Transportation Cost and the Geography of Foreign Investment*

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Abstract

Falling transportation costs and rapid technological progress in recent decades have precipitated an explosion of cross-border flows in goods, services, investments, and ideas led by multinational firms. Extensive research has sought to understand the geographic patterns of foreign direct investment (FDI). This chapter reviews existing theories and evidence specifically addressing questions including: How is FDI distributed across space? Why does the law of gravity apply? How do the costs of transporting goods, tasks, and technologies influence firms' decisions to separate tasks geographically and locate relative to one another? We discuss a variety of theoretical mechanisms through which transport cost and other geographic friction influence FDI and present the key empirical studies and findings.

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1 Introduction

In recent decades, falling transportation costs, dismantled policy barriers, and rapid technological progress have precipitated an explosion of cross-border flows in goods, services, investments, and ideas.[1] Multinational corporations (MNCs) are a key driver of this phenomenon, engaging in increasingly complex organization decisions at home and abroad and transporting products, tasks, capital, and technology across countries. Foreign direct investment (FDI) flows as a share of GDP have more than doubled in both developed and developing nations in the past two decades, as shown in Figure 1 based on UNCTAD FDI statistics, while marked with considerable volatility especially during economic downturns.

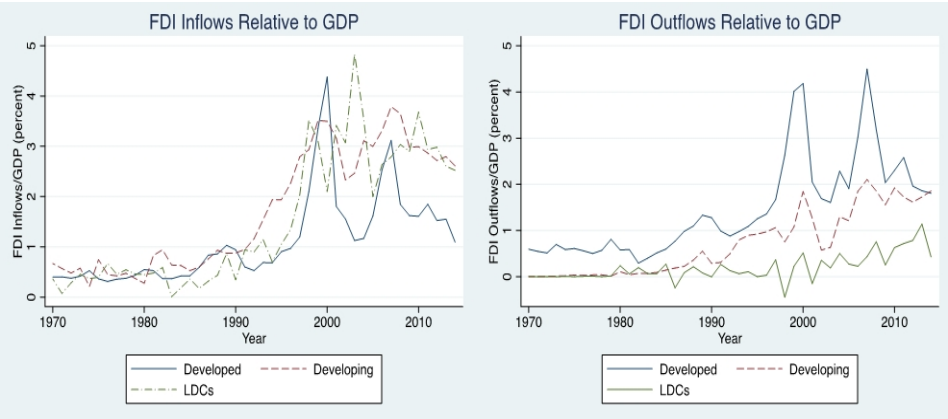

Figure 1: The growth of FDI in 1970-2014

How is FDI distributed across space? How do transportation costs affect the flow of investment which seemingly involves only a movement of capital? Does the law of gravity apply, like to the flow of goods and people? In Figure 2, we take a look at the distribution of FDI flows across distances using, respectively, U.S. FDI outflow and inflow data in 2001 and 2010 obtained from the U.S. Bureau of Economic Analysis (BEA) Direct Investment and Multinational Enterprises Data. An array of stylized facts emerge. First, about 30 percent of U.S. FDI abroad moves less than 5,000 km. More than 80 percent of U.S. outward FDI occurs over distances less than 10,000 km. These are similarly true for U.S. FDI inflows though a greater share occurs over distances between 5,000 km and 10,000 km. Second, when comparing the distance distribution of FDI flows with the distance distribution of trade shown in Head and Mayer (2013), world trade appears more concentrated at short distances: about 60 percent of trade, as opposed to 30 percent of U.S. FDI, moves less than 5,000 km. Third, when comparing the distribution in 2001

[1] An extensive literature has investigated the role of transport cost in trade; see, for example, Hummels (2007) and related chapters in this handbook. Hummels (2007) shows that air shipping costs have dropped over an order of magnitude in recent decades. As a result, airborne trade has grown rapidly and international trade has experienced a significant rise in speed.

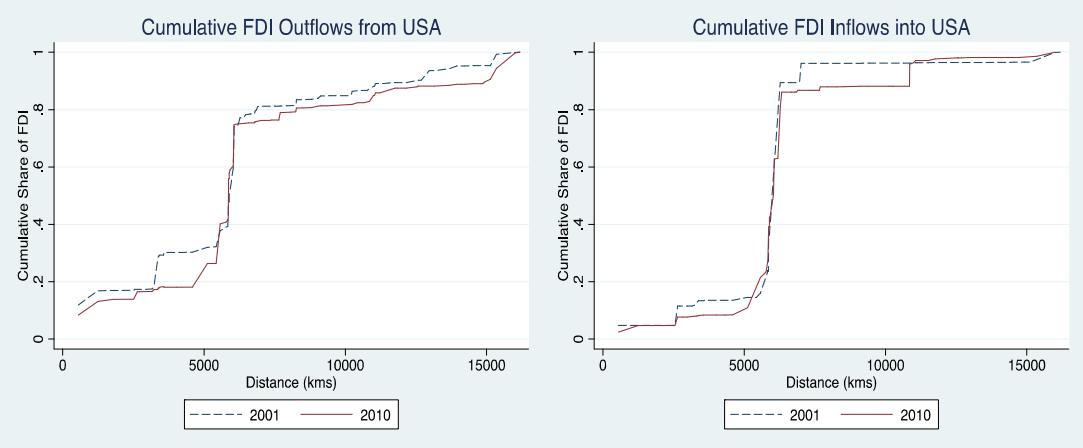

Figure 2: The distribution of FDI across distance in 2001 and 2010

with the distribution in 2010, there exists a rightward shift along the distance axis; for example, the share of U.S. outward FDI concentrated at less than 5,000 km has fallen from around 30 percent to around 20 percent. This change suggests an expansion of FDI flow across space in an era when transportation and communication costs have sharply declined.

The above observations are also reflected in Figure 3 where we regress U.S. FDI flows on the distance between the U.S. and the host country. The figure shows that the distance elasticity of U.S. FDI outflow was around -1.43 in 2001, suggesting a 10-percent increase in distance is associated with a 14.3-percent decrease in U.S. FDI outflow. This elasticity dropped to -0.8 in 2010, indicating less responsiveness to distance in FDI. U.S. FDI inflow appears to exhibit a greater distance elasticity than the outflow, though the magnitude similarly dropped from 2001 to 2010.

In this survey, we overview how transportation costs, including broadly the costs of transporting goods, services, and ideas, have shaped FDI and multinational production. As shown in a vast theoretical literature, there are a variety of distinctively different mechanisms through which transport cost and geographic friction in general could influence FDI decisions and the interaction evolves with the integration and sourcing strategies of multinational firms. First, the nature of the effect depends critically on the specific motives to invest abroad. While high transportation costs may promote the incentive to replicate production across countries (horizontal FDI), reduction in transportation costs will allow firms to better exploit cross-country cost differences and engage in vertical or complex FDI strategies where trade and FDI complement each other. Second, as FDI involves not only the flow of goods and inputs but also the flow of information, the geographic friction and the consequent gravity in FDI can be explained by an interplay between the cost of transporting physical goods and the cost of communicating ideas. Recent theories suggest that communication of ideas between headquarters and affiliates could be a substitute for trade in goods in certain situations; consequently, the role of transportation

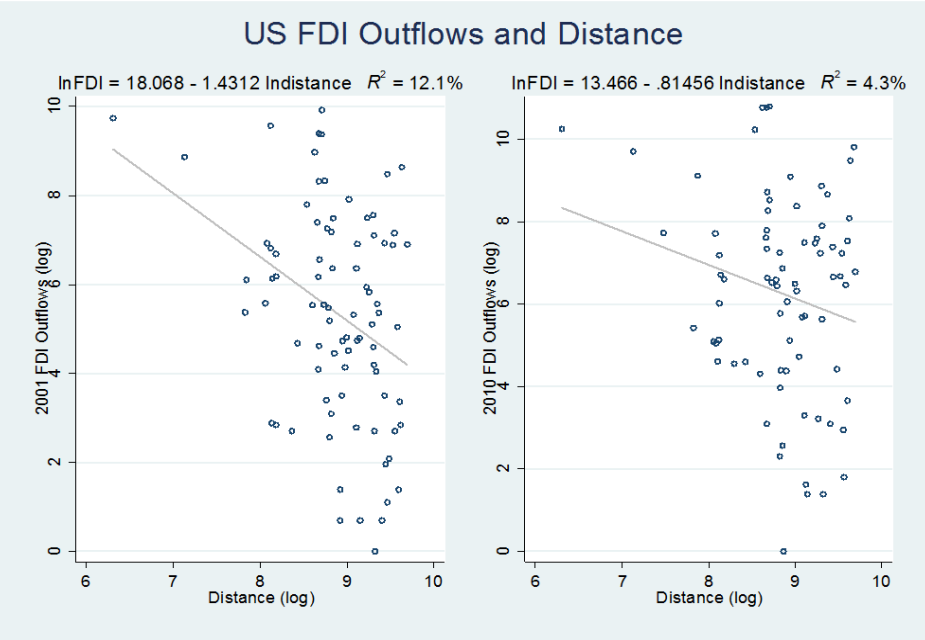

Figure 3: The correlation between U.S. outward FDI and distance in 2001 and 2010

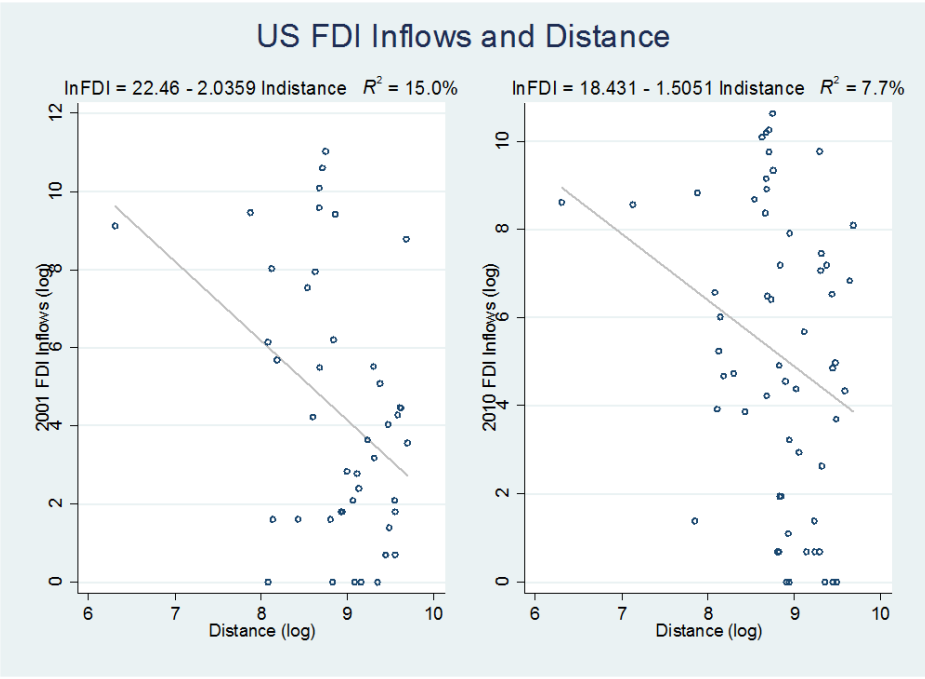

Figure 4: The correlation between U.S. inward FDI and distance in 2001 and 2010

cost in FDI could be conditional on an industry's knowledge intensity and communication complexity, and better information technology could help multinational firms mitigate the effect of transport cost and facilitate an expansion of FDI across space. Finally, the cost of transmitting goods and information affects not only firms' decisions to geographically separate production tasks but also the decisions to locate next to one another. Agglomeration economies, which stress the benefits of geographic proximity between individuals or firms in realizing product- and factor-market externalities and technology diffusion, could play a particularly important role in multinational production as multinational firms account for the majority of trade and technology flow. Compared to domestic firms, multinational corporations often incur large trade costs in sourcing their intermediate inputs and reaching downstream buyers. Reductions in transportation costs could hence be especially valuable for multinational firms as they source goods, tasks and ideas from each other. In fact, as we survey in this chapter, the emergence of new multinational clusters represents one of the most notable phenomena in the process of globalization.

