Size, Geography, and Foreign Direct Investment*

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Abstract

This paper analyzes the cross-country distribution and volume of Foreign Direct Investment (FDI), its barriers, and its impact on welfare. From the observed patterns of FDI, three facts stand out: a very small fraction of countries engages in FDI; geography remains a significant impediment to FDI; countries' size is important in determining the existence and volume of bilateral FDI. I present a theory which treats FDI as sales of affiliates of multinational firms, and qualitatively captures the salient features of the data. FDI is introduced into a competitive, multicountry, general equilibrium model with fixed costs. This model delivers a structural equation for bilateral FDI that predicts zero as well as positive volumes between country-pairs, and where positive flows are related to technology and barriers. Using data on bilateral sales of affiliate plants, for OECD and non-OECD countries, I estimate barriers to FDI using an indirect inference procedure derived from the theory. Estimates suggest that distance remains the most important impediment to FDI, with countries twice as far facing a 45% higher cost. Policy variables, such as preferential treaties or taxes, have small effects. Finally, welfare calculations show that there are large, unrealized gains of removing *bilateral* barriers to FDI.

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1. INTRODUCTION

One of the most notable features of economic globalization has been the increasing importance of multinational firms and Foreign Direct Investment (FDI) around the world. In fact, international production has become one of the most important mechanisms through which countries exchange goods, capital, and technologies[1]. For 2001, total sales of foreign affiliates of multinational firms represented almost 60% of world GDP, while world exports were around a fourth; these figures imply a ratio of sales of foreign affiliates to world exports of around two and a half. Furthermore, over the past two decades, international production has outpaced the expansion of international trade. While exports have almost quadrupled, sales of affiliates have increased by a factor of more than seven[2].

Despite its importance, little work has been done on the cross-country dynamics of FDI, its barriers, and its impact on welfare. This paper tries to fill that gap by analyzing the determinants of the cross-country distribution and volume of FDI, quantifying the size of its barriers, and assessing its effects on welfare.

Extending some of the recently developed models of international trade[3], I first introduce FDI as foreign sales of affiliates of multinational firms, in a competitive, multicountry, general equilibrium model with fixed costs, that qualitatively reproduces salient features of the observed cross-country pattern of FDI[4]. Using various information sources, I then assemble a data set on bilateral sales of affiliate plants and other measures of FDI, for

[1] International production does not always take the form of FDI. International production involves the activity of foreign affiliates in a host country. FDI is a capital account category in the Balance of Payment of a country, and is one of the mechanisms through which multinational firms can fund their affiliate plants (e.g. if they fund the investment through local or international banks, then no FDI would be observed). Throughout this paper, I use the term FDI to refer to the activity of affiliate plants of multinational firms.

[2] See Table 1 in the paper.

[3] See Eaton and Kortum (2002); Melitz (2003); Alvarez and Lucas (2004); Helpman, Melitz and Rubinstein (2004); Chaney (2005).

[4] I focus on "horizontal FDI" by contrast to "vertical FDI". Horizontal FDI refers to foreign facilities which are set up to serve consumers in a host market. Vertical FDI involves the fragmentation of the production process among different locations in order to take advantage of lower inputs' prices (see Helpman (1984); Helpman and Antras (2003)).

OECD and non-OECD countries, from 1990 to 2002[5]. The availability of several measures of bilateral FDI allows me to accurately construct the sample of country-pairs with no FDI. Using the structural equations delivered by the model, and data on both country-pairs with zero and positive bilateral FDI, I derive a procedure to estimate the size of barriers to FDI. Finally, I present some preliminary calculations on welfare gains of liberalizing and lowering barriers to FDI, both world-wide and for selected economies.

Previous literature has typically examined the determinants of trade volumes between countries by using a gravity approach[6]. According to this approach, the magnitude of bilateral flows between two countries is proportional to the product of their income, with the proportionality factor depending on bilateral barriers, such as geographical distance. Indeed, gravity has been very successful in fitting international trade flows, with increasingly accurate estimates of the size of trade barriers, and their impact on welfare. Despite the fact that FDI has become an increasingly important mechanism through which firms serve foreign buyers, to my knowledge, there is no study that incorporates bilateral FDI as bilateral sales of affiliates of multinational firms in a theoretical model that delivers a gravity equation able to predict zero as well as positive FDI volumes, and uses it to quantify the size of barriers, and the impact on welfare, for OECD and non-OECD countries[7]. Even though a model with only FDI might be as extreme as one with only international trade, such a benchmark gives new and interesting insights into the importance of impediments to FDI, and their effects on welfare[8].

[5] The data set includes the two standard FDI measures, stocks and flows, computed in the balance of payment of countries, and, more importantly, variables related to the activity of affiliate plants of foreign firms (sales, assets, employment, and number of plants).

[6] See Anderson and Van Wincoop (2003). The exception is Helpman, Melitz and Yeaple (2003), that I discuss below.

[7] See Stein and Daude (2001) for an estimate of a gravity equation for bilateral FDI stocks, for OECD countries.

[8] Besides, in most service sectors, the only way of serving foreign markets is by setting up local operations through FDI or licensing. In fact, FDI in services sectors has grown more rapidly than FDI in other sectors, representing in some countries, 80% of total FDI stocks. However, as the World Investment Report (2004) points out, "given the non-tradability of many services, one would expect services to be delivered to foreign

Section 2 presents cross-country facts on bilateral FDI. Three facts stand out. First, only a small fraction of countries engages in FDI relationships. Second, geography remains an important impediment to FDI. Third, size (measured as GNP) seems to be an important factor determining both the existence and volume of FDI between two countries.

The theory is presented in Section 3. FDI is introduced as the decision to replicate production abroad in a sector with a continuum of goods. Along the lines suggested by Eaton and Kortum (2002), firms differ in their productivity levels within a country, and countries differ in their productivity distribution. I assume that affiliate plants inherit the technology levels of their parent firm. However, to transfer this technology to a host country, firms have to pay a fixed cost. This fixed cost is specific to a pair of trading countries, and can be thought as the cost of forming subsidiaries and distribution networks, adapting technology to the local environment, as well as any information, transaction and legal costs related to market access. In particular, it can be proxied by variables such as geography, regulations, and cultural factors, some of which are observable while others are not. Hence, a firm opens an affiliate plant abroad as long as its profits are high enough to cover the fixed cost, and the price charged is lower than that of potential competitors of any other origin. Once established in the host market, affiliate plants produce using local labor, sell output exclusively in the host market, and eventually, repatriate profits to the home economy.

The model delivers a set of implications for sales of affiliate plants from country j in the host country i. First, similar to the model in Helpman, Melitz, and Rubinstein (2004) for international trade, it allows each firm in country j to choose not to do FDI in country i, since no firm in j may have a productivity level such that it can set the lowest price in market i and break-even. As a result, the model is consistent with zero FDI two-ways between some country-pairs, as well as zero FDI from j to i, but positive FDI from i to j,

markets mainly via FDI, and goods mainly via trade". Data for the United States and other European countries show that the ratio of sales of foreign affiliates to total export at the end of the 90's was 2.5 for goods and almost 2 for services. Still, international transactions in goods rely on FDI much more than on trade, and much more so than international transactions in services.

for other country-pairs; both types of patterns are observed in the data. Second, the model predicts positive FDI two-ways for some country-pairs, which is also observed in the data. Finally, the model generates a gravity equation in which positive flows are proportional to the product of partners' size, dampened by bilateral barriers to FDI.

Although similar to the gravity equation derived in Eaton-Kortum (2002) for trade flows, the one in this paper is fundamentally different in several respects, beyond the possibility for zero flows. In fact, my model highlights the role of absolute rather than comparative advantages in determining the distribution of bilateral FDI: since production in affiliate plants is done employing inputs from the host economy, and input prices are uniform across plants of any origin, input costs do not matter in determining which plants produce in the host market; relative productivities and fixed costs are the only relevant variables determining the cross-country distribution of FDI. Moreover, my model complements the results in Helpman, Melitz and Yeaple (2004): while their paper analyzes the competing forces between exports and "horizontal" FDI at the firm-level, mine analyzes the competing forces that determine why firms from certain countries produce a given good in some countries, and not others[9].

Section 4 develops the empirical framework to estimate the model's parameters, particularly the ones related to barriers to FDI. The presence of fixed costs and zero FDI volumes do not allow one to apply traditional linear regression methods to consistently estimate the barrier parameters. Therefore, I use an indirect inference procedure derived from the theory that deals with biases present in traditional estimates of gravity equations. The indirect inference estimator is the one that minimizes the distance between the vectors of "auxiliary" parameters computed from the actual and simulated data, respectively. The "auxiliary" parameters are statistical moments chosen to properly capture the empirical

[9]Furthermore, while in my model variables such as geographic distance (that is a proxy for fixed costs to FDI) should decrease the *level* of bilateral sales of foreign affiliates, in theirs, it should decrease their *ratio* to bilateral exports. This does not exclude the fact that both variables might be positively correlated.

In fact, in the data, both bilateral exports and bilateral sales of affiliates are positive correlated (see Table 10 in this paper), and bigger distance decreases both exports and FDI between two countries, but proportionally more the former.

patterns presented in Section 2.

Studies which incorporate countries that do not trade with each other are almost non-existent in the international trade literature, with the notable exception of Helpman, Melitz and Rubinstein (2004), and Razin, Rubinstein and Sadka (2003). Both papers incorporate zero bilateral trade and FDI flows, respectively, in a two-step estimation procedure that corrects for biases present in traditional estimates[10]. The empirical part of my paper addresses similar concerns to the ones in the two mentioned papers, but it deals with them in a different way. Even though the theory I present could potentially be used to derive a two-step estimation procedure, the nature of the selection term, which is different from the one derived using Melitz's framework, makes it intractable. Apart from being computationally simpler, the estimation method I propose allows me to estimate other important parameters, necessary to carry out a welfare analysis.

Section 5 presents estimates of the barriers to FDI using the approach developed in Section 4, compares them with OLS estimates, and calculates the impact of barriers on FDI flows. It turns out that bilateral distance remains the most important impediment to FDI: country-pairs twice as far face a 45% higher cost of FDI than otherwise. This estimate translates into a 43% lower share of sales of affiliates from country j on income of country i. Policy variables such as preferential taxation treaties or bilateral corporate tax rates have a small impact on the cost of FDI. Using the theory and estimates, I calculate real income gains for each country under various regime changes: (i) moving to autarky; (ii) removing *bilateral* barriers to FDI and lowering them to a uniform level; and (iii) moving the United States to autarky. Additionally, I calculate real income changes when barriers to FDI are lowered within NAFTA and the EU. Preliminary results suggest that average real income losses of going to world-wide autarky would be more than 50%, but unevenly spread across countries (e.g. the United States would loose around 20%, while Mexico more than 50%). Conversely, average real income gains of "balancing the field" across firms of different origins in each country would be more than 60%. Moreover, if the EU further liberalized

[10] Razin *et al.* use information on bilateral FDI stocks, for OECD countries. However, their theory does not deliver a gravity equation.

FDI among its members, it would experience an increase in real income of around 30%, while further liberalization of FDI within NAFTA would increase real income in the United States by 10%, with ambiguous effects on Mexico.

Section 6 concludes.

2. CROSS-COUNTRY FDI FACTS

International production has become increasingly important in the last decades of the twentieth century, as the mechanism through which countries exchange goods, capital and technologies.

	Value at Current Prices (Billions of dollars)				Annual Growth Rate (Per cent)				
	1982	1990	1996	2001	82-90	90-96	96-01	90-01	82-01
World GDP	11,758	22,610	29,024	31,900	7.3	4.2	1.9	3.1	**5.3**
World sales of foreign affiliates	2,765	5,727	9,372	18,517	8.1	8.2	13.6	10.7	**10.0**
as % of world GDP	**24%**	**25%**	**32%**	**58%**					
World export of goods and non-factor services	2,247	4,261	6,523	7,430	7.1	7.1	2.6	11.1	**6.3**
as % of world GDP	**19%**	**19%**	**22%**	**23%**					
World exports of foreign affiliates	730	1,498	1,841	2,600	8.0	3.4	6.9	5.0	**6.7**
as % of world exports	**32%**	**35%**	**28%**	**35%**					
as % of sales of affiliates	**26%**	**26%**	**20%**	**14%**					
FDI stocks*	628	1,769	3,238	6,846	11.5	10.1	15.0	12.3	**12.6**
as % of world GDP	**5%**	**8%**	**11%**	**21%**					

(*): Inward FDI stocks computed from the Balance of Payment of countries
Source: UNCTAD, WIR 2004

Table 1: World International Production and Trade

Table 1 shows world totals for GDP, sales of foreign affiliates of multinational firms, and exports. While world exports have steadily represented between 20% and 25% of world GDP, total sales of foreign affiliates of multinational firms have increased from 24% of world GDP in 1982, to 58% in 2001. Moreover, over the period 1982-2001, while GDP and exports grew at an average annual rate of around 5% and 6%, respectively, sales of foreign affiliates did it at more than 10% per year. Meanwhile, the share of world exports of affiliates in world sales of affiliates, has been decreasing in the last two decades, reaching 14%, in 2001. These magnitudes suggest that not only FDI is the most important mode through which firms serve foreign consumers, but also that "horizontal FDI" remains much more important than "vertical FDI"[11].

The data set on bilateral FDI that I introduce in this paper includes six measures of FDI and international production. In particular, I record FDI stocks and flows from country j in country i, as measured in the Balance of Payment of a country, and, more importantly, variables related to the activity of affiliates of firms from country j in country i: sales, number of plants, employment, and assets. Additionally, OECD and non-OECD countries with population over one million are included. In the following figure and tables, observations are averages over the period 1990-2002.

(The Appendix reports data details).

I consider that country j has a FDI relationship with country i if at least one of the six FDI recorded measures is positive. On the contrary, a country j is considered to have zero FDI in country i, if *all six* measures of FDI are missing values or zeros. Among the 151 countries in the sample, there are 22,650 possible bilateral FDI pairs; only 3,810 of these pairs have positive FDI.

Figure 1 shows the composition of country-pairs according to FDI status: country-pairs with FDI in both directions, country-pairs with FDI in only one direction, and country-pairs that do not have any FDI with one-another. Three year averages over the period 1990-2002 are considered. There is a significant high fraction of country-pairs that does not engage in any FDI activity: more than 75% of all possible country-pairs have zero FDI in both directions, during the 90s'; the comparable figure for international trade is around 50% for the mid-nineties[12]. Since engaging in a FDI relationship implies to have a significant participation in the ownership of either a preexistent or new plant abroad, unlike international trade flows, the nature of the FDI relationship makes implausible to attribute

[11] See Footnote 4.

[12] See Helpman, Melitz and Rubinstein (2004).

