is measured by the investment risk profile. The control variables are initially real GDP, distance from the U.S., linguistic tie, the effective corporate income tax rate, and a dummy variable for the benchmark year 1994. Because serial correlation may be a problem even though the data are in 5-year intervals, standard errors have been corrected for serial correlation within countries.

Table 3 shows that uncertainty adversely affects both vertical and horizontal FDI, but hurts vertical FDI more. In regressions (1) and (2), the coefficients on the uncertainty measures are all negatively signed. They are all significant at the 5% confidence level with one exception. Consistent with the model, volatility in productivity does not have a significantly negative effect on horizontal FDI. Regression (3) confirms the model's basic prediction that uncertainty has a more adverse effect on vertical FDI. We find that supply-side volatility and sovereign risk have a significantly more negative effect on vertical FDI than on horizontal FDI.

The three regressions in Table 3 generate other interesting observations. Affiliate exports and affiliate local sales are each significantly higher in countries that have larger GDPs and hence larger markets. In regression (3), the coefficient on GDP is significantly negative, suggesting that in larger markets affiliates are more geared towards local sales while in

Table 3
Impact of uncertainty on vertical and horizontal FDI

Dep. variable	(1) Exports	(2) Local sales	(3) Exports/Local sales
Real GDP	0.560** (0.235)	0.792** (0.192)	– 0.232** (0.098)
Distance from USA	– 0.909** (0.353)	– 0.758** (0.238)	– 0.151 (0.248)
English speaking	0.503 (0.623)	0.947** (0.425)	– 0.443 (0.375)
(1 – tax rate)	2.816** (1.128)	0.391 (0.863)	2.424** (0.567)
Volatility output/worker	– 1.635** (0.688)	– 0.626 (0.531)	– 1.008** (0.445)
Volatility terms of trade	– 0.769** (0.225)	– 0.482** (0.144)	– 0.287 (0.196)
Investment risk profile	– 0.377** (0.134)	– 0.182** (0.083)	– 0.195** (0.074)
Dummy 1994	– 0.662* (0.355)	– 0.072 (0.224)	– 0.590** (0.220)
Number of observations	75	75	75
R^2	0.48	0.64	0.42

OLS parameter estimates. Standard errors in parentheses corrected for serial correlation within countries. The ** (*) represent significance at the 5% (10%) level. Specifications include unreported constant. All variables in logarithms except for English-speaking dummy, investment risk profile, and year dummy. Dependent variable based on sales by U.S. majority-owned non-bank affiliates operating in 42 countries in 1989 and 1994. Exports represent exports by affiliates to the U.S. and to other foreign countries.

Table 4
FDI response to volatility and sovereign risk

Dep. variable	(1) Exports to U.S.	(2) Exports to U.S./Local sales	(3) Exports to U.S. and others/ Local sales	(4) Exports to U.S. and others/ Local sales
Volatility output/worker	− 1.460* (0.823)	− 0.833 (0.641)	− 0.634 (0.417)	− 0.229 (0.260)
Volatility terms of trade	− 0.316 (0.277)	0.166 (0.260)	− 0.734** (0.203)	− 0.296 (0.182)
Investment risk	− 0.380** (0.142)	− 0.198** (0.092)	− 0.177** (0.059)	− 0.092** (0.043)
n	75	75	113	113
R^2	0.39	0.31	0.46	0.34

** (*) represent significance at the 5% (10%) level. Standard errors in parentheses corrected for serial correlation within countries. Controls are log real GDP, log distance, log of one minus the effective corporate income tax rate, and a dummy variable for linguistic tie. Regressions (1) and (2) use data for benchmark years 1989 and 1994 and include a dummy for year 1994. Regressions (3) and (4) use data for benchmark years 1989, 1994 and 1999 and include dummies for years 1994 and 1999. Data based on affiliate sales in about 40 countries in each benchmark year.

smaller markets affiliates are more focused on exports.[15] Increased distance from the U.S. significantly discourages both vertical and horizontal FDI. However, the coefficient on distance is insignificant in regression (3), suggesting that distance does not have an important differential effect on the two types of FDI. Sharing a common language with the U.S. is associated with an increase in horizontal and vertical FDI, through the linguistic tie is not significant in the case of vertical FDI and it does not have a significantly different impact on vertical and horizontal FDI. A lower corporate tax rate significantly increases vertical FDI and it has a significantly greater positive effect on vertical FDI than on horizontal FDI.