A central challenge in empirically investigating these theoretical predictions is the absence of global plant-level data that tracks multinational firms' investment, trade, and technology transfer across locations around the world. Existing empirical work has exploited both macro and micro level data and novel methodologies to differentiate the motives of FDI and cast light on the complex roles of transportation cost and the various sources of gravity and geographic friction in FDI. We present the key empirical regularities that have been shown by this continually growing literature. Given the aim of the handbook, the survey intends to concentrate on transportation cost and related geographic friction in FDI and does not review the roles of other critical determinants of FDI such as product- and factor-market factors and economic policies. We refer to existing reviews (including, most recently, Antras and Yeaple, 2014) for a thorough discussion on the decisions, structure and effects of multinational production.[2]

The rest of this chapter is organized as follows. In Section 2, we define FDI and discuss central theories on the types and drivers of FDI and their relations to transportation and information costs. In Section 3, we review empirical evidence on the gravity of FDI and the spatial interdependence of FDI across countries. In Section 4, we present recent empirical evidence on how the cost and technology of transmitting information might affect FDI jointly with the cost of transporting goods. In Section 5, we discuss the implications of transport cost and agglomeration economies for multinational firms' decisions to cluster with one another. Section 6 concludes with a brief discussion of policy implications and directions for future research.

[2] The academic literature on foreign direct investment is vast and has been surveyed many times. See Markusen (1995), Caves (1996), Blomström and Kokko (1998), Hanson (2001), Lipsey (2002), Barba Navaretti and Venables (2004), Görg and Greenaway (2004), Blonigen (2005), Harrison and Rodríguez-Clare (2009), Antràs and Yeaple (2014) and Alfaro (2015) for surveys on determinants, effects, and empirical findings.

2 Definition and Theoretical Hypotheses

2.1 Definition

A multinational corporation (MNC), sometimes referred to as a multinational enterprise (MNE) or transnational corporation (TNC), is a firm that owns and controls production facilities, R&D centers, or other income generating assets and decision entities in at least two countries. Parents are entities in the source country that control facilities, called affiliates, in host countries.

In terms of control, when a foreign investor begins a greenfield operation (i.e., constructs new production facilities) or acquires control of an existing local firm, that investment is regarded as a direct investment in the balance of payments statistics if a foreign investor holds at least 10 percent of a local firm's equity. This arbitrary threshold is meant to reflect the notion that large stockholders, even if they do not hold a majority stake, will have a strong say in a company's decisions and participate in and influence its management. To create, acquire, or expand a foreign subsidiary, MNCs undertake FDI. When a foreign investor purchases a local firm's securities or bonds without exercising control over the firm, that investment is regarded as a portfolio investment.

Regardless of measurement difficulties, it is the desire for partial or complete control over the activities of a firm in another country that distinguishes FDI from portfolio investment. However, the fundamental question underlying FDI activities is: Why is an investor willing to acquire a foreign firm or build a new factory abroad? After all, there are added costs of doing business in another country, including communication and transport costs, the expense of stationing personnel abroad, and barriers due to language, customs, and exclusion from local business and government networks.

It may seem that the answer is simply the ordinary pursuit of profit: The multinational firm expects to enjoy either larger annual cash flows or a lower cost of capital. Evidence, however, shows that investors often fail to bring all the investment capital with them when they take control of a foreign company; instead, they tend to finance an important share of their investment from the local market. FDI flows—particularly among developed countries and increasingly from emerging markets—also proceed in both directions and are often in the same industry. Moreover, if the lower cost of capital were the only advantage, why would a foreign investor endure the headaches of operating a firm in a different political, legal, and cultural environment rather than simply making a portfolio investment? And how can a foreign firm offset the domestic firm's local advantage?

Hymer (1960) proposed an alternative framework, derived from the industrial organization literature, and suggested that a firm engages in FDI not because of differences in the cost of capital but because certain assets are worth more under foreign rather than local control, which allows the firm to compete in different environments. An investor's decision to acquire a foreign company or build a foreign plant rather than simply exporting or engaging in other forms of

contractual arrangement with foreign firms thus involves the choice of the production location, and the choice of whether or not to keep the asset internal to the firm. This view is later extended in a large theoretical literature centering on the motives of FDI which we discuss next.

2.2 Theoretical Hypotheses: Transport Cost and Motives of FDI

Although patterns of foreign investment have long been recognized to be complex owing to the diversity of MNEs and varying motives for investing abroad, the literature has, for analytical tractability, traditionally emphasized two forms of—and motivations for—FDI, namely, horizontal FDI motivated by market access and vertical FDI motivated by comparative advantage. Two strands of theory have emerged with sharply different predictions on how country characteristics including transportation cost influence FDI.

In the theory of horizontal FDI, a firm invests abroad by replicating a subset of its activities or production process in another country to avoid transportation costs, tariffs and other types of trade costs. This strategy, referred to as the market access (or tariff jumping) motive, leads firms to duplicate production processes across countries. The incentives to engage in horizontal FDI are introduced by Markusen (1984) and Markusen and Venables (1998, 2000), who show that multinational firms arise endogenously when there are positive trade costs and low economies of scale at the plant level. In horizontal FDI models, exports and FDI constitute substitutes and the decision to serve a market via exports or FDI centers on a proximity-concentration tradeoff, that is, a tradeoff between the economies of scale from concentrating production in one plant and serving foreign countries via exports and the benefits of saving trade costs by serving foreign countries via local production. When market size is large and plant-level scale economy is low (due to low plant-level fixed costs), firms are more likely choose to expand their production across locations via horizontal FDI. The key hypothesis concerning transportation cost (as well as trade cost in general) is that the volume of multinational activity (as well as its share in total activity) increases when transportation cost and other types of trade cost are high.

In contrast, firms engage in vertical FDI when they fragment production by function, that is, when they break up the value chain, because of cost considerations arising from countries' factor cost differences.[3] Firms are motivated to fragment production and locate a production stage in a country where the factor used intensively in that stage is abundant. This strategy is referred to as the comparative advantage motive and is introduced by Helpman (1984) and Helpman and Krugman (1985) who predict that multinationals geographically separate production stages to exploit countries' varying comparative advantages and the size of vertical multinational activity

[3] As a conceptual point, vertical FDI is the result of a parent firm's decision to (1) source an input from abroad, and (2) source it from within the boundaries of the firm. In terms of the arm-length versus in-sourcing decision, the literature that analyzes the ability/capacity of firms to write contracts has focused on the characteristics of specialized inputs (contractibility, capital intensity, position in the value chain) and countries (capital abundance, capacity to enforce contracts). Antràs (2003, 2005), Antràs and Helpman (2004, 2008), Grossman and Helpman (2004), Antràs and Chor (2013), Alfaro, Antràs, Chor and Conconi (2015) among others, have recently addressed the choice between integration and contractual outsourcing. See Antràs (2015) for a comprehensive review.

increases in countries' relative factor endowment differences. In contrast to the positive relationship in horizontal FDI, the effect of trade cost, including transportation cost, should be negative on vertical FDI as trade and FDI operate as complements in this case; lower transportation costs lead to greater vertical FDI and intra-firm trade.

An increasing number of multinational firms employ complex integration strategies as noted in Yeaple (2003a). These MNCs are both horizontally and vertically integrated, establishing affiliates in some foreign countries to save on transport cost and establishing affiliates in others to take advantage of factor price differentials. Yeaple (2003a) presents a three-country model to analyze why firms might follow a strategy of complex integration. In the model, firms from one developed, northern country may invest in either another developed, northern country (horizontal integration) or a developing, southern country (vertical integration) or both (complex integration). A key feature of the model is that north–north and north–south FDI reduce the cost of serving international markets in complementary ways, creating a complementarity between the two forms of FDI. Firms that undertake vertical (horizontal) foreign investments lower their unit costs and thereby expand their sales. Having expanded the number of units sold, these firms stand to gain proportionately more by further reducing their unit cost by undertaking horizontal (vertical) foreign investments. Low transport costs encourage vertical FDI while high transport costs encourage horizontal FDI. Complex integration strategies dominate other foreign investment strategies when the level of transport costs falls within an intermediate range.

Another complex FDI strategy is export-platform FDI which arises when multinational firms invest in a foreign country motivated by the country's comparative advantage and market potential and use the foreign country as a production platform to serve home or third countries. Ekholm, Forslid and Markusen (2007) show that export-platform FDI arises endogenously in a three-country model with two large, high-cost countries (North) and a small, low-cost country (South) particularly when one of the North countries forms a Free Trade Area with the South country that lowers regional trade costs. Thus, countries with great market potential which takes into account not only domestic market size but also export market potential become attractive export-platform FDI locations.

2.3 Theoretical Hypotheses: The Role of Information

An important input required in investment activities is communications between headquarters and foreign subsidiaries. Traditional models have tended to emphasize the role of physical transport costs and market size. Several important studies exploit how the cost of transmitting information helps explain the gravity patterns of FDI. Head and Ries (2008) look at the role of information frictions in explaining FDI patterns and in particular mergers and acquisitions. The authors assume that headquarters have imperfect information regarding assets in potential host countries and monitoring costs are an increasing function of distance. In their model, a country's

likelihood of acquiring a foreign plant via bidding successfully for assets in another country depends not only on the distance between the two countries, but also their location relative to bidders in other countries. That is, the authors incorporate geography into their analysis of bilateral FDI flows and establish what they label as "ability versus proximity tradeoff" by considering the tradeoff between the benefit of shifting control to a better owner and the costs of having that owner remote from the target.