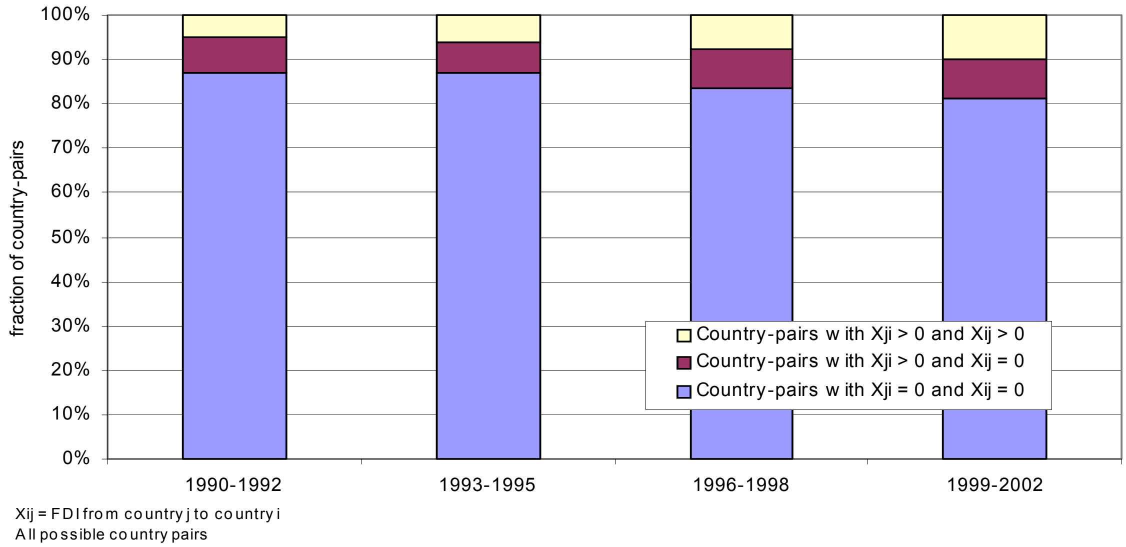

Figure 1: Cross-country distribution of FDI

such a high fraction of zeros to an statistical problem, that either bunches small flows in an "other" category, or does not compute them at all.

Table 2 shows that the bulk of FDI occurs among country-pairs that have positive FDI volumes in both direction; average volumes for country-pairs with positive volumes in only one direction are much smaller, according to any of the FDI measures shown.

The gravity approach suggests that FDI should be a multiplicative function of trading partners' sizes, dampened by barriers to FDI. One widely use variable is geography. Table 3 shows the average distance among country-pairs with zero FDI in both and one direction, and positive FDI in both directions. Particularly, the average distance among the group of country-pairs that does not have any FDI is much higher than among country-pairs with positive FDI. The table also shows that the fraction of country-pairs with a common border and a common colonial past is higher among pairs with positive FDI than for pairs with no FDI. Unexpectedly, sharing a language does not seem to be a factor that promotes FDI. The last two variables are related to taxation of foreign firms: the average bilateral tax

FDI measures (millions of current U$)	All possible country-pairs *	Country-pairs with Xij> 0 and Xji > 0	Country-pairs with Xij > 0 and Xji= 0
FDI stocks	**146**	**1,531**	**44**
	2,513	8,126	543
	21,786	2,010	2,342
FDI flows	**22**	**223**	**8**
	359	1,143	69
	21,888	2,080	2,374
Sales of foreign affiliates	**289**	**8,015**	**16**
	5,736	29,271	144
	19,686	706	1,546
Assets of foreign affiliates	**369**	**18,490**	**13**
	10,296	70,746	135
	19,297	384	1,479
Number of foreign affiliates	**4**	**119**	**2**
	60	298	13
	19,849	702	1,713

Mean, standard errors, and number of observations reported
FDI stocks and flows computed from the Balance of Payment of countries
(*) For country-pairs with zero bilateral FDI, missing values are replaced by zeros
Xij= FDI from country j to country i

Table 2. Volumes of FDI Bilateral. Summary Statistics.

rate for firms from country j in country i, and the average fraction of country-pairs that share a double-taxation treaty that reduces taxes for foreign companies in the host country. Bilateral corporate taxes are substantially lower among country-pairs with positive FDI than among the ones with zero FDI (16% against 34%), while the fraction of country-pairs sharing a treaty is much higher among the first than the second group, respectively (67% and 4%).

Barriers' measures:	Country-pairs with Xij > 0 and Xji > 0	Country-pairs with Xij > 0 and Xji = 0	Country-pairs with Xij = 0 and Xji = 0
mean distance between country-pairs (in km)	5862	7028	7504
% of country-pairs with common language	0.143	0.133	0.141
% of country-pairs with common border	0.08	0.03	0.02
% of country-pairs ever in colonial relationship	0.05	0.02	0.01
% of country-pairs with double taxation treaty	0.67	0.27	0.04
mean corporate tax rate between country-pairs	16.8	26.3	34.1
Number of country-pairs	1202	1406	8717
% of country-pairs	0.11	0.12	0.77

Barriers values for country-pairs in column 1 and 3 are significantly different for all variables but common language

Table 3: Bilateral Barriers to FDI

Gross National Product	mean (in millions of current U$)	mean (as % of world mean)	std. dev. (as % of mean)	# of country-pairs
Country-pairs with Xij > 0 and Xji > 0	728,764	3.7	1.6	1,292
Country-pairs with Xij > 0 and Xji = 0	355,894	1.9	2.1	1,407
country j (source)	614,778	3.3	2.4	
country i (host)	95,688	0.5	4.3	
Country-pairs with Xij = 0 and Xji = 0	82,890	0.4	2.9	8,717

Xij : FDI from country j to country i

Table 4: Size distribution of country-pairs. Summary Statistics.

Lastly, Table 4 suggests that FDI mainly takes place among large countries in terms of GNP, and from large to small countries. The lack of FDI is mainly observed among small economies, and from small to large economies. In fact, country-pairs with positive FDI in both directions involve countries almost 4 times larger than the world average, and fairly similar in terms of size (the standard deviation of GNP as percentage of the mean is 1.6).

Among country-pairs with FDI in only one direction, source countries are more than 3 times larger than the world average, while host countries are half the size of the world average. Country-pairs with zero bilateral FDI in both directions are mainly small countries with an average size less than half the world average.

Indeed, the evidence summarized in the previous tables suggests that size and geography are important factors in explaining the existence and distribution of FDI volumes between countries. Moreover, a theory that tries to explain the cross-country dynamics of FDI has to be able to predict zero FDI between some country-pairs.

3. MODEL'S SET UP

I introduce FDI as the decision of replicating production abroad, in a competitive, multi-country model with country-pair specific fixed costs to FDI. The model delivers a "modified" gravity equation for FDI, that relates the volume of bilateral FDI to the size of trading partners and the costs of access a market, allowing for FDI to be zero between some countries. I present the basic set up of the model, the closed economy, and the open economy with FDI.

There are N countries which produce goods using only labor. Country i has L_i consumers that supply one unit of labor each. Each country i has two types of goods. One is a homogeneous consumption good, that can be freely traded, produced under a constant returns to scale technology that uses $1/w_i$ units of labor per unit of output. Provided that each country produces it, the homogeneous good is the numeraire, and its price normalized to one, such that the wage rate in country i is w_i.

The other good is a composite good, made of a continuum of goods indexed by $\omega \in [0, 1]$, produced with the technology described below, under perfect competition. FDI is allowed in this sector so that firms from country j can replicate production of good ω in country i, by opening affiliate plants. In particular, affiliate plants from country j in country i inherit the productivity level of their parent company, carry production hiring local labor, sell output exclusively in the host market, and repatriate (all or part of) profits to the home economy (in units of the homogenous consumption good).

Subscripts denote country of operation and country of origin, respectively.

Technology. There is a continuum of plants in the production of each good ω that behaves competitively. Each plant operates under an only-labor decreasing returns to scale production technology that is assumed to be:

$$q_{ij}(\omega) = x_j(\omega)^{-\theta} s_{ij}(\omega)^{\alpha}, \tag{1}$$

where $\alpha < 1$, $q_{ij}(\omega)$ is output for a plant from country j in country i, $s_{ij}(\omega)$ is labor required by a plant from country j to produce good ω in country i, and $x_j(\omega)$ is stochastic, specific to plants from country j that produce good ω, and amplified in percentage terms by the parameter θ. In each country i, the productivity parameter $x_i(\omega)$ is randomly drawn across symmetric goods from an exponential function with *bounded* support:

$$\phi_i(x_i) = \frac{\lambda_i e^{-\lambda_i x_i}}{e^{-\lambda_i \underline{x}} - e^{-\lambda_i \bar{x}}}$$

where $x_i \in [\underline{x}, \bar{x}]$. Moreover, since productivity is independently distributed across countries, the density function for the vector $x(\omega) = [x_1(\omega), x_2(\omega), ..., x_n(\omega)]$ is:

$$\phi(x) = \prod_{i=1}^{n} \phi_i(x_i). \tag{2}$$

This configuration of productivity draws is similar to Eaton-Kortum (2002) and Alvarez and Lucas (2004), except for the bounded productivity support.

Preferences. Consumers have preferences given by:

$$u(c, Q) = c^{1-\mu} Q^{\mu} \tag{3}$$

where c is the homogenous good, and Q is a symmetric CES aggregate over the continuum of goods ω, given by:

$$Q = [\int_{\omega \in [0,1]} q(\omega)^{\frac{\eta-1}{\eta}} d\omega]^{\frac{\eta}{\eta-1}} \tag{4}$$

These goods are substitute, with elasticity of substitution $\eta > 1$. The parameter μ is the exogenous fraction of income spent on the composite good Q.

Since the only parameter that varies across goods is productivity, and goods enter symmetrically the aggregate in equation (4), it is convenient to rename each good ω by its productivity x. From now on, I refer to "good x" instead of "good ω", where x is the vector of productivity draws across countries $(x_1, x_2, ..., x_n)$. The aggregate good in equation (4) is rewritten as:

$$Q = [\int q(x)^{\frac{\eta-1}{\eta}} \phi(x)dx]^{\frac{\eta}{\eta-1}}, \tag{5}$$

and the production function in equation (1) as:

$$q_{ij}(x) = x_j^{-\theta} s_{ij}(x)^{\alpha} \tag{6}$$

where x_j is the productivity draw specific to plants from country j that produce good x in country i.

Preferences in (4) generate the following demand function for good x, in country i:

$$(\frac{p_i(x)}{P_i})^{-\eta} Q_i L_i \tag{7}$$

where $p_i(x)$ is the price of good x in country i, and P_i is the price index associated with the aggregate good Q_i, given by:

$$P_i = [\int p_i(x)^{1-\eta} \phi(x)dx]^{\frac{1}{1-\eta}} \tag{8}$$

The aggregate demand for Q_i is given by the expenditure condition:

$$L_i P_i Q_i = \mu Y_i. \tag{9}$$

National income in country i, denoted by Y_i, is given by labor income plus profits, and is fixed.

Bilateral fixed cost. There is an unbounded pool of potential entrants into the production of good x. A subsidiary plant that enters the production of good x in country i at the same technology level as the one of its parent company in country j, has to pay a fixed cost, t_{ij} (in units of the homogenous consumption good). This cost is specific to the pair of "trading" countries, and can be thought as the costs of forming subsidiaries and distribution networks, adapting the technology to the local environment, as well as any information, transaction, and legal costs related to market access. This fixed cost is also borne by domestic plants, denoted by t_{ii}, and might include any overhead cost of production.

Given the vector x, potential entrants decide whether to enter the production of good x, in country i, pay the fixed cost, and start production hiring local labor. There is free entry into the industry, and the mass of plants from country j in country i, in sector x, is denoted by $m_{ij}(x)$.

3.1. Closed economy

The closed economy is such that $t_{ij} \to \infty$, for all $j \neq i$. As a result, FDI is not possible, and only local plants carry on production. "Good x" in country i is just given by country i's productivity draw, x_i. For notational simplicity, in what follows, I drop the subscript i.

A potential firm with productivity x enters the industry as long as profits are as high as the fixed cost:

$$\pi(x) \geq t \tag{10}$$

where $\pi(x)$ is the profit function:

$$\pi(x) = \max_{s(x)} \{p(x)x^{-\theta}s(x)^{\alpha} - ws(x)\}. \tag{11}$$

In any equilibrium where entry is unrestricted, the value of entering the industry could not be positive since the mass of prospective entrants is unbounded. Further, if this value were negative, no firm would enter. Thus, in equilibrium, firms enter the production of good x until equation (10) holds with equality. Condition (10) pins down the equilibrium price for *each* good x. In fact, the price $p(x)$ adjusts such as (10) is satisfied, for each x. Consequently, all goods x are produced in equilibrium. Under perfect competition, the maximization problem in (11) yields:

$$\pi[p(x)] = (1-\alpha)(\frac{\alpha}{w})^{\frac{\alpha}{1-\alpha}}[x^{-\theta}p(x)]^{\frac{1}{1-\alpha}}, \tag{12}$$

Replacing (12) in (10), and solving for $p(x)$ yields:

$$p(x) = \gamma_0 \cdot w^{\alpha} \cdot t^{1-\alpha} \cdot x^{\theta}, \tag{13}$$

where

$$\gamma_0 \equiv (\frac{\alpha}{1-\alpha})^{1-\alpha}\frac{1}{\alpha} \tag{14}$$

Prices are fully determined by the supply side of the economy; productivity x, costs t, and wages w determine the position of the long run supply curve. The size of the industry is determined by the demand side of the economy, $\mu(p(x)/P)^{-\eta}(Y/P)$, where P is the aggregate price index:

$$P^{1-\eta} = (\gamma_0 w^{\alpha})^{1-\eta} t^{(1-\alpha)(1-\eta)} \lambda\Gamma, \tag{15}$$

where

$$\lambda\Gamma \equiv \int_{\underline{x}}^{\bar{x}} x^{\theta(1-\eta)} \phi(x) dx,$$

and Y is total income.

3.2. Open economy with FDI

Each country i has the structure described in the set up, with preferences and technology parameters, ρ, η, μ, θ, and α, common across countries. Given the vector x, a producer from country j opens a plant in country i as long as the value of opening such plant is non-negative:

$$-t_{ij} + \pi_{ij}(x) \geq 0 \tag{16}$$

where

$$\pi_{ij}(x) = \max_{s_{ij}(x)} \{p_i(x) x_j^{-\theta} s_{ij}(x)^{\alpha} - w_i s_{ij}(x)\}, \tag{17}$$

for all i, j. x_j is the productivity draw for good x specific to firms from country j, and $p_i(x)$ is the price for good x in country i. Since there is an unbounded pool of potential entrants and free entry, in equilibrium, (16) holds with equality. The price for good x at which new plants from country j break even in country i is given by:

$$p_{ij}(x) = \gamma_0 \cdot w_i^{\alpha} \cdot t_{ij}^{1-\alpha} \cdot x_j^{\theta} \tag{18}$$

for all i, j, and γ_0 is a constant given by (14). There are n source countries of potential suppliers of good x, but consumers buy from the cheapest one. Hence, the prevailing price for good x in country i is the minimum price among all potential sources that satisfies (18):

$$p_i(x) = \gamma_0 \cdot w_i^\alpha \cdot \min_j \{t_{ij}^{1-\alpha} \cdot x_j^\theta\}_{j=1}^n. \tag{19}$$

As for the closed economy, equation (19) determines the position of the long run supply curve.