We next examine the impact of uncertainty when vertical FDI is defined more narrowly as affiliate sales back to the parent country only. The results are shown in the first two columns of Table 4. The three uncertainty measures continue to have a negative effect on vertical FDI, narrowly defined, with two of the three measures—investment risk and volatility in productivity—significant at standard confidence levels. Now investment risk is the one source of uncertainty that has a significantly more negative effect on affiliate sales back to the U.S. than on local sales.

The last two columns of Table 4 report results using data from all three benchmark years, 1989, 1994 and 1999 when vertical FDI is defined more broadly. All uncertainty measures continue to have negative effects on both vertical and horizontal FDI, with investment risk and terms of trade volatility significant at 5% confidence levels. Investment risk has a significantly more deleterious effect on vertical FDI than on horizontal FDI.

Correlations among the uncertainty measures increase substantially when the data from benchmark year 1999 are included. For example, the correlation more than doubles between productivity volatility and terms-of-trade volatility or between productivity volatility and investment risk, and the correlation increases fivefold between terms-of-trade volatility and investment risk. To address problems introduced by multicollinearity,

[15] Hanson et al. (2002) obtain similar results for a different set of years.

Table 5
FDI Response to various measures of volatility and sovereign risk

Dep. variable	(1) Exports	(2) Exports/ Local sales	(3) Manufacturing exports	(4) Manuf. exports/ Local sales
Volatility output/worker	– 1.162** (0.484)	– 0.473 (0.309)	– 1.385** (0.566)	– 0.686* (0.348)
Volatility terms of trade	– 0.905** (0.207)	– 0.372* (0.192)	– 1.246** (0.204)	– 0.810** (0.137)
Volatility CPI	– 0.585** (0.140)	– 0.228** (0.081)	– 0.561** (0.155)	– 0.338** (0.080)
Investment Risk	– 0.357** (0.083)	– 0.154** (0.055)	– 0.400** (0.127)	– 0.186** (0.076)
Law and order	– 0.567** (0.111)	– 0.158** (0.077)	– 0.631** (0.164)	– 0.349** (0.098)
Institutional quality	– 0.102** (0.025)	– 0.030* (0.017)	– 0.112** (0.034)	– 0.061** (0.019)

** (*) represents significance at the 5% (10%) level. Standard errors in parentheses are corrected for serial correlation within countries. Each cell is from a separate regression. Controls are log real GDP, log distance, log of one minus the effective corporate tax rate, a dummy variable for linguistic ties, and year dummies for 1994 and 1999. Exports represent exports by affiliates to the U.S. and to other foreign countries. Data based on affiliate sales in about 40 countries in 1989, 1994 and 1999.

we also examine the effects of a variety of volatility and sovereign risk measures introduced sequentially into the regressions.

The first two columns of Table 5 display the results. All volatility and sovereign risk measures have a significant negative effect on vertical FDI and in all but one case uncertainty has a significantly more negative effect on vertical FDI than on horizontal FDI. The one exception is the case of productivity volatility. Contrary to the prediction of the model, we find that our measure of supply-side uncertainty does not have a more adverse impact on vertical FDI at standard confidence levels. The results are unchanged when the difference between skill intensities in the U.S. and host country is added to the set of controls, even though the skill differential is positively correlated with measures of uncertainty and introduces a problem of multicollinearity.

To further check the robustness of our results, we try some additional tests.[16] First, we investigate the effects of volatility and sovereign risk on the *share* of total affiliate sales destined for export markets. We find that sovereign risk always has a significantly negative effect on the share of sales exported. The other uncertainty measures also reduce the share of vertical FDI, though not significantly in all specifications or time periods.

