Trade and Multinational Production in a Risky Environment

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Abstract

This paper analyzes how the joint pattern of trade and the activity of multinational firms is affected by the existence of country specific uncertainty, in a world with frictionless financial markets. We find that country-pairs with less correlated business cycles do more trade relatively to multinational production (MP). Moreover, the stochastic properties of world output fluctuations also affect the cross-country patterns of trade and MP flows. Using US data on trade and MP sales data from the Bureau of Economic Analysis, we find empirical support for the predictions of the model. For instance, our estimates suggest that, if business cycles of New Zealand and US became perfectly synchronized, New Zealand's exports would drop by 2%, relative to sales by its affiliates in the US. This drop is equivalent to a reduction of more than 4% in the distance between New Zealand and the US.

1 Introduction

The economic literature has emphasized the link between the patterns of international trade flows and cross-country risk. In the presence of country specific shocks, goods are expected to flow from countries experiencing an upturn towards economies hit by a negative shock. In

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this way, international trade has a role in the diversification of country risk and the reduction of consumption volatility. However, international trade is not the only way through which firms can serve a foreign market, nor it is the sole channel through which consumers diversify country risk. For instance, a firm can supply a foreign market by setting subsidiaries there, or by contractual arrangements with foreign firms (e.g. licensing). Correspondingly, consumers in each country can hold portfolios of financial assets that entail equities of foreign firms, or multinational firms with foreign affiliates, that help to diversify country specific uncertainty.

This paper analyzes how the joint pattern of trade and the activity of multinational firms is affected by the existence of country specific uncertainty. We analyze this question in an environment where consumers and firms have access to frictionless and integrated financial markets.

We build our analysis on a crucial distinction between these two ways of serving a foreign market: exported goods are produced in the source country and, thus, their unit production cost fluctuates with domestic shocks. Foreign direct investment (FDI), on the other hand, entails production located in the destination country, and therefore, bears the *host* country shock. This feature introduces different co-movement properties for trade and multinational production (MP), leading to the following findings:

First, in line with previous results on international trade and risk sharing, we find that firms have more incentives to trade rather than opening affiliates, with economies least correlated with their source country fluctuations. In this way, firms exploit the labor cost differential between the source and destination countries that results from the realization of uncorrelated productivity shocks. Along the same lines, highly volatile economies are not the preferred destination for affiliates of multinationals. Rather, firms prefer to serve those economies through exports, taking advantage of the labor cost differentials resulting from large deviations in productivity shocks.

Second, we find that the existence of non-diversifiable world risk also affects the joint pattern of trade and MP across countries. Firms maximize their stock market value, so they prefer to locate production in markets for which the unit cost of production is lower when world output is scarce. In this way, firms expect a higher flow of profits when consumers value them the most, which results in a higher market price of their stocks. The resulting allocation of affiliates across countries is efficient; simply, with complete financial markets, firms internalize consumers' risk aversion, and locate production in order to reduce world output fluctuations.

We present a multi-country model where the only source of uncertainty is the existence of country shocks, in the spirit of Backus, Kehoe, and Kydland (1992). Risk-averse consumers have access to a full set of contingent claims. With a freely-tradable final consumption good, consumers attain perfect risk sharing: consumption in each country fluctuates with world output.

The structure of the intermediate-good sector builds on Melitz (2003) and Helpman, Melitz, and Yeaple (2004). As in their work, firms producing intermediate goods are heterogenous in productivity and face the so-called "proximity-concentration" trade-off when choosing to serve a market through trade or MP. That is, trade entails a variable "iceberg" cost, while opening an affiliate abroad saves on variable costs but entails (large) fixed costs. We treat firms as technology entities, in the sense that the same technology parameter characterizes the parent firm and its affiliates -"firm embedded" productivity.

Country shocks affect the unit cost of production of all plants located in the country, both national firms and foreign affiliates located there. Hence, the decision of serving a foreign market by exporting or opening affiliates takes into consideration the stochastic properties of source and host country shocks. While for exports, production is affected by shocks in the home market, for MP, the relevant production shock is the one to the host country. The predictions derived by Helpman, Melitz, and Yeaple (2004) in a deterministic environment with heterogenous firms and many industries are also present in this paper. We add to their findings predictions on the patterns of trade and MP sales across country pairs related to the stochastic properties of partners' business cycles.

Using bilateral data of US trade and MP sales from the Bureau of Economic Analysis (BEA), we find supporting evidence for the main predictions of the model. Moreover, the effect of country uncertainty on the joint patterns of trade and multinational activities is economically important. According to our estimates, if Spain output volatility, computed at 3.2%, is reduced to 1.9% (equivalent to Denmark's), the ratio of US exports relative to sales by US affiliates in Spain would drop by almost 12%. The impact of country uncertainty on the pattern of trade and MP is important also relative to other factors typically included in traditional gravity equations. For example, if New Zealand, for which its output correlation with the US is computed at 0.30, were perfectly in-line with US fluctuations, our estimates predict the ratio of its exports relative to sales by its affiliates in the US, to drop by 2%. This drop is equivalent to a reduction of more than 4% in the distance between New Zealand and the US.

Our model also builds on Grossman and Razin (1984, 1985), and more generally, the literature on trade and international risk sharing.[1] Grossman and Razin introduce production risk into a model that jointly determines the international pattern of trade and capital flows. They analyze the choice between risky and risk-free production done by asymmetric economies, and find —as we do– that risky production in the small economy is more valuable. We build on that result by endogenizing the location decision of affiliates in a similar risky environment. The findings in this paper reinforce those in Grossman and Razin. Affiliates producing intermediate goods endogenously locate in "large" economies. This way, "small" countries can allocate more labor to the production of the final good. As a result, more world output is produced in states of nature with relative scarcity.

Finally, our paper adds to the literature on Foreign Direct Investment (FDI) and risk di-

[1]See Grossman and Razin (1984, 1985), Svensson (1988), Obstfeld and Cole (1991), Tesar (1993), and Backus and Smith (1993), Baxter and Crucini (1995).

versification.[2] However, this literature typically considers an environment in which firms have imperfect access to financial markets; doing MP enables firms to hedge cross country risk.[3] In the model presented in this paper, firms do not choose the location of subsidiaries or their export markets to diversify risk within the boundaries of the corporation. With complete financial markets, it is more efficient to diversify risk by holding an optimal portfolio of financial securities than by costly changing the location of production or setting up export networks in different countries. Still, this model finds that risk considerations affect the decisions of the firm. Moreover, according to our empirical estimates, this effect is potentially considerable.

The paper is organized as follows. Section 2 presents the model. Section 3 defines and solves the equilibrium. Section 4 characterizes how cross country risk patterns affects the firm's choice between trade and MP. Section 5 derives empirical predictions and test them using US bilateral trade and MP flows data from the Bureau of Economic Analysis. Finally, section 6 concludes.

2 The Model with Trade and MP

There are I countries of size L_i, $i = 1, ..., I$, respectively. There are two periods. In the first period, *before* country-shocks are realized, consumers make their portfolio decisions, and firms set up foreign facilities (i.e. Foreign Direct Investment -FDI) and export networks. In the second period, *after* uncertainty is realized, production and consumption take place.

Let the vector $s \in S$ denote the state of the world economy in the second period, characterized by the joint realization of country-specific productivity shocks, $s = [A_1, ..., A_I]$. These productivity shocks are the only source of uncertainty in this world; we make that explicit using notation $A(s)$. Without loss of generality, we normalize the expected productivity to one: for

[2] See our previous work for a treatment of MP in a risky environment with complete financial markets (Ramondo and Rappoport, 2008).

[3] See for example Aizenman and Marion (2004), and Goldberg and Kolstad (1995).

$i = 1, ..., I, E\{A_i(s)\} = 1$.[4] Assume that there is a finite number of states, $S = \{s_1; s_2; ...; s_n\}$, each occurring with probability $\Pr(s)$.

The representative consumer in country i supplies L_i units of labor, and maximizes expected utility from final consumption,

$$U = \beta \sum_{s \in S} \Pr(s) \left\{ \frac{C_i(s)^{1-\sigma}}{1-\sigma} \right\},$$

where $\sigma \geq 1$ is the relative risk aversion.

Production. Each country produces a final good and a continuum of intermediates. In the intermediate goods sector there is a continuum of firms of measure one. Each intermediate good ω is produced with an only-labor constant returns technology and firm-specific productivity $z(\omega)$. This parameter is known and drawn from a country-specific distribution, $G_i(z)$, $z \in [z^i_{\min}, \infty)$, independently distributed across countries. Crucially, firms can open affiliate plants abroad with the same technology parameter $z(\omega)$ as the one they have at home.