Oldenski (2012) incorporates the importance of interacting with customers and communicating complex information within firms into the location decision of production. The paper shows that goods and services requiring direct communication with consumers are more likely to be produced in the destination market while activities requiring complex within firm communication are more likely to occur at the multinational's headquarters for export, especially when the destination market has weak institutions.

Keller and Yeaple (2013) develop a theory of technology transfer by multinationals to their foreign affiliates in which gravity for technology arises because direct communication and intermediate input trade are alternate means for firms to transfer knowledge. The paper challenges the assumption at the heart of theories of multinational enterprise: that is, technology is easily transferred while goods are expensive to move. The authors show that in the foreign operations of U.S. multinational firms, technology is subject to the laws of gravity: individual multinational affiliates sell less the further away they are from their home country especially in knowledge-intensive goods. They explain the stylized fact exploring the nature and size of international technology transfer costs. Assuming communication becomes more difficult the greater an industry's knowledge intensity, the model predicts that in knowledge-intensive industries trade costs dampen affiliate intermediate imports the least while affiliate sales are deterred the most. Further, the average knowledge content of affiliate imports is increasing in trade costs.

Table 1 summarizes the various theoretical predictions discussed in this section positing the effects of transportation cost on different types FDI.

Table 1: Theoretical Predictions on the Relationship between Transport Cost and FDI

	Transport Cost		Key References
	Source-Host	Host-ROW	
Horizontal FDI	Positive	—	Markusen (1984)
Vertical FDI	Negative	—	Helpman (1984)
Complex FDI	Bell-Shape	—	Yeaple (2003a)
Export Platform FDI	Negative	Negative	Ekholm, Forslid and Markusen (2007)
M&As	Negative	Negative	Head and Ries (2008)
FDI's knowledge content	Negative	—	Keller and Yeaple (2013)

3 Gravity in FDI

The theoretical studies outlined above have spurred a substantial volume of empirical literature. Motivated by the hypotheses, extensive empirical studies have adapted a gravity equation from the international trade literature and examined the patterns of FDI as a function of country characteristics including market size, factor endowment, transportation cost, tariff, and other factors such as corporate tax, institutional quality and exchange rate.[4] As discussed in the previous section, the relationship between transport cost and FDI varies sharply with the nature and type of investment. The gravity equation provides an intuitive specification to empirically examine the net effect of transport cost; given that the effect is expected to vary between horizontal and vertical/complex FDI (as summarized in Table 1), the empirical result can then help infer the type of FDI dominant in the data. To measure transportation cost, distance and a ratio of cost, insurance and freight (cif) relative to free-on-board import value have usually been used while it is widely acknowledged that distance could capture not only various forms of geographic friction including the costs of communication and monitoring but also other factors such as cultural distance and historical ties (see, for example, Head and Mayer, 2013).

The first stream of evidence presents evidence in favor of horizontal FDI by showing a positive relationship between FDI on the one hand and market size and trade cost on the other. Brainard (1997), one of the first empirical studies examining the proximity-concentration tradeoff, finds that the patterns in which country characteristics relate to U.S. FDI are broadly in alignment with the market access motive. Specifically, she uses U.S. trade and affiliate sales data from the 1989 BEA Benchmark Survey of U.S. Direct Investment Abroad and evaluates the following form of gravity equation:

$$affiliate\ share_{jk} = \alpha_0 + \alpha_1 marketsize_j + \alpha_2 transport_{jk} + \alpha_3 tariff_{jk} + \gamma X_j + \lambda Z_k \quad (1)$$

where $affiliate\ share_{jk}$ is the share of total U.S. sales of good k in country j accounted for by U.S. owned affiliates located in country j, $marketsize_j$ is the logged per capita income of country j, $transport_{jk}$ is the freight cost, measured by the ratio of freight and insurance costs relative to import values, for good k transported between the U.S. and country j, $tariff_{jk}$ is the foreign average tariff on imports of good k in country j, X_j is a vector of other country characteristics including average effective corporate income tax rate, trade openness, FDI openness, and changes in the exchange rate of country j relative to the dollar, and Z_k includes industry characteristics, namely, plant-level scale economy. Brainard (1997) finds $\alpha_1 > 0$, $\alpha_2 > 0$, and $\alpha_3 > 0$, that is, FDI increases with host-country income and trade cost including the transportation cost to ship goods between the headquarters country and the host country, consistent with the market access motive in horizontal FDI.

[4] See, for example, Anderson and Van Wincoop (2003), Chaney (2008), Disdier and Head (2008), Head and Mayer (2013), and Head and Mayer (2014) for overviews of the trade gravity literature.

Similar findings are shown in Carr, Markusen, and Maskus (2001) who incorporate both horizontal and vertical FDI into a knowledge-capital model of multinational firms and estimate the following specification:

$$affiliate\ sales_{ijk} = \alpha_0 + \alpha_1 marketsize_{ij} + \alpha_2 distance_{ij} + \alpha_3 tradeopenness_{ij} + \alpha_4 skilldiff_{ij} + \gamma X_j \quad (2)$$

where $affiliate\ sales_{ijk}$ is the logged real volume of sales by manufacturing affiliates in host country j that are majority owned by parents in source country i, $marketsize_{ij}$ is the joint market size, captured by the logged bilateral sum of real GDP in the parent country i and the host country j, $distance_{ij}$ is the logged geographic distance in kilometers, $tradeopenness_{ijk}$ are indices of trade openness in countries i and j, $skilldiff_{ij}$ is the difference in a measure of skilled-labor abundance in the parent country i relative to that in the host country j, X_i includes a vector of other country characteristics such as the GDP difference between countries i and j and its square, the interaction of GDP difference and skill difference, and the investment openness of host country j. The above equation differs from Brainard's (1997) specification by incorporating countries' differences in skilled-labor abundance, which would help detect multinational firms' motive to explore countries' factor endowment and comparative advantage. The results show that $\alpha_1 > 0$, $\alpha_2 < 0$, and $\alpha_4 > 0$, which offer support to both market access and knowledge capital hypotheses. In particular, the elasticity of affiliate sales with respect to distance is estimated to range from -0.8 to -1.8, suggesting strong gravity in FDI patterns. Affiliate sales tend to diminish by around 8 to 18 percent when the distance between parent and host countries rises by 10 percent. In fact, the extent of gravity in FDI is comparable to the extent of gravity in trade that has been found in the literature (see, for example, Head and Mayer, 2013).

Yeaple (2003b) extends earlier work by exploring an interaction between country and industry determinants of FDI and offers empirical support to both market access and comparative advantage motives. Specifically, he uses U.S. affiliate sales data in 39 countries and 50 manufacturing industries from the BEA Benchmark Survey of 1994 and considers the following equation:

$$\begin{aligned} affiliate\ sales_{jk} \;=\; & \alpha_0 + \alpha_1 marketsize_j + \alpha_2 transport_{jk} + \alpha_3 tariff_{jk} + \alpha_4 skill_j \\ & + \alpha_5 skill_j \times skillintensity_k + \alpha_6 skillintensity_k + \gamma X_j \end{aligned} \quad (3)$$

where $skill_j \times skillintensity_k$ is an interaction between the skilled-labor abundance of country j and $skillintensity_k$ is the skilled-labor intensity of industry k. Yeaple (2003b) finds that U.S. multinational firms from unskilled-labor intensive industries tend to invest in unskilled-labor abundant countries, a result consistent with the hypothesis that countries' factor endowment differences lead to vertical FDI. Unlike in Brainard (1997), the role of transportation cost is found to be negative and statistically insignificant, departing from the expected sign in the context of horizontal FDI.

Introducing firm heterogeneity into the decision between exports and horizontal FDI, Helpman, Melitz and Yeaple (2004) investigate the important role of within-sector firm productivity differences, along with conventional variables including transportation cost, tariff, capital intensity and others, in explaining the structure of international trade and investment. The paper shows that not only are the most productive firms most likely to engage in FDI, FDI sales relative to exports are also larger in sectors with more firm heterogeneity, higher transportation cost, higher tariff, and greater capital intensity. The work by Helpman, Melitz and Yeaple (2004) is extended in numerous studies including, for example, Yeaple (2009) and Chen and Moore (2010). Both papers examine the role of firm heterogeneity in investment decisions and find that more productive multinational firms invest in a larger number of countries. Only the most productive multinational firms can afford to invest in tough countries, including countries geographically remote from headquarters. Consequently, distance between host and headquarter countries not only reduces aggregate affiliate sales and the number of multinational affiliates, but also raises the cutoff and average productivity of active multinational firms.

Alfaro and Charlton (2009) use a cross-country firm-level dataset from Dun & Bradstreet's WorldBase database to characterize global patterns of multinational activity and show that large FDI flows across rich countries do not fit the traditional classification of horizontal FDI. Compared to other cross-country firm-level datasets, the WorldBase data contains plant-level observations in over 100 countries. The unit of observation in WorldBase is the establishment rather than the firm. WorldBase records industry information including the four-digit SIC code of the primary industry in which each establishment operates and, for most countries, the SIC codes of up to five secondary industries listed in descending order of importance, ownership information, and operational information including sales, employment, and so forth. The data set allows identifying plants in the same family (firm). The authors define an establishment as foreign owned if it reports to a global parent firm located in a different country.

Alfaro and Charlton (2009) identify vertical FDI by exploiting the input-output relationships between a multinational firm's headquarters industry and the industry of its subsidiary and document that much vertical FDI occurs within high-skill sectors and between developed countries, highlighting the growing importance of intra-firm intermediate trade in multinational activity. Similar to earlier work, Alfaro and Charlton (2009) assess a gravity equation in the form of equation (3) for a cross-section of country pairs and find strong gravity in intra-industry FDI. An increase in the distance between parent and subsidiary countries has a negative effect on the level of bilateral vertical multinational activity. Specifically, a movement from the 25th percentile (e.g., the United Kingdom and Norway) to the 75th percentile (e.g., the United Kingdom and Mexico) of the distribution of distance is associated with a reduction in the number of subsidiaries equivalent to 32 percent of the mean number of subsidiaries.

The results in Alfaro and Charlton (2009) suggest that the share of vertical FDI is larger than commonly thought. A significant amount of vertical FDI could be misclassified as hori-

zontal FDI because intra-industry vertical subsidiaries generally produce inputs similar in skill intensity to the parent-produced final goods and as a result much of vertical FDI is North-North between parent and subsidiaries in similarly skilled activities. These new observations imply that the negative role of transportation cost and geographic distance and conversely the importance of facilitating transportation might have been under-stressed in the past as vertical and complex FDI is much more prevalent than traditionally viewed and grows rapidly with declining transportation and trade policy barriers.