Next, I introduce the conditions under which the model generates zero FDI. Let B_{ij} be the set of goods x produced in country i by affiliate plants of firms from country j, i.e., goods for which plants from country j are able to charge the minimum price in country i, defined by:

$$B_{ij} = \{x \in \Theta : p_{ij}(x) < p_{ik}(x) \text{ for all } k\}, \tag{20}$$

where $\Theta \subset R^n : \Theta = [\underline{x}, \bar{x}]^n$. Equivalently, B_{ij} can be defined in terms of productivity draws:

$$B_{ij} = \{x \in \Theta : x_j < (\frac{t_{ik}}{t_{ij}})^{\frac{1-\alpha}{\theta}} x_k \text{ for all } k\}. \tag{21}$$

However, B_{ij} might be empty because there could be no good x for which (i) $x_j \in [\underline{x}, \bar{x}]$, and (ii) $p_{ij}(x) < p_{ik}(x)$ for all k, simultaneously. The following condition is needed for B_{ij} to be non-empty:

$$\underline{x} < (\frac{t_{ik}}{t_{ij}})^{\frac{1-\alpha}{\theta}} \bar{x} \tag{22}$$

for *all* $k \neq j$. When the support condition in (22) is not satisfied, no firm from country j produces in i. The following assumption assures that there is always some production done by domestic plants (i.e., B_{ii} is never empty).

Assumption 1. For all $k \neq i$,

$$\underline{x} < (\frac{t_{ik}}{t_{ii}})^{\frac{1-\alpha}{\theta}} \bar{x}.$$

In each country i, goods are supplied by either foreign or domestic plants, but not both, and all available goods are produced (i.e. $\cup_j B_{ij} = \Theta$). However, due to country-pair specific costs, not necessarily, goods are produced by plants from the country with the best technology; plants from more than one country produce the same good in different parts of the world. Moreover, some countries might not produce any good in some other countries, generating zero bilateral FDI. However, note that the condition in (21) does not involve the cost of inputs, as standard trade models do. Since production in affiliate plants is done employing local inputs, and input prices are uniform across plants of any origin, the cost of inputs does not matter in determining which plants produce in country i; the only thing that matters is relative productivities compared with relative fixed costs. In this sense, the model with FDI is driven by absolute instead of comparative advantages.

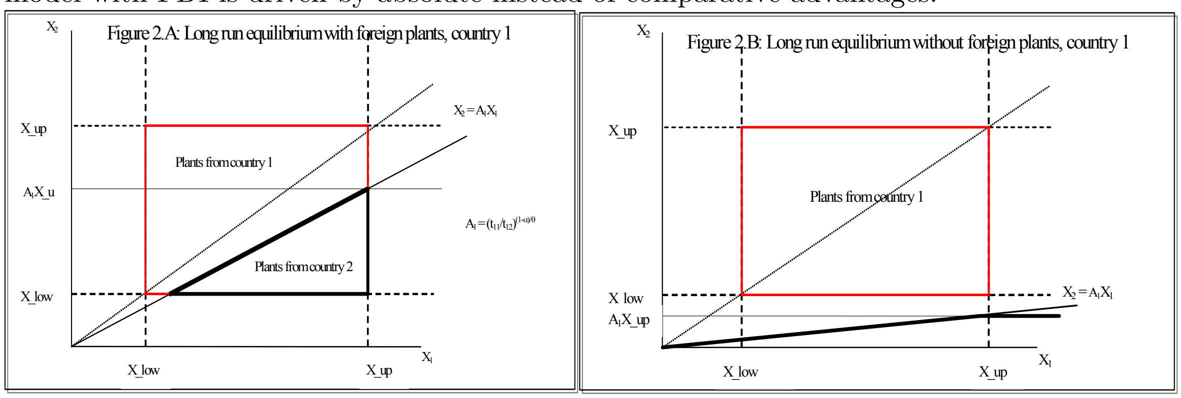

Figure 2: Two-country world equilibrium with FDI (A) and without FDI (B)

Figure 2 shows a two-country world example. Productivity for country 1 (x_1) is in the x-axis, and productivity for country 2 (x_2) in the y-axis. Situation in country 1 is depicted. Goods for which $x_2 < (t_{11}/t_{12})^{\frac{1-\alpha}{\theta}} x_1$ are produced by plants from country 2. Figure 2.A shows the case in which FDI from country 2 to country 1 is positive. Figure 2.B shows the case in which the relative cost t_{11}/t_{12} is so low that the support condition (22) is not satisfied. Hence, there is zero FDI from country 2 to country 1.

Bilateral FDI and gravity. Bilateral FDI from country j to country i is defined as the total value of sales of affiliate plants of firms from country j in country i, denoted by X_i^j. In equilibrium, X_{ij} is given by:

$$X_{ij} = \begin{cases} \mu \cdot \int_{B_{ij}} (\frac{p_i(x)}{P_i})^{1-\eta} \cdot Y_i \cdot \phi(x) \cdot dx \text{ if } B_{ij} \neq \varnothing \\ \\ 0 \text{ if } B_{ij} = \varnothing \end{cases} \tag{23}$$

Replacing $p_i(x)$ by equation (19) and P_i by equation (8) in equation (23) yields:

$$X_{ij} = \mu \cdot \varsigma_{ij} \cdot Y_i \tag{24}$$

where ς_{ij} is the effective market share of plants from country j in i:

$$\varsigma_{ij} \equiv \frac{t_{ij}^{(1-\alpha)(1-\eta)} \lambda_j \Gamma_{ij}}{\sum_k t_{ik}^{(1-\alpha)(1-\eta)} \lambda_k \Gamma_{ik}},$$

$\sum_j \varsigma_{ij} = 1$, and $\varsigma_{ij} = 0$ for $B_{ij} = \varnothing$. The expression $\lambda_j \Gamma_{ij}$ is defined by[13]:

$$\lambda_j \Gamma_{ij} \equiv \int_{B_{ij}} x_j^{\theta(1-\eta)} \phi(x) dx.$$

The variable Γ_{ij} mirrors the one in Helpman, Melitz and Rubinstein (2004). The main difference is that Γ_{ij} depends on the whole vector of (relative) barriers to FDI in country i, $\{t_{ij}/t_{ik}\}_{k \neq j}$, as well as the vector of average country productivities, $(\lambda_1, ..., \lambda_n)$, and the support bounds, $\underline{x}$ and $\bar{x}$. All these parameters determine the cross-country *distribution* of FDI.

First, the set B_{ij} may be empty for some (or all) $j \neq i$, so that Γ_{ij} equals zero, and FDI from country j into i is zero. Hence, the model is able to generate zero FDI volumes between some country-pairs, $X_{ij} = 0$. However, firms from country j may have affiliate plants in other destinations, and country i may host plants from other sources. Since Γ_{ij} is different from Γ_{ji}, even with symmetric barriers (i.e. $t_{ij} = t_{ji}$), the theory allows for asymmetric bilateral FDI, which may be zero in one direction, with $X_{ij} = 0$ and $X_{ji} > 0$, or $X_{ij} > 0$ and $X_{ji} = 0$, zero in both directions, $X_{ij} = X_{ji} = 0$, or positive in both directions but of different magnitude, $X_{ij} \neq X_{ji} > 0$. Such asymmetric FDI relationships are widely spread in the data, as shown in Section 2. Second, for the group of country-pairs with positive FDI, gravity regulates the magnitude of flows; in fact, expression (24) relates bilateral sales from country j in i to the "importer" size, Y_i, and barriers to access the importer's market, embedded in ς_{ij}. The higher Y_i or λ_j, the larger X_{ij}, and the higher t_{ij}, the lower X_{ij}.

[13]
$$\lambda_j \Gamma_{ij} \equiv \lambda_j \int_{\underline{x}}^{\bar{x}} x_j^{\theta(1-\eta)} e^{-\lambda_j x_j} \prod_{k \neq j} [e^{-x_j \lambda_k (\frac{t_{ij}}{t_{ik}})^{\frac{1-\alpha}{\theta}}} - e^{-\lambda_k \bar{x}}] dx_j$$

Finally, note that the stronger decreasing returns are (lower α), the larger the effect of bilateral costs on bilateral sales.

Besides bilateral sales of affiliate plants, employment, assets and number of affiliates plants of firms from country j in i, could be considered as measures of bilateral FDI. Since all these measures are proportional to sales, the previous analysis still holds[14].

Symmetric example. Let $t_{ij} = t_i$, for all j. Then, $\Gamma_{ij} = \Gamma_j$, for all i, and strictly positive. Assume that the ratio of productivity to size, λ_i/L_i, is uniform across countries. For the rest, countries are identical. Bilateral FDI between countries is non-zero, and follows a basic gravity equation[15]:

$$X_{ij} \quad = \quad \mu \cdot \frac{(\Gamma_j/w_j)}{\sum_k (\Gamma_k/w_k) Y_k} \cdot Y_j \cdot Y_i. \tag{25}$$

The volume of bilateral sales is a function of the product of the trading partners' size, given by total income, Y_i and Y_j. Notice that barriers to access the market do not affect equation (25). Indeed, the stock of *plants* from country j in i depends on barriers, and is

[14] Bilateral employment from country j in i is:

$$S_{ij} = \frac{\alpha}{w_i} X_{ij};$$

the bilateral number of affiliate plants is:

$$m_{ij} = \frac{1-\alpha}{t_{ij}} X_{ij};$$

and the bilateral value of assets is given by the value of installed plants from country j in i:

$$a_{ij} = t_{ij} m_{ij} = (1-\alpha) X_{ij}.$$

[15] I use the fact that total labor costs are given by:

$$w_i L_i = [1 - \mu(1-\alpha)] Y_i$$

given by:

$$m_{ij} \quad = \quad \mu(1-\alpha) \cdot \frac{(\Gamma_j/w_j)}{\sum_k (\Gamma_k/w_k) Y_k} \cdot \frac{1}{t_i} \cdot Y_j \cdot Y_i.$$

Lastly, the theory can be used to analyze the effects of foreign plants on the performance of a small open economy. In fact, it delivers a set of predictions about the behavior of prices, productivity, size and turnover of plants in a host industry when foreign entry occurs, that matches some widely documented empirical evidence about foreign plants in host economies. In the Appendix, I present the implications of the theory for a host economy, and characterize the transition path from the closed to the open economy for a small country.

4. EMPIRICAL FRAMEWORK

Equation (24) relates the volume of bilateral sales of foreign affiliates to characteristics of the source and host country, and the cost of FDI in the host country. When condition (22) is not satisfied, no firm from country j is productive enough to open an affiliate in country i, inducing zero FDI from j to i. For positive FDI, equation (24) governs the volume of bilateral sales of affiliates from country j in i. sales. Rearranging terms, equation (24) can be expressed in log-linear form as

$$\ln \frac{X_{ij}}{Y_i} = \ln \mu + \ln \lambda_j - \ln[\sum_k \lambda_k t_{ik}^{(1-\alpha)(1-\eta)} \Gamma_{ik}] - \ln t_{ij}^{(1-\alpha)(\eta-1)} + \ln \Gamma_{ij} \qquad (26)$$

if $\Gamma_{ij} > 0$.

The term capturing the cost of FDI for plants from country j and i, t_{ij}, has observable and unobservable components. Following the gravity literature on international trade, I relate it to observable variables such as geography, language, colonial past, and policy variables related to taxation of foreign firms. I further assume that these costs are stochastic due to unobservable FDI frictions that are country-pair specific, and denoted by ϵ_{ij}. In particular, for $i \neq j$, let t_{ij} have the following form:

$$\ln t_{ij}^{(1-\alpha)(\eta-1)} = \delta_d \ln d_{ij} - \epsilon_{ij} \qquad (27)$$

where d_{ij} is an observable measure of bilateral costs, and it is easily extended to be a vector, and ϵ_{ij} is unobservable. Particularly, I assume that:

$$\epsilon_{ij} = u_i + v_{ij}, \tag{28}$$

so that $\epsilon_{ij}^{\prime}s$ are not independent across $j's$, for a given i. The term u_i is country i' fixed effect, independently and normally distributed across countries, with mean zero and variance σ_u^2, and v_{ij} is i.i.d. across country-pairs, normally distributes with mean zero and variance σ_v^2[16].

Notice that t_{ii} cannot be approximated by observable variables. Hence, I set t_{ii} to be a fraction τ of the minimum cost faced by firms from any other country j in i:

$$t_{ii} = \tau \cdot \min_{j \neq i}\{t_{ij}\}. \tag{29}$$

where τ must satisfy Assumption 1[17]. Replacing (27) in (26), for $j \neq i$, yields:

$$\ln \frac{X_{ij}}{Y_i} = \ln \mu + S_j - S_i - \delta_d \ln d_{ij} + \ln \Gamma_{ij} - \epsilon_{ij} \tag{30}$$

if $\Gamma_{ij} > 0$, where $S_j \equiv \ln \lambda_j$, and $S_i \equiv \ln[\sum_k \lambda_k t_{ik}^{(1-\alpha)(1-\eta)} \Gamma_{ik}]$. Equation (30) looks much as the gravity equation that is traditionally estimated through OLS using only positive bilateral

[16] ϵ_{ij} are normally distributed, with zero mean and variance-covariance matrix given by:

$$V = \begin{bmatrix} \Sigma & 0 & ... & 0 \\ 0 & \Sigma & ... & 0 \\ ... & ... & ... & ... \\ 0 & ... & 0 & \Sigma \end{bmatrix}$$

where Σ is an (nxn) matrix equal to:

$$\Sigma = \begin{bmatrix} \sigma_u^2 + \sigma_v^2 & \sigma_u^2 & ... & \sigma_u^2 \\ \sigma_u^2 & \sigma_u^2 + \sigma_v^2 & ... & \sigma_u^2 \\ ... & ... & ... & ... \\ \sigma_u^2 & ... & ... & \sigma_u^2 + \sigma_v^2 \end{bmatrix}.$$

[17]

$$\tau < \left(\frac{\bar{x}}{\underline{x}}\right)^{\frac{\theta}{1-\alpha}}.$$

flows, i.e., $X_{ij} > 0$, and two sets of country fixed effects. The first important difference that equation (30) bears with traditional gravity equations is the new variable $\ln \Gamma_{ij}$. This variable mirrors the one in Helpman, Melitz and Rubinstein (2004), and depends on the vector of (relative) barriers to FDI in country i, $\{t_{ij}/t_{ik}\}_{k \neq j}$,, among other parameters, transforming equation (30) in a non-linear function of the coefficient δ_d and the error terms ϵ_{ij}. When $\ln \Gamma_{ij}$ is not included as a regressor, the OLS estimate of the coefficient on d_{ij}, can no longer be interpreted as an estimate of δ_d. The second important difference is the bias arising from the fact that, considering positive flows only, the error term of the OLS regression is no longer independent of the regressors. This selection effect induces a positive correlation between the unobservable term ϵ_{ij}, and the observable barriers d_{ij}: country-pairs with large observable barriers (high d_{ij}) that have positive FDI are likely to have low unobservable barriers (high ϵ_{ij}), inducing a downward bias in the OLS coefficient on d_{ij}.

4.1. Estimation procedure

The goal is to get consistent estimates of the parameters corresponding to barriers, to calculate bilateral costs of FDI, and explore some counterfactual exercises. As shown in the previous subsection, when the productivity support is bounded and information on zero FDI is disregarded, OLS estimates of the gravity equation are biased.

I use an indirect inference procedure to estimate the parameters of interest of the model. I compute so-called "auxiliary" parameters with the actual data and simulations of the model. The indirect inference estimator of the model parameters is the one that minimizes the distance between the two sets of auxiliary parameters.