Then, the production function for a firm from country j producing intermediate good ω in country i:

$$q^m_{ji}(\omega, s) = z(\omega) \cdot l_{ji}(\omega, s). \tag{1}$$

where $q^m_{ji}(\omega, s)$ is output produced in country i by an affiliate of a firm from country j and $l_{ji}(\omega, s)$ is the respective labor requirement. Similarly, goods produced domestically by national firms, either for the domestic market or for exporting is given by:

$$q_{ii}(\omega, s) + q^x_{ij}(\omega, s) = z(\omega) \cdot [l_{ii}(\omega, s) + l_{ij}(\omega, s)]$$

where $q_{ii}(\omega, s)$ is output sold in the domestic market by a national firm and $q^x_{ij}(\omega, s)$ denotes

[4] In this economy, all asymmetries of $E(A_i(s))$ across countries can be equivalently expressed as differences in labor size L_i.

goods produced in country i and exported to country j.

The final consumption good is produced under perfect competition with a constant returns to scale technology that combines labor and intermediate goods. The final good is freely tradable and, provided that it is produced everywhere, its price is equalized across countries, and normalized to one. Production of the final good is affected by the country-specific productivity shock, $A_i(s)$. The realization of this shock across countries characterizes each state $s \in S$. Then, the production function for the final good in country i is given by:

$$Y_i(s) = A_i(s) \cdot L_i^f(s)^{\alpha} \cdot Q_i(s)^{1-\alpha}, \tag{2}$$

with $0 < \alpha < 1$. The index $Q_i(s)$ aggregates intermediate goods with constant elasticity of substitution $\eta > 1$

$$Q_i(s) = \left[\int_{\omega \in \Omega_i} q_{ii}(\omega, s)^{\frac{\eta-1}{\eta}} d\omega + \sum_{j=1}^{I} \int_{\omega \in \Omega_j} q_{ji}^x(\omega, s)^{\frac{\eta-1}{\eta}} d\omega + \sum_{j=1}^{I} \int_{\omega \in \Omega_j} q_{ji}^m(\omega, s)^{\frac{\eta-1}{\eta}} d\omega \right]^{\frac{\eta}{\eta-1}}, \tag{3}$$

and the associated price index is given by

$$P_i(s) = \left[\int_{\omega \in \Omega_i} p_{ii}(\omega, s)^{1-\eta} d\omega + \sum_{j=1}^{I} \int_{\omega \in \Omega_j} p_{ji}^x(\omega, s)^{1-\eta} d\omega + \sum_{j=1}^{I} \int_{\omega \in \Omega_j} p_{ji}^m(\omega, s)^{1-\eta} d\omega \right]^{\frac{1}{1-\eta}}.$$

Thus, total expenditure in each intermediate good ω is

$$x_{ij}(\omega, s) = \left[\frac{p_{ij}(\omega, s)}{P_j(s)} \right]^{1-\eta} P_j(s) Q_j(s). \tag{4}$$

Multinational Production and Trade. Firms compete monopolistically and can serve foreign consumers by exporting or opening affiliates abroad. Foreign affiliates inherit the productivity parameter $z(\omega)$ from the parent home firm. Exporting firms incur in an iceberg-type transportation cost per unit of the good shipped from i to j, $\tau_{ij} \geq 1$.

If a firm with productivity z from country i opens an affiliate in country j, the price of the product in the host market is equal to the price charged by a national firm:[5]

$$p_{ij}^{m}(z,s) = p_j(z,s) = \frac{\eta}{\eta - 1} \cdot W_j(s) \cdot \frac{1}{z}, \tag{5}$$

where $W_j(s)$ denotes wages in country j, state s. If instead, the firm decides to serve country j with exports from its source country i, the price in j is:

$$p_{ij}^{x}(z,s) = \tau_{ij} \cdot p_i(z,s) = \tau_{ij} \cdot \frac{\eta}{\eta - 1} \cdot W_i(s) \cdot \frac{1}{z} \tag{6}$$

where τ_{ij} is the iceberg cost of shipping goods from country i to j.

Assets Structure. The representative consumer in country i holds two types of assets: shares of firms, $\theta_i(z)$, and contingent claims, $B_i(s)$. Without loss of generality, firms are assumed to be owned by national consumers: $\theta_i(z) = 1$ for $z \in [z_{\min}^{i}, \infty)$.[6] The budget constraint for a consumer from country i is:

$$\sum_{s \in S} \varphi(s) C_i(s) = B_i^0 + \sum_{s \in S} \varphi(s) \left[L_i W_i(s) + \int_z \pi_i(z,s)\, dG_i(z) \right], \tag{7}$$

where $\varphi(s)$ is the time-zero price of an Arrow-Debreu security that pays one unit of final good in state s, and B_i^0 is initial net wealth for country i.

[5] Since the only parameter that varies across differentiated goods is the firm-specific productivity $z(\omega)$, and intermediate goods are symmetric in demand, we can rename each good ω by its productivity z.

[6] The results are not affected if firms from country i are initially owned by national consumers and then sold in the international market.

Profits for a firm with productivity z from country i are given by:

$$\pi_i(z,s) = \pi_i^d(z,s) + \sum_{j=1}^{I} \iota_{ij}^x(z)\pi_{ij}^x(z,s) + \sum_{j=1}^{I} \iota_{ij}^m(z)\pi_{ij}^m(z,s),$$

where $\iota_{ij}^x(z)$ and $\iota_{ij}^m(z)$ are one if the firm exports or does MP in country j, respectively, and zero otherwise. The variables $\pi_i^d(z,s)$, $\pi_{ij}^x(s,z)$, and $\pi_{ij}^m(s,z)$, denote profits from domestic sales, exports, and MP sales, in market j, respectively.

The Euler equation from the consumer's optimization problem is:

$$\varphi(s) = \frac{\beta}{\lambda_i} \Pr(s) C_i(s)^{-\sigma}, \tag{8}$$

where λ_i is the multiplier on the budget constraint for country i's consumers.

Foreign Direct Investment and Export Networks. Firms decide whether to become multinationals, exporters, or just serve the domestic market before the realization of country shocks. A firm from country j that decides to open an affiliate in country i pays an entry cost f_{ji}^m. If it decides to export into country i has to pay a fixed cost given by f_{ji}^x. We assume that exporting requires a lower fixed cost than setting up and affiliate and restrict parameters such that "export platforms" are ruled out.

Assumption 1. *$f_{ji}^x < f_{ji}^m$, for all j, i.*

Countries are endowed with a stock of an investment tradable good, K_i. MP entry costs and export costs are paid at time zero in units of this good which international price is p_k. The value of becoming an exporter into country j for a firm with productivity z from country i is given by

$$V_{ij}^x(z) = \sum_{s \in S} \varphi(s)\pi_{ij}^x(z,s), \tag{9}$$

while the value of opening an affiliate is given by

$$V_{ij}^{m}\left(z\right)=\sum_{s\in S}\varphi(s)\pi_{ij}^{m}(z,s), \tag{10}$$

where $\varphi\left(s\right)$ correspond to the price of a security that pays a unit of the consumption good in state s, and satisfies the Euler equation (8).

The optimal MP and export entry decisions into a market j for firms from country i are characterized by a productivity level z_{ij}^{m}, and z_{ij}^{x}, respectively, such that:[7]

$$\begin{aligned} V_{ij}^{x}\left(z_{ij}^{x}\right) &= f_{ij}^{x}\cdot p_{k} && (11)\\ V_{ij}^{m}\left(z_{ij}^{m}\right)-V_{ij}^{x}\left(z_{ij}^{m}\right) &= \left[f_{ij}^{m}-f_{ij}^{x}\right]\cdot p_{k}, && (12)\end{aligned}$$

Firms from country i with $z\geq z_{ij}^{m}$ open affiliates in country j; firms with productivity z with $z_{ij}^{x}\leq z<z_{ij}^{m}$ become exporters; and firms with $z<z_{ij}^{x}$ do not engage in international activities.