Irarrazabal, Moxnes and Opromolla (2013) further exploit the source of gravity in FDI by introducing intra-firm trade into the framework of Helpman, Melitz and Yeaple (2004) and generating gravity relationships for both exports and multinational production. The model rationalizes gravity in FDI by assuming that the headquarters produce a firm-specific tangible or intangible input that is required for production in any location and trade in such input is subject to trade costs including transportation costs or tariffs in the case of physical inputs and cultural and geographic remoteness from the headquarters in the case of headquarters services. Matching the model with data using a unique Norwegian firm-level dataset of both exports and multinational production, the paper estimates firm-level gravity equations and calculates the within-firm elasticities of exports and multinational production with respect to distance. A comparison of the elasticities of exports and multinational production enables the paper to infer the magnitude of intra-firm trade. The results suggest that intra-firm trade appears to play a crucial role in shaping the geography of multinational production; to justify the gravity observed, the affiliate's cost share related to input purchases from the headquarters must be about 90 percent. As suggested in the paper, this result may have captured other mechanisms that are dampening firms' multinational production as trade costs increase, such as imperfect transmission of technology between parents and affiliates either because of imperfect codifiability as discussed in Keller and Yeaple (2013) or because of higher frictions in the match between firms and workers.

Addressing the long standing issue that FDI data are not systematically available across countries and over time, Ramondo, Rodriguez-Clare and Tintelnot (2015) present a comprehensive dataset on the bilateral activity of multinational firms using UNCTAD data and an extrapolation procedure, with focus on two variables: affiliate revenues and the number of affiliates across country pairs. Among the various stylized facts, the analysis shows that the effects of distance on multinational production shares are similar to the ones found for trade shares (close to -1) and the extensive margin of multinational production is much more elastic to distance than the intensive margin.

While most empirical studies have examined FDI as bilateral relationships, an emerging literature accounts for the multi-country spatial interdependence of FDI flows predicted in Yeaple (2003a) and Ekholm, Forslid and Markusen (2007) as most multinational firms today employ complex integration strategies and operate multilateral production networks. Head and Mayer

(2004) examine hypotheses of export-platform FDI and show that a country's market potential, measured by the distance-weighted sum of domestic and export market size, plays a significant role in countries' ability to attract multinational firms. Specifically, they use a dataset of firm-level location choices by Japanese firms between 1984 and 1995 and estimate each firm's decision to locate in a region in the following equation:

$$affiliate_{mj} = \Phi\left(\alpha_0 + \alpha_1 regional\ marketsize_j + \alpha_2 market\ potential_j + \gamma X_j\right) \qquad (4)$$

where $affiliate_{mj}$ is a binary variable representing whether firm m invests in region j, $regional\ marketsize_j$ is region j's GDP, and $market\ potential_j$ is the market potential of region j measured by the total demand of other locations weighted by their geographic accessibility from region j, and X_j is a vector of other regional characteristics including, for example, wage rate and corporate tax rate. The results show that Japanese multinationals are more likely to locate in regions proximate to large markets, suggesting that geographic proximity between host and third countries could also influence the investment decisions of multinational firms, especially those seeking to engage in export-platform FDI.

Spatial interdependence across FDI flows is also shown in Baltagi, Egger and Pfaffermayr (2007), Blonigen *et al.* (2007, 2008), and Chen (2011). Baltagi, Egger and Pfaffermayr (2007) estimate a knowledge-capital model that incorporates spatial correlations in the independent variables and find that third-country characteristics exert significant effects on FDI flows. The linkage between host countries declines with bilateral distance among the host countries. Using sectoral FDI data, Blonigen *et al.* (2007) examine how investments in third countries affect a country's receipt of U.S. FDI. They find evidence of negative interdependence across proximate host countries, a result consistent with export-platform FDI theory, among European OECD members. The importance of third-country effects in inbound FDI is shown in Blonigen *et al.* (2008). The authors find a strong parent market proximity effect whereby parent markets' proximity to large third nations increases the volume of FDI. Similarly, Chen (2011) examines the cross-country interdependence in French multinationals' production networks using subsidiary-level data and finds strong spatial interdependence in multinationals' foreign production networks. The role of distance and transportation cost depends on the input-output linkages between subsidiary locations. MNCs are more likely to locate final-good production in countries with large market potential, vertically linked subsidiaries in proximate countries, and horizontally linked subsidiaries in remote locations.[5]

Table A.1 summarizes the main empirical findings of studies discussed in this section, in particular, how transport cost, distance and other gravity variables have been found to affect various measures of FDI.

[5] Alfaro and Chen (2012) show that multilateral networks are crucial for multinationals' ability to diversify both product and financial markets and mitigate subsidiaries' vulnerabilities to host country shocks. Operation in a larger number of countries not only lends subsidiaries stronger resilience to negative host-country demand shocks, but also provides more sources of internal capital flows.

Revisiting the Evidence

In the remainder of this section, we incorporate various hypotheses discussed in Section 2.2 and revisit the empirical findings using a large cross-country manufacturing firm dataset drawn from Orbis that covers around 60 countries during the 2002-2007 period.[6] The dataset, published by Bureau van Dijk, is a leading source of company information and business intelligence, containing comprehensive financial, operation, and ownership information for public and private companies around the world. Orbis combines information from around 100 sources and information providers. Primary sources include Tax Authorities, Ministry of Statistics, Provincial Bureau of Legal Entities, Securities and Investments Commissions, National Banks, Municipal Chambers of Commerce, and State Registry of Accounts. Over 99 percent of the companies included in the database are private.

Specifically, we examine multinationals' entry decisions in the following specification:

$$affiliate\ entry_{ijk} = \Phi(\alpha_0 + \alpha_1 market\ potential_j + \alpha_2 transport_{ijk} + \alpha_3 tariff_{ijk} + \alpha_4 skill_{ij} + \gamma X_{ij} + \mu_k) \tag{5}$$

where $affiliate\ entry_{ijk}$ is the number of multinational entries during 2005-2007 in country j and industry k from country i, $market\ potential_j$ is the market potential of country j measured by the distance-weighted sum of country j's and other countries' GDP taken from CEPII Market Potential dataset, $transport_{ijk}$ is either the distance or the ratio of freight cost relative to import value between countries i and j obtained from CEPII's Trade Unit Values database, tariff is the tariff rate by country j on country i in industry k obtained from TRAINS, and $skill_{ij}$ is the skilled-labor abundance difference, measured by difference in average years of schooling, between countries i and j available from the World Development Indicators, X_{ij} is a vector of other country factors including, for example, contiguity and language sharing obtained from CEPII's GeoDist database, and μ_k is a vector of industry dummies. Given the count nature of the dependent variable, Poisson estimations are used in the analysis.

As shown in Table 1, we find that most of the empirical regularities established in previous studies hold in our broad cross-country data. Conventional determinants of multinational activity exert a significant and expected effect on multinational entry. As in earlier studies, we document gravity in multinational firms' entry decisions: entry into a host country significantly diminishes with the distance between host and source countries. In contrast, contiguity and formal colony relationships are associated with greater multinational entry. Host-country tariff is found to exert a positive and significant effect on multinational entry, consistent with the market access motive of multinational firms. Countries with greater market potential attract more multinational entry, similar to the result in Head and Mayer (2004). When controlling for transportation cost, we find a positive relation between transportation cost and entry, again

[6] We limited the analysis to 2002-2007 to avoid the global financial crisis starting in 2008 during which FDI became more volatile and less representative.

in alignment with the market access motive. Moreover, controlling for transport cost leads to little change in the negative distance elasticity of entry, suggesting that the role of distance in deterring entry goes beyond the cost of transporting goods.[7] One possible explanation is the cost of transmitting information which we turn to next.

4 Information Cost and FDI

Within the broad literature of FDI, an emerging strand of studies analyze the role of communication costs in determining the patterns of multinational activity.[8] As the information and communication revolution transforms societies allowing different and new ways to produce, sell, buy, and organize economic activities, lower communication costs and better information technology can exert important effects on MNC activity, especially in communication-intensive sectors, by lowering information frictions between headquarters and affiliates and substituting for trade in intermediates. First, information and communication technology (ICT) could enable firms to better monitor assets and operations in host countries, where there exists imperfect information and monitoring costs are likely to increase in distance as considered in Head and Ries (2008). Second, as noted in Oldenski (2012), interactions with customers could require firms to locate close to destination markets, while communication within firms could motivate firms to stay close to headquarters. Information technology revolution that improves the quality and lowers the cost of remote communication could hence either increase or decrease FDI incentives. Third, as shown in Keller and Yeaple (2013), direct communication can substitute for the transfer of technology embodied in traded intermediates, in which context the adverse effect of transport cost could be particularly strong when communication is costly or complex.

These theoretical hypotheses are broadly supported by new empirical evidence. Built on their FDI model in which headquarters bid to control overseas assets and information frictions in monitoring overseas assets increases in distance, Head and Ries (2008) derive an equation for bilateral FDI stocks given below that resembles the fixed effects approach to modelling bilateral trade flows:

$$FDI_{ij} = O_i + I_j - distance_{ij}\theta \tag{6}$$

where FDI_{ij} is the logged FDI flow from country i to country j, O_i and I_j represent source-country and host-country fixed effects, respectively, and $distance_{ij}$ is a vector of geographic and culture distances. The parameters of the equation and the predictions are then examined using

[7] The sample size, however, drops significantly when controlling for freight cost due to the availability of the data.

[8] A related literature has analyzed how information and communication technologies affect the performance of multinational firms. Bloom, Sadun, and van Reenen (2012), for example, show that U.S. multinational firms operating in Europe obtain higher productivity from IT than non-U.S. multinational firms. See Draca, Sadun, and Van Reenen (2007) for an overview of the literature on the impact of information and communication technologies on productivity and Alfaro and Chen (2016b) for the different mechanisms through which FDI can affect host-country productivity.

bilateral FDI data for 30 OECD countries and 32 partner countries. Applying the model and estimates from bilateral regressions, the paper compares predicted inward and outward shares of world FDI for all countries in 2001 to actual values and find that the model fits the data well. These results suggest that information frictions play an important role in explaining the geographic patterns and gravity of FDI.