Next, we disaggregate the affiliate sales data more finely and examine the impact of uncertainty on foreign affiliates involved just in manufacturing. The advantage of using manufacturing sales data is that exports and local sales may more closely replicate the production processes for vertical and horizontal FDI described in the theoretical model. The disadvantage of using manufacturing sales data is that a number of observations are not reported in order to preserve confidentiality, thus reducing the sample size.

The last two columns of Table 5 provide the estimated coefficients on volatility and sovereign risk measures for the manufacturing sales data. Volatility and sovereign risk have significant negative effects on vertical FDI in manufacturing, and they have a

[16] All of these tests use "micro-level" affiliate sales data. In an earlier version of this paper (NBER Working Paper #8631, Dec. 2001), we used macro data, examining the effect of volatility on the average share of net FDI inflows in GDP for 103 countries over the 1980–1999 period. We found that real exchange-rate volatility had a differential impact on FDI inflows into mature and emerging markets, where mature markets are thought to attract mainly horizontal FDI, while emerging markets receive relatively more vertical FDI inflows.

significantly more negative impact on vertical FDI than on horizontal FDI in manufacturing. The results are unchanged when the skill differential is added to the set of control variables. All uncertainty measures still have more negative effects on vertical FDI than on horizontal FDI, though the significance of productivity volatility declines. When we examine how uncertainty affects the share of sales exported by affiliates involved just in manufacturing, we find that in all cases, uncertainty significantly reduces the share of sales exported. We thus have additional evidence that greater volatility and sovereign risk discourage vertical FDI more than horizontal FDI.

6. Conclusion

Our theory suggests that volatility has a more negative impact on vertical FDI than on horizontal FDI. Demand shocks discourage both vertical and horizontal production modes. Supply shocks discourage vertical FDI and may actually increase horizontal FDI. Sovereign risk has a more deleterious impact on vertical FDI than on horizontal FDI. Multinationals face both demand and supply shocks and sovereign risk to various degrees. A test of the theory is to check whether volatility and sovereign risk considerations differentially impact vertical and horizontal FDI and, if so, whether they have a more negative impact on vertical FDI.

Using the destination market for sales by foreign affiliates of U.S.-parent companies to distinguish between vertical and horizontal FDI, we find that volatility generally has a much more negative impact on vertical FDI than on horizontal FDI. Sovereign risk, measured by investment risk related to contract viability/expropriation, profits repatriation, and payments delays, always has a much greater negative impact on vertical FDI.

The effects of demand-side and supply-side volatility on vertical FDI relative to horizontal FDI deserve further investigation. When we use data from all three benchmark years and enter uncertainty measures sequentially, terms of trade volatility, our measure of demand-side uncertainty, has a more robust negative impact on the ratio of vertical to horizontal FDI than does the volatility of output per worker, our measure of supply-side volatility. Our model predicts that supply-side volatility would always have the stronger negative effect. It may be that sharper measures of supply-side and demand-side volatility would yield different results. Additionally, it could be the case that market imperfections absent in the model alter the differential response of the two production modes to shocks.

We close the paper with an overview of two issues left for future research. First, our model can be extended to consider the impact of economic structure on the multinational's choice between vertical and horizontal FDI under uncertainty. For example, capital-market imperfections, financial constraints, and institutional quality can interact with uncertainty to influence the type of FDI pursued. Second, we treated volatility and sovereign risk as exogenous, so that any implied causality ran from volatility/risk to the pattern of FDI. Yet in the long run, there may be a two-way interaction between volatility/risk and the multinational's production structure. Volatility/risk may not only affect the pattern of FDI, but the structure of FDI may, in turn, influence the amount of uncertainty. Modeling and testing such a two-way interaction is left for future research.

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Appendix A

This appendix derives the main results of the paper.

A.1. Demand for good Y

Applying Eq. (1), the demand for good Y in each country is

$$Y^d = (A/P_y)^{\eta}; \quad \eta = \frac{1}{1-\delta} > 1. \tag{A1}$$

Hence, the total demand facing the multinational is $2Y^d$.

