Logistics Infrastructure and the International Location of Fragmented Production[*]

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ABSTRACT

Casual evidence suggests that multinational companies increasingly look for places with adequate transport and logistics infrastructure to locate affiliates that participate in cross-border production sharing. Yet, there are no systematic empirical analyses examining how logistics infrastructure interacts with the location decisions made by multinationals. Most studies on the determinants of FDI address the issue of transportation-logistics by examining the impact of distance on the relevant outcome, but distance does not capture by itself the quality of the logistics systems in place. An additional challenge is that investments in logistics infrastructure and FDI flows could be potentially endogenous. We overcome these shortcomings in the literature by embedding indicators of infrastructure into an empirical framework that examines whether countries with adequate logistics systems attract more vertical FDI in industries that are more dependent on logistics services. We find that logistics infrastructure positively impacts vertical FDI in addition to the impact typically found on distance. A change from the first quartile to the third quartile of the distribution of logistics infrastructure is associated with an average increase in the number of vertically-integrated subsidiaries equivalent to 15 percent.

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1. Introduction

Basso is a producer of combustion engine valves located in the city of Rafaela, Argentina. The firm is successfully inserted in various international production networks providing valves to car makers in Europe and in the US under just-in-time delivery services. To fulfill its shipping commitments, Basso keeps permanent stocks of valves on ships to cover for possible delays and other eventualities that may occur within the transportation and logistics systems of the country (González, Hallak, Schott and Soria, 2012). The example of Basso is characteristic of the issues faced by companies inserted in global production networks which tend to be highly sensitive to the quality of the logistics systems in place.

Firms around the world are increasingly fragmenting production processes and locating different stages of the production in specialized plants across different nations. But uncertainty and delays in the arrival of any single component can disrupt the production of the final good as entire production lines might be shut down until all the necessary inputs have arrived. Companies can mitigate this uncertainty by holding large quantities of inventory but modern supply chain practices are increasingly moving towards low inventory-holdings in an effort to cut costs, part of the so call lean production strategies. Accordingly, multinational corporations (MNCs) fragmenting production internationally look to operate in locations with adequate transport and logistics infrastructure to reduce delays and disruptions in the supply chain, inventory-holding costs, depreciation costs as well as handling costs. The examples of MNCs operating in environments with proper logistics support abound from BMQ, a subsidiary of Bombardier in the Queretaro aerospace park in Mexico relying on an international airport specifically built to handle the logistics of this park (Brown-Grossman and Domínguez-Villalobos, 2012), to Hewlett-Packard-Singapore, a subsidiary of Hewlett-Packard taking advantage of the frequency of shipments in the port of Singapore for a steady supply of cartridge components to an assembly plant in Malaysia. The quality of logistics infrastructure seems to be an intrinsic part of the location decision of many MNCs that seek to engage in cross-border production sharing.

The importance of the logistic infrastructure for the unbundling of production is also implicit in various frameworks of the production fragmentation theory (Jones and Kierzkowski, 1990 and Deardorff, 2001a, b). Central to these models is the notion that firms fragment a production process into various production blocks and relocate them to places with different location advantages as long as the resulting saved costs from the fragmentation outweigh the additional costs of coordinating and moving the production blocks around. The latter is inherently dependent on the logistics systems in place.

While the role of logistics seems prominent in the case studies and in some theoretical frameworks, there is no systematic empirical analysis assessing the extent to which the quality of logistics infrastructure affects the location of vertical FDI. Most studies of the determinants of FDI address the issue of logistics and transportation by examining the effect of distance on the relevant outcome (Carr, Markusen and Maskus, 2001, 2003; Alfaro and Charlton, 2009). Distance is clearly an important component of the costs of transportation between partner countries, but does not capture by itself the quality of the logistics systems in place. Other empirical studies of FDI employ more specific measures of transport costs, like freight costs (Yeaple, 2003; Hanson, Mataloni, Salughter, 2005) that in principle reflect both distance and transport-infrastructure factors.[1] Still, these studies fall short of explicitly measuring the specific impact of the logistics systems because the estimated effect of freights on FDI compounds the impact of both distance and the logistics infrastructure, and thus, without explicitly introducing a measure capturing either of them separately it is not possible to disentangle which part can be attributed to distance and which part can be attributed to the quality of the existing logistics systems.