Finally, net wealth in the budget constraint (7) for country i's consumers is given by

$$B_{i}^{0}=p_{k}\left[K_{i}-\sum_{j=1}^{I}f_{ij}^{x}\left(G_{i}\left(z_{ij}^{m}\right)-G_{i}\left(z_{ij}^{x}\right)\right)-\sum_{j=1}^{I}f_{ij}^{m}\left(1-G_{i}\left(z_{ij}^{m}\right)\right)\right], \tag{13}$$

that is, the value of the endowment K_i net of the entry cost of setting up foreign affiliates and

[7] From (6) and (5), prices $p_{ij}^{x}\left(z,s\right)$ and $p_{ij}^{m}\left(z,s\right)$ are inversely related to the firms's productivity z. Thus, with elastic demand function ($\eta>1$), profits increase in z. And, under Assumption (1), MP profits increase with z relatively more than export profits:

$$\sum_{s\in S}\varphi(s)\frac{\partial}{\partial z}\pi_{ij}^{x}(z,s)>0 \qquad \sum_{s\in S}\varphi(s)\left[\frac{\partial}{\partial z}\pi_{ij}^{m}(z,s)-\frac{\partial}{\partial z}\pi_{ij}^{x}(z,s)\right]>0.$$

Hence, there is a productivity level $\overline{z}_{ij}^{x}$ such that $V_{ij}^{x}\left(\overline{z}_{ij}^{x}\right)-f_{ij}p_{k}=0$ and for all firms with productivity $z>\overline{z}_{ij}^{x}$, the condition $V_{ij}^{x}\left(z\right)>f_{ij}p_{k}$ holds. Equivalent there is a productivity level $\overline{z}_{ij}^{m}$ such that $V_{ij}^{m}\left(\overline{z}_{ij}^{m}\right)-V_{ij}^{x}\left(\overline{z}_{ij}^{m}\right)=\left(f_{ij}^{m}-f_{ij}^{x}\right)p_{k}$ and for all $z>\overline{z}_{ij}^{m}$, the condition $V_{ij}^{m}\left(z\right)-V_{ij}^{x}\left(z\right)>\left(f_{ij}^{m}-f_{ij}^{x}\right)p_{k}$. Therefore, the optimal entry rule is characterized by those two cut-off points.

export networks.

3 Equilibrium

We define the equilibrium in two steps. First, we characterize *national* equilibrium prices and quantities as functions of the number of firms doing MP and exporting in each country. Second, we define the *international* equilibrium, and characterize the MP and export decisions of firms.

3.1 National Equilibrium

Definition 1. *Given the cut-off rules* $\left\{z_{ji}^{x}, z_{ji}^{m}\right\}_{i,j=1}^{I}$, *the National Equilibrium in country* i *and state* s *is defined by the vector of output* $\left[\left\{\langle q_{ji}(z,s)\rangle_{z\in Z}\right\}_{j=1}^{I}, Y_i(s)\right]$, *wage* $W_i(s)$, *prices* $\left\{\langle p_{ji}(z,s)\rangle_{z\in Z}\right\}_{j=1}^{I}$, *labor demands* $\left[\left\{\langle l_{ji}(z,s)\rangle_{z\in Z}\right\}_{j=1}^{I}, L_i^f(s)\right]$, *such that:*

1. *Firms producing intermediate and final goods maximize profits;*

2. *The market for each variety* z *clears:*

$$q_{ij}(z,s)\cdot p_{ij}(z,s) = x_{ij}(z,s)$$

3. *The labor market clears:*

$$L_i = L_i^f(s) + L_i^d(s) + \sum_{j=1}^{I} L_{ij}^x(s) + \sum_{j=1}^{I} L_{ji}^m(s),$$

where $L_i^d(s) = \int_{z_{min}^i}^{\infty} l_j^d(z,s)\,dG_i(s)$, $L_{ij}^x(s) = \int_{z_{ij}^x}^{z_{ij}^m} l_{ij}^x(z,s)\,dG_i(z)$, *and* $L_{ji}^m(s) = \int_{z_{ij}^m}^{\infty} l_{ji}^m(s)\,dG_j(z)$, *are aggregate demands in the intermediate good sector by domestic plants, exporters, and foreign plants located in country* i;

4. *The law of one price for the final good holds.*

Define the following aggregate productivity indices for domestic, exporters, and multinational firms supplying country i:

$$Z_i^d \equiv \int_{z_{min}^i}^{\infty} z^{\eta-1} dG_i(z) \qquad Z_{ji}^x \equiv \int_{z_{ji}^x}^{z_{ji}^m} z^{\eta-1} dG_j(z) \qquad Z_{ji}^m \equiv \int_{z_{ji}^m}^{\infty} z^{\eta-1} dG_j(z), \tag{14}$$

Since investment decisions are taken before uncertainty is resolved, productivity for the marginal exporter and multinational firm, z_{ij}^x and z_{ij}^m, do not vary across states s. Thus, Z_i^d, Z_{ji}^x and Z_{ji}^m are constant. Finally, let $Z_i(s)$ be the aggregate productivity index in the intermediate good sector for firms from all countries supplying country i,

$$Z_i(s) = Z_i^d + \sum_{j=1}^{I} Z_{ji}^m + \sum_{j=1}^{I} \left(\tau_{ji} \frac{W_j(s)}{W_i(s)} \right)^{1-\eta} Z_{ji}^x.$$

Note that, although the productivity indices Z_i^d, Z_{ji}^x and Z_{ji}^m are constant across states of nature, the overall aggregate productivity $Z_i(s)$ is state dependent. This is because the realization of foreign productivity shocks is transmitted into the domestic market through the price of imported intermediate goods. Then, the index for local productivity $Z_i(s)$ increases when imported goods are produced with relatively cheaper labor cost.

The law of one price in the final good sector implies that unit costs of production are equalized across countries, which combined with equilibrium prices in equations (5) and (6), results in the following equilibrium expressions for the wage level and price index:

$$W_i(s) = \phi_1 \cdot A_i(s) \cdot Z_i(s)^{\frac{1-\alpha}{\eta-1}} \tag{15}$$

$$P_i(s) = \phi_2 \cdot A_i(s) \cdot Z_i(s)^{-\frac{\alpha}{\eta-1}}, \tag{16}$$

where ϕ_1 and ϕ_2 are positive constants.[8] Wages in country i depend positively on realizations of country shocks $A_i(s)$ through two reinforcing channels: a positive direct effect, and a positive indirect effect through $Z_i(s)$. This productivity index is higher when imported intermediate goods are produced at lower cost than the local ones; that is, in states with high realization of the domestic shock $A_i(s)$. The presence of imported intermediate goods also explains why the price index $P_i(s)$ increases less than proportionally with local wages. A positive realization of the country shock $A_i(s)$ increases wages, and hence prices, but also as imported goods are relatively cheaper, which dampens the overall effect on the price index $P_i(s)$.

With Cobb-Douglas production functions, the final good is produced with constant shares of labor and the aggregate intermediate good,

$$W_i(s)L_i^f(s) = \alpha Y_i(s) \tag{17}$$

$$P_i(s)\,Q_i(s) = (1-\alpha)Y_i(s). \tag{18}$$

Combining the market clearing conditions for intermediate goods to solve for labor requirements, the labor market clearing condition for country i can be expressed as[9]

$$Y_i(s) = \frac{\eta}{(\eta-1)+\alpha} W_i(s)\,L_i - \frac{(\eta-1)}{(\eta-1)+\alpha} NX_i(s), \tag{19}$$

where net exports are $NX_i(s) = \sum_{j=1}^{I} X_{ij}^x(s) - X_{ji}^x(s)$, and $X_{ij}^x(s) = \left(\tau_{ij}\frac{W_i(s)}{W_j(s)}\right)^{1-\eta}\frac{Z_{ij}^x}{Z_j(s)}(1-\alpha)\,Y_j(s)$ are exports in intermediate goods from i to j.

In an open economy, total output in final goods is more elastic to country shocks: first, as explained above, wages $W_i(s)$ are more responsive to $A_i(s)$ (through $Z_i(s)$); and second, in

[8] $\phi_1 \equiv \alpha^\alpha(1-\alpha)^{1-\alpha}\left(\frac{\eta-1}{\eta}\right)^\alpha$ and $\phi_2 \equiv \frac{\eta}{\eta-1}\phi_1$.

[9] Labor requirements of domestic, exporters, and foreign plants producing in country i are: $L_i^d(z,s) = \frac{(\eta-1)(1-\alpha)}{\eta}\frac{Z_i^d}{Z_i(s)}\frac{Y_i(s)}{W_i(s)}$, $L_{ji}^m(z,s) = \frac{(\eta-1)(1-\alpha)}{\eta}\frac{Z_{ji}^m}{Z_i(s)}\frac{Y_i(s)}{W_i(s)}$, $L_{ij}^x(z,s) = \frac{(\eta-1)(1-\alpha)}{\eta}\frac{Z_{ij}^x}{Z_j(s)}\left(\tau_{ij}\frac{W_i(s)}{W_j(s)}\right)^{1-\eta}\frac{Y_j(s)}{W_i(s)}$.

states with high realization of the domestic shock, net exports in intermediate goods are lower. In those states, foreign countries are relatively less productive in assembling final goods, and hence they allocate labor to the production of intermediate goods. Correspondingly, the home country imports intermediates and allocates labor to the production of the final good.