A.2. Eq. (8)

We calculate employment and profit for the multinational engaged in vertical FDI, assuming first that domestic and foreign productivity shocks are observed simultaneously. Applying Eqs. (5) and (6), it follows that employment in the final-good sector (Y) and in the intermediate-good sector (M) is:

$$L_Y = \left[\frac{Y}{(1+\varepsilon)b}\right]^2; \quad L_M^* = \left[\frac{Y}{(1+\varepsilon^*)b^*}\right]^2 \tag{A2}$$

Monopoly profits are

$$\Pi_f = 2Y^d P_y - L_y - w^* L_M^* - C_f. \tag{A3}$$

Substituting Eqs. (A1) and (A2) into Eq. (A3), we find that

$$\Pi_f = 2AY^{\delta} - 2\left[\frac{Y}{(1+\varepsilon)b}\right]^2 - 2w^*\left[\frac{Y}{(1+\varepsilon^*)b^*}\right]^2 - C_f \tag{A4}$$

where Y denotes the consumption level in H. The first-order condition characterizing optimal output ($\tilde{Y}$) and the resultant profits are

$$\tilde{Y} = \left[\frac{0.5\delta\ A}{[(1+\varepsilon)b]^{-2} + w^*[(1+\varepsilon^*)b^*]^{-2}}\right]^{\frac{1}{2-\delta}}; \quad \Pi_f = 2A\tilde{Y}^{\delta}\{1-0.5\delta\} - C_f. \tag{A5}$$

The profits can be rewritten as

$$\Pi_f = k_f[\theta_f(1+\varepsilon)^{-2} + \theta_f^*(1+\varepsilon^*)^{-2}]^{-\frac{\eta-1}{\eta+1}} - C_f \tag{A6}$$

where

$$k_f = (1-0.5\delta)(A)^{\frac{2\eta}{\eta+1}}(2)^{\frac{2}{\eta+1}}\left[\frac{\delta}{b^{-2}+w^*(b^*)^{-2}}\right]^{\frac{\eta-1}{\eta+1}}; \quad \theta_f = \frac{[b]^{-2}}{b^{-2}+w^*(b^*)^{-2}};$$
$$\theta_f^* = \frac{w^*(b^*)^{-2}}{b^{-2}+w^*(b^*)^{-2}}.$$

Suppose now that the intermediate output is produced prior to the realization of the productivity shock in H. In these circumstances, the optimal level of Y is determined by maximizing expected profits:

$$E[\Pi_f] = 2AY^{\delta} - (Y/b)^2E[(1+\varepsilon)^{-2}] - w^*\left[\frac{Y}{(1+\varepsilon^*)b^*}\right]^2 - C_f, \tag{A4$'$}$$

Output and profits are:

$$\tilde{Y} = \left\{\frac{0.5\delta A}{E[\{(1+\varepsilon)b\}^{-2}] + w^*[(1+\varepsilon^*)b^*]^{-2}}\right\}^{\frac{1}{2-\delta}}; \quad \Pi_f = 2A\tilde{Y}^{\delta}\{1-0.5\delta\} - C_f. \tag{A5$'$}$$

A.3. Eq. (9)

Horizontal FDI implies that the multinational will produce the same good in multiple locations in order to minimize the cost of production: The multinational tries to minimize costs:

$$\min_{L_Y;L_Y^*}[\{L_Y + w^*L_Y^*\} - \lambda\{(1+\varepsilon)a\sqrt{L_Y} + (1+\varepsilon^*)a^*\sqrt{L_Y^*} - \tilde{Y}\}] \tag{A7}$$

The firm allocates production to equate the marginal cost in the two locations:

$$\frac{w^*\sqrt{L_Y^*}}{2(1+\varepsilon^*)a^*} = \frac{\sqrt{L_Y}}{2(1+\varepsilon)a} \tag{A8}$$

Consequently,

$$\frac{L_Y}{L_Y^*} = \frac{[a(1+\varepsilon)]^2}{[a^*(1+\varepsilon^*)/w^*]^2}. \tag{A8$'$}$$

The multinational's profits are

$$\Pi_h = 2A\left[\frac{(1+\varepsilon)a\sqrt{L_Y} + (1+\varepsilon^*)a^*\sqrt{L_Y^*}}{2}\right]^{\delta} - L_Y - w^*L_Y^* - C_h \tag{A9}$$