Oldenski (2012) theoretically and empirically examines the role of communication in the tradeoff between exports and FDI. The empirical analysis shows that because services require more interaction with consumers than manufacturers, the difference in the importance of communication can explain much of the difference in export-to-FDI ratios between the two sectors. Controlling for standard determinants of trade and investment, the analysis also shows that the level of complexity of production has a negative effect on offshoring. Because non-routine activities are less codifiable and it is more difficult to successfully transfer these processes to teams in another country and to specify clear quality standards for these more abstract tasks, their production is less likely to be offshored to foreign affiliates.

Similarly looking at the role of information costs, Abramovsky and Griffith (2006) study the role of information and communication technology in a firm's decision to outsource or offshore services, that is, decisions on whether to produce in-house or outsource services, and the decision over the location of activity. The authors use UK census micro level data at the establishment level and find that more information technology-intensive firms purchase a greater amount of services on the market and they are more likely to purchase offshore than less information technology-intensive firms.

Focusing on the cost of transferring technology across borders, Keller and Yeaple (2013) examine how the spatial costs of transferring knowledge might affect multinationals' operation overseas. Assuming firms can transfer knowledge to their foreign affiliates in either embodied (traded intermediates) or disembodied form (direct communication), the authors model the share of imported intermediates in the affiliate's total costs as the result of a tradeoff between costly technology transfer and costly trade. The authors find that both the level of the affiliate's sales and its imports are affected by the ease with which knowledge can be transferred across space. Affiliate sales fall as trade costs rise, and the effect of trade costs is strongest for knowledge-intensive goods as the scope for offshoring is most limited by costly disembodied knowledge transfer. Further, as trade costs increase, multinational affiliates substitute away from importing inputs but their ability to do so is constrained by how high disembodied knowledge transfer costs are. Therefore, trade costs have the weakest influence on affiliate imports in relatively knowledge-intensive industries. These predictions are examined in the following equations using a firm-level dataset for U.S. multinationals obtained from the BEA surveys of U.S. Direct Investment

Abroad:

$$\begin{aligned} affiliate\ importshare_{jk} &= \beta_0 + \beta_1 tradecost_{jk} + \beta_2 tradecost_{jk} \times knowledgeintensity_k + \gamma X_j \\ affiliate\ sales_{jk} &= \beta_0' + \beta_1' tradecost_{jk} + \beta_2' tradecost_{jk} \times knowledgeintensity_k + \gamma' X_j \end{aligned}$$

where $affiliate\ importshare_{jk}$ is imports for further processing from the US parent relative to total affiliate sales, $affiliate\ sales_{jk}$ is the volume of local affiliate sales to unaffiliated customers, $tradecost_{jk}$ is the sum of an ad-valorem measure of freight costs and an ad-valorem measure of tariffs, $knowledgeintensity_k$ is the ratio of total R&D spending relative to total sales by the parents of U.S. multinational firms in a given industry, and X_j is a vector of country characteristics including income, population, tax rate, skill endowment, capital endowment, intellectual property rights, judicial quality, language, and cost of phone call. The empirical results, which show that $\beta_1 < 0$, $\beta_2 > 0$, $\beta_1' < 0$, and $\beta_2' < 0$, confirm the theoretical predictions. Trade costs dampen both the imports and the sales of multinational affiliates, but the adverse effect on imports is weaker, while the adverse effect on affiliate sales is stronger, in knowledge-intensive industries since substituting communication for intermediate input imports is more difficult in those industries.

Cristea (2014) looks at the role of communication costs and headquarter export services and the possible substitution between knowledge and the use of skilled foreign workers. Combining data on information costs and service exports by parents of U.S. multinationals to their foreign affiliates covering 32 countries during 1993-2008, the author finds that communication costs negatively affect the export of headquarter services by U.S. multinationals relative to the total U.S. exports of service. The author then considers the role of skilled labor using data on the average educational attainment of the labor force in foreign countries and finds that the effect on intra-firm service exports is attenuated by the average education level of the workforce in the host country. The author argues their findings are suggestive of positive substitution effects between the knowledge held by the foreign workers and the headquarter knowledge services.

Bahar (2014) shows that multinational corporations are significantly less likely to horizontally expand in relatively knowledge-intensive sectors. The evidence shows that when firms do expand their knowledge-intensive activities, they tend to do so at shorter geographic distances. Locating a foreign subsidiary in the same time zone as its headquarters reduces barriers to knowledge transmission by easing communication and effectively reducing the distance between them by, on average, 3500 km.

Recently, Alfaro and Chen (2015) examine the relationship between information and communication technology adoption and multinational activity. Using a cross-country firm-level panel dataset drawn from Orbis, the authors present a description of how the location patterns of multinational firms vary across countries depending on their levels of information and communication technology adoption. Controlling for a number of host- and headquarter-country characteristics that have traditionally been used to explain multinationals location choices, the

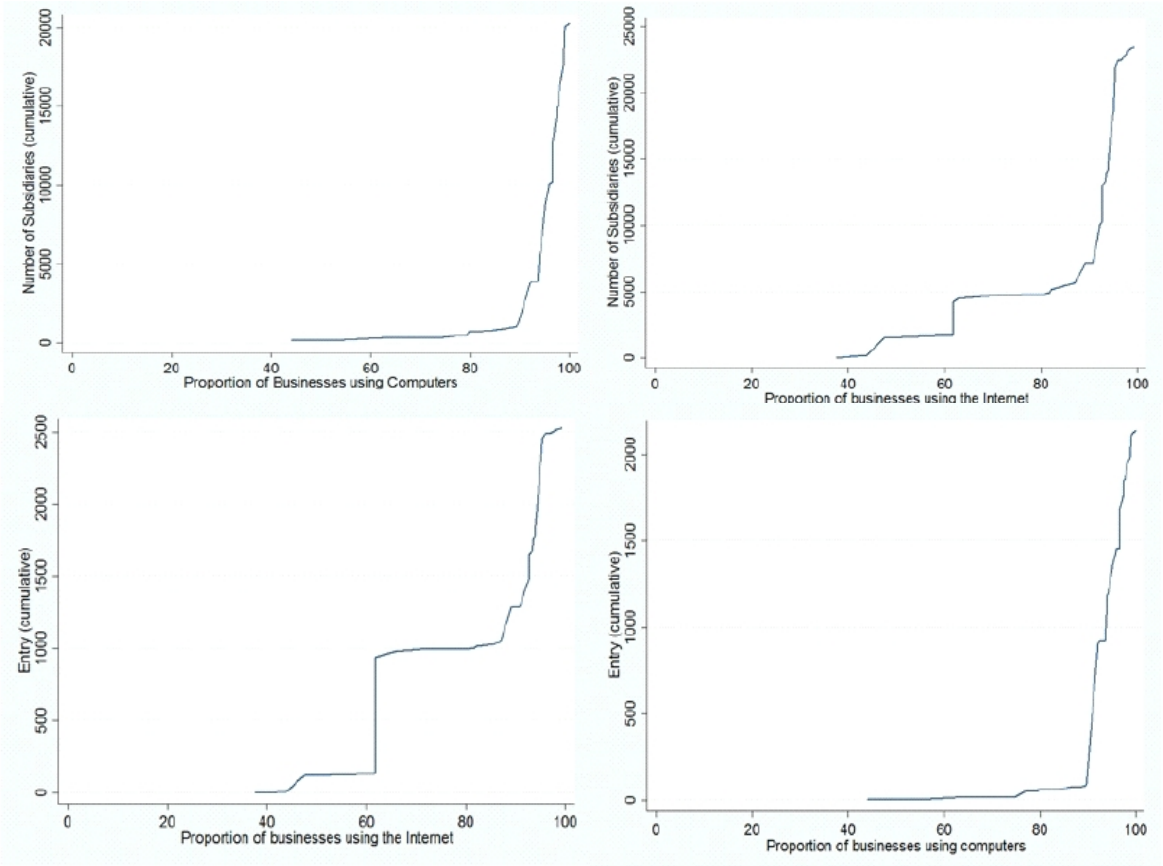

Figure 5: The distribution of multinational activity across information and communication technology levels

authors find a positive relation between information technology adoption levels and multinational entry.

As shown in Figure 5 taken from the above paper where countries' information and communication technology adoption rates are measured by UNCTAD's data on the business uses of internet and computers across countries, most foreign subsidiaries are located in countries with high business usages of internet and computers. A similar observation is found when examining multinational entry. The number of entries by multinational companies into a foreign country (opening up a foreign subsidiary) is positively correlated with businesses' information technology adoption measures in that country.

We now look at the role of information and communication technology variables in explaining the entry of multinational activity more systematically. We append our previous equation and

estimate the following equation:

$$affiliate\ entry_{ijk} = \Phi(\alpha_0 + \alpha_1 market\ potential_j + \alpha_2 transport_{ijk} + \alpha_3 tariff_{ijk} + \alpha_4 skill_{ij} + \alpha_5 ICT_j + \gamma X_{ij} + \mu_k) \quad (8)$$

where ICT_j captures measures of host-country information and communication technology characteristics using specifically the proportion of businesses using computers (UNCTAD B1) and proportion of businesses placing orders over the internet (UNCTAC B8).

Table 3 presents the results. The information technology characteristics of host countries play a significant role in countries' ability to attract multinational firms. Column (1) indicates that countries with a greater proportion of businesses using computers attract a significantly larger number of multinational entries. We then examine how the technology adoption might affect the adverse effect of distance on multinational entry by interacting a host country's technology adoption level with the distance between host and source countries. The results show that a greater usage of computers and internet could mitigate the negative role of distance in multinational entry, suggesting that information technological improvements could help tackle the information frictions underlying the gravity pattern of FDI.

The above evidence confirms that communication costs and technologies play an important role in the patterns of multinational activity and the effects of transport cost. First, information and communication technology could stimulate greater FDI by either reducing monitoring costs or improving communications between headquarters and subsidiaries. Second, better communications can substitute for the transfer of technology embodied in traded intermediates and consequently mitigate the adverse effect of transport cost on FDI.

5 Agglomeration Economies in FDI

Transportation costs, broadly defined as the costs of transmitting goods, people, information, and ideas, affect not only the attractiveness of a location but also the decision of firms to locate relative to one another. Agglomeration economies stress the benefits of geographic proximity that can emerge from the savings in transportation costs when firms and workers cluster and draw from a common pool of resources. These benefits include lower transport costs between input suppliers and final good producers (vertical linkages), labor-market and capital-good-market externalities due to the proximity of firms with similar demand for labor and capital goods, and technology diffusion thanks to low costs of technology transfer at close distance. An extensive literature in regional and urban economics has been devoted to evaluating the importance of Marshallian agglomeration forces in economic geography.[9] As Glaeser (2010)

[9] Marshall (1890) first introduced the idea that concentrations of economic factors, such as knowledge, labor, and inputs, can generate positive externalities. See Ottaviano and Puga (1998), Head and Mayer (2004), Ottaviano and Thisse (2004), Rosenthal and Strange (2004), Duranton and Puga (2004), Puga (2010), and Redding (2010,

notes, an interesting paradox relates to the fact that as the movement of people, goods, and ideas has become easier, agglomeration economies have become more important, not less. Despite the reduction in transportation and communication costs, industrial clusters and cities dominate economic activity.