3.2 International Equilibrium

Definition 2. *For a given vector of initial endowments, $\{K_i\}_{i=1}^{I}$, the international equilibrium is defined by a matrix of country-pair cut-off rules, $\{z_{ij}^{m}, z_{ij}^{x}\}_{i,j=1}^{I}$, the price of the investment good p_k, prices of Arrow-Debreu securities $\{\varphi(s)\}_{s\in S}$, the vector of consumption, and holdings of Arrow-Debreu securities, in each $s \in S$, $\{C_i(s), B_i(s)\}_{i=1}^{I}$, such that:*

1. *The Euler equation (8) is satisfied, for $i = 1, ..., I$;*

2. *The budget constraint in (7) is satisfied, for $i = 1, ..., I$;*

3. *The productivity cutoffs $\{z_{ij}^{x}, z_{ij}^{m}\}_{i,j=1}^{I}$ satisfy the zero profit conditions for trade and MP, in equations (11), and (12), respectively;*

4. *Arrow-Debreu securities are in zero net supply, for each s:*

$$\sum_{i=1}^{I} B_i(s) = 0;$$

5. *The world resource constraint for the investment good (at time zero) is satisfied:*

$$\sum_{i=1}^{I} K_i = \sum_{i=1}^{I}\sum_{j=1}^{I}\left[1 - G_i(z_{ij}^{m})\right] f_{ij}^{m} + \sum_{i=1}^{I}\sum_{j=1}^{I}\left[G_i(z_{ij}^{m}) - G_i(z_{ij}^{x})\right] f_{ij}^{x}; \tag{20}$$

6. *The world resource constraint for the final good is satisfied, for each $s \in S$:*

$$\sum_{i=1}^{I} C_i(s) = \sum_{i=1}^{I} Y_i(s) \tag{21}$$

World aggregate supply of the final good is $Y_W(s) = \sum_{i=1}^{I} Y_i(s)$, or equivalently, $Y_W(s) = \frac{\eta}{(\eta-1)+\alpha} \sum_{i=1}^{I} W_i(s) L_i$. With perfect risk sharing as our economy displays, consumption in the final good in each country is a constant share of the world supply,

$$C_i(s) = \mu_i Y_W(s), \tag{22}$$

where $\mu_i \equiv \lambda_i^{1/\sigma} / \sum_l^I \lambda_l^{1/\sigma}$ with $\sum_{i=1}^{I} \mu_i = 1$. Hence, the stochastic discount factor $\varphi(s)$ in (8) reflects world scarcity of final goods,

$$\varphi(s) = \phi_3 Y_W(s)^{-\sigma} \Pr(s), \tag{23}$$

where ϕ_3 is a positive constant.

4 Trade and Multinational Production under Uncertainty

In this section, we characterize trade and MP flows across countries under uncertainty. We analyze the choice of a given firm from country i with productivity z, deciding whether to supply country j by exporting goods produced in its home country i, or opening an affiliate in the host market j. As explained in the previous section, this choice follows a cut-off rule where the productivity thresholds for exporting and MP, $\left\{z_{ij}^x, z_{ij}^m\right\}$, satisfy the zero profit conditions in (11) and (12), respectively. To understand how these productivity thresholds are affected by country risks, we analyze the stochastic properties of the stream of profits earned by affiliates and exporting firms, respectively.

Combining the expenditure function in (4) with equilibrium prices in (6) and (16), profits of affiliates of a firm with productivity z from country i located in country j are given by

$$\pi_{ij}^{m}\left(z,s\right)=\frac{1-\alpha}{\eta}\cdot sh_{ij}^{m}\left(z,s\right)\cdot Y_{j}\left(s\right),$$

where the market share $sh_{ij}^{m}\left(z,s\right)$ in state s is

$$sh_{ij}^{m}\left(z,s\right)=\frac{z^{\eta-1}}{Z_{j}\left(s\right)}. \tag{24}$$

Analogously, a firm with productivity z from country i that *exports* to j has profits

$$\pi_{ij}^{x}\left(z,s\right)=\frac{1-\alpha}{\eta}\cdot sh_{ij}^{x}\left(z,s\right)\cdot Y_{j}\left(s\right),$$

where

$$sh_{ij}^{x}\left(z,s\right)=\tau_{ij}^{1-\eta}\left[\frac{W_{i}\left(s\right)}{W_{j}\left(s\right)}\right]^{1-\eta}\cdot\frac{z^{\eta-1}}{Z_{j}\left(s\right)}. \tag{25}$$

Profits of exporters and affiliates fluctuate with demand for intermediate goods in the host country, determined by the level of output in final goods $Y_j\left(s\right)$, and their market shares $sh_{ij}^{x}\left(z,s\right)$ and $sh_{ij}^{m}\left(z,s\right)$, respectively. Note that, as exporters and affiliates differ in their location of production, realizations of country shocks differently affect market shares for exporters and multinationals supplying intermediate goods to market j. For exporters, whose production is located in their home country i, the unit cost of production is lower when country i is hit by a low productivity shock $A_i(s)$, which results in lower wages $W_i\left(s\right)$. Market shares sh_{ij}^{x} are then larger in those states. Conversely, the unit cost of production for affiliates located in country j is lower when the host country shock $A_j(s)$ is relatively lower. Then, market shares sh_{ij}^{m} are higher in those states.

Combining equations (9) and (10) with (23), the value of becoming an exporter in country j for a firm with productivity z from country i can be written as

$$V_{ij}^{x}(z) = \phi_5 E_s \left\{ Y_W^{-\sigma} \cdot Y_j \cdot sh_{ij}^{x}(z) \right\}, \tag{26}$$

while the value of opening an affiliate in country j for a firm with productivity z from country i is

$$V_{ij}^{m}(z) = \phi_5 E_s \left\{ Y_W^{-\sigma} \cdot Y_j \cdot sh_{ij}^{m}(z) \right\}. \tag{27}$$

The firms' decision of open an affiliate or exporting to a foreign market is given by the value of such options net of the corresponding entry costs. From the free entry conditions in (12) and (11), the relative productivity cut-offs that characterize the firms' decision are given by

$$\left(\frac{z_{ij}^{x}}{z_{ij}^{m}} \right)^{\eta-1} = \frac{f_{ij}^{x}}{f_{ij}^{m} - f_{ij}^{x}} \cdot \frac{V_{ij}^{m} - V_{ij}^{x}}{V_{ij}^{x}},$$

where V_{ij}^{m} and V_{ij}^{x} correspond to the value functions in (26) and (27), respectively, evaluated at $z = 1$.

As previous literature has pointed out, more firms opt to export rather than open affiliates to serve a foreign market if the cost of production in the home country i is higher relative to the one in the host country j. The relative cost of production is given by the relative labor cost (W_i/W_j), the iceberg cost τ_{ij}, and the fixed cost of setting-up an affiliate f_{ij}^{m} relative to an export network f_{ij}^{x}. These factors also affect the number of exporters and affiliates (i.e. the productivity cut-offs) in a risk-less environment, and explain the relative productivity cut-offs in an equilibrium with certainty:

$$\left(\frac{\overline{z}_{ij}^{x}}{\overline{z}_{ij}^{m}} \right)^{\eta-1} = \frac{f_{ij}^{x}}{f_{ij}^{m} - f_{ij}^{x}} \cdot \left[\left(\tau_{ij} \frac{\overline{W}_i}{\overline{W}_j} \right)^{\eta-1} - 1 \right]. \tag{28}$$

Over-lined variables denote equilibrium outcomes under certainty. Lower costs of exporting result in a lower ratio $\overline{z}_{ij}^x/\overline{z}_{ij}^m$, meaning that a larger fraction of firms from i opt for exporting rather than opening affiliates to serve country j.