Analyzing the role of logistics infrastructure on the location of international production networks confronts an additional challenge: improvements in logistics infrastructure might attract vertical FDI but logistics infrastructure investments might also be shaped by existing FDI trends. Therefore, estimates of the impact of logistics on the location of vertical FDI could be biased if this potential reverse-causality is not properly addressed.

This paper fills a gap in the literature by explicitly examining the effects of logistics infrastructure on the location of vertical FDI. We use a detailed cross-sectional worldwide dataset of multinationals and several indicators of infrastructure in an extended gravity framework that addresses the potential reverse-causality issue. The identification is based on a difference-in-difference estimation that examines whether countries with adequate logistics infrastructure attract more vertical subsidiaries in industries that are more dependent on logistics services. The results indicate that logistics infrastructure is important for the location of vertically-integrated plants. We find a positive and statistically significant association between transport-logistics infrastructure and vertical FDI in addition to the impact of distance suggesting that both variables have separate effects on the location decisions of MNCs.

The magnitude of the effect is economically meaningful. We find, for instance, that a change from the first quartile to the third quartile of the distribution of logistics infrastructure is associated with an average increase in the number of vertically-integrated subsidiaries equivalent to 15 percent.

A series of robustness checks confirms our baseline results. We show that the findings hold after employing alternative definitions of vertically-integrated plants and estimation methods.

[1] Clark, Dollar and Micco (2004), for example, show how maritime freight rates are determined by distance and by the quality of port infrastructure.

Our study contributes to two different literatures. First, by explicitly analyzing the role of logistics infrastructure on multinational activity, the paper adds to an important body of research that examines the determinants of FDI (Carr, Markusen and Maskus, 2001, 2003; Yeaple, 2003; Hanson, Mataloni, Slaughter, 2005; Alfaro and Charlton, 2009)[2] and more generally the drivers of product fragmentation (Jones and Kierzkowski, 1990, Arndt and Kierzkowski, 2001, and Deardorff, 2001a,b; Venables, 1999, Markusen, 2005, Grossman & Rossi-Hansberg, 2008).

Second, a growing line of research has evolved in recent years showing how logistics-infrastructure measures, like port and airport efficiency, affect international trade flows (Limao and Venables, 2001; Clark, Dollar and Micco, 2004; Micco and Serebrisky, 2006). Our analysis complements this literature by showing how similar measures of logistics also affect cross-border investments.

The rest of the paper is divided as follows. The next section provides a brief summary of the literature on fragmentation which guides our empirical analysis. In this section we also describe the econometric model employed as well as the construction of the datasets. Section 3 discusses the results of the estimations. Section 4 finalizes with some concluding remarks.

2. Theoretical background and empirical specification

During the last two decades the literature on the so call theory of fragmentation or offshoring has been growing rapidly. Following the work in Jones and Kierzkowski (1990), economists have been writing models that explicitly recognize the fact that firms are increasingly fragmenting production processes in various stages or tasks and moving them to places with different location advantages (Findlay and Jones, 2001; Jones & Kierkowski, 2000, 2001; Deardorff, 2001a, b; Grossman and Rossi-Hansberg, 2008). These studies examine the main forces behind the international organization of production. Most of the models in this literature share features from an earlier literature on FDI,[3] namely that firms will fragment production or tasks across different countries to arbitrage international differences in factor prices (Helpman, 1984 and Helpman and Krugman, 1985).[4]

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[2] Blonigen (2005) provides a survey for the general literature on FDI determinants.