The estimation procedure works as follows. Let ρ denote the $(px1)$ vector of "auxiliary" parameters. Let Δ be the $(qx1)$ vector of parameters of the model. I first calculate ρ with the actual data. I simulate the model for H realizations of the matrix $\{\epsilon_{ij}^h\}_{i,j}$, for each vector Δ. With the simulated data, for each h and Δ, I calculate again the vector ρ. The indirect inference estimator Δ^* is the solution to the following minimization problem[18]:

$$\Delta^* = \arg\min_{\Delta} [\rho_d - \frac{1}{H}\sum_{h=1}^{H}\rho_s^h(\Delta)]'\hat{\Omega}[\rho_d - \frac{1}{H}\sum_{h=1}^{H}\rho_s^h(\Delta)] \quad (31)$$

where ρ_d is the vector of auxiliary parameters from the actual data, and $\rho_s^h(\Delta)$ is the one from simulation h of the model evaluated at Δ. The (pxp) matrix $\hat{\Omega}$ is the weighting matrix that is set to be the identity matrix.

I restrict the vector Δ to be a subset of the structural parameters of the model:

$$\Delta = [\delta_d, \sigma_u^2, \sigma_v^2, \tau, \bar{x}, \kappa]$$

where δ_d is the contribution of the observable component to the total magnitude of barriers to FDI in equation (27); σ_u^2 and σ_v^2 are the variances of u_i and v_{ij}, respectively, in (28); τ is defined by equation (29); $\bar{x}$ is the upper bound of the productivity support; and κ is a scale parameter defined below.

Parameter	***Value***	***Definition***	***Source***
θ	**0.25**	*variability of productivity draws*	*Eaton-Kortum*
μ	**0.5**	*share of CES sector in total expenditure*	*avg. sales of foreign affiliates in a host economy, as share of GDP^*
η	**3.1**	*elasticity of substitution*	*from Broda-Weinstein*
$\underline{x}$	**1**	*lower bound of productivity support*	*normalization*
Y_i	**GNP_i**	*National income or GNP for country i*	*Data on GNP*
H	**1**	*Number of simulations of the model at each Δ*	
α	0.55	*effective equipped labor share in production*	*from Alvarez-Lucas*
1-μ(1-α)	0.78	*share of labor costs in income*	*implied from α and μ*

^ Countries for which data in all sectors are available (UNCTAD): United States, Ireland, Czech Rep., Finland, Germany, Hungary, Sweden, Netherlands, Poland, Slovenia, Canada

Table 5: Calibrated parameters of the model

I set the remaining parameters needed to estimate the gravity equation at the values summarized in Table 5. The vector of technology parameters $(\lambda_1, ..., \lambda_n)$ is not observable. Using data on countries' GNPs, I calibrate it to capture the idea that larger countries have

[18] The indirect inference estimator Δ^* is consistent under the assumptions in Gourieroux, Monfort and Renault (1993). The minimized value of (31) is distributed as a $\chi^2(p-q)$ where $p = dim(\rho)$ and $q = dim(\Delta)$.

on average more technology draws that smaller countries, relative to the United States. The parameter κ gives the proportionality factor:

$$\lambda_i = \kappa \frac{Y_i}{Y_{us}}$$

The parameter μ is the expenditure share of goods from the sector where FDI is allowed. Since I calibrate it to the average sales of foreign affiliates as share of GDP in the actual data, for selected developed economies, it can be thought as a lower bound.

Besides dimensionality problems in the numerical computations, I chose these parameters to be in Δ because they are the ones that govern the size of barriers, and the existence and distribution of bilateral FDI.

The outcome of each simulation h, for a given set Δ, is the matrix of sales of affiliate plants from country j in i, $\{\tilde{X}_{ij}^h(\Delta)\}_{i,j}$. Creating this simulated data set requires data on observable bilateral barriers, $\{d_{ij}\}_{j\neq i}$, and on GNPs to calibrate the vector of countries' income, $(Y_1, ..., Y_n)$, and technology parameters $(\lambda_1, ..., \lambda_n)$, for the 151 countries in the sample.

The data I use to compute the vector of auxiliary parameters ρ_d are aggregate sales of affiliates from country j in i, $\{X_{ij}\}_{j\neq i}$, measures of observable barriers between country-pairs, $\{d_{ij}\}_{j\neq i}$, and GNPs, $(Y_1, ..., Y_n)$.

In particular, ρ_d contains the following statistics: fraction of country-pairs with $X_{ij} > 0$ and $X_{ji} > 0$; fraction of country-pairs with $X_{ij} = 0$ and $X_{ji} = 0$; mean value of observable barriers among country-pairs with (i) $X_{ij} > 0$ and $X_{ji} > 0$, (ii) $X_{ij} = 0$ and $X_{ji} > 0$, and (iii) $X_{ij} = 0$ and $X_{ji} = 0$; mean value of bilateral sales of foreign affiliates for country-pairs with (i) $X_{ij} > 0$ and $X_{ji} > 0$, and (ii) $X_{ij} > 0$ and $X_{ji} = 0$; mean value of GNP for country-pairs with (i) $X_{ij} > 0$ and $X_{ji} > 0$, (ii) $X_{ij} = 0$ and $X_{ji} > 0$, and (iii) $X_{ij} = 0$ and $X_{ji} = 0$; mean value of GNP for source countries (countries j) and host countries (countries i), for country-pairs with $X_{ij} > 0$ and $X_{ji} = 0$; lastly, the OLS coefficients of the following regression:

$$\ln \frac{X_{ij}}{Y_i} = a + a_d \ln d_{ij} + C_i + C_j + e_{ij}, \tag{32}$$

for all observations with $X_{ij} > 0$, where C_i and C_j are host and source country fixed effects, respectively, and the error term e_{ij} has variance σ_e^2. The regression in (32) is a traditional estimate of the gravity equation using data on positive bilateral sales of affiliate plants.

The vector ρ_s has the same statistics as in ρ_d, except that they are computed with simulated data.

(Tables A.3.7 and A.3.8 in the appendix summarize the values of the auxiliary parameters calculated from the actual data, ρ_d, and simulated data at the optimal model parameters' value, $\rho_s(\Delta^*)$; a description of each parameter is also included. In tables in Section 2, statistics in the set ρ_d are highlighted in red).

The indirect inference method focuses on some moments of the data, instead of the whole joint distribution. Since (30) is non-linear in the parameters of interest, an alternative to indirect inference is to use maximum likelihood, writing down the likelihood function from the set of conditional probabilities that the model dictates. Similarly, a two-step procedure that corrects for the selection of country-pairs into FDI partners would be adequate. However, the complex structure of Γ_{ij}, a multivariate truncated distribution that depends on the entire vector of (relative) bilateral barriers in country i, makes both methods hard to apply.

5. ESTIMATES

I use the following variables as observable barriers to FDI: bilateral distance d_{ij}, common border δ_{ij}^c, common language δ_{ij}^l, colonial ties δ_{ij}^{col}, and the presence of a double taxation treaty δ_{ij}^{dtt}, between country-pairs. $\delta_{ij}^{\prime}s$ are all dummy variables. Equation (27) ends up being

$$\ln t_{ij}^{(1-\alpha)(\eta-1)} = \delta_d \ln d_{ij} - \sum_{s=c,l,\text{col},dtt} \delta_{ij}^s \ln b_s - \epsilon_{ij}.$$

Alternatively to the double taxation treaty dummy, I use corporate tax rates applied to firms from country j in i[19].

(Details on variables are provided in the appendix).

[19] I am very grateful to Ernesto Stein and Christian Daude for providing me with data on corporate tax rates.

The first two columns in Tables 6.1 show OLS estimates of equation (32), for country-pairs with $X_{ij} > 0$, and different sets of observable barriers, for the all countries in the sample. Each observation is an average over the period 1990-2002[20].

	OLS				Probit [1]	
Dependent variable:	sales of affiliates from country j in i (in logs, as % of country i' s GNP)				1 for positive FDI from country j to i	
	Country-pairs with positive FDI		All possible country-pairs [1,2]			
	I	II	III	IV	V	VI
log of bilateral distance (thousands of km)	-1.137	-1.144	-0.512	-0.576	-0.699	-0.717
	[0.099]**	[0.099]**	[0.027]**	[0.028]**	[0.031]**	[0.031]**
1 for pairs with common official language or >20% pop. same language	0.497	0.49	-0.178	-0.168	0.342	0.344
	[0.224]*	[0.224]*	[0.050]**	[0.051]**	[0.066]**	[0.066]**
1 for pairs with a common border	-0.065	-0.09	0.619	0.608	0.358	0.356
	[0.261]	[0.259]	[0.117]**	[0.120]**	[0.110]**	[0.110]**
1 for pairs with double taxation treaty	0.108		2.76		0.648	
	[0.199]		[0.062]**		[0.050]**	
1 for pairs ever in colonial relationship	0.85	0.848	-0.905	-0.745	0.052	0.086
	[0.283]**	[0.284]**	[0.160]**	[0.163]**	[0.117]	[0.117]
bilateral corporate tax rates		0.001		-0.066		-0.019
		[0.007]		[0.002]**		[0.002]**
Observations	846	846	19684	19684	21906	21906
R-squared	0.86	0.86	0.63	0.62		

Standard errors in brackets. * significant at 5%; ** significant at 1%
All specifications with constant, and source and host country fixed effects
(1): FDI=0 if all measures of FDI are zero or missing values
(2): for country-pairs with no FDI, sales are replaced by one dollar

Table 6.1: Traditional gravity for FDI and participation equation. All countries.

From the first two columns, it clearly emerges that affiliates from country j have more sales in country i, as share of country i's GNP, when the two countries are closer to each other, share a language, and have colonial ties. Even if insignificant, sharing a border seems to have the opposite effect than expected on bilateral FDI. The presence of a bilateral double taxation treaty has a positive but insignificant effect, while bilateral tax rate seems to have the wrong sign but still insignificant.

[20] Considering 3-year average observations yields similar results.

Among the 151 countries considered in the sample, there are 22,801 possible bilateral FDI relationships; only 3,810 of these relationships have non-zero FDI[21]. Columns III and IV show estimates in which all possible country pairs are included and the ones with zero FDI are assigned a one-dollar value. Estimates change drastically; the coefficient on bilateral distance drops by half, and the one on common language turns negative, while coefficients on common border and having a double taxation treaty increase substantially. The effects of bilateral tax rate on sales of affiliates is negative and significant: a 10% increase in the tax rate of country i for firms from country j decreases sales of affiliates of that country, as share of country i's income, by 0.6%. The last two columns show Probit estimates for the presence of FDI from country j into i, using the same explanatory variables as for the OLS regressions. The dependent variable is one if country j has positive FDI in country i, and zero otherwise. Results show that the same variables that impact FDI volumes from country j to i also impact the probability that j engages in an FDI relationship with i. Moreover, all variables have the expected sign, even bilateral taxes, even though the dummy for colonial ties looses significance.

Table 6.2 shows the same estimates as Table 6.1. restricting the sample to OECD countries, among which the presence of zero bilateral FDI is very small.

(Estimates using other measures of bilateral FDI are shown in the appendix).

Tables 7.1 and 7.2 summarize the vector of model parameters' estimates, Δ^*. While Table 7.1 shows estimates which include as observable barriers double taxation treaties, Table 7.2 includes bilateral corporate tax rates. Results for the 151 countries in the sample, and only OECD countries, among which the fraction of zero FDI is small, are shown. According to these estimates, bilateral distance is the most important barrier to FDI: countries that are twice as far away have a cost of FDI that is around 45% higher than otherwise. This magnitude translates in a 43% lower share of bilateral FDI in the host country's income. Sharing a border or a language decreases the cost of FDI by 0.15% and 0.14%, respectively, while sharing a colonial past does it by around 0.25%. Country-pairs with a double taxation

[21] A country j has zero FDI in country i for the period 1990-2002, if *all the six measures* of FDI in the database are missing values.

Dependent variable:	sales of affiliates from country j in i (in logs, as % of country i's GNP)			
	Country-pairs with positive FDI		All possible country-pairs [1,2]	
	I	II	III	IV
log of bilateral distance (thousands of km)	**-0.83** [0.129]**	**-0.84** [0.129]**	**-1.19** [0.280]**	**-1.19** [0.281]**
1 for pairs with common official language or >20% pop. same language	**0.26** [0.270]	**0.25** [0.271]	**0.84** [0.584]	**0.84** [0.584]
1 for pairs with a common border	**0.60** [0.270]*	**0.62** [0.271]*	**0.42** [0.597]	**0.39** [0.596]
1 for pairs ever in colonial relationship	**0.41** [0.306]	**0.47** [0.306]	**0.63** [0.680]	**0.61** [0.678]
1 for pairs with double taxation treaty	**-0.8** [0.359]*		**0.3** [0.675]	
bilateral corporate tax rates		**0.014** [0.010]		**0.005** [0.020]
Observations	396	396	432	432
R-squared	0.82	0.82	0.74	0.74

Standard errors in brackets. * significant at 5%; ** significant at 1%
All specifications with constant, and source and host country fixed effects
(1): FDI=0 if all measures of FDI are zero or missing values
(2): for country-pairs with no FDI, sales are replaced by one dollar

Table 6.2: Traditional gravity for FDI. OECD countries. OLS.

treaty have only 0.0003% lower barriers to FDI. The standard errors σ_u and σ_v are 0.11 and 0.15, so that σ_ϵ is 0.18.

Table 7.2. shows estimates with corporate tax rates as an observable measure of barriers. The effect of distance is even stronger than in Table 7.1: countries twice as far have 55% higher costs to FDI. Common colonial past becomes more important, decreasing by 0.40% total costs to FDI. Similarly to results in Table 7.1, tax rates have a very small effect on total costs: doubling bilateral corporate tax rates increase costs to bilateral FDI by 0.8%.

Regarding the rest of the estimates of the model's parameters, estimates in Table 7.1 suggest that domestic plants face barriers to entry that are half the magnitude of the ones faced by the most favoured foreign plants (i.e. the parameter τ in equation (29)). This

Parameters	Estimates				Effect of barriers on X_i^j/Y_i		Definition
	All countries		OECD countries				
	I	*OLS (I)*	*II*	*OLS (II)*	*I*	*II*	
δ_d	0.47	0.40	0.55	0.29	-0.45	-0.52	*coefficient on bilateral distance*
$\ln(b_c)$	0.15	-0.02	0.12	0.21	0.139	0.12	*coefficient on common language*
$\ln(b_l)$	0.14	0.17	0.14	0.09	0.129	0.13	*coefficient on common border*
$\ln(b_{col})$	0.26	0.30	0.27	0.14	0.248	0.26	*coefficient on colonial ties*
$\ln(b_{dtt})$	0.0003	0.038	0.0003	-0.3	0.0003	0.0003	*coefficient on sharing a double taxation treaty*
σ_v	0.15	0.39	0.16	0.39			*standard error of* v_{ij}
σ_u	0.11		0.09				*standard error of* u_{ij}
σ_ε	0.18		0.18				*standard error of* ε_{ij}
τ	0.494		0.52				*parameter on barriers for domestic plants*
κ	2.46		2.18				*scale parameter*
$\bar{x}$	19.5		46.9				*upper bound of the productivity support*
chi-square	79		10				
p-value	0.000		0.95				
correlation between actual and simulated data for:							
bilateral FDI: Xij	0.21		0.38				
total FDI *in* country i: log(jXij)	0.87		0.87				
total FDI *from* country i: log(jXji)	0.24		0.25				

Xij: sales of affiliates from country j in country i

Table 7.1: Parameters' Estimates I

means that foreign plants that face the lowest value of barriers to FDI in a host country have to be at least 3 times more productive than domestic plants in the same sector. Conversely, estimates in Table 7.2 suggest that domestic plants are more productive than the most favoured foreign plant (i.e. $\tau > 1$).