As the focus of this chapter, MNCs are likely to exhibit different motives of agglomeration than domestic firms due to their greater revenue and productivity, vertically integrated production, and higher knowledge- and capital-intensities. In contrast to domestic production which emphasizes domestic geography and natural advantage, multinational production stresses foreign market access and international comparative advantage. Moreover, as highlighted in a growing literature (e.g., Helpman, Melitz, and Yeaple, 2004; Antras and Helpman, 2004, 2008; Yeaple, 2009; Chen and Moore, 2010), the economic attributes and organization of multinationals are, by selection, distinctively different from average domestic firms. Thus, the advantage of geographic proximity can differ dramatically between multinational and domestic firms.

For example, the benefit of low transport cost between suppliers and customers can be a particularly important incentive for MNCs to cluster with each other. Because MNCs tend to be the largest customers as well as the largest suppliers, the input-output relationship between MNCs (e.g., Dell and Intel, Ford and Delphi) can be far stronger than that between average domestic firms. Externalities from the movement of workers can also motivate MNCs to locate close to each other as they are often characterized by similar skill requirements and large expenditures on worker training. MNCs can have a strong incentive to lure workers from one another because the workers tend to receive certain types of training that are well suited for working in most multinational firms. Moreover, MNCs' proximity to one another can shield workers from the vicissitudes of firm-specific shocks. External scale economies can also arise in capital-good markets. This force has particular relevance to multinational firms given their large involvement in capital-intensive activities.[10] Geographically concentrated industries offer better support to providers of capital goods (e.g. producers of specialized components and providers of machinery maintenance) and reduce the risk of investment (due to, for example, the existence of resale markets), thereby expanding the supply and lowering the cost of capital goods. Lastly, technology diffusion, through movement of workers or direct interaction between firms, can be particularly prevalent between proximate MNCs. This has been noted by Barba Navaretti and Venables (2004), who predict that MNCs may benefit from setting up affiliates in proximity to other MNCs with advanced technology (e.g., "so-called centers of excellence").

Indeed, the literature, as surveyed below, has found consistent evidence that MNC agglomeration patterns differ from those of their domestic counterparts. Data restrictions, however, have been an important obstacle for the progress of studying economic geography at a global scale; most related research in regional economics has focused on a geographic area such as the United States (Rosenthal and Strange, 2001) or the United Kingdom (Overman and Puga, 2009).

2011) for excellent reviews of these literatures.

[10] See Alfaro and Hammel (2007) for evidence on capital flows and capital goods imports.

In the field of international trade, the advantage of proximity and low transport cost between customers and suppliers is a form of agglomeration economies that has received particular attention. A number of studies have examined the role of production linkages in multinationals' location decisions (see, e.g., Head, Ries and Swenson, 1995; Head and Mayer, 2004; Crozet, Mayer and Mucchielli, 2004; Blonigen, Ellis and Fausten, 2005; Bobonis and Shatz, 2007; Amiti and Javorcik, 2008; Debaere, Lee and Park, 2010). These studies show that MNCs with vertical linkages tend to agglomerate regionally in countries such as the U.S., China, and the EU.

For example, Head, Ries, and Swenson (1995) estimate the location choices of Japanese firms who set manufacturing factories in the US during the period 1980-1992. They find that Japanese investments do not mimic domestic plants; rather, their agglomeration is driven by positive externalities of colocation rather than fundamental forces (such as infrastructure, natural resources, and labor). The authors note that the dependence of Japanese manufacturers on the "just-in-time" inventory system exerts a particularly strong incentive for vertically linked Japanese firms to agglomerate.

Looking at Japanese investments in Europe, Head and Mayer (2004) find fundamental forces (market potential) to matter. In particular, the authors find a 10 percent increase in a region's market potential to increase the likelihood of multinational entry by 3 to 11 percent. However, these forces do not fully explain location choices as they can also be driven by forces of agglomeration. Consistent with these findings, Blonigen, Ellis, and Fausten (2005) find information sharing incentives to play a key role in Japanese FDI activity.

Crozet, Mayer and Mucchielli (2004) find agglomeration forces to be an important determinant of foreign firm investments in France, while Bobonis and Shatz (2007), using data on the U.S. state-level stock of foreign-owned property, plant, and equipment (PPE), find agglomeration to be an important externality. Amiti and Javorcik (2008), studying foreign firm entry in China during the period 1998-2001, find market and supplier access to be key determinants of foreign entry. In particular, access to markets and suppliers in the province of entry matters more than access to the rest of the country. The evidence suggests significant transportation costs and trade barriers across Chinese provinces.

Alfaro and Chen (2014, 2016a) assess the different patterns underlying the global agglomeration of multinational and non-multinational firms using a spatially continuous index of agglomeration and a unique worldwide plant-level dataset from World Base. The data, as mentioned previously, reports detailed location, ownership, and operation information for plants in over 100 countries, and in particular, detailed plant-level physical location information used to obtain latitude and longitude codes by means of which distances between pairs of establishments could be computed. The paper evaluates how agglomeration economies, particularly the value of external scale economies in knowledge and capital goods, affect MNCs relative to domestic firms, given MNCs' vertically-integrated organizational form and large investment in technologies and capital goods.

Extending an empirical methodology introduced by Duranton and Overman (2005), the authors quantify patterns of agglomeration by constructing an index of agglomeration at both the pairwise industry and plant levels. The index measures the extent of geographic localization at a given spatial scale by estimating the density function of distance between MNC establishments relative to the counterfactual. The index, being spatially continuous and thus unbiased with respect to the scale of geographic units and level of spatial aggregation, quantifies the extent to which MNC establishments are more or less likely than their domestic counterparts to agglomerate.

The analysis generates an array of new stylized facts about worldwide agglomeration patterns of multinational and domestic firms and shows that the offshore agglomeration patterns of MNCs are distinctively different from those of their headquarters and their domestic counterparts. First, across different types of establishments, multinational headquarters are, on average, the most agglomerative. For example, the average probability of agglomeration at 50 kilometers (km) is about 1 percentage point for MNC headquarters, 0.5 percentage point for MNC foreign subsidiaries, and 0.4 percentage point for domestic plants. Second, the agglomeration of multinational foreign subsidiaries exhibits a low correlation with the agglomeration of domestic plants, suggesting that the offshore clusters of MNCs are not merely a projection of the domestic clusters. Third, multinational foreign subsidiaries are significantly more agglomerative than domestic plants in capital-, skilled-labor-, and R&D-intensive industries as shown in Figure 6 which plots the distributions of pairwise industries' agglomeration densities at 50 km for multinational foreign subsidiaries and domestic plants, respectively. For example, in industries with above-median capital intensity, the distribution shifts rightward for multinational foreign subsidiaries compared to domestic plants. The probability of agglomeration at 50 km is, on average, 0.1 percentage point (or equivalently 23%) higher for MNC foreign subsidiaries than for domestic plants. This pattern is similarly observed for industries with greater than median levels of skilled-labor intensity and R&D intensity.

When running a horse-race between the two distinct economic forces in MNCs' location decision including location fundamentals and agglomeration economies, Alfaro and Chen (2016a) find that location fundamentals including market access and comparative advantage and agglomeration economies including capital-good market externality and technology diffusion both play an important role in multinationals' economic geography.

To quantify location fundamentals, the authors construct a measure that incorporates existing empirical approaches from the literature discussed in Section 3. First, the authors obtain estimates of multinational activity, predicted by location fundamentals including market size, transport cost, tariff, comparative advantage and natural advantage, among other related char-

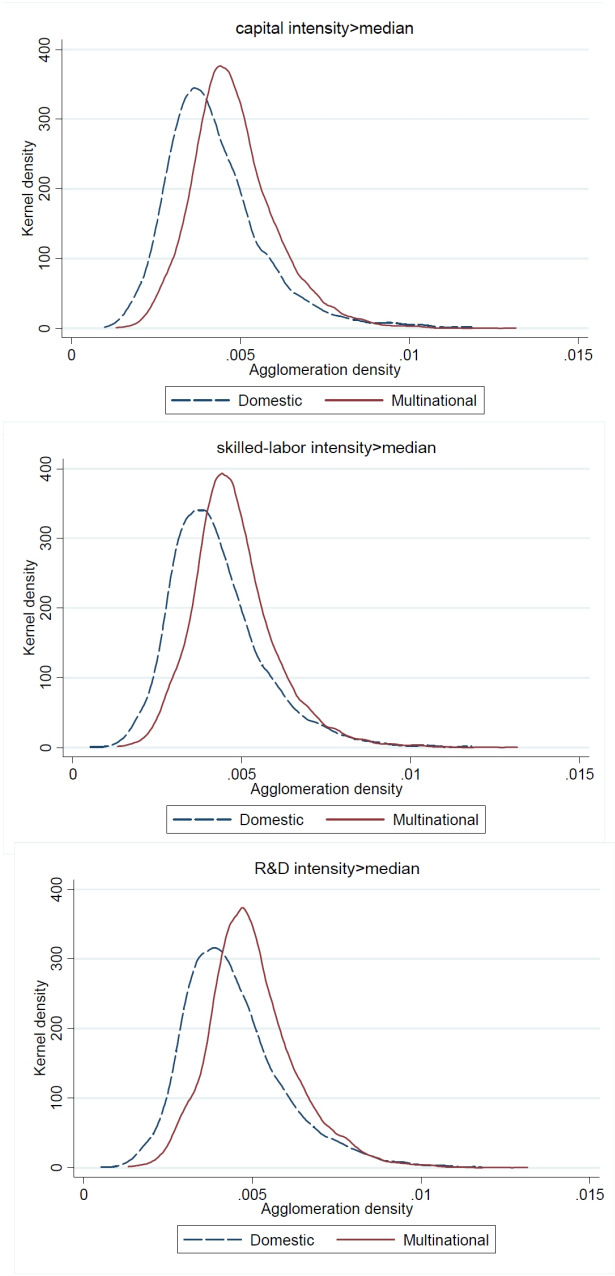

Figure 6: The agglomeration-density distributions of multinational foreign subsidiaries and domestic plants: Pairwise industry level

acteristics based on the following specification:

$$affiliate\ count_{ijsk} = \alpha_0 + \alpha_1 marketsizesize_{ij} + \alpha_2 distance_{ij} + \alpha_3 tariff_{ijk} + \alpha_4 skill_{ijs} + \alpha_5 skill_{ijs} \times skillintensity_k + \gamma X_{js} + \mu_{ik} + \mu'_{jk} + \varepsilon_{ijsk} \quad (9)$$

where $affiliate\ count_{ijsk}$ denotes the number of subsidiaries in country j's region s and industry k owned by MNCs in country i, $skill_{ijs}$ represents the difference in skill endowment, measured by percentage of labor with tertiary education, between the home country and the host region, and X_{js} is a vector of host-country-region characteristics including the region's corporate tax level, length of roadway, ports, and airports based on a detailed compiled database of regional characteristics taken from a number of national sources.[11] Then, the authors construct an index of MNC agglomeration based on MNC activities predicted exclusively by location fundamental forces.