[3] The new models of fragmentation are generally not limited to the study of multinationals exclusively. The main predictions of these models tend to apply to companies that fragment production internationally regardless of whether this is done within the boundaries of the firm or through independent suppliers. A more recent strand of the literature examines the more specific issue of whether the fragmentation of production occurs within the boundaries of the firm or through an independent supplier (Antràs, 2003; Antràs and Helpman, 2004, 2008). This is called the internalization decision.

[4] This class of models is called the vertical model of FDI and it was developed in parallel to the horizontal model of FDI in which the motive behind the MNC is to save on trade costs associated with exporting by setting up foreign subsidiaries producing similar goods to those produced at home (Markusen, 1984 and Horstmann and Markusen, 1987). Later on, the knowledge-capital model was developed allowing for a simultaneous horizontal and vertical motives of FDI (Markusen, 1997)

The rationale behind the theory of fragmentation is as follows: in traditional production processes, inputs are organized and combined to generate final outputs in the same location. In the presence of many inputs, coordination is normally necessary and proximity helps keep the costs of coordination low. But if firms could separate the production process into various production blocks and relocate them in places with lower factor costs, the total costs of production could be lowered. Thus, firms may unbundle their production processes as long as the saved production costs arising from the fragmentation process compensate the additional costs of coordinating remotely located production blocks plus the costs of moving these production blocks around.

The framework highlights the main forces behind the international unbundling of production, namely comparative advantage considerations like differences in factor prices across countries, as well as the overall costs of coordinating activities and moving the various inputs between the supplier's country and the parent country. Trade impediments like tariffs as well as the costs of transportation are the main factors behind the costs of moving the inputs across borders. Transportation costs, in turn, depend not only on the distance traveled but also on the quality of the transport-related infrastructure in place (Limao and Venables, 2002; Clark, Dollar and Micco, 2004). With respect to the costs of coordinating production processes at a distance, the state of the information and communication technologies (ICT) has been signaled as the main factor determining these costs (Baldwin, 2011). Our empirical model then includes variables that capture these main forces. More specifically, as we will explain below, the model includes proxies for factor endowments in order to capture comparative advantage considerations; trade policy measures to capture traditional trade impediments; distances between the supplier and the home countries to capture the non-infrastructure determinants of transport costs, and transport- and ICT-logistics indicators to capture the infrastructure-related determinants of transportation and coordination costs.

Empirical Specification

We analyze the impact of logistics infrastructure on vertical FDI within the context of a gravity equation. A growing empirical literature uses the gravity equation to investigate the determinants of various types of cross-border investments (Eaton and Tamura, 1994; Wei, 2000; Loungani et al., 2003; Eichengreen and Tong, 2007; Mutti and Grubert, 2004; Stein and Daude, 2007; Hijzen, Gorg and Manchin, 2005; di Giovanni, 2005; Bénassy-Quéré et al., 2007; Daude and Stein, 2007 and Head and Ries, 2008). In its basic form, the gravity equation relates the log of bilateral investments to the logs of the sizes of the partner countries and the log distance between them. Our baseline model takes the following form:

$$Y_{ijk} = \theta + D_i + D_j + D_k + \delta X_{ij} + \beta_1 f_{ij} + \varepsilon_{ijk} \qquad (1)$$

where Y_{ijk} is a measure of vertical FDI consisting on the number of vertical subsidiaries from parent country *i* that are located in host country *j* in sector *k*; D_i , D_j and D_k are fixed effects for parent country *i*, host country *j* and industry *k*, respectively, and X_{ij} is a vector of bilateral variables. The formulation follows others in using individual country fixed effects to estimate trade equations (Feenstra, 2004; Eaton and Kortum, 2001, 2002) and FDI equations (Head and Ries, 2008).[5]

The X_{ij} vector comprises a series of variables that are standard in trade and FDI gravity models. These variables are the bilateral distance between the host and the parent countries and dummy variables for same border, same language and same colonial ties. The X_{ij} vector also includes three variables that capture the additional forces behind the international production fragmentation mentioned above. Comparative advantage considerations are considered by including the ratio of the parent country's skills to the host country's skills, where country skill is the average years of schooling in the population aged 25 and over. A dummy variable for same trade agreement is introduced to control for traditional trade policy barriers. Finally, f_{ij} measures the quality of the logistics infrastructure in both countries which we explain in detail below.

Endogeneity

As mentioned in the introduction, better logistics infrastructure might induce more vertical FDI but existing FDI trends might also encourage logistics infrastructure investments. Accordingly, estimations from equation (1) could be biased due to the potential reverse causality between the two variables. To alleviate the potential endogeneity problem associated with cross-country regressions, we examine a cross-country, cross-sector interaction effect. That is, we ask if countries with adequate logistics infrastructure attract more vertical subsidiaries in industries that are more dependent on logistics services. The methodology essentially relies on a difference-in-difference estimation that captures the differential effect of a country variable across industries that have varying levels of responsiveness to this variable. Accordingly, the identification of the effect comes from the differences across sectors. This estimator would suffer from reverse causality if the FDI flows to a given sector *relative* to the FDI flows to another sector have a causal effect on the overall level of logistics infrastructure. While this would be a threat to the identification strategy, it seems much less likely to be the case than in the more common cross-country regressions in which total FDI flows could have a causal effect on the overall level of logistics infrastructure investment. In a different context, this methodology has been applied by Rajan and Zingales (1998) to examine whether sectors that are more dependent on external finance develop disproportionally faster in countries with more developed financial markets. The rationale in the context of this paper is that industries differ in terms of their dependence on logistics services. For instance, some industries are more sensitive to shipping times than others. A recent study about offshoring, for example, found that time to marker (i.e., ability to rapidly supply local markets) was the most important

[5] These individual country fixed effects play the same role as the multilateral resistance index introduced by Anderson and van Wincoop (2003). Additionally, potential econometric problems related to exogeneity and omitted variables are largely reduced by using these fixed effects (Anderson and Yotov, 2012)

decision driver in the development of a manufacturing sourcing strategy in the consumer electronics industry (Hackett Group, 2012). The study found that this factor which is highly dependent on transportation and logistics tends to drive the location decision of highly dynamic industries with short product life cycles and high levels of demand variability. However, time considerations are much less important in other supply chains, for instance, in the less dynamic but highly price-sensitive industries such as furniture manufacturing, for which raw material and components costs are much more important factors driving the location decision. This implies that multinationals deciding to locate vertical subsidiaries abroad are more likely to pay attention to differences in the quality of logistics infrastructures the higher is the industry dependence on logistics services. Therefore, we augment the gravity model in equation (1) as follows:

$$Y_{ijk} = \theta + D_i + D_j + D_k + \delta X_{ij} + \beta_1 f_{ij} + \beta_2 f_{ij} \cdot s_k + \varepsilon_{ijk} \qquad (2)$$

where s_k is a measure of the dependence of sector *k* to logistics services, and the rest of the variables are defined as before.

FDI Data

Our main data come from D&B Worldbase dataset covering more than 230 countries and territories. The data are compiled by Dun & Bradstreet (D&B) which is a company that provides information about businesses and corporations around the world mainly for use in credit and investment decisions, market research, business-to-business marketing and supply chain management. The data have also been used in academic studies for various purposes including the comparison of size and diversification patterns of foreign investment in North America (Caves, 1975), the development of microdatasets on enterprises (Lipsey, 1978), the effect of bank credit availability and business creation (Black and Strahan, 2002), the relationship between financial development and vertical integration (Acemoglu, Johnson and Mitton, 2009), the patterns of intra-industry and inter-industry FDI (Alfaro and Charlton, 2009) and the relationship between foreign ownership and establishment performance (Alfaro and Chen, 2011).

D&B collects the information from a broad spectrum of sources including public registries, partner firms, telephone company data, print directory records, news and media sources, and websites. All the pieces are pulled together and a number of information computer and manual validations checks and reviews are used to ensure quality control.

The entire D&B dataset for the year 2011 has around 85 million public and private establishments or 13 million after services are excluded. Most of these companies, however, are stand-alone businesses with no formal linkages to other companies. About 1 million establishments, however, are subsidiaries or branches with a corporate linkage and from this group around 140,000 have corporate linkages that transcend borders.[6] This is the group that we work with. [7] Alfaro and Charlton (2009) present a number of tests to validate the coverage of the Worldbase dataset and argue that it is one of the most complete sources of information to capture the global population of multinational firms at the plant-level.[8]

We follow Alfaro and Charlton (2009) in identifying whether the relationship between a parent company and its subsidiary is horizontal (the parent and the subsidiary produce the same good), vertical (the subsidiary produces an input to the parent) or complex (the relationship is both horizontal and vertical). We present a sketch of this methodology in Appendix A, which essentially entails comparing the industry codes (at the 4-digit SIC level) of both parents and subsidiaries to examine whether they produce the same good and/or whether the subsidiary is a supplier to its parent. The latter is determined using the industry codes in combination with an input-output table to identify whether the industry of the subsidiary corresponds to an upstream industry of the parent's output. Similarly to Alfaro and Charlton (2009) we use the Bureau of Economic Analysis 1987 benchmark input-output table and employ alternative thresholds of the input-output total requirements coefficient.[9] In this paper we work only with the affiliates that are vertically-linked to a firm in another country which are identified at the 4-digit SIC level. [10]

Logistics infrastructure data

Our infrastructure data comprises two dimensions that are relevant for the location of fragmented production, as mentioned in section 2. The first dimension is related to the quality of port and airport infrastructure. Improvements in the quality of port and airport infrastructures are typically associated with declines in transport costs, waiting times and also with lower handling costs that could arise from moving

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[6] A corporate linkage occurs when one business location has financial and legal responsibility for another business location. In the D&B dataset a corporate linkage occurs between a subsidiary and its parent or between a branch and its headquarter. A subsidiary is a corporation that is more than 50% owned by another corporation. A parent is a corporation that owns more than 50% of another corporation. A headquarter is a business establishment that has branches reporting to it, and is financially responsible for those branches. A branch is a secondary location of its headquarters and it has no legal responsibility for its debts. There are other types of family relationships that may occur between companies which are not linked in the D&B dataset because the relationship does not involve legal or financial responsibility. For instance, one company owns a part or minority interest, less than 50%, in another company or joint ventures where there is a 50/50 split in the ownership.

[7] D&B data have marketable and non-marketable records. Non-marketable records are firms that have been delisted from the database or whose information is under revision or incomplete (like lack of business name, physical-mailing address or sector code). We only have access to the marketable records.

[8] D&B uses a top down process to gather the corporate family tree of multinationals. D&B typically contacts a knowledgeable source at the parent company or one of its high-level subsidiaries to ascertain the proper family tree structure. Therefore, once a multinational enters the database, all of the establishments in its ownership hierarchy also enter the database regardless of their location. The process minimizes the likelihood that subsidiaries and branches are underrepresented in developing countries relative to industrial countries. The top down approach is also complemented with a bottom up process in which a subsidiary/parent company or a branch/headquarter linkage is collected at the country level during regular revisions.

[9] Specifically, we employ a baseline threshold equal to 0.001 but run all the regressions with alternative thresholds. The robustness tests in the next section indicate that the results do not change in any significant way. Appendix B discusses in more detail the use and the selection of thresholds.

[10] From the group of establishments in which a link with a parent can be established, around 40% tend to be purely vertical subsidiaries.

shipments in and out of vessels (Limao and Venables, 2001; Clark, Dollar and Micco, 2004; Micco and Serebrisky, 2