Which are the differences with the OLS estimates of barriers to FDI? A model without zero FDI flows, that generates a "traditional" gravity equation as the one in (32), would allow us to calculate the parameter δ_d in equation (27) from the OLS coefficient a_d in equation (32)[22]. Using OLS estimates in table 6 (II), and calibrating the rest of the model

[22] The model generates a "traditional" gravity equation as long as $\underline{x} = 0$ and $\bar{x} \to \infty$. Bilateral sales of affiliates from country j in i, as share of country i's GNP, are given by (in logs):

$$\ln \frac{X_{ij}}{Y_i} = \ln \mu + \hat{C}_j - \hat{C}_i + a_d \ln d_{ij} + e_{ij}$$

Parameters	*Estimates*				*Effect of barriers on* X_i^j/Y_i		*Definition*
	All countries		*OECD countries*				
	I	***OLS (I)***	***II***	***OLS (II)***	***I***	***II***	
δ_d	**0.55**	**0.40**	**0.54**	**0.30**	**-0.52**	**-0.51**	*coefficient on bilateral distance*
$\ln(b_c)$	**0.11**	**-0.03**	**0.12**	**0.22**	**0.10**	**0.11**	*coefficient on common language*
$\ln(b_l)$	**0.15**	**0.17**	**0.16**	**0.09**	**0.14**	**0.15**	*coefficient on common border*
$\ln(b_{col})$	**0.40**	**0.30**	**0.33**	**0.17**	**0.38**	**0.31**	*coefficient on colonial ties*
$\ln(\delta_t)$	**0.008**	**-0.0004**	**0.008**	**0.005**	**-0.01**	**-0.01**	*coefficient on bilateral corporate taxes*
σ_v	**0.114**	**0.39**	**0.110**	**0.386**			*standard error of* v_{ij}
σ_u	**0.077**		**0.084**				*standard error of* u_{ij}
σ_ε	**0.137**		**0.138**				*standard error of* ε_{ij}
τ	**1.09**		**0.55**				*parameter on barriers for domestic plants*
κ	**2.40**		**2.37**				*scale parameter*
$\bar{x}$	**8.10**		**44.31**				*upper bound of the productivity support*
chi-square	**62**		**10**				
p-value	0.000		0.95				
correlation between actual and simulated data for:							
bilateral FDI: Xij	**0.19**		**0.36**				
total FDI *in* country i: log(?$_j$Xij)	**0.87**		**0.89**				
total FDI *from* country i: log(?$_j$Xji)	**0.35**		**0.14**				

Xij: sales of affiliates from country j in country i

Table 7.2: Parameters' Estimates II

parameters at the values in table 5, doubling distance between country-pairs increases barriers by 40%, while sharing a language decreases them by 0.17% and having colonial ties by

where $\hat{C}_j$ and $\hat{C}_i$ are source and host country fixed effects:

$$\hat{C}_j \equiv \ln \lambda_j$$

$$\hat{C}_i \equiv \ln \sum_k \lambda_k t_{ik}^{-\frac{1+\alpha\theta(1-\eta)}{\theta}} - \frac{1+\alpha\theta(\eta-1)}{(1-\alpha)(\eta-1)\theta} u_i$$

$$a_d \equiv \frac{1+\alpha\theta(\eta-1)}{(1-\alpha)(\eta-1)\theta} \delta_d$$

$$e_{ij} \equiv \frac{1+\alpha\theta(\eta-1)}{(1-\alpha)(\eta-1)\theta} v_{ij}.$$

0.3%. The existence of a double taxation treaty decreases barriers by 0.038%.

The indirect inference estimators differ from the OLS estimators regarding the coefficients on distance and common border. In particular, this comparison suggests that OLS estimates are downward biased, since the impact of distance and common border on the cost of FDI is much stronger as estimated by the indirect inference estimators.

How well the model reproduces the data? Tables A.3.7 and A.3.8 in the appendix show the "auxiliary" parameters calculated with the simulated data at the optimal Δ^*, for estimates in Table 7.1 and 7.2, respectively. Even though the model captures fairly well the fraction of zero and positive bilateral FDI, as well as the mean values of barriers, for country-pairs with positive, zero, and one-way FDI, it fails to pick features related to size. Even though a chi-square test on the optimality criterion in equation (31) does not lead us to accept that the actual data are generated by a model with parameter Δ^*, the correlation coefficient between simulated and actual data on sales of affiliates from country j in i is around 0.20, while the one for (log of) total sales of foreign affiliates *into* country i is 0.87, and the one for (log of) total sales of affiliates abroad *from* country i ranges between 0.24 and 0.35 (table 7.1. and 7.2, respectively). The fit for the sample of OECD countries is better for bilateral sales of affiliates (0.36-0.38), similar for total sales of foreign affiliates into a host country (0.87), and worse for total sales of affiliates abroad (0.14-0.25). Indeed, the chi-square test is not rejected.

5.1. Welfare gains of FDI

The estimation above provides parameters' values to quantify the model with FDI, and pursue the analysis of counterfactuals, in the same spirit as the experiments studied by Eaton and Kortum (2002 and 2003), and Alvarez and Lucas (2004) in the context of international trade in goods.

The criteria to examine counterfactuals is overall welfare in country i, measured as real income: $W_i = Y_i / P_i^{\mu}$[23]. The change in welfare decomposes into income and price effects:

$$\ln \frac{W_i'}{W_i} = \ln \frac{Y_i'}{Y_i} - \mu \ln \frac{P_i'}{P_i} \tag{33}$$

where z_i' denotes the counterfactual value of a variable z_i, and where the price index is given by:

$$P_i^{1-\eta} = (\gamma_0 w_i^{\alpha})^{1-\eta} \sum_j t_{ij}^{(1-\alpha)(1-\eta)} \lambda_j \Gamma_{ij} \tag{34}$$

where γ_0 is given by (14).

Proposition 1 *For each country i, the aggregate price index for the economy with FDI, P_i^{fdi}, is lower than the one for the closed economy, P_i^c.*

Equation (24) for bilateral sales of affiliates from country j in i, along with (34) comprise the general equilibrium for the open economy with FDI. Notice that since labor supply L_i and wages w_i are fixed, income Y_i, in terms of the numeraire, is also fixed; welfare effects are due to changes in the aggregate price index.

I first consider the effects of raising barriers to FDI to their autarky level ($t_{ij} \to \infty, i \neq j$) in each country simultaneously. I then present the effects of removing bilateral barriers and set them to a uniform level, equal to t_{ii}, for plants from any origin, in each country i ("zero-gravity").

	World Average (1)		World Average (2)	
	(I)	(II)	(I)	(II)
Avg. value of barriers*	9	5	11	10
Avg. sales of foreign affiliates (model):				
baseline	69,639	77,645	81,164	81,083
zero-gravity	91,962	91,962	91,962	91,962
US in autarky	56,993	59,618	61,232	61,236
Avg. sales of foreign affiliates (data):	40,461	(in)		
	54,797	(out)		

[23] Since the homogeneous good is the numeraire, the price level in country i is P_i^{μ}.

	welfare (% change in real income)	
	(I)	(II)
Effects of moving from baseline to:		
autarky		
all countries (1)	-58%	-68%
all countries (2)	-78%	-79%
"zero-gravity"		
all countries (1)	84%	66%
all countries (2)	72%	70%
US in autarky		
all countries (1)	-0.01%	-0.03%
all countries (2)	-0.4%	-0.1%
corporate tax rates = 100%		
all countries (1)	-	-12%
all countries (2)	-	-13%

(1): parameters' estimates using all the sample of countries (151)
(2): parameters' estimates using the sample of OECD countries (28)
(I): Estimates from Table 7.1. include bilateral double taxation treaties
(II): Estimates from Table 7.2. include bilateral corporate tax rates
baseline: estimated bilateral barriers; autarky: tij→8 , for all j?i. "zero-gravity": tij=tii, for all j
(*) tij/tii: ratio of barriers faced by plants from country j in i, to barriers for plants from country i

Table 8: Welfare gains of changing barriers to FDI, world average

Table 8 shows world averages of costs of FDI, sales of foreign affiliates into country i and from country i, as well as world average welfare gains of changing FDI costs, from estimates in Table 7.1. (I) and 7.2 (II), for both parameters' estimates calculated using the whole sample of countries (1) and OECD countries (2). On average, world real income would decrease by 60-70% if each of the 151 countries in the sample moved to autarky from the baseline case. Going to a "zero-gravity" world, in which bilateral barriers to FDI would be removed, would increase average world real income by 65-85%; unrealized gains of removing bilateral barriers seem quite large. The effects on average world welfare if the United States moved to autarchy are rather small, while real income losses of increasing bilateral corporate taxes to 100% in each country would be more than 10%.

Table 9 shows counterfactual exercises for the United States, Mexico and Canada, and for the European Union (25), calculated from estimates in Table 7.1 (I) and 7.2 (II). As expected, income losses of moving to autarky are smaller for the United States, while gains

	Welfare Changes (real income % change)									
	US		Mexico		Canada		EU		World Average	
	(I)	(II)	(I)	(II)	(I)	(II)	(I)	(II)	(I)	(II)
Effects of moving from baseline to:										
autarky	**-18%**	**-31%**	-50%	-76%	-26%	-43%	**-55%**	**-66%**	**-58%**	**-68%**
zero-gravity	**104%**	**91%**	135%	58%	110%	89%	**84%**	**68%**	**84%**	**66%**
US in autarky	-	-	-0.3%	-1%	54%	48%	-0.1%	-0.1%	**-0.01%**	**-0.03%**
Canada in autarky	**39%**	**33%**	0.05%	5%	-	-	-	-	**-**	**-**
NAFTA (zero-gravity among members)	**12%**	**9%**	**10%**	**1%**	**16%**	**7%**	0.01%	-0.1%	0.3%	-0.1%
EU (zero-gravity among members)	-0.01%	-0.1%	0.00%	-0.7%	0.00%	-0.1%	**39%**	**26%**	**6%**	**4%**

baseline: estimated bilateral barriers; autarky: tij? 8 , for all j?i. "zero-gravity": tij=tii, for all j
(I): Estimates from Table 7.1. include bilateral double taxation treaties
(II): Estimates from Table 7.2. include bilateral corporate tax rates

Table 9: Welfare gains of changing barriers to FDI, selected economies

of removing bilateral barriers to FDI world-wide ("zero-gravity") are quite large for all countries shown.

The effect on neighbors' countries if United States moved to autarky are uneven: while Mexico would experience a small drop in real income, Canada would be better off. Conversely, if Canada moved to autarky, both the United States and Mexico would be better off. However, further liberalizing NAFTA ("zero-gravity" among NAFTA members) would be beneficial for all three members, even though Mexico would benefit the least. Finally, there are large unrealized gains of further liberalizing FDI among EU members ("zero-gravity" among EU members): real income would increase more than 25%.

6. CONCLUSIONS

This paper analyzes the determinants of the cross-country distribution and volume of FDI, quantifies the size of its barriers, and its impact on welfare. For that purpose, I introduce FDI in a competitive, multicountry model with fixed costs, close to Eaton-Kortum's (2002) and Alvarez and Lucas (2004), where FDI is treated as sales of foreign affiliate plants of multinational firms. Delivering a "modified" gravity equation for FDI volumes, the theory is able to capture some stylized facts on cross-country FDI: a very small fraction of countries engages in FDI; geography remains a significant impediment to FDI; countries' size matters. However, even if similarly to international trade theories, gravity governs FDI volumes, the driven forces behind it are fundamentally different. In fact, this model with only FDI highlights the role of absolute rather than comparative advantages in determining cross-country FDI volumes.

To take the theory to the data, I first assemble a new data set on bilateral FDI that includes OECD and non-OECD countries, as well as several measures of FDI and international production. The availability of several bilateral FDI measures allows me to accurately construct the sample of country-pairs with no FDI. I then use the theory to derive an estimation procedure that includes both information on country-pairs with zero as well as positive FDI, and corrects for biases present if linear methods were used.

From preliminary estimates, it turns out that bilateral distance remains the most important impediment to FDI: country-pairs twice as far face a 45% higher cost of FDI than otherwise. This estimate translates into a 43% lower share of sales of affiliates from country j on income of country i. Unexpectedly, policy variables such as tax treaties or bilateral corporate tax rates have very small effects on the costs of FDI.

Finally, I explore welfare gains of moving to autarky, and removing *bilateral* barriers to FDI, world-wide and for selected economies. Even though there would be much to loose if each country reverted to autarchy (a world average drop in real income of more than 50%), there would be large unrealized gains of removing *bilateral* barriers to FDI, and lowering them to a uniform level across firms of any origin (more than 60% increase in real income). Conversely, if the United States closed to FDI, losses would be rather small, even for Mexico, while Canada would experience large gains in real income. Additionally, preliminary results suggest that if the EU further liberalized FDI among its members, it would experience an increase in real income of around 30%, while further liberalizing FDI within NAFTA members would increase real income in the United States and Canada by 10%, with ambiguous effects on Mexico.

Indeed, a theory with both FDI and trade in goods is desiderable. In particular, this paper presents a benchmark for thinking about the determinants/impediments of cross-country FDI, using a structural model that can be easily to be taken to the data. In fact, it might be a useful point of departure for further analysis on the interaction between both international flows and their different determinants/impediments, aimed to address questions such as: how are trade and FDI related; are these flows substitute or complement; is there substantial trade when there is no FDI; how comparative and absolute advantages interact when both flows are combined; how do policies that liberalize and/or restraint one of these flows affect the other.

The challenge for future research is twofold: (i) building a theoretical model that incorporates both FDI and trade flows, and delivers a positive aggregate correlation between both flows, as preliminary empirical evidence suggests; and (ii) designing an empirical strategy able to deal with the potential simultaneity problem arising from the fact that FDI might enhance trade in goods, and viceversa[24].

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[24] The empirical evidence shown in Table 1 suggests that foreign affiliates are an important channel for international trade: they exports represent one third of world exports; this figure goes up to two third if international shipments from parents companies are also considered. Therefore, it seems that multinational firms play a key role in spreading international trade and its potential benefits.

Moreover, the presence of an FDI relationship from country j to i seems to have a positive and significant impact on the probability of positive trade between the same country-pair; the unconditional correlation between the two dummies is 0.305, for the period 1985-2003.

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APPENDIX 1. THE EFFECTS OF FDI IN THE HOST ECONOMY

The equilibrium presented in this paper can be interpreted as a long-run equilibrium in which plants disappear at the exogenous rate δ, and there is new entry such that the size of the industry is constant (i.e. $n_{ij}(x) = \delta m_{ij}(x)$), future is discounted at the rate ρ equal to the world interest rate, r. Hence, future flows of profits are discounted at the constant rate $(1-\delta)/(1+r)$.

I further assume that additionally to variable labor costs, a plant in country i bears a per-period fixed cost of production f_i. Let t_{ij} be modified to take into account this extra fixed cost:

$$t_{ij} \equiv F_{ij} + \frac{1-\delta}{r+\delta} f_i$$

where F_{ij} is the entry cost for a plant from country j in i.