Incorporating the roles of location fundamentals and the various agglomeration economies proxied by pairwise industries' linkages in production, labor market, capital good market, and patent citations, the paper then examines their relative importance in explaining the observed agglomeration patterns of multinational firms using the following specification:

$$\begin{aligned} agglomeration_{k\widetilde{k}}(T) &= \alpha_K + \beta_1 fundamentals_{k\widetilde{k}} + \beta_2 IOlinkage_{k\widetilde{k}} + \beta_3 labor_{k\widetilde{k}} \\ &\quad + \beta_4 capitalgood_{k\widetilde{k}} + \beta_5 technology_{k\widetilde{k}} + \varepsilon_{k\widetilde{k}}, \end{aligned} \quad (10)$$

where $agglomeration_{k\widetilde{k}}(T)$ is the agglomeration index of industry pairs k and $\widetilde{k}$ at threshold distance T (relative to the counterfactuals) and the right-hand side includes the agglomeration patterns predicted by multinational production location fundamentals ($fundamentals_{k\widetilde{k}}$) constructed following the procedure described above, $IOlinkage_{k\widetilde{k}}$ represents the input-output linkage between industry pairs, $labor_{k\widetilde{k}}$ is an industry pair's similarity in occupational labor demand, $capitalgood_{k\widetilde{k}}$ is an industry pair's similarity in capital-good demand, $technology_{k\widetilde{k}}$ captures the extent of patent citations between an industry pair and α_K is a vector of industry dummies that takes the value of 1 if either industry k or $\widetilde{k}$ corresponds to a given industry and zero otherwise.[12]

Table 3 shows that input-output linkages have a significant effect on MNCs' agglomeration decisions overseas. Upstream and downstream multinationals are more likely to locate close to each other. Further, the proxy for technology diffusion and industry pairs' correlations in

[11] The authors compile a detailed database of regional characteristics from a number of national sources. For most countries, there is limited information available at the state or province level. Specifically, for Europe, data was compiled from the Eurostat Regional Database at the NUTS 2 level disaggregation, both to compare with other data and for availability reasons. For other countries, such as the US, Australia, Brazil, Canada, China, Japan, Mexico, and South Korea, state or province level data was used.

[12] The author use the 2002 Benchmark Input-Output (I-O) data and the capital flow published by the Bureau of Economic Analysis (BEA); the Bureau of Labor Statistics' (BLS) 2006 National Industry-Occupation Employment Matrix (NIOEM), and patent citation flow data taken from the NBER Patent Database.

capital-good demand, a proxy for potential capital-good market externality, also exert a strong effect on the agglomeration of MNC foreign subsidiaries. Comparing the relative importance of location fundamentals and agglomeration economies, the effect of location fundamentals, albeit significant, is outweighed by the cumulative effect of agglomeration forces.

Multinational subsidiaries in industries with greater potential labor market externalities exhibit significantly higher level of employment agglomeration. Technology diffusion, another force of agglomeration that involves close labor interaction and mobility, also plays a significant role in explaining the agglomeration of MNC subsidiary workers between industries. In fact, technology spillover appears to be the strongest agglomeration factor at most distance thresholds. Further, at more aggregate geographic levels, the effects of labor market externalities and technology spillovers diminish, while capital-good market correlation exerts a significant and positive effect.

These findings are largely consistent with MNCs' high investments in technologies and capital goods as well as the increasing segmentation of activities within the boundaries of MNCs, in particular, the market-seeking and input-sourcing focuses of offshore production and emphasis of headquarters on such knowledge-intensive activities. The results further underscore the importance of geographic proximity and reduced frictions in the movement of capital goods and technology, both within and between the boundary of multinational firms.

6 Conclusion

In this survey, we reviewed how transportation costs and geographic frictions broadly have shaped the geography of FDI and multinational production. Collapsing trade barriers and technological progress have precipitated an explosion in the flows of goods, tasks, investments, and technologies where MNCs have played a key role. These changes represent great opportunities and challenges, to not only companies who face increasingly complex organization decisions but also countries and the global economy as economic interdependence deepens.

Existing theoretical literature shows that there are a variety of different mechanisms through which transport cost and geographic friction in general could influence FDI decisions. Not only does the effect of transport cost depend critically on the specific motives to invest abroad, there are also important interplays between the cost of transporting physical goods and the cost of communicating ideas. Further, these costs affect not only firms' decisions to geographically separate production tasks but also their decisions to locate next to one another because of the agglomeration economies involving the benefits of geographic proximity in realizing product and factor market externality and technology diffusion.

These theoretical predictions are broadly supported by a continually growing empirical literature which has exploited macro- and micro-level data and novel methodologies to cast light on the complex and interlinked roles of geographic frictions in FDI despite the absence of worldwide plant-level data that tracks multinational firms' investment, trade, and technology transfer

across locations. Recent evidence suggests that the interaction between transport cost and FDI could become increasingly important and complex as companies adapt their integration and sourcing strategies and expand their value chains around the world.

In future research, it is worthy of particular importance to further understand the interactions of trade, FDI, and technology flows and the underlying roles of transport and information costs. As the flows of goods, tasks, capital, and technology become more interdependent on one another, the impact of transportation and information barriers could be amplified. It is also crucial to investigate such interactions in a multilateral context going beyond bilateral country relationships as countries become integrated into global value chains. More comprehensive and disaggregated data on intra- and inter-national transport and communication costs would facilitate empirical research in this area. Policy efforts to reduce transportation and communication barriers both within and across countries are even more vital today as production and information networks expand around the world.

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Table 1: Determinants of Multinational Entry

Dep. variable: MNC entry count	(1)	(2)	(3)	(4)
Host market potential	0.0813***	0.0924***	0.0655**	0.0764**
	(0.025)	(0.024)	(0.031)	(0.030)
HQ GDP per capita	1.036***	0.976***	1.024***	0.969***
	(0.037)	(0.033)	(0.052)	(0.047)
Skill difference	-0.0352***	-0.0240**	-0.0448***	-0.0339**
	(0.011)	(0.011)	(0.016)	(0.016)
Tariff	0.215*	0.367***	-0.27	0.085
	(0.126)	(0.087)	(0.362)	(0.154)
Distance		-0.173***		-0.171***
		(0.037)		(0.053)
Freight cost			0.0359***	0.0359***
			(0.008)	(0.008)
Contiguity	1.237***	0.876***	1.292***	0.940***
	(0.083)	(0.084)	(0.090)	(0.128)
Language	0.347***	0.375***	0.285***	0.311***
	(0.074)	(0.075)	(0.079)	(0.080)
Colony	0.707***	0.712***	0.694***	0.698***
	(0.060)	(0.060)	(0.067)	(0.068)
Industry FE	Yes	Yes	Yes	Yes
Observations	411,304	411,304	202,384	202,384
Log likelihood	-13629	-13595	-7662	-7643

Notes: This table reports baseline Poisson estimation results. Robust standard errors are reported in the parentheses. ***, **, and * denote significance at 1, 5, and 10 percent, respectively.

Table 2: ICT and Multinational Entry

Dep. variable: MNC entry count	(1)	(2)	(3)	(4)
Host market potential	0.0767**	0.0256	0.130***	0.037
	(0.031)	(0.024)	(0.030)	(0.024)
HQ GDP per capita	0.857***	0.851***	0.894***	0.858***
	(0.046)	(0.041)	(0.049)	(0.042)
Skill difference	0.0216	0.0537**	0.0196	0.0509**
	(0.020)	(0.025)	(0.020)	(0.025)
Tariff	0.282***	0.19	0.315***	0.195
	(0.097)	(0.122)	(0.095)	(0.125)
Distance	-0.182***	-0.200***	-3.197***	-0.316***
	(0.053)	(0.046)	(0.243)	(0.059)
Freight cost	0.0427***	0.0414**	0.0425***	0.0407**
	(0.016)	(0.017)	(0.016)	(0.017)
Contiguity	0.838***	0.925***	0.907***	0.937***
	(0.143)	(0.128)	(0.139)	(0.126)
Language	-0.362***	0.248***	-0.273**	0.259***
	(0.109)	(0.092)	(0.112)	(0.091)
Colony	0.889***	0.679***	0.786***	0.665***
	(0.083)	(0.062)	(0.076)	(0.061)
Computer use by business	0.017***		-0.250***	
	(0.002)		(0.020)	
Distance*Computer use by business			0.032***	
			(0.002)	
Internet use by business		0.005		-0.026**
		(0.003)		(0.012)
Distance*Internet use by business				0.004***
				(0.001)
Industry FE	Yes	Yes	Yes	Yes
Observations	153,288	167,734	153,288	167,734
Log likelihood	-5822	-6700	-5778	-6696

Notes: This table reports baseline Poisson estimation results. Robust standard errors are reported in the parentheses. ***, **, and * denote significance at 1, 5, and 10 percent, respectively.

Table 3: Location Fundamentals, Agglomeration Economies, and MNC Offshore Agglomeration

	T= 200 km	T= 400 km	T= 800 km	T= 1600 km
IO Linkages	0.249**	0.541*	1.252***	2.413***
	(0.112)	(0.302)	(0.222)	(0.576)
Capital Good	0.037**	0.092***	0.237***	0.499***
	(0.017)	(0.017)	(0.092)	(0.153)
Labor	0.001	-0.001	-0.045	0.153
	(0.014)	(0.015)	(0.165)	(0.135)
Technology	0.573***	1.101***	2.330***	3.943*
	(0.161)	(0.458)	(0.343)	(2.560)
Location Fundamentals (Regional)	0.006	0.004***	0.002*	0.001
	(0.007)	(0.001)	(0.001)	(0.003)
Obs.	7875	7875	7875	7875
R^2	0.570	0.600	0.626	0.630
		Beta Coefficients		
IO Linkages	0.013	0.013	0.013	0.012
Capital Good	0.034	0.038	0.042	0.045
Labor	0.004	-0.001	-0.009	-0.015
Technology	0.029	0.025	0.023	0.019
Location Fundamentals (Regional)	0.038	0.025	0.013	0.006

Notes: Bootstrapped standard errors in parentheses. ***, **, and * denote significance at 1, 5, and 10 percent, respectively. All regressions include industry fixed effect. Normalized beta coefficients are reported in the lower panel.