Applying Eqs. (A8) and (A9) we find that

$$\Pi_h = 2^{1-\delta}A[L_Y]^{0.5\delta}\left[(1+\varepsilon)a + \frac{[(1+\varepsilon^*)a^*]^2}{w^*(1+\varepsilon)a}\right]^{\delta} - L_Y\left[1 + \frac{[(1+\varepsilon^*)a^*]^2}{w^*[(1+\varepsilon)a]^2}\right] - C_h \tag{A10}$$

The optimal employment allocation is obtained by maximizing Eq. (A10), implying that

$$\tilde{L}_Y = [\delta 2^{-\delta}A]^{\frac{1}{1-0.5\delta}}\left[[(1+\varepsilon)a]^2 + \frac{[(1+\varepsilon^*)a^*]^2}{w^*}\right]^{-\frac{2(1-\delta)}{2-\delta}}[(1+\varepsilon)a]^{\frac{2(2-\delta)}{2-\delta}}. \tag{A11}$$

Substituting Eq. (A11) into Eq. (A10) and collecting terms, we find that

$$\Pi_h = k_h[\theta_h(1+\varepsilon)^2 + \theta_h^*(1+\varepsilon^*)^2]^{\frac{\eta-1}{\eta+1}} - C_h; \tag{A12}$$

where

$$k_h = (1-0.5\delta)(A)^{\frac{2\eta}{\eta+1}}(2)^{\frac{2}{\eta+1}}\left[\delta\left\{a^2 + \frac{(a^*)^2}{w^*}\right\}\right]^{\frac{\eta-1}{\eta+1}}; \quad \theta_h = \frac{a^2w^*}{a^2w^* + (a^*)^2};$$

$$\theta_h^* = \frac{(a^*)^2}{a^2w^* + (a^*)^2}.$$

Proof of Proposition 1. We derive Proposition 1 by examining the concavity properties of Eqs. (A6) and (A12) around $\varepsilon = \varepsilon^* = 0$. Consider the function

$$Z = [\theta(1+\varepsilon)^{\alpha} + \theta^*(1+\varepsilon^*)^{\alpha}]^{\beta} \tag{A13}$$

where $\theta^* + \theta = 1$. Fragmentation (vertical FDI) corresponds to $\alpha = -2$; $-1 < \beta < 0$ (see Eq. (A6)). Diversification (horizontal FDI) corresponds to $\alpha = 2$; $0 < \beta < 0$ (see Eq. (A12)).

It is easy to confirm that

$$\text{sign}\frac{d^2Z}{d\varepsilon^2}\Big|_{\varepsilon=0;\ e^*=0} = \text{sign}\{\alpha\beta[(\beta-1)\theta\alpha + (\alpha-1)]\}. \tag{A14}$$

$$\text{sign}\frac{d^2Z}{d\varepsilon^2}\Big|_{\alpha=-2;-1<\beta<0;\varepsilon=0;\varepsilon^*=0} = \text{sign}[-2(\beta-1)\theta - 3] < 0$$

Hence,

$$\operatorname{sign}\frac{d^2Z}{d\varepsilon^2}\bigg|_{\alpha=2;0<\beta<1;\varepsilon=0;\varepsilon^*=0} = \operatorname{sign}[2(\beta-1)\theta+1] > 0 \qquad \square$$

Identical results hold for $\operatorname{sign}(d^2Z)/(d(\varepsilon^*)^2)|_{\varepsilon=0;\varepsilon^*=0}$.

Proof of Proposition 2. Recall that the demand for the product in each country is

$$Y^d = (A/P_y)^\eta; \qquad \eta = \frac{1}{1-\delta} > 1. \tag{A1}$$

Suppose now that demand is random, subject to multiplicative uncorrelated, i.i.d., mean zero, country-specific disturbances, v, v^*:

$$A = \begin{cases} (1+v)^{1/\eta}A_0 & \text{country H} \\ (1+v^*)^{1/\eta}A_0 & \text{country F} \end{cases},$$

where A_0 is a positive scale constant. Applying the modified A and Eq. (A1), we find that the global demand curve facing the multinational shifts at a rate given by the average of the country-specific demand shocks, with $Y^d_{\rm H}+Y^d_{\rm F}=2[1+0.5(v+v^*)](A_0/P_y)^\eta$.