In this appendix, I analyze the transition between a closed and open long-run equilibrium, for a small economy that opens up to FDI. I describe the industry "shake out" in the host economy when foreign plants enter: prices drop, relatively less productive domestic plants exit, and are replaced by more productive foreign plants, but, at the same time, new and incumbent domestic plants become on average more productive. In this way, the model matches some widely documented facts about foreign plants, namely that they are larger and more productive than domestic plants, and even if they represent a small fraction of the total number of plants in the host industry, they have a large share in the value of production[25].

I assume that the rest of the world is in its long-run open equilibrium. Interest rate is given for the small economy, and fixed over time.

A.1.1. Transition equilibrium

The main feature in which the transition differs from the long run is that, in some sectors, new foreign plants coexist with old incumbent domestic plants. In fact, by virtue

[25] In Ramondo (2004), I used plant-level data from the Chilean manufacturing sector to document some salient facts about foreign plants, and found evidence supporting the model's implications.

of the decreasing returns to scale technology, some incumbent domestic plants are able to survive at a smaller scale; they are productive enough to cover the per period fixed costs of production and break-even. However, productivity of domestic plants in those sectors is not high enough for *new* domestic plants to enter the industry. Consequently, since plants die at the rate δ, and there is only foreign entry, in the long run, these sectors end up having only foreign plants. Simultaneously, during the transition, some other sectors host exclusively domestic plants, and others exclusively foreign plants. In this latter sector, foreign plants are so productive and able to charge such a low price, that incumbent domestic plants must exit; they are not able to cover the fixed cost of production and break-even at any scale.

Let superscripts d, f and fd, denote domestic, foreign and "mixed" sectors, respectively. Variables that change over time have the subscript t.

The problem of a new firm is analogous to the one in equation (16), corresponding to the long run equilibrium (see next subsection):

$$\frac{1-\delta}{r+\delta}[\pi_{ij}(x) - f_i] \geq F_{ij} \tag{35}$$

As long as the vector of productivity draws and the interest rate are fixed over time, so do prices and profits. New domestic plants break-even at the price given in equation (18) rewritten as:

$$p_{ii}^N(x) = \gamma_0 w_i^\alpha t_{ii}^{1-\alpha} x_i^\theta \tag{36}$$

The problem for an incumbent domestic plant is whether to stay or exit the industry. As long as current profits are large enough to cover the fixed cost of production, it stays:

$$\pi_{ii}(x) \geq f_i \tag{37}$$

By setting (37) to equality, and replacing $\pi_{ii}(x)$ by equation (17), the price at which an incumbent domestic plant breaks-even is:

$$p_{ii}^I(x) = \gamma_0 w_i^\alpha (\frac{1-\delta}{r+\delta} f_i)^{1-\alpha} x_i^\theta, \tag{38}$$

where $p_{ii}^N(x) > p_{ii}^I(x)$. Consumers buy from the cheapest producer, so that plants able to charge the lowest price get the market. The relationship between $p_{ii}^I(x)$ and $p_{ij}^N(x)$, for

$j \neq i$, determines which goods are produced by only foreign plants, only domestic plants, and both.

i) Goods produced exclusively by foreign plants. Let B_{ij}^f be the set of goods in country i produced by exclusively plants from country j. Plants from country j have a productivity draw such that $p_{ij}^N(x) < p_{ii}^I(x)$, $j \neq i$, and $p_{ij}^N(x) < p_{ik}^N(x)$, for all $k \neq j$. In terms of productivity draws, B_{ij}^f is defined by:

$$B_{ij}^f = \{x \in \Theta : x_j < (\frac{1-\delta}{r+\delta}\frac{f_i}{t_{ij}})^{\frac{1-\alpha}{\theta}} x_i \text{ and } x_j < (\frac{t_{ik}}{t_{ij}})^{\frac{1-\alpha}{\theta}} x_k,\ \forall k \neq j\}$$

Additionally, the support condition in order to have B_{ij}^f non-empty is:

$$\underline{x} < \bar{x} \min[(\frac{1-\delta}{r+\delta}\frac{f_i}{t_{ij}})^{\frac{1-\alpha}{\theta}}; (\frac{t_{ik}}{t_{ij}})^{\frac{1-\alpha}{\theta}}]$$

for all $k \neq j$.

ii) Goods produced exclusively by domestic plants. Let B_i^d be the set of goods in country i produced by exclusively plants from country i. Domestic plants have a productivity draw such that $p_{ii}^N(x) < p_{ik}^N(x)$, for all $k \neq i$. In terms of productivity draws, B_i^d is defined by:

$$B_i^d = \{x \in \Theta : x_i < (\frac{t_{ik}}{t_{ii}})^{\frac{1-\alpha}{\theta}} x_k\}$$

where B_i^d is always non-empty.

iii) Goods produced by both foreign and domestic plants. Let B_{ij}^{fd} be the set of goods in country i produced by both plants from country j and i. The relationship between productivity draws are such that $p_{ii}^I(x) < p_{ij}^N(x) < p_{ik}^N(x)$, for all $k \neq j$, and $j \neq i$. In terms of productivity draws, B_{ij}^{fd} is defined by:

$$B_{ij}^{fd} = \{x \in \Theta : (\frac{1-\delta}{r+\delta}\frac{f_i}{t_{ij}})^{\frac{1-\alpha}{\theta}} x_i < x_j < (\frac{t_{ik}}{t_{ij}})^{\frac{1-\alpha}{\theta}} x_k\}$$

The support condition is:

$$\underline{x} < (\frac{t_{ik}}{t_{ij}})^{\frac{1-\alpha}{\theta}} \bar{x}$$

for all $k \neq j$.

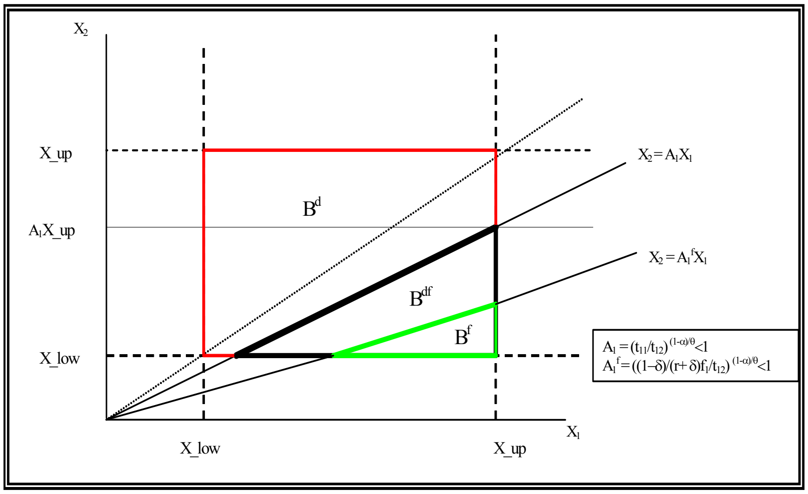

Figure 3: Transition equilibrium for country 1

Figure 3 presents a two-country world example. The productivity space is partitioned according to which type of plants carries production of good x in country 1; goods with "extreme" draws are produced by either plants from country 1 or 2 exclusively -i.e., the sets B^d and B^f, respectively; goods with "balanced" draws are produced by plants from both countries, i.e. the set B^{fd}.

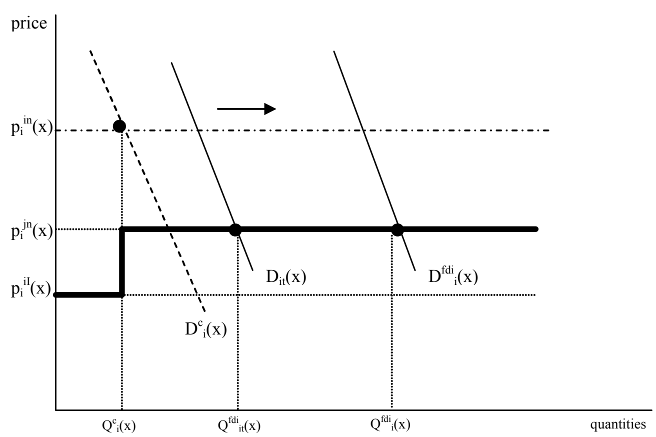

Figure 4: Equilibrium for good $x \in B_{ij}^{fd}$

Remark. Goods in the set B_{ij}^{fd} have a step supply curve (see Figure 4): the price $p_{ii}^{I}(x)$ prevails till the stock of shrinking inherited domestic plants is hit; then on, the price set by new foreign plants, $p_{ij}^{N}(x)$, is the relevant one. For the small economy, I conjecture that the equilibrium for good $x \in B_{ij}^{fd}$ is in the upper step of the supply curve, meaning that, at least, the demand for good x is as large as the one for the closed economy, for all $t > t_0$.

Even though prices do not change along the transition path, *aggregate* quantities do as the economy becomes wealthier, demand increases, and more plants enter the industry. The mass of plants producing goods in either B_{ij}^{f} or B_{i}^{d}, are pinned down from the market equilibrium condition, $\mu(p_i(x)/P_i)^{1-\eta}Y_i(t) = p_i(x)q_{ij}(x)m_{it}^{j}(x)$, where $q_{ij}(x)$ is individual output for a plant from country j operating in country i, and $m_{ijt}(x)$ is the mass of plants from country j operating in country i at time t , that evolves according to:

$$m_{ij,t+1}(x) = (1-\delta)m_{ij,t}(x) + n_{ij,t}(x).$$

The mass of foreign and domestic plants for $x \in B_{ij}^{fd}$ evolves, respectively:

$$m_{ij,t+1}(x) = (1-\delta)m_{ij,t}(x) + n_{ij,t}(x)$$

$$m_{i,t+1}^{ij}(x) = (1-\delta)m_{i,t}^{ij}(x)$$

where $m_{i,t}^{ij}(x)$ is the mass of plants from country i sharing production with plants from j, in country i, at time t. Note that the number of domestic plants is related to the number of plants in the closed economy. In particular, $m_{i,t}^{ij}(x) = (1-\delta)^{t-t_0}m_i^c(x)$, where t_0 is the period in which the economy opens to foreign plants. The mass of foreign plants $m_{ij,t}(x)$ is pinned down from the market clearing condition, $\mu(p_i(x)/P_i)^{1-\eta}Y_i(t) = p_i(x)[q_{ij}(x)m_{ij,t}(x)$ $+q_i^{ij}(x)m_{i,t}^{ij}(x)]$.

The recursive problem of a firm.—

I show that the recursive problem of a firm boils down into the problem in equation (35) for new plants, and equation (37) for incumbent plants. The value of opening a plant in country i for a potential producer from country j is:

$$V_{ij}(x, M_i) = \max[0, -F_{ij} + \frac{1-\delta}{1+r} W_{ij}(x, M_i')]$$

for all i, j. If the value of opening a new plant is non-negative, the producer pays the fixed cost F_{ij}, and start production next period, with a survival probability of $1 - \delta$. The vector $M_i = \{m_{ij}\}_{i,j}$ represents the state of the economy, given by the mass of foreign and domestic plants in country i. In equilibrium, the present value of opening a plant is equal to its cost, so that:

$$W_{ij}(x, M_i') = \frac{1+r}{1-\delta} F_{ij}; \tag{39}$$

$W_{ij}(x, M_i')$ is strictly positive in equilibrium. The value of an incumbent plant from country j operating in i is given by:

$$W_{ij}(x, M_i) = \max[0, \pi_{ij}(x, M_i) - f_i + \frac{1-\delta}{1+r} W_{ij}(x, M_i')] \tag{40}$$

for all i, j. Replacing $W_{ij}(x, M_i)$ by (39) yields:

$$\pi_{ij}(x, M_i) - f_i = \frac{r+\delta}{1-\delta} F_{ij}, \tag{41}$$

that is condition (35). Clearly, from (41), profits are constant over time.

A.1.2. Effects of foreign plants in the host economy

The arrival of foreign plants to a host economy affects its performance in various ways. The entry of more productive plants that displace less productive plants endogenously increases aggregate productivity in the host economy. With the entry of these more productive plants, competition gets tighter, and consequently, also domestic plants, new and incumbent, become more productive.

The model reproduces some stylized facts about foreign plants in a host economy, widely documented by the empirical literature on FDI. In particular, the model predicts that not only foreign plants are larger and more productive than domestic plants, they also contribute significantly to the value of production, in spite of being a very small fraction of the total number of plants. In Ramondo (2004), I exhaustively document these facts for the Chilean manufacturing sector, using plant-level data.

Assumption 1'. $F_{ij} > F_{ii}$, for all $j \neq i$

Proposition 2 *(foreign plants size advantage). Under Assumption 1', foreign plants are on average larger, in terms of sales and employment, than domestic plants.*

Proposition 3 *(foreign plants productivity advantage). Assume $\lambda_i = \lambda$, $\underline{x} = 0$ and $\bar{x} \to \infty$, for all i. Under Assumption 1', plants from country j have a productivity advantage with respect to plants from country i, in country i.*

Proposition 4 *Assume $\underline{x} = 0$ and $\bar{x} \to \infty$, for all i. the productivity distribution for domestic plants in the open economy first order stochastic dominates the one for the closed economy.*

Since domestic entry occurs in the set B_{ii}, *new* domestic plants are more productive in the open than in the closed economy. Exit of domestic plants occurs in the sets B_{ij}, meaning that foreign plants enter sectors in which domestic plants had relatively low productivity, relatively fewer plants, and higher prices.