Table A.1: Summary of Main Empirical Findings

Dependent variable	Effect on FDI			
	Freight cost	Distance	Tariffs	Other
Brainard (1997): 1989 Benchmark Survey of Direct Investment Abroad (BEA)				
Export shares: log of share of good j in country i accounted for by exports from the US	Negative*	Not included	Negative*	Negative: Adjacency (dummy=1 for Canada/Mexico)
Outward affiliate sales shares, Sales by foreign affiliates of US owned multinationsl and US exports	Positive* / Negative	Not included	Positive*	Positive*/ Negative: Adjacency
Import shares	Negative*	Not included	Positive	Positive*: Adjacency
Inward affiliate sales shares, Sales by US affiliates of foreign owned multinationsl and US imports	Positive*	Not included	Positive*	Negative: Adjacency
Log outward affiliate sales	Positive*	Not included	Positive*	Positive: Adjacency
Gross exports - affiliate employment and net assets (instrument for affiliate sales)	Negative*	Not included	Negative*	Positive*: Adjacency
Log of inward affiliate sales	Positive	Not included	Positive*	Negative*: Adjacency
Gross imports	Negative*	Not included	Positive	Positive*: Adjacency
Carr, Markusen and Maskus (2001): 1986-1994 (US Dept. of Commerce)				
Real sales volume of affiliates	Not included	Negative*	Not included	Positive*: Trade cost index host; Negative*: Trade cost index parent; Negative*: investment costs host
Yeaple (2003): 1994 Benchmark Survey				
Total affiliate sales (sales made by US multinational affiliates in country j to all customers	Negative*	Not included	Positive*	Negative*: Openness to FDI dummy (1 is closed)
Local affiliate sales	Negative*	Not included	Positive*	Negative*: Openness to FDI dummy (1 is closed)
Export sales back to the US	Negative*	Not included	Negative	Negative*: Openness to FDI dummy (1 is closed)
Log of ratio of exports from the US to a host country divided by the sum of these exports plus US multinational affiliate sales to host country customers	Negative*	Not included	Negative*	Positive: Openness to FDI dummy (1 is closed)
Helpman, Melitz and Yeaple (2004): Bureau van Dijck Electronic Publishing and BEA				
Exports to FDI sales	Negative*	Not included	Negative*	
Feinberg and Keane (2006): BEA 1983-1996 (for US parents and their Canadian affiliates)				
Intermediate input share (for US parents)	Not included	Not included	Positive*: Canadian tarriff and transport cost; Negative: US tarriff and transport cost	
Intermediate input share (for foreign affiliates)	Not included	Not included	Negative*: Canadian; Positive*: US	
Bergstrand and Egger (2007) : UNCTAD 1990, 17 'most developed' OECD countries				
Bilateral FDI Flows (pooled)	Not included	Negative*	Not included	Negative*: Regional Trade Agreement dummy; Positive*: Same Language
Bilateral FDI Flows (FE)	Negative	Not included	Not included	Negative: Investment Costs
Blonigen, Davies, Waddell and Naughton (2007): BEA 1983-1998				
Affiliate Sales (full sample and country group subsamples)	Not included	Negative*	Not included	Negative*: Host trade costs; Negative*: Host investment costs
Affiliate Sales (by industry)	Not included	Not included	Not included	Postive* and Negative*: Host trade costs; Negative* (for some industries): Host investment costs

Appendix A.1: Summary of Main Empirical Findings (Continued)

Amiti and Javorcik (2008): China National Bureau of Statistics, 1998-2001				
Change in the number of foreign firms operating in industry i, province p, at time t	Not included	Negative*	Positive*: average tariff on imports to China and average tariff imposed on imports from China	Positive*: number of sea berths and length of railroads Negative*: number of river berths
Head and Ries (2008): 2001 bilateral FDI stocks (OECD) / Cumulative 1990-1999 M&A transactions				
All FDI, FDI in OECD	Not included	Negative*	Not included	Postive*: Same Language
FDI in M&A	Not included	Negative*	Not included	Postive*: Same Language
Alfaro and Charlton (2009): 2005 (D&B), 2-digit and 4-digit SIC, multinational activity in each bilateral industry pair				
Number of firms (US parents only)	Not included	Negative*	Not included	
Number of firms	Not included	Negative*	Not included	
Sales	Not included	Negative*	Not included	
Number employees	Not included	Negative*	Not included	
Yeaple (2009): 1994 (BEA), same key results for aggregate multinational activity by components and disaggregated multinational activity by component				
Aggregate multinational sales	Not included	Negative*	Not included	
Number of US firms that own an affiliate in a given country	Not included	Negative*	Not included	
Average productivity of the parent firms (sales in the US) that own an affiliate in a given country	Not included	Positive	Not included	
Scale	Not included	Negative*	Not included	
Average affiliate sales to local customers	Not included	Negative	Not Included	
Chen and Moore (2010): AMADEUS (French firms, 1993-2001)				
Location	Not included	Negative*	Positive*: host; Negative*: home	Positive*: contiguity
Location	Not included	Negative*	Positive*: host; Negative: home	Positive*: contiguity
Chen (2011): BvDEP AMADEUS (French firms, 2005 and 2007)				
Final-good production location decision	Not included	Negative*	Positive*: host; Negative*: home	
Intermediate-good production location decision	Not included	Negative*	Negative*: host; Positive*: home	
Final-good production location decision	Not included	Negative*	Negative/Positive: host; Negative/Positive: home	Positive*: Horizontal (weighted distance and tariff); Negative*: Vertical (weighted distance and tariff)
Intermediate-good production location decision	Not included	Negative*	Negative/Positive: host; Positive*: home	Positive*: Horizontal (weighted distance and tariff); Negative*: Vertical (weighted distance and tariff)
Oldenski (2012): BEA(1982, 1989, 1994, 1999, 2004)				
Exports/FDI (goods)	Not included	Negative*	Not included	Positive*: language & distance
Exports/FDI (services)	Not included	Negative	Not included	Positive*: language & distance
Exports/FDI (goods and services)	Not included	Negative*	Not included	Positive*: language & distance
FDI (dummy for probit)	Not included	Positive*	Not included	Positive*: language & distance
Exports/FDI (affiliated and unaffiliated Exports)	Not included	Negative*	Not included	Positive*: language & distance
Exports/FDI (goods)	Not included	Negative*	Not included	
Exports/FDI (services, excluding rarely exported services	Not included	Positive	Not included	
Exports/FDI (goods and services, excluding rarely Exported services)	Not included	Negative*	Not included	
Irarrazabal, Moxnes and Opromolla (2013) : 2004, Statistics Norway's Capital Database				
Total exports, total affiliate sales, number of exporters, number of parents, firm exports, affiliate sales	Not included	Negative*	Not included	

Appendix A.1: Summary of Main Empirical Findings (Continued)

Keller and Yeaple (2013): BEA (1994, 1999, 2004)				
Imports for further processing from the US relative to total affiliate sales	Negative*	Not included	Not included	Positive*: common language
Local affiliate sales to unaffiliated customers	Negative*	Not included	Not included	Positive*: common language
Imports for further processing from the US relative to total affiliate sales	Negative*	Not included	Not included	Not included
Local affiliate sales to unaffiliated customers	Negative*	Not included	Not included	Not included
Local sales	Negative*	Not included	Not included	Positive*: common language
Third country sales	Positive*	Not included	Not included	Positive: common language
US sales	Negative*	Not included	Not included	Positive*/Negative*: common language
All sales	Negative/Positive	Not included	Not included	Positive*: common language
Ramondo, Rappaport and Ruhl (2013): 1994, 1999 and 2004 from BEA affiliates sales by industry and country (also exports by industry-country in Feenstra et al. (2002))				
US exports/affiliate sales in country j (country)	Negative	Negative/Positive	Negative*	Negative: Common Language; Positive: Border Share; Positive: Landlocked
US exports/affiliate sales in country j (country-industry)	Negative	Negative*	Negative*	Positive: Common Language; Positive*: Border Share; Positive: Landlocked
US exports/affiliate sales in country j (country-industry) (year = 1994)	Positive	Negative	Negative	Positive: Common Language; Positive*: Border Share; Positive: Landlocked
US exports/affiliate sales in country j (country-industry) (year = 1999)	Negative	Negative	Negative*	Positive: Common Language; Positive*: Border Share; Negative: Landlocked
US exports/affiliate sales in country j (country-industry) (year = 2004)	Negative*	Negative	Negative*	Positive: Common Language; Positive*: Border Share; Negative: Landlocked
US exports/affiliate sales in country j (country-industry) (year = 2004) and exports source is Census	Negative	Negative	Negative*	Positive: Common Language; Positive: Border Share; Negative: Landlocked
US exports/affiliate sales in country j (country-industry) (OECD countries)	Positive/ Negative	Negative*	Negative*	
US exports/affiliate sales in country j (country-industry) (non-OECD)	Negative*	Negative*	Negative	
Selection bias check	Positive/ Negative	Negative*/ Positive*	Negative*/ Positive*	Positive* (some): Common Language; Positive* (some): Border Share; Positive* (some): Landlocked
Antras and Yeaple (2015): 2009 and 1989 Benchmark Survey (BEA)/ 2000-2011 (US Census Related Party Trade Database)				
Logexports by US in j to country i/ (exports by US in j to country i + sales by US affiliates in industry j located in country i) (only manufacturing)	Negative* (for 2009 and 1989) Not significant when industry fixed effects included	Not included	Negative* (for 2009 and 1989) Not significant when industry fixed effects included	
Intrafirm imports/total imports	Negative*	Not included	Negative*	
Ramondo, Rodriguez-Clare and Tintelnot (2015): 1996-2001 (UNCTAD, Thomson Reuters)				
Affiliate Revenues from I in L	Not included	Negative*	Not included	Negative: Common border; Positive*: Common language
Trade share: trade flow from I to N as share of expenditure in N	Not included	Negative*	Not included	Positive*: Common border; Positive*: Common language
MP share	Not included	Negative*	Not included	Positive: Common border; Positive*: Common language
No. of affiliates	Not included	Negative*	Not included	Positive*: Common border; Positive*: Common language
Rev/affiliate	Not included	Negative*	Not included	Positive: Common border; Positive*: Common language

Notes: The table summarizes the effects of transportation cost and gravity variables on FDI found in various empirical studies. * denotes statistical significance with a p value of 0.1 or lower.