The logic of the solution procedure described in Eqs. (A2)–(A12) continues to hold, subject to the modified values of demand conditions [summarized now by the country-specific A coefficients] and zero supply disturbances. Applying these conditions, expected profits under both horizontal and vertical modes are given by Eqs. (A6) and (A12), for the case where the coefficient A is replaced by $A_0[1+0.5(v+v^*)]^{1/\eta}$. Comparing the constant terms in Eqs. (A6) and (A12), k_f and k_h, it follows that expected profits are proportional to $A^{2\eta/(\eta+1)}$ under *both* production modes. This result implies that with demand uncertainty, expected profits under both production modes are proportional to $[1+0.5(v+v^*)]^{2/(\eta+1)}$. Recalling that $\eta>1$, it follows that $2/(1+\eta)<1$. Hence, expected profits are concave with respect to the global demand shock. Consequently, demand uncertainty reduces expected profits under *both* production modes. This effect is more pronounced in more competitive industries. □

A.4. Eq. (11)

Applying Eq. (8) to the case where $\varepsilon=\varepsilon^*=0$, and recalling that the opportunity cost of labor is constant, we infer that the surplus associated with vertical FDI is k_f-C_f, and that in the absence of agreement, the surplus would be $-C_f$. Hence, the net surplus associated with agreement is k_f. The bargaining outcome would allocate a fraction ϕ of the surplus to the multinational [and a fraction $1-\phi$ to country F]. The equilibrium outcome is determined by maximizing the corresponding Nash product:

$$\max_\phi[\phi k_f + I_0 - C_f - (I_0 - C_f)][U_0 + (1-\phi)k_f - U_0] \tag{A15}$$

where I_0 is the outside income of the multinational [i.e., the income not affected by the production decisions regarding good Y], and U_0 is the utility of the host country in the absence of agreement. Eq. (A15) is equivalent to max[$\phi(1-\phi)$], implying that $\phi = 0.5$. Consequently, the multinational's net profits in the bargaining regime are

$$0.5k_f - C_f. \tag{A16}$$

A.5. Eq. (12)

Applying Eq. (A12) in the case where $\varepsilon = \varepsilon^* = 0$, and recalling that the labor's opportunity cost is constant, we infer that the profit associated with undisturbed production under horizontal FDI is:

$$\Pi_h = k_h - C_h \tag{A17}$$

In the absence of agreement, the multinational would produce only in one plant. The resultant profit is found by evaluating Eq. (A12) for the case where $a^* = 0$, resulting in

$$\Pi_h = k_h^0(\theta_h)^{\frac{\eta-1}{\eta+1}} - C_h \tag{A18}$$

where $k_h^0 = (1-0.5\delta)2(A2^{-\delta})^{2\eta/(\eta+1)}(\delta a^2)^{(\eta-1)/(\eta+1)}$.

Hence, the agreement would increase profits by

$$\Delta\Pi_h = (1-0.5\delta)2(A2^{-\delta})^{\frac{2\eta}{\eta+1}}\left[\delta\left(\left[a^2 + \frac{(a^*)^2}{w^*}\right]^{\frac{\eta-1}{\eta+1}} - [a^2\theta_h]^{\frac{\eta-1}{\eta+1}}\right)\right] \tag{A19}$$

The bargaining outcome is the solution to

$$\max_{\phi}[\phi\Delta\Pi_h + I_0 - C_f - (I_0 - C_f)][U_0 + (1-\phi)\Delta\Pi_h - U_0] \tag{A20}$$

Eq. (A20) is equivalent to max$\{\phi(1-\phi)\}$, implying that $\phi = 0.5$. The multinational's net profits in the bargaining regime are

$$0.5\left[k_h + k_h^0(\theta_h)^{\frac{\eta-1}{\eta+1}}\right] - C_h \tag{A21}$$