Proposition 5 *Under Assumption 1', the share of foreign plants in the value of production is higher than the share in the total number of plants.*

Proposition 6 *For $x \in B_{ij}^{fd}$, a foreign plant has a size advantage over a domestic plant.*

Proposition 7 *For $x \in B_{ij}^{fd}$, a domestic plants shrinks with foreign entry.*

APPENDIX 2. PROOFS OF PROPOSITIONS

Proof of Proposition 1. Let P_i^{fdi} be given by (34), and rewritten as:

$$(P_i^{fdi})^{1-\eta} = (\gamma_0 w_i^{\alpha})^{1-\eta} \sum_j \int_{\omega \in \Omega_{ij}} [t_{ij}^{\frac{1-\alpha}{\theta}} x_j(\omega)]^{\theta(1-\eta)} d\omega \tag{42}$$

where

$$\Omega_{ij} = \{\omega \in [0,1] : x_j(\omega) < (\frac{t_{ik}}{t_{ij}})^{\frac{1-\alpha}{\theta}} x_i(\omega),\ \text{for } j \neq k\}, \tag{43}$$

and it might be empty for some j. Let P_i^c be given by equation (15), and rewritten as:

$$(P_i^c)^{1-\eta} = (\gamma_0 w_i^{\alpha})^{1-\eta} \int_{\omega\in[0,1]} [t_{ii}^{\frac{1-\alpha}{\theta}} x_i(\omega)]^{\theta(1-\eta)} d\omega \tag{44}$$

Under Assumption 1, from (43), $x_i(\omega) t_{ii}^{\frac{1-\alpha}{\theta}} > x_j(\omega) t_{ij}^{\frac{1-\alpha}{\theta}}$. Comparing (42) and (44) for each ω, it follows that $P_i^{fdi} < P_i^c$.■

Proof of Proposition 2. Sales and employment are given respectively by:

$$p_{ij}(x) q_{ij}(x) = \frac{r+\delta}{(1-\alpha)(1-\delta)} t_{ij} \tag{45}$$

$$s_{ij}(x) = \frac{r+\delta}{1-\delta} \frac{\alpha}{1-\alpha} \frac{t_{ij}}{w_i} \tag{46}$$

Under Assumption 1', $p_{ij}(x) q_{ij}(x) > p_{ii}(x) q_{ii}(x)$ and $s_{ij}(x) > s_{ii}(x)$.■

Proof of Proposition 3. Plants from country j that operate in country i have its productivity draw belonging to the set $B_{ij} = \{x \in \Theta : x_j < (t_{ik}/t_{ij})^{\frac{1-\alpha}{\theta}} x_k \text{ for all } k \neq j\}$. Then, the cumulative distribution function for x_j in country i is given by:

$$G_i(x_j) = 1 - e^{-(\sum_k \lambda (\frac{t_{ij}}{t_{ik}})^{\frac{1-\alpha}{\theta}} x_j} \tag{47}$$

Average productivity for plants from country j is given by:

$$\int_0^{\infty} x_j^{\theta(1-\eta)} g_i(x_j) dx_j = \frac{\lambda \Gamma(\xi)}{[\sum_k \lambda (t_{ij}/t_{ik})^{\frac{1-\alpha}{\theta}}]^{\theta(1-\eta)}} \tag{48}$$

where $g_i(x_j) = \partial G_i(x_j)/\partial x_j$, and $\Gamma(\xi)$ is the Gamma function evaluated at $\xi = 1+\theta(1-\eta)$. For plants from country i, average productivity is:

$$\int_0^{\infty} x_i^{\theta(1-\eta)} g_i(x_i) dx_i = \frac{\lambda \Gamma(\xi)}{[\sum_k \lambda (t_{ii}/t_{ik})^{\frac{1-\alpha}{\theta}}]^{\theta(1-\eta)}} \tag{49}$$

where $g_i(x_i) = \partial G_i(x_i)/\partial x_i$. Under Assumption 1', $(t_{ii}/t_{ik}) < 1$. Comparing (48) and (49), yields the following inequality: $(\sum_k (t_{ik}/t_{ii})^{\frac{1-\alpha}{\theta}})^{\theta(1-\eta)} < (\sum_k (t_{ik}/t_{ij})^{\frac{1-\alpha}{\theta}})^{\theta(1-\eta)}$. Then, foreign plants from country j are on average more productive than plants from i.■

Proof of Proposition 4. Domestic plants in the open economy have productivity belonging to the set $B_{ii} = \{x \in R^n_+ : x_i < (t_{ik}/t_{ii})^{\frac{1-\alpha}{\theta}} x_k \text{ for all } k\}$. Then, the cumulative distribution function for x_i is:

$$G_i^{fdi}(x_i) = 1 - e^{-(\sum_k \lambda_k (t_{ii}/t_{ik})^{\frac{1-\alpha}{\theta}})x_i} \tag{50}$$

For the closed economy, that distribution is:

$$G_i^c(x_i) = 1 - e^{-\lambda_i x_i} \tag{51}$$

Comparing (50) and (51), it is clear that $G_i^{fdi}(x_i) > G_i^c(x_i)$ for all x_i, i.e., $G_i^c(x_i)$ first order stochastic dominates $G_i^{fdi}(x_i)$.■

Proof of Proposition 5. Summing across j in (24), and dividing by total sales yields the share of foreign plants in the total value of production:

$$\frac{\sum_{j \neq i} X_{ij}}{X_i} = 1 - \frac{\lambda_i t_{ii}^{(1-\alpha)(1-\eta)-1} \Gamma_{ii}}{\sum_j \lambda_j t_{ij}^{(1-\alpha)(1-\eta)-1} \Gamma_{ij} (t_{ij}/t_{ii})} \tag{52}$$

where ς_{ii} is the effective market share of domestic plants in country i, given by (**??**).The share of foreign plants in the total number of plants is given by:

$$\frac{\sum_{j \neq i} m_{ij}}{M_i} = \frac{\sum_{j \neq i} \varsigma_{ij}/t_{ij}}{\sum_j \varsigma_{ij}/t_{ij}} = 1 - \frac{\lambda_i t_{ii}^{(1-\alpha)(1-\eta)-1} \Gamma_{ii}}{\sum_j \lambda_j t_{ij}^{(1-\alpha)(1-\eta)-1} \Gamma_{ij}} \tag{53}$$

Comparing (53) and (52), since $t_{ii} < t_{ij}$, yields the following inequality

$$\frac{1}{\sum_j \lambda_j t_{ij}^{(1-\alpha)(1-\eta)-1} \Gamma_{ij} t_{ij}/t_{ii}} < \frac{1}{\sum_j \lambda_j t_{ij}^{(1-\alpha)(1-\eta)-1} \Gamma_{ij}}$$

Then, it follows that the expression in (**??**) is always higher than the one in (53).■

Proof of Proposition 6. Sales and employment for domestic plants are, respectively:

$$sales_{ij}^d = sales_{ij}^f (\frac{x_j}{x_i})^{\frac{\theta}{1-\alpha}} \tag{54}$$

$$emp_{ij}^d = emp_{ij}^f (\frac{x_j}{x_i})^{\frac{\theta}{1-\alpha}} \tag{55}$$

where $sales^f_{ij}$ and emp^f_{ij} are sales and employment for a foreign plant from country j in country i, given by (45) and (46), respectively. In the set B^{fd}_{ij}, the relationship between productivity draws for countries j and i is $x_j < (t_{ii}/t_{ij})^{\frac{1}{\theta}} x_i$. Since $(t_{ii}/t_{ij})^{\frac{1}{\theta}} < 1$, it follows that $x_j < x_i$. Then, $sales^d_{ij} < sales^f_{ij}$, and $emp^d_{ij} < emp^f_{ij}$.■

Proof of Proposition 7. Comparing individual sales and employment for plants from country i producing $x \in B^{fd}_{ij}$, in the closed and open economy, yields:

$$\frac{sales^{fdi}_{ij}}{sales^c_{ij}} = \frac{emp^{fdi}_{ij}}{emp^c_{ij}} = (\frac{t_{ij}}{t_{ii}})^{1-\alpha}(\frac{x_j}{x_i})^{\frac{\theta}{1-\alpha}}$$

Under Assumption 1' ($t_{ii} < t_{ij}$), the first term inside the brackets is more than one. By definition of the set B^{fd}_{ij}, it follows that $(x_j/x_i)^{\frac{\theta}{1-\alpha}} > (t_{ij}/t_{ii})$. It follows that

$$(\frac{t_{ij}}{t_{ii}})^{1-\alpha}(\frac{x_j}{x_i})^{\frac{\theta}{1-\alpha}} > (\frac{t_{ii}}{t_{ij}})^{\frac{(2-\alpha)\alpha}{1-\alpha}} > 1.$$

Then, sales and employment are lower for the open than for the closed economy.■

APPENDIX 3. DATA

The procedure to estimate barriers to FDI requires data from several sources. In particular, I need accurate data on bilateral FDI, measures of observable bilateral barriers to FDI, and data on GNP and GDP of trading partners.

Table A.3.1 summarizes data sources for each variable; table A.3.2 lists the countries in the sample; and tables A.3.3 and A.3.4 present descriptive statistics.

Bilateral FDI data.—

Contrary to international trade data, there is no systematic data base for bilateral measures of FDI. I assemble a bilateral data set that includes six different measures of FDI, using as main sources UNCTAD and OECD[26]. These organisms have data on FDI flows and stocks from country j to i as measured in the Balance of Payment of a country, and variables related to the activity of foreign affiliates from country j in i (sales, number of

[26] As basic data source, I use published and unpublished UNCTAD, and complete with OECD's International Direct Investment, and Globalization databases

plants, employment, and assets). For the first two variables, there are 109 countries that are information source, for the period 1985-2003. Data related to the activity of foreign affiliates are much more scarce. The sample of countries that are source of information drops to no more than 65, and the number of years for which data is available also shrinks. I hence restrict the analysis to the period 1990-2002. I end up with a sample of 147 (150) countries observed in the sample (at least once) as source (host) countries, for at least one of the measures of FDI

Likewise import and export data, most of the countries record both outward and inward FDI. Thus, I first consider inward magnitudes reported by a given country, and complete missing values with outward magnitudes reported by a partner countries.

Unfortunately, bilateral FDI data are available at the aggregate level, not sector or product level.

The definition of FDI flows and stocks follows the definitions from the IMF Manual of Balance of Payment Statistics. The concept of FDI flows includes capital flows for: (i) acquiring or sell existing firms, (ii) establishing a new firm, (iii) new investments as long as funds come from the parent company or other affiliates, (iv) reinvested earnings, and (v) any debt with the parent company or other affiliates, as long as the foreign resident owns more than 10% of the firm. FDI stocks are the result of accumulating FDI flows. These two variables are comparable across countries[27].

A foreign affiliate is defined as a plant who has more than 10% of its shares owned by a foreigner. For these plants, I record sales, assets, employment and number of affiliates owned by country j in i. Data on the activity of foreign affiliates are more prone to have some comparability problems. Specifically, while some countries report these variables for only majority-owned affiliates, others do so for all affiliates with more than 10% of foreign capital[28]. Nonetheless, majority-owned affiliates are the largest part of the total number of foreign plants in a host economy. In terms of sector coverage, data mostly refer to non-financial affiliates in all sectors. However, some countries report data only on foreign

[27] In general, some countries don't include (v) in the definition of FDI flows and stocks.

[28] Affiliates in which a foreigner owns more than 50% of the firm.

affiliates in manufacturing. These countries are marked in red in Table A.3.2.

Data on countries' GDP and GNP are from the World Development Indicators, and International Financial Indicators (IMF). These are nominal values, converted to US dollars, and they are not on purchasing power parity basis.

Bilateral barriers data.—

As observable measures for bilateral barriers to FDI, I include the following variables: bilateral distance between trading partners, common border, common language, and common colonial past (ever in a colonial relationship). I also include a dummy variable for country-pairs that have signed a double taxation treaty by virtue of which affiliates of multinational firms have their tax rate in the host country reduced. Variables related to geography, language, and colonial ties, are compiled by the *"Centre d'etudes prospectives et informations internationales (CEPII)"*[29]. Bilateral distance is the distance in kilometers between the largest cities of the two countries. Common language is a dummy equal to one if both countries have the same official language or more than 20% of the population share the same language even if it is not the official one. Common border is equal to one if two countries share a border. Colonial ties is equal to one if the two countries had ever been in a colonial relationship. The list of countries that signed a bilateral double taxation treaty is compiled by UNCTAD. This variables is equal to one if the countries have signed a bilateral treaty, and zero otherwise.

Bilateral corporate tax rates are computed from tax rates applied to foreign corporations in country i, corrected by the preferential rate stipulated in the bilateral double taxation treaty, if there were one. A country j that has signed a double taxation treaty with country i, but no data is available on bilateral tax rates, is assigned the average bilateral tax rate in country i. Country pairs without a treaty and missing values for bilateral tax rates are assumed to be subject to the corporate tax rate in the host country.

[29] See the following link for documentation: www.cepii.fr/anglaisgraph/bdd/distance.htm

Table A.3.1
Data Sources

Variables:	Sources:
Bilateral FDI measures:	
Stocks and Flows	*FDI database for individual countries (UNCTAD), unpuplished data* *International Direct Investment Database (OECD)*
Sales, number, employment and assets of affiliates	*FDI database for individual countries (UNCTAD), unpublished data* *Globalisation Database (OECD)*
Gross National Product (in current U$)	*World Development Indicators, WB* *International Financial Statistics, IMF*
Population	*World Development Indicators, WB*
Bilateral Barriers' Measures:	
Distance **Common Language** **Common Border** **Colonial Ties***	*Centre d'etudes prospectives et informations internationales (CEPII)* *(www.cepii.fr/anglaisgraph/bdd/distance.htm)*
Bilateral Double Taxation Treaties	*UNCTAD*
Bilateral Corporate Taxes	*World Tax Database from U. of Michigan and* www.taxanalysts.com

Table A.3.2
List of countries, by observed source/host status, and data availability

Country	Observed as:		Data source for:				
	source	host	flows/stocks of FDI	sales	assets	employment	number of plants
Afghanistan	X	X					
Albania	X	X					
Algeria	X	X	X	X	X	X	X
Angola	X	X	X	X	X	X	X
Argentina	X	X	X	X	X	X	X
Armenia	X	X	X	X		X	X
Australia	X	X	X			X	
Austria	X	X	X				X
Azerbaijan	X	X	X				
Bangladesh	X	X	X				
Belarus	X	X					
Belgium	X	X	X				
Belgium/Luxembourg	X	X	X				
Benin	X	X	X				
Bolivia	X	X	X	X	X	X	X
Bostwana	X		X	X	X	X	X
Bosnia and Herzegovina	X	X					
Brazil	X	X	X	X	X	X	X
Bulgaria	X	X	X				
Burkina Faso	X	X	X	X	X		X
Burundi	X	X	X				
Cambodia	X	X	X				X
Cameroon	X	X	X	X	X	X	X
Canada	X	X	X	X	X	X	
Central African Republic	X	X	X	X	X		
Chad	X	X	X				
Chile	X	X	X	X	X	X	X
China	X	X	X				
Colombia	X	X	X	X	X	X	X
Congo, Republic of	X	X					
Costa Rica	X	X	X	X	X	X	X
Cote d'Ivoire	X	X					
Croatia	X	X	X				
Cuba	X	X	X		X	X	X
Czech Republic	X	X	X	X		X	
Dem. People's Rep. of Korea	X	X					
Denmark	X	X	X	X		X	X
Dominican Republic	X	X	X	X	X	X	X
Ecuador	X	X	X	X	X	X	X
Egypt	X	X					
El Salvador	X	X	X	X	X	X	X
Estonia	X	X	X				
Ethiopia	X	X	X				
Finland	X	X	X	X	X	X	X
France	X	X	X	X		X	
Gabon	X	X					
Gambia	X	X	X				
Georgia	X	X	X				
Germany	X	X	X	X	X	X	X
Ghana	X	X					
Greece	X	X	X				
Guatemala	X	X	X	X	X	X	X
Guinea	X	X					

Country	Observed as:		Data source for:				
	source	host	flows/stocks of FDI	sales	assets	employment	number of plants
Guinea-Bissau	X						
Haiti	X	X	X	X	X	X	X
Honduras	X	X	X	X	X	X	X
Hong Kong (China)	X	X	X				X
Hungary	X	X	X				
India	X	X	X	X			X
Indonesia	X	X	X				
Iran	X	X					
Iraq	X	X					
Ireland	X	X	X	X		X	X
Israel	X	X					
Italy	X	X	X	X		X	X
Jamaica	X	X	X	X	X	X	X
Japan	X	X	X	X	X	X	X
Jordan	X	X					
Kazakhstan	X	X	X				
Kenya	X	X					
Korea	X	X	X				
Kuwait	X	X					
Kyrgyzstan	X	X	X				
Laos	X	X					
Latvia	X	X	X				
Lebanon	X	X					
Lesotho	X	X					
Liberia	X	X					
Libya	X	X					
Lithuania	X	X	X				
Madagascar	X	X					
Malawi	X	X	X	X	X	X	X
Malaysia	X	X	X				
Mali	X	X	X	X	X	X	X
Mauritania	X	X					
Mauritius	X	X	X				
Mexico	X	X	X	X	X	X	X
Moldova	X	X	X				
Mongolia		X	X				
Morocco	X	X	X	X	X	X	X
Mozambique	X	X					
Myanmar		X	X				X
Namibia	X	X					
Nepal	X	X					
Netherlands	X	X	X	X	X	X	X
New Zealand	X	X	X				
Nicaragua	X	X	X	X	X		X
Niger		X					
Nigeria	X	X					
Norway	X	X	X	X		X	X
Oman	X	X					
Pakistan	X	X	X				
Panama	X	X	X	X	X	X	X
Papua New Guinea	X	X	X				
Paraguay	X	X	X	X	X	X	X
Peru	X	X	X	X	X	X	X
Philippines	X	X	X				
Poland	X	X	X	X	X	X	X