In a risky environment, not only the average unit cost of production affects the decision of exporting relative to opening an affiliate; the stochastic properties of country shocks become crucial. In particular, the relative productivity cut-offs that characterize the firms' decision depend on the co-movement between world scarcity, given by $Y_W^{-\sigma}$, and profits of the chosen international activity, which are determined by the demand in the host country, Y_j, and the cost of production – W_j in the case of MP and W_i in the case of exporting–:

$$\left(\frac{z_{ij}^x}{z_{ij}^m}\right)^{\eta-1} = \left(\frac{f_{ij}^x}{f_{ij}^m - f_{ij}^x}\right) \cdot \left[\frac{E_s\left\{Y_W^{-\sigma} \cdot Y_j \cdot w_j^{1-\eta}\right\}}{\tau_{ij}^{1-\eta} E_s\left\{Y_W^{-\sigma} \cdot Y_j \cdot (w_i e_{ij})^{1-\eta}\right\}} - 1\right], \tag{29}$$

where w_i is real wage in country country i, W_i/P_i, and e_{ij} is the real exchange rate, P_i/P_j.

4.1 The case of symmetric countries

The effect of cross country risk on the firm's decision between opening an affiliate and trading to a foreign country can be more clearly analyzed in the case of symmetric countries, which only differ in the stochastic process of their country risk. That is, country size, bilateral transport, and entry costs, are assumed equal across countries —i.e. for all $i = 1, ..., I : L_i = L, \tau_{ij} = \tau, f_{ij}^m = f^m$, and $f_{ij}^x = f^x$. Countries differ only in their variance, covariance across countries, and covariance with world aggregate fluctuations. The following proposition characterizes the relative productivity cutoffs that describes the decision of firms from country i supplying country j in this case:

Proposition 1 (Symmetry). *A linear approximation of the productivity cutoffs in (29) around* *the certainty values in (28), results in the following expression:*

$$\widehat{\left(z_{ij}^{x}/z_{ij}^{m}\right)} = \Phi \left\{ \left[cov\left(\widehat{y}_i, \widehat{y}_j\right) - var\left(\widehat{y}_j\right) \right] - \sigma \left[cov\left(\widehat{y}_i, \widehat{y}_w\right) - cov\left(\widehat{y}_j, \widehat{y}_w\right) \right] \right\}, \tag{30}$$

where Φ *is a positive constant, and hut variables denote percentage deviations from certainty,* $\widehat{X} \equiv (X(s) - \overline{X})/\overline{X}$.

Proof: In the Appendix. □

The effect of risk on the decision of the firm can be decomposed into two effects. First, a pure *risk sharing* effect, by which firms have incentives to trade relative to engage in multinational activities to countries that least co-move with their home economy. To isolate this effect, we present next the case with no aggregate risk, in which risk sharing is the only extra feature added in a risky environment. Second, when we consider a world with aggregate fluctuations of final output, firms have incentives to locate production in markets where the flow of profits is higher in states with relative scarcity of final goods. We refer to this phenomenon as *risk reallocation* effect.

No Aggregate Risk (Risk Sharing Effect). Consider first the case where country risk is diversifiable. Thus, world output is constant across states of nature, $Y_W(s) = Y_W$. The relevant correlation affecting the values of exporting and opening affiliates is the one between final output in the host market, Y_j, and the respective market shares, sh_{ij}^{m} and sh_{ij}^{x}. The bilateral ratio of exports to MP in equation (30) collapses to

$$\widehat{\left(z_{ij}^{x}/z_{ij}^{m}\right)} = \Phi \left[cov\left(\widehat{y}_i, \widehat{y}_j\right) - var\left(\widehat{y}_j\right) \right].$$

The number of firms opting for exporting relative to the ones opening affiliates is higher (i.e. lower ratio) when the country pair has a lower output covariance. Moreover, countries with higher output volatility are served relatively more by exports than by foreign affiliates located there.

The intuition is as follows. In states where final output in the host country is relatively high (high $\widehat{y}_j$), all production located in country j (both domestic and by foreign affiliates) face higher labor cost, and lose market share to imported goods. Exporters that gain the most in terms of market shares are those located in countries with relatively lower labor cost, and hence output realizations (low $\widehat{y}_i$). Therefore, the relative value of exporting from country i to country j is larger if the destination economy is volatile and its fluctuations are uncorrelated with those in the home country.

Country pairs with a low correlation of their country shocks have more incentives to share risk by trading. In this way, the country with lower realization of aggregate shocks in the final good sector allocates labor to the production of intermediate goods, which are exported to trade partners with high realization of the productivity shocks in the final good sector.

Aggregate Risk (Risk Reallocation Effect). Consider now the case where world output fluctuates across states. The discount factor in equation (23) reflects consumers' risk aversion. Thus, a stream of profits is more valuable when it is concentrated in states when world output is scarce. As a result, the existence of aggregate risk adds another consideration to the decision of the firms. It is more valuable to locate production of intermediate goods in countries with shocks most correlated with world risk; in this way, labor costs are lower, and market shares larger, in states of nature where world output is more scarce. As a result, economies more correlated with world output are characterized by a larger number of exporters relative to multinational firms. And correspondingly, countries with shocks least correlated with world output receive more import flows rather than foreign affiliates.

This effect is represented in the second term of equation (30). Source countries with high $cov\left(\widehat{y}_i, \widehat{y}_w\right)$ present a lower ratio z_{ij}^x/z_{ij}^m, which results in larger share of national firms opting for exporting rather than opening foreign affiliates. By the same logic, more affiliates are located in economies that highly co-move with world output. That is, a destination country j with high $cov\left(\widehat{y}_j, \widehat{y}_w\right)$ present a higher ratio z_{ij}^x / z_{ij}^m.

Summarizing, in presence of aggregate risk, firms have incentives to locate production of intermediate goods in economies most correlated with world output. Conversely, economies with productivity shock least correlated with world output allocate labor to the production of the final good. In this way, production is allocated in a way that more final good is produced when it is more scarce, which tends to reduce consumption volatility.[10]

5 Empirical Results

In this section, we derive the model's implications regarding the effect of risk on the firms' decision between exporting or opening an affiliates when serving a foreign market, and test them using data from the Bureau of Economic Analysis (BEA).

First, we derive the model's predictions in terms of observable data: US exports and imports relative to sales by multinational affiliates, by country of destination and origin, and industry. Second, we describe the data. Finally, we present the results.

5.1 Testable Implications

We derive testable implications in a world with many industries. One reason to derive industry implications is empirical. We only have data on bilateral trade and MP activities when the United States is one of the trading partners. Thus, we expand the number of observations by considering industry-country pairs. Additionally, the relationship between the entry decision to

[10]The decentralize allocation of production is efficient. See Ramondo and Rappoport (2009) for a more detailed analysis of this phenomenon.

foreign markets and risk may differ across industries with different characteristics.

The basic set up in section 2 is expanded to $H+1$ types of goods: a tradable final good, Y, and H intermediate tradable goods. Each industry h produces a CES-composite intermediate good Q^h that aggregates a continuum of varieties ω,

$$Q_i^h(s) = \left(\int_{\omega \in \Omega_h} q_i^h(\omega)^{\frac{\eta_h}{\eta_h - 1}} d\omega \right)^{\frac{\eta_h - 1}{\eta_h}}.$$

The variable η_h corresponds to the elasticity of substitution among varieties in a given industry h. Industries are aggregated Cobb-Douglas into a composite of intermediate goods, $Q_i(s) = \prod_{h=1}^{H} Q_i^h(s)^{\beta_h}$, with $\sum_{h=1}^{H} \beta_h = 1$. The Appendix presents the complete set-up for the multi-industry model.

Given a productivity distribution $G_i(z)$, the equilibrium ratio of cut-off productivities that characterizes the international choice of the firm determines the flow of trade relative to MP sales between two economies. Indeed, combining the expenditure function (4) with the productivity index (14), we obtain the ratio of trade to MP sales from country i to j, in industry h:

$$R_{ij}^h(s) \equiv \frac{X_{ij}^{x,h}(s)}{X_{ij}^{m,h}(s)} = \left(\tau_{ij} \frac{W_i(s)}{W_j(s)} \right)^{1-\eta_h} \cdot \frac{Z_{ij}^{x,h}}{Z_{ij}^{m,h}}, \tag{31}$$

where $Z_{ij}^{x,h}$ and $Z_{ij}^{m,h}$ are the productivity indexes defined in equation (14), for the industry h.

The distribution function for the firm specific productivities, $G_i(z)$, is assumed to be a Pareto distribution, with shape parameter κ. Then, the aggregate productivity for exporters relative to affiliates from country i to j, in industry h is uniquely given by the ratio of productivity cut-offs in (29).

$$\frac{Z_{ij}^{x,h}}{Z_{ij}^{m,h}} = \left(\frac{z_{ij}^{m,h}}{z_{ij}^{x,h}} \right)^{\kappa+1-\eta_h} - 1,$$

where $\kappa + 1 - \eta_h$ is assumed positive, so that more firms exporting relative to doing MP results in larger flow of exports relative to MP sales.