Consequently, the switch to the bargaining regime reduces the multinational's gross profits at a rate of

$$\left[k_h - 0.5\left\{k_h + k_h^0[\theta_h]^{\frac{\eta-1}{\eta+1}}\right\}\right]\Big/k_h = 0.5\left[1 - \frac{k_h^0}{k_h}(\theta_h)^{\frac{\eta-1}{\eta+1}}\right] = 0.5\left[1 - (\theta_h)^{2\frac{\eta-1}{\eta+1}}\right] \quad \square \tag{A22}$$

Appendix B. Data Appendix

Vertical FDI = exports to the U.S., or exports to the U.S. and other foreign countries, by majority-owned non-bank foreign affiliates of U.S.-parent companies, measured in millions or billions of 1995 U.S. dollars. Source: U.S. Department of Commerce, Bureau of

Economic Analysis, *U.S. Direct Investment Abroad* for the affiliate sales data, *World Economic Outlook* (IMF) for the U.S. GDP deflator.

Horizontal FDI = local market sales by majority-owned non-bank foreign affiliates of U.S.-parent companies, measured in millions or billions of 1995 U.S. dollars. Source: Bureau of Economic Analysis, *U.S. Direct Investment Abroad* (sales data) and *World Economic Outlook*, IMF (deflator).

Real GDP = real gross domestic product per capita, chain index (gdpch), multiplied by population. Source: Penn World Tables 6.0.

Distance = miles from the geographic center of the host country to the geographic center of the U.S. Source: Glick and Rose (2002).

Linguistic tie = dummy variable that takes the value of one if the host country is English-speaking and is zero otherwise. Source: country web sites.

Corporate tax rate = effective corporate income tax rate faced by controlled foreign corporations of U.S. corporations. Source: U.S. Internal Revenue Service Statistics of Income Division, obtained from Harry Grubert (U.S. Treasury) and John Mutti (Grinnell) and from Altshuler et al. (2001). Available for even-numbered years through 1996. The 1988 tax rate was used for benchmark year 1989 and the 1996 tax rate was used for year 1999.

Skill difference = the difference between the ratio of skilled labor to total labor force in the U.S. and that in the host country, with skilled labor measured as managerial and professional, technical, and kindred workers. Source: *Yearbook of Labor Statistics*, International Labor Organization.

Terms-of-trade volatility = the standard deviation of the average annual percentage change in the terms-of-trade based on twenty years of annual terms-of-trade data. Source for annual TOT data: World Bank, unpublished series.

Volatility of output per worker = the standard deviation of the innovation from a first-order autoregressive process based on twenty years of annual data. Source: *World Development Indicators* (nominal GDP at PPP exchange rates, national labor force), *World Economic Outlook*, IMF (U.S. deflator).

Inflation volatility = the standard deviation of the innovation from a first-order autoregressive process based on twenty years of CPI data. Source for inflation series: IMF *International Financial Statistics*.

Investment profile = an assessment of three factors relating to investment risk: (1) viability of contracts/expropriation, (2) profits repatriation, and (3) payments delays. Countries are ranked monthly on a 0–12 scale, with a higher value indicating lower risk. Annual values are computed as averages of monthly values. For ease of interpretation, values are multiplied by -1 so that a higher value signifies greater investment risk. Source: International Country Risk Guide, Political Risk Services Group.

Law and order = an assessment of the strength and impartiality of the legal system and popular observance of the law. Countries are ranked monthly on a 0–6 scale, with a higher value indicating more law and order. Annual values are computed as averages of monthly values. For ease of interpretation, values are multiplied by -1 so that a higher value signifies less law and order. Source: International Country Risk Guide, Political Risk Services Group.

Institutional quality = an unweighted average of four indicators: (1) investment profile, (2) law and order, (3) bureaucratic quality, and (4) corruption within the political system. Each individual indicator has been converted to a 0–12 scale on an annual basis before averaging. Source: International Country Risk Guide, Political Risk Services Group.

References

Acemoglu, D., Johnson, S., Robinson, J., 2001. The colonial origins of comparative development: an empirical investigation. American Economic Review 91 (5), 1369–1401 (December).