Country	Observed as:		Data source for:				
	source	host	flows/stocks of FDI	sales	assets	employment	number of plants
Portugal	X	X	X	X		X	X
Puerto Rico	X	X					
Romania	X	X					
Russia	X	X	X				
Rwanda	X	X	X		X		
Saudi Arabia	X	X					
Senegal	X	X					
Serbia and Montenegro	X	X					
Sierra Leone	X	X	X				
Singapore	X	X	X				
Slovak Republic	X	X	X				
Slovenia	X	X	X				X
Somalia	X	X	X		X	X	
South Africa	X	X	X				
Spain	X	X	X	X		X	
Sri Lanka	X	X	X				
Sudan	X	X					
Suriname	X	X	X	X	X	X	X
Sweden	X	X	X	X	X	X	X
Switzerland	X	X	X			X	
Syria	X	X					
TFYR Macedonia	X	X	X				
Taiwan	X	X	X				
Tajikistan	X	X					
Tanzania		X	X				X
Thailand	X	X	X				
Togo		X					
Trinidad and Tobago	X	X	X	X	X	X	X
Tunisia	X	X	X				
Turkey	X	X	X	X		X	
Turkmenistan	X	X					
Uganda	X	X	X	X	X	X	X
Ukraine	X	X					
United Arab Emirates	X	X					
United Kingdom	X	X	X	X		X	X
United States	X	X	X	X	X	X	X
Uruguay	X	X		X	X	X	X
Uzbekistan	X	X	X	X		X	X
Venezuela	X	X	X	X	X	X	X
Vietnam	X	X	X				
Yemen	X	X					
Zambia	X	X	X	X	X	X	X
Zimbabwe	X	X	X	X	X	X	X
Zaire	X	X					

(X) : Source OECD, Globalisation data set. Includes only manufacturing sector

Table A.3.3
Descriptive statistics for bilateral FDI measures

	All possible country pairs *	Country-pairs with $X^j_i > 0$ and $X^i_j > 0$
FDI stocks	**0.0011**	**0.008**
	[0.012]	[0.03]
	22031	2984
FDI flows	**0.0002**	**0.001**
	[0.003]	[0.007]
	22241	3200
Sales of affiliates	**0.0011**	**0.025**
	[0.017]	[0.08]
	19889	842
Assets of affiliates	**0.0010**	**0.046**
	[0.019]	[0.11]
	19497	450
Number of affiliates	**0.0001**	**0.002**
	[0.0024]	[0.007]
	20028	987

* For country-pairs with zero bilateral FDI, missing values are replaced by zeros
X_i^j = FDI from country j to country i
Observations as share of GNP of host country (X^j_i/Y_i)
Standard errors in brackets

Table A.3.4
Descriptive statistics for measures of barriers' to FDI

	Mean	Std. Dev.	Min	Max
Bilateral distance (km)	7270	4204	10	19951
% of country-pairs with common language	0.140	0.347	0	1
% of country-pairs with common border	0.024	0.154	0	1
% of country-pairs with a double taxation treaties	0.136	0.342	0	1
% of country-pairs ever in a colonial relationship	0.013	0.114	0	1
Bilateral corporate tax rates	31.3	12.12	0.5	57.3
number of observations	22650			

All possible country pairs

Table A.3.5

Traditional gravity and bilateral FDI stocks. OLS.

Dependent variable: stocks from country j in i (in log, as % of country i' s GNP)	**Country-pairs with positive FDI**			**All possible country-pairs [1,2]**		
	I	**II**	**III**	**IV**	**V**	**VI**
log of bilateral distance	**-1.185**	**-1.152**	**-1.173**	**-1.397**	**-1.057**	**-1.17**
(thousands of km)	[0.050]**	[0.050]**	[0.050]**	[0.037]**	[0.036]**	[0.036]**
1 for pairs with common official language or	**0.879**	**0.59**	**0.622**	**0.088**	**-0.015**	**-0.002**
>20% pop. same language	[0.133]**	[0.135]**	[0.136]**	[0.072]	[0.069]	[0.070]
1 for pairs with a common border	**0.724**	**0.595**	**0.604**	**0.932**	**1.016**	**1.045**
	[0.159]**	[0.158]**	[0.159]**	[0.152]**	[0.145]**	[0.148]**
1 for pairs ever in colonial relationship		**1.269**	**1.213**		**-0.062**	**0.018**
		[0.188]**	[0.188]**		[0.193]	[0.197]
1 for pairs with double taxation treaty		**0.67**			**3.727**	
		[0.095]**			[0.075]**	
bilateral corporate taxes			**-0.022**			**-0.096**
			[0.004]**			[0.002]**
Observations	**2992**	**2894**	**2894**	**21732**	**21732**	**21732**
R-squared	**0.74**	**0.75**	**0.75**	**0.49**	**0.55**	**0.52**

Notes:

Standard errors in brackets

* significant at 5%; ** significant at 1%

All specifications with constant, and source and host country fixed effects

Observations with dependent variables < 1.5

Countries with popupation over one million

(1): FDI=0 if all measures of FDI are zero or missing values

(2): for country-pairs with no FDI, stocks are replaced by one dollar

Table A.3.6

Traditional gravity and bilateral number of affiliate plants. OLS.

Dependent variable: number of affiliate plants from country j in i (in log, as % of country i' s GNP)	Country-pairs with positive FDI			All possible country-pairs [1,2]		
	I	II	III	IV	V	VI
log of bilateral distance	-0.937	-0.905	-0.905	-0.676	-0.549	-0.585
(thousands of km)	[0.058]**	[0.058]**	[0.057]**	[0.024]**	[0.024]**	[0.024]**
1 for pairs with common official language or	0.417	0.39	0.388	-0.132	-0.17	-0.165
>20% pop. same language	[0.148]**	[0.148]**	[0.148]**	[0.045]**	[0.044]**	[0.045]**
1 for pairs with a common border	0.556	0.511	0.523	0.445	0.501	0.513
	[0.176]**	[0.177]**	[0.176]**	[0.105]**	[0.102]**	[0.103]**
1 for pairs ever in colonial relationship		0.679	0.674		-0.235	-0.129
		[0.192]**	[0.191]**		[0.140]	[0.141]
1 for pairs with double taxation treaty		0.365			1.829	
		[0.115]**			[0.054]**	
bilateral corporate taxes			-0.016			-0.045
			[0.004]**			[0.002]**
Observations	1009	1009	1009	19847	19847	19847
R-squared	0.89	0.89	0.89	0.64	0.66	0.65

Notes:

Standard errors in brackets

* significant at 5%; ** significant at 1%

All specifications with constant, and source and host country fixed effects

Observations with dependent variables < 1.5

Countries with popupation over one million

(1): FDI=0 if all measures of FDI are zero or missing values

(2): for country-pairs with no FDI, number of plants is replaced by 0.001

Table A.3.7

Auxiliary parameters

Parameters	*All Countries*		*OECD countries*		*Definition*
	ρ_d	$\rho_s(\Delta^*)$	ρ_d	$\rho_s(\Delta^*)$	
a_d	-0.011	-0.003	-0.008	-0.004	*OLS coefficient on bilateral distance*
a_c	-0.0007	0.001	0.0060	0.0062	*OLS coefficient on common border*
a_l	0.0049	0.001	0.0026	0.0018	*OLS coefficient on common language*
a_{col}	0.009	0.002	0.0041	0.0021	*OLS coefficient on common colonial past*
a_{dtt}	0.001	0.000	-0.0080	0.0000	*OLS coefficient on bilateral double taxation treaty*
σ_e	0.18	0.023	0.1858	0.0384	*Standard error of error term, in OLS regression*
f_0	0.11	0.055	0.91	0.46	*fraction of country-pairs with Xji>0 and Xij>0*
f_2	0.77	0.806	0.01	0.14	*fraction of country-pairs with Xji=0 and Xij=0*
d_0	0.81	0.198	0.96	0.31	*mean distance, country-pairs with Xji>0 and Xij>0*
c_0	3.36	14.371	1.06	6.90	*fraction of country-pairs with Xji>0 and Xij>0 sharing a border*
l_0	1.02	2.951	1.03	2.97	*fraction of country-pairs with Xji>0 and Xij>0 sharing a language*
col_0	3.64	5.248	1.10	3.80	*fraction of country-pairs with Xji>0 and Xij>0 sharing past colonial ties*
dtt_0	4.88	2.323	0.98	0.95	*fraction of country-pairs with Xji>0 and Xij>0 with a double taxation treaty*
Y_0	3.94	0.823	1.06	0.88	*mean value of GNP, country-pairs with Xji>0 and Xij>0*
X_0	27.74	11.600	1.13	4.78	*mean value of sales of affiliates, country pairs with Xji>0 and Xij>0*
d_2	1.03	1.119	1.87	0.86	*mean distance, country-pairs with Xji=0 and Xij=0*
c_2	0.63	0.032	0.00	0.00	*fraction of country-pairs with Xji=0 and Xij=0 sharing a border*
l_2	1.00	0.679	0.00	0.55	*fraction of country-pairs with Xji=0 and Xij=0 sharing a language*
col_2	0.48	0.553	0.00	0.73	*fraction of country-pairs with Xji=0 and Xij=0 sharing past colonial ties*
dtt_2	0.30	0.803	2.51	1.03	*fraction of country-pairs with Xji=0 and Xij=0 with a double taxation treaty*
Y_2	0.45	1.048	0.17	1.19	*mean value of GNP, country-pairs with Xji=0 and Xij=0*
d_1	0.97	0.631	1.36	1.39	*mean distance, country-pairs with Xji>0 and Xij=0*
c_1	1.23	1.291	0.41	0.08	*fraction of country-pairs with Xji>0 and Xij=0 sharing a border*
l_1	0.95	2.086	0.70	0.82	*fraction of country-pairs with Xji>0 and Xij=0 sharing a language*
col_1	1.82	1.902	0.00	0.33	*fraction of country-pairs with Xji>0 and Xij=0 sharing past colonial ties*
dtt_1	1.98	1.617	1.09	0.99	*fraction of country-pairs with Xji>0 and Xij=0 with a double taxation treaty*
Y_1	1.92	0.791	0.35	0.83	*mean value of GNP, country-pairs with Xji>0 and Xij=0*
X_1	0.05	2.582	0.03	0.82	*mean value of sales of affiliates, country pairs with Xji>0 and Xij=0*
Y_1^s	3.32	0.680	0.43	0.71	*mean value of GNP for country i (source), country-pairs with Xji>0 and Xij=0*
Y_1^h	0.52	0.902	0.27	0.95	*mean value of GNP for country j (host), country-pairs with Xji>0 and Xij=0*

** significant at 1%; * significant at 5%

Table A.3.8

Auxiliary parameters

Parameters	All Countries		OECD countries		Definition
	ρ_d	$\rho_s(\Delta^*)$	ρ_d	$\rho_s(\Delta^*)$	
a_d	-0.01144	-0.0039	-0.0084	-0.0043	*OLS coefficient on bilateral distance*
a_c	-0.0009	0.0010	0.0062	0.0005	*OLS coefficient on common border*
a_l	0.0049	0.0010	0.0025	0.0015	*OLS coefficient on common language*
a_{col}	0.00848	0.0028	0.0047	0.0021	*OLS coefficient on common colonial past*
a_t	0.00001	-0.0001	0.0001	-0.0001	*OLS coefficient on bilateral corporate tax rate*
σ_e	0.18	0.02	0.19	0.023	*Standard error of error term, in OLS regression*
f_0	0.11	0.08	0.91	0.43	*fraction of country-pairs with Xji>0 and Xij>0*
f_2	0.77	0.78	0.01	0.13	*fraction of country-pairs with Xji=0 and Xij=0*
d_0	0.81	0.24	0.96	0.336	*mean distance, country-pairs with Xji>0 and Xij>0*
c_0	3.36	10.99	1.06	2.244	*fraction of country-pairs with Xji>0 and Xij>0 sharing a border*
l_0	1.02	2.93	1.03	1.224	*fraction of country-pairs with Xji>0 and Xij>0 sharing a language*
col_0	3.64	5.04	1.10	1.546	*fraction of country-pairs with Xji>0 and Xij>0 sharing past colonial ties*
t_0	0.54	0.83	0.98	0.858	*mean corporate tax rate, country-pairs with Xji>0 and Xij>0*
Y_0	3.94	0.81	1.06	0.685	*mean value of GNP, country-pairs with Xji>0 and Xij>0*
X_0	27.74	10.42	1.13	1.552	*mean value of sales of affiliates, country pairs with Xji>0 and Xij>0*
d_2	1.03	1.16	1.87	1.762	*mean distance, country-pairs with Xji=0 and Xij=0*
c_2	0.63	0.051	0.00	0.000	*fraction of country-pairs with Xji=0 and Xij=0 sharing a border*
l_2	1.00	0.65	0.00	0.206	*fraction of country-pairs with Xji=0 and Xij=0 sharing a language*
col_2	0.48	0.29	0.00	0.000	*fraction of country-pairs with Xji=0 and Xij=0 sharing past colonial ties*
t_2	1.09	1.04	2.51	1.425	*mean corporate tax rate, country-pairs with Xji=0 and Xij=0*
Y_2	0.45	1.06	0.17	2.233	*mean value of GNP, country-pairs with Xji=0 and Xij=0*
d_1	0.97	0.54	1.36	1.423	*mean distance, country-pairs with Xji>0 and Xij=0*
c_1	1.23	0.94	0.41	0.074	*fraction of country-pairs with Xji>0 and Xij=0 sharing a border*
l_1	0.95	1.91	0.70	1.024	*fraction of country-pairs with Xji>0 and Xij=0 sharing a language*
col_1	1.82	2.72	0.00	0.768	*fraction of country-pairs with Xji>0 and Xij=0 sharing past colonial ties*
t_1	0.84	0.87	1.09	1.010	*mean corporate tax rate, country-pairs with Xji>0 and Xij=0*
Y_1	1.92	0.79	0.35	0.930	*mean value of GNP, country-pairs with Xji>0 and Xij=0*
X_1	0.05	1.52	0.03	0.763	*mean value of sales of affiliates, country pairs with Xji>0 and Xij=0*
Y_1^s	3.32	0.98	0.43	0.854	*mean value of GNP for country i (source), country-pairs with Xji>0 and Xij=0*
Y_1^h	0.52	0.60	0.27	1.006	*mean value of GNP for country j (host), country-pairs with Xji>0 and Xij=0*