A linearization of equation (31) around the certainty equilibrium results in the following expression:

$$R_{ij}^{h} \approx \overline{R}_{ij}^{h} - (\kappa + 1 - \eta_h) \left[1 + \left(\frac{\overline{Z}_{ij,h}^{x}}{\overline{Z}_{ij,h}^{m}}\right)\right]^{-1} \left(\widehat{z_{ij,h}^{x}/z_{ij,h}^{m}}\right)$$

where over-lined variables refer to equilibrium in a risk-less economy and $\left(\widehat{z_{ij,h}^{x}/z_{ij,h}^{m}}\right)$ refers to percentage deviation of the productivity-cutoffs relative to the one under certainty, given by equation (30). Replacing, we obtain the following expression:

$$R_{ij}^{h} \approx \overline{R}_{ij}^{h} + \Phi_{ij}^{h} \left[var\left(\widehat{y}_j\right) - cov\left(\widehat{y}_i, \widehat{y}_j\right)\right] + \Phi_{ij}^{h} \sigma \sum_{n=1}^{I} \omega_n \left[cov\left(\widehat{y}_i, \widehat{y}_n\right) - cov\left(\widehat{y}_j, \widehat{y}_n\right)\right] \qquad (32)$$

where Φ_{ij}^{h} is a positive constant. Assuming that countries are symmetric apart from the properties of their stochastic productivity shocks, the parameter Φ_{ij}^{h} is constant across country pairs: $\Phi_{ij}^{h} = \Phi^{h}$.

As explained in previous section, the first term in equation (32) represents the risk sharing motive, while the second term in equation (32) refers to the risk reallocation effect.

We approximate world output as a weighted average of cross-country fluctuations, $\widehat{y}_w = \sum_{n=1}^{I} \omega_n \widehat{y}_n$, where ω_n is given by the share of output from country n in world output. Focussing on US cross country output co-movements and bilateral flows, for which MP sales and trade data are available, we derive the following testable implications.

US exports and sales by American affiliates abroad (OUT). Focussing on the US as the source country, the ratio of exports to MP sales into country n is approximated by

$$R_{n,OUT}^{h} \approx \overline{R}_{n,OUT}^{h} - \Phi_{OUT}^{h} \left(1 + \sigma\left(\omega_U - \omega_n\right)\right) cov\left(\widehat{y}_U, \widehat{y}_n\right) + \Phi_{OUT}^{h} \left(1 - \sigma\omega_n\right) var\left(\widehat{y}_n\right) + \varepsilon_n^{h}, \quad (33)$$

where subscript U refer to US variables.

US imports and sales by foreign affiliates in the US (IN). Focussing on the US as the destination country, the ratio of imports relative to MP sales from country n is given by

$$R^h_{n,IN} \approx \overline{R}^h_{n,IN} - \Phi^h_{IN} \left(1 - \sigma \left(\omega_U - \omega_n\right)\right) cov\left(\widehat{y}_U, \widehat{y}_n\right) + \Phi^h_{IN} \sigma \omega_n var\left(\widehat{y}_n\right) + \varepsilon^h_n. \tag{34}$$

As explained in the previous section, firms have incentives to trade rather than doing MP when the covariance between trade partners is low. In this way, firms exploit the labor cost differential between the source and destination countries that results from the realization of uncorrelated productivity shocks. Note that this effect is symmetric. Both US exporters to the rest of the world (OUT flows) an importers into the US (IN flows) equally take advantage of the bilateral labor cost differential. Therefore, the risk sharing effect implies a negative effect of $cov\left(\widehat{y}_n; \widehat{y}_U\right)$ on the ratio of exports to MP sales of both IN and OUT flows. Along the same lines, firms prefer to trade rather than opening affiliates to highly volatile economies. High shock volatility results in larger labor cost differentials across states of nature, which opens profitable opportunities for exporters. That is, the risk sharing effect implies a positive impact of $var\left(\widehat{y}_n\right)$ on the ratio of US exports to MP sales ($R_{n,OUT}$).

The risk reallocation effect refers to the incentives of producing intermediates in economies that highly co-move with world output. This way, firms benefit from larger market shares in states of nature where consumption is relatively scarce and valuable. Since the US represents a large share of world output -i.e. for all $n : \omega_U > \omega_n-$, economies that highly co-move with the US have, on average, large correlation with world output. As a result, more production of intermediates is located in economies with high covariance with the US -i.e. high $cov\left(\widehat{y}_n; \widehat{y}_U\right)$. That is, economies with high $cov\left(\widehat{y}_n; \widehat{y}_U\right)$ are predicted to export intermediates rather than doing MP into the US (high $R_{n,IN}$). And, correspondingly, they are predicted to host US affiliates, rather than receiving imports from the US (low $R_{n,OUT}$).

Along the same lines, highly volatile economies have larger impact on world fluctuations and therefore tend to co-move with world output; their impact is even larger if they represent a large share of world output —i.e if ω_n is large. Therefore, the model predicts that, everything else equal, countries with large output volatility —i.e. large $var(\widehat{y}_n)$– tend to host more production of intermediate goods. As a result, they export, rather than locating production facilities in the US, which results in high $R_{n,IN}$. Correspondingly, the risk reallocation effect gives incentives to US firms to locate affiliates rather than exporting in highly volatile economies (low $R_{n,OUT}$).

The following table summarizes the effect of country risk on the ratio of trade to MP sales for US inflows and outflows.

	risk-sharing	risk-reallocation	overall
Flows out from US			
$cov(\widehat{y}_n;\widehat{y}_U)$	$-\Phi^h_{OUT}<0$	$-\Phi^h_{OUT}\sigma(\omega_U-\omega_n)<0$	$-$
$var(\widehat{y}_n)$	$\Phi^h_{OUT}>0$	$-\Phi^h_{OUT}\sigma\omega_n<0$	$\pm$
Flows into US			
$cov(\widehat{y}_n;\widehat{y}_U)$	$-\Phi^h_{IN}<0$	$\Phi^h_{IN}\sigma(\omega_U-\omega_n)>0$	$\pm$
$var(\widehat{y}_n)$		$\Phi^h_{IN}\sigma\omega_n>0$	$+$

Predicted overall effect of $var(\widehat{y}_n)$ and $cov(\widehat{y}_n;\widehat{y}_U)$ on the ratio of US exports to sales by US affiliates in country n (flows out from US), and the ratio of US imports to sales by country n's affiliates in US (flows into US), is reported in column 3. '$-$', '$+$', and '$\pm$' refer to negative, positive, and ambiguous effect respectively. First and second columns decompose the overall impact of country risk into risk-sharing and risk-reallocation.

Table 1: Predicted effect of country-shock properties on ratio of trade to MP sales

where $\pm$ denotes an ambiguous prediction. Although the theory is not conclusive with respect to the effect of $var(\widehat{y}_n)$ on the ratio of US exports to MP sales, in our sample there is no country (except for the US) with a share larger than 25% of world real output. Then, for any reasonable magnitude of risk aversion (σ) we expect the risk sharing effect to prevail and $var(\widehat{y}_n)$ to have a positive impact on $R_{n,OUT}$. Along the same lines, we expect $cov\left(\widehat{y}_n;\widehat{y}_U\right)$ to have a negative impact on $R_{n,IN}$. However, US represents a much larger share of output than its average trade partner. So, if negative, the overall effect of $cov\left(\widehat{y}_n;\widehat{y}_U\right)$ on $R_{n,IN}$ is not expected to be large.

We test these predictions using data on the ratio of trade to MP sales from the US to country n, and into the US from country n. We find supporting evidence for the predictions of the model. Results are presented in section 5.3.

5.2 Data

We use a sample of 38 countries that trade and do MP with the United States.[11] Using data from the Bureau of Economic Analysis (BEA) for sales by affiliates and trade data from Feenstra, we compute the ratio of US exports to sales of American affiliates in country n, in industry h, as well as the ratio of US imports to sales of affiliates from country n, in industry h. All magnitudes are for the year 2000.

We compute output's standard deviation for all countries in the sample, as well as their correlation coefficient with respect to US output, for the period 1970-2000. We use (log of) real GDP per capital from Penn World Tables (cgdp), de-trended using a Hodrick-Prescott filter.

The Appendix reports summary statistics for the ratio of exports to MP sales by industry, across countries, and output correlation coefficients.

Finally, we proxy the ratio of exports to MP sales from/to country n in the deterministic environment, $\overline{R}^h_{n,OUT}$ and $\overline{R}^h_{n,IN}$, respectively, using geographical distance between the US and country n, a dummy for common language between the partners, and the average real income per capita of the source relative to the one for the destination country, over the period 1970-2000.

[11] Australia, Austria, Belgium, Canada, Switzerland, Chile, China, Colombia, Denmark, Egypt, Spain, Finland, France, United Kingdom, Germany, Greece, Hong Kong, India, Indonesia, Ireland, Israel, Italy, Japan, Korea, Morocco, Mexico, Malaysia, Netherlands, Norway, New Zealand, Pakistan, Philippines, Portugal, Singapore, Sweden, Thailand, Turkey, United States, South Africa.

5.3 Results

Results from running OLS in equations (33) and (34), respectively, are presented in the following two tables. Table 2 presents results for the flows from the US to country n (OUT), while Table 3 presents analogous results for flows into the US from country n (IN). All results are drawn both using the *aggregate* and *industry* ratio of export to MP sales from/to country n.[12]

Table 2 shows results from running OLS in equation (33). Results give support to the predictions of the theory regarding the relationship between flows from the US and the stochastic properties of country n's and US business cycle.

Dependent Variable:	$\log R_n^{out} \equiv X_n^x / X_n^m$		$\log R_n^{out,h} \equiv X_n^{x,h} / X_n^{m,h}$	
	aggregate		industry	
log of distance between U and n	-0.12	-0.22**	-0.23	-0.41**
	(0.11)	(0.09)	(0.17)	(0.16)
common language between U and n	0.24	0.33**	0.03	0.24
	(0.16)	(0.15)	(0.25)	(0.24)
log of ratio $\overline{y}_U$ to $\overline{y}_n$	0.55***	0.47***	0.38**	0.21
	(0.07)	(0.06)	(0.16)	(0.18)
$STD(\widehat{y}_n)$		9.4**		15*
		(4.3)		(8)
$COR(\widehat{y}_U, \widehat{y}_n)$		-0.61		-1.58*
		(0.48)		(0.78)
Industry fixed-effects	no	no	yes	yes
R^2	0.55	0.67	0.98	0.98
Observations	38	38	163	163

Estimation results of OLS specification (33). The dependent variable is the ratio of US exports to sales by US affiliates in country n. In column 1 and 2 the dependent variable corresponds to aggregate flows, while in columns 3 and 4 it is desegregated into 7 industries. Standard errors (in parenthesis) are clustered at the country level. ***, **, and * statistical significance at 1%, 5%, and 10% respectively

Table 2: Ratio of export to MP sales from the US and partners' co-movement. OLS.

[12] Regressions at the industry level just add industry fixed-effects.

The United States serve more volatile destination countries relatively more through exports than MP: the coefficient on $std(\widehat{y}_n)$ is positive and significant, ranging from more than 9.4 to 15 in the different specifications. This effect is economically significant. The computed semi-elasticity of 9.4 implies that, if Spain output volatility, computed at 3.2%, is reduced to 1.9% (equivalent to Denmark's), the ratio of US exports relative to sales by US affiliates in Spain would drop by almost 12%.

Consistent with the predictions of the model, the US does more MP relatively to exports into markets more correlated with their own business cycle (the coefficient on $COR(\widehat{y}_U, \widehat{y}_n)$). According to the computed semi-elasticity of -1.58, this is effect is economically significant; particularly when compared with factors typically considered in the standard gravity approach. For example, if New Zealand, for which its output correlation with the US is computed at 0.30, were perfectly in-line with US fluctuations, the ratio of US exports relative to sales by its US affiliates in New Zealand, would drop by 1.1%. This drop is equivalent to a reduction of more than 2.7% in the distance between New Zealand and the US (as implied by a distance-elasticity of -0.41).

Table 3 presents results from running OLS in equation (34). Results give support to the predictions of the theory on the relationship between flows into the US and the stochastic properties of country n's, and US business cycle.

The real income per capita's volatility of the source country is positively and significantly correlated with the ratio of exports to MP sales into the US (the coefficient on $STD(\widehat{y}_n)$), while the correlation between US and source's country business cycle is negatively correlated, but only significant for aggregate flows (the coefficient on $COR(\widehat{y}_U, \widehat{y}_n)$). The non-significance of the coefficient on $COR(\widehat{y}_U, \widehat{y}_n)$ when industry fixed-effects are considered is not a rejection of the theory: the prediction on this effect is ambiguous as the risk sharing and risk reallocation effect off-set each other.

Dependent Variable:	$\log R_n^{in} \equiv X_n^x / X_n^m$		$\log R_n^{in,h} \equiv X_n^{x,h} / X_n^{m,h}$	
	aggregate		industry	
log of distance between U and n	-0.11	-0.48**	-0.05	-0.17
	(0.28)	(0.18)	(0.21)	(0.20)
common language between U and n	-0.14	0.20	0.88*	1.02**
	(0.40)	(0.32)	(0.45)	(0.43)
log of ratio $\overline{y}_n$ to $\overline{y}_U$	-2.01***	-1.76***	-2.3***	-1.8***
	(0.22)	(0.17)	(0.34)	(0.40)
$STD(\widehat{y}_n)$		26***		32
		(8.9)		(24)
$COR(\widehat{y}_U, \widehat{y}_n)$		-2.98***		-2.04
		(0.73)		(1.45)
Industry fixed-effects	no	no	yes	yes
R^2	0.7	0.81	0.98	0.98
Observations	38	38	105	105

Estimation results of OLS specification (34). The dependent variable is the ratio of US imports from country n to sales by country n's affiliates in the US. In column 1 and 2 the dependent variable corresponds to aggregate flows, while in columns 3 and 4 it is desegregated into 7 industries. Standard errors (in parenthesis) are clustered at the country level. ***, **, and * statistical significance at 1%, 5%, and 10% respectively

Table 3: Ratio of export to MP sales into the US and partners' co-movement. OLS.

The pattern of US trade and MP inflows appears to be more responsive to risk factors than pattern of US outflows. The volatility semi-elasticity of imports to MP sales ratio is computed to be above 25. Using again the case of Spain as an example, a reduction of its output volatility from 3.2% (as computed in the data) to 1.9% (equivalent to Denmark's), is predicted to reduce the ratio of Spain's exports to the US relative to sales by its affiliates in the US, by 33%. The correlation semi-elasticity of US imports to MP sales ratio is computed to be almost -3. This estimate implies that, for example, if New Zealand, for which its output correlation with the US is computed at 0.30, were perfectly in-line with US fluctuations, our estimates predict the ratio of its exports relative to sales by its affiliates in the US, to drop by 2%. This drop is equivalent to a reduction of more than 4% in the distance between New Zealand and the US (using the computed distance elasticity of -0.48).

6 Conclusions

This paper analyzes how the joint pattern of trade and the activity of multinational firms is affected by the existence of country specific uncertainty. We analyze this question in an environment where consumers and firms have access to frictionless and integrated financial markets. Still, we find that risk considerations affect the location of affiliates and the patterns of trade flows. The predictions of the model build on the assumption that affiliates bear the host country uncertainty. This assumption arises naturally in this model, as the country-specific shock directly impacts on the cost of labor, which equally affects domestic production, both by national firms or foreign affiliates. However, this analysis may seem somehow restrictive. One can think of different types of uncertainty affecting MP activities, such as firm or industry risk that affect all activities of the firm irrespectively of its location. Further research on this topic is encouraged. Yet, as long as there are shocks that affect all production located in a country, the results presented in this paper hold. Moreover, we present empirical evidence based on US data on trade flows and MP sales, which suggests that the effect of country uncertainty on the location of affiliates and the direction of trade flows is economically important.

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A Proofs of Propositions

Define $\widehat{X} \equiv (X(s) - \overline{X})/\overline{X}$, where $\overline{X}$ denotes values under certainty. The ratio of productivity cutoffs can be approximated by:

$$\widehat{\left(\frac{z_{ij}^x}{z_{ij}^m}\right)} = (\eta - 1)\frac{\overline{V}_{ij}^m}{\overline{V}_{ij}^m - \overline{V}_{ij}^x} \cdot \left(\widehat{V}_{ij}^m - \widehat{V}_{ij}^x\right). \tag{35}$$

Similarly, the value functions can be approximated by

$$\begin{aligned} \widehat{V}_{ij}^x &= E_s\left(\widehat{y}_j \widehat{sh_{ij}^x}\right) - \sigma E_s\left\{\widehat{y}_w \widehat{y}_j\right\} - \sigma E_s\left(\widehat{y}_w \widehat{sh_{ij}^x}\right) \\ \widehat{V}_{ij}^m &= E_s\left(\widehat{y}_j \widehat{sh_{ij}^m}\right) - \sigma E_s\left(\widehat{y}_w \widehat{y}_j\right) - \sigma E_s\left(\widehat{y}_w \widehat{sh_{ij}^m}\right) \end{aligned}$$

Disregarding moments higher than the second ones, the above expression can be summarized to:

$$\widehat{V}_{ij}^m - \widehat{V}_{ij}^x = E_s\left[\widehat{y}_j\left(\widehat{sh_{ij}^m} - \widehat{sh_{ij}^x}\right)\right] - \sigma E_s\left[\widehat{y}_w\left(\widehat{sh_{ij}^m} - \widehat{sh_{ij}^x}\right)\right]. \tag{36}$$

Proof. Proposition 1. For symmetric countries, we can obtain:

$$\begin{aligned}
\frac{\overline{V}_{ij}^{m}}{\overline{V}_{ij}^{m}-\overline{V}_{ij}^{x}} &= \frac{1}{1-\tau^{1-\eta}} \\
\left(\widehat{W}_i-\widehat{W}_j\right) &= \Phi\cdot\left(\widehat{y}_i-\widehat{y}_j\right) \\
where \quad : \quad & \Phi=\frac{(\eta-1+\alpha)-(\eta-1)(1-\alpha)\left(1-\frac{Z_L}{\overline{Z}}\right)}{(\eta-1+\alpha)+(\eta-1)^2(1-\alpha)\left(1-\frac{Z_L}{\overline{Z}}\right)\left(2-\frac{Z^x}{\overline{Z}}\tau^{1-\eta}\right)}.
\end{aligned}$$

Therefore:

$$\begin{aligned}
\widehat{sh}_{ij}^{x}(s) &= -(\eta-1)\,\Phi\left[\left(\widehat{y}_i(s)-\widehat{y}_j(s)\right)+\left(1-\frac{Z^L}{\overline{Z}}\right)\left(\widehat{y}_j(s)-\widehat{y}_w(s)\right)\right] \\
\widehat{sh}_{ij}^{m}(s) &= -(\eta-1)\,\Phi\left(1-\frac{Z^L}{\overline{Z}}\right)\left(\widehat{y}_j(s)-\widehat{y}_w(s)\right).
\end{aligned}$$

Replacing these expressions into equation (36), we get

$$\widehat{V}_{ij}^{m}-\widehat{V}_{ij}^{x}=(\eta-1)\,\Phi\left[E_s\left\{\widehat{y}_j\cdot\left(\widehat{y}_i-\widehat{y}_j\right)\right\}-\sigma E_s\left\{\widehat{y}_w\cdot\left(\widehat{y}_i-\widehat{y}_j\right)\right\}\right]$$

Replacing into (35), equation (30) is obtained. □

B Multi-industry model

Assume that each economy produces $H+1$ types of goods: a tradable final good, and H intermediate tradable goods. Each industry H produces a CES-composite intermediate good Q_h that aggregates a continuum of varieties z,

$$Q_i^h(s)=\left(\int_z q_i^h(z)^{\frac{\eta_h}{\eta_h-1}}dG_i(z)\right)^{\frac{\eta_h-1}{\eta_h}}.$$

The variable η_h corresponds to the elasticity of substitution among varieties in a given industry h. Total expenditure in each individual good ω in industry h, country i, is

$$x_i^h(\omega,s)=\left[\frac{p_i^h(\omega,s)}{P_i^h(s)}\right]^{1-\eta_h}Q_i^h(s)P_i^h(s). \tag{37}$$

where P_i^h is the price index associated with $Q_i^h(s)$, for industry h, state s, Industries are aggregate in the following way,

$$Q_i(s) = \prod_{h=1}^{H} Q_i^h(s)^{\beta_h},$$

$\sum_{h=1}^{H} \beta_h = 1$. The composite intermediate good $Q_i(s)$ has associated price index $P_i(s) = \prod_{h=1}^{H}(P_i^h(s))^{\beta_h}$. Combined with labor, this aggregate intermediate good is used in the production of the final good, as in the basic model, $Y_i(s) = A_i(s)L_i^f(s)^{\alpha}Q_i(s)^{1-\alpha}$.

Wages and the aggregate price index are analogous to the ones in the basic model,

$$\begin{aligned} W_i(s) &= \Lambda_1 \cdot A_i(s) \cdot \prod_{h=1}^{H} Z_i^h(s)^{(1-\alpha)\frac{\beta_h}{\eta_h-1}} \\ P_i(s) &= \Lambda_2 \cdot A_i(s) \cdot \prod_{h=1}^{H} Z_i^h(s)^{-\alpha\frac{\beta_h}{\eta_h-1}}, \end{aligned}$$

where Λ_1 and Λ_2 are constants, and Z_i^h is the aggregate productivity index for industry h, in country i.[13] The realization of the country productivity $A_i(s)$ qualitatively affects the wage and price index as in the basic set-up.
Finally, the ratio of exports to MP sales from country i to country j, in industry h, is

$$\frac{X_{ij}^{x,h}(s)}{X_{ij}^{m,h}(s)} = (\tau_{ij})^{1-\eta_h} \cdot \left(\frac{W_i(s)}{W_j(s)}\right)^{1-\eta_h} \cdot \frac{Z_{ij}^{x,h}}{Z_{ij}^{m,h}},$$

where now $Z_{ij}^{x,h}$ and $Z_{ij}^{m,h}$ are different across industries.

C Summary Statistics

[13] $\Lambda_2 \equiv \Lambda_1 \prod_{h=1}^{H}(\frac{\eta^h}{\eta^h-1})^{\beta_h}$ where $\Lambda_1 \equiv \alpha^{\alpha}(1-\alpha)^(1-\alpha)$.

country j	US exports to country j / Sales US affilates in country j	US imports from country j / Sales country-j's affiliates in US	std(yj)	corr(yj,yus)
AUS	0.1910	0.1642	0.027	0.741
AUT	0.2520	0.7773	0.030	0.489
BEL	0.1961	0.3561	0.030	0.382
CAN	0.5096	1.0534	0.032	0.698
CHE	0.1376	0.0809	0.033	0.571
CHL	0.3692	10.8242	0.082	0.384
CHN	0.9496	28.0803	0.043	0.368
COL	0.4216	17.6473	0.036	0.551
DNK	0.2477	0.4831	0.019	0.681
EGY	0.8863	23.4599	0.066	0.517
ESP	0.1908	1.7361	0.032	0.062
FIN	0.4375	0.2006	0.053	0.524
FRA	0.1938	0.2003	0.025	0.620
GBR	0.1449	0.1094	0.023	0.804
GER	0.1895	0.1977	0.030	0.504
GRC	0.3085	0.8517	0.038	0.527
HKG	0.3460	1.6848	0.051	0.484
IDN	0.3738	9.7152	0.068	0.418
IND	0.7520	23.2535	0.032	0.563
IRL	0.1818	0.5681	0.034	0.547
ISR	0.6787	3.1243	0.031	-0.050
ITA	0.1607	1.0876	0.031	0.641
JPN	0.3419	0.2878	0.033	0.477
KOR	1.2265	1.1628	0.050	0.139
MAR	0.6147	29.0541	0.045	0.373
MEX	0.8477	6.4176	0.071	0.455
MYS	0.6007	16.6178	0.069	0.311
NLD	0.1345	0.0504	0.023	0.561
NOR	0.1890	0.3465	0.048	0.555
NZL	0.2050	0.7440	0.032	0.305
PAK	0.7627	21.6708	0.034	0.575
PHL	0.6750	21.4979	0.047	0.414
PRT	0.1559	9.0091	0.043	0.146
SGP	0.2772	5.6245	0.057	0.255
SWE	0.2098	0.1928	0.030	0.453
THA	0.4604	32.1210	0.066	0.162
TUR	0.5215	22.8569	0.032	0.070

Table A.1: Bilateral Statistics

Note: Sales by affiliates from the Bureau of Economic Analysis. Trade flows assembled by Feenstra. Standard deviation and output correlation with US computed using (log of) real GDP per capita from Penn World Table (cgdp), period 1970-2000, de-trended using a Hodrick-Prescott filter.