Aizenman, J., 1994. Monetary and real shocks, productive capacity and exchange rate regimes. Economica, November, 407–434.

Aizenman, J., 2003. Volatility, employment and the patterns of FDI in emerging markets. Journal of Development Economics 72 (2), 585–601.

Aizenman, J., and Marion, N., 2001. The merits of horizontal versus vertical FDI in the presence of uncertainty. NBER Working Paper 8631, December.

Altshuler, R., Grubert, H., Newlon, T.S., 2001. Has U.S. investment abroad become more sensitive to tax rates? In: Hines Jr., J.R. (Ed.), International Taxation and Multinational Activity. University of Chicago Press, Chicago.

Blonigen, B., Davies, R.B., 2001. The Effects of Bilateral Tax Treaties on U.S. FDI Activity. University of Oregon, Working Paper.

Brainard, S.L., 1997. An empirical assessment of the proximity-concentration tradeoff between multinational sales and trade. American Economic Review 87, 520–544.

Carr, D.L., Markusen, J.R., Maskus, K.E., 2001. Estimating knowledge-capital model of the multinational enterprise. American Economic Review 91 (3), 693–708 (June).

Dunning, J.H., 1993. Multinational Enterprises and the Global Economy Addison Wesley, New York.

Feenstra, R.C., Hanson, G.H., 1997. Foreign direct investment and relative wages. Journal of International Economics 42, 371–394.

Glick, R., Rose, A., 2002. Does a currency union affect trade? European Economic Review 46 (6), 1125–1151.

Goldberg, L.S., Kolstad, C.D., 1995. Foreign direct investment, exchange rate variability and demand uncertainty. International Economic Review 36 (4), 855–873.

Grossman, G.M., Helpman, E., 2001. International outsourcing. Presented at the ITI NBER Summer Institute, Cambridge, MA.

Hall, R., Jones, C., 1999. Why do some countries produce so much more output per worker than others? Quarterly Journal of Economics 114 (1), 83–116 (February).

Hanson, G.H., Mataloni Jr., R.J., Slaughter, M.J., 2002. Expansion strategies of U.S. multinational firms. Brookings Trade Forum 2001. Brookings Institution, Washington, DC.

Hausmann, R., Gavin, M., 1995. Overcoming volatility. Part II of Economic and Social Progress in Latin America. Inter-American Development Bank, Washington, DC.

Janeba, E., 2000. Tax competition when governments lack commitment: excess capacity as a countervailing threat. American Economic Review 90, 1508–1519.

Knack, S., Keefer, P., 1995. Institutions and economic performance: cross-country tests using alternative institutional measures. Economics and Politics 7 (3), 207–227 (November).

Lapan, H., Sung, H., 2000. Strategic foreign direct investment and exchange rate uncertainty. International Economic Review 41 (2), 411–423.

Markusen, J.R., Maskus, K.E., 2001. General-equilibrium approaches to the multinational firm: a review of theory and evidence. NBER WP 8334.

Markusen, J.R., Venables, A., 1998. Multinational firms and the new trade theory. Journal of International Economics 46, 183–204.

Markusen, J.R., Venables, A., 2000. The theory of endowment, intra-industry, and multinational trade. Journal of International Economics 52, 209–234.

Milgrom, P., Roberts, J., 1990. The economics of modern manufacturing: technology, strategy, and organization. American Economic Review 80, 511–528.

Pyndyck, R.S., 1988. Irriversilbe investment, capacity choice, and the value of the firm. American Economic Review 78, 969–985.

Sheshinski, E., Dreze, J.H., 1976. Demand fluctuations, capacity utilization and costs. American Economic Review 66, 731–742.

Spiegel, M.M., 1994. Sovereign risk exposure with potential liquidation: the performance of alternative forms of financing. Journal of International Money and Finance, 400–414.

Tirole, J., 1988. The Theory of Industrial Organization. MIT Press, Cambridge.

Wei, S.-J., 2000. How taxing is corruption on international investors? Review of Economics and Statistics 82 (1), 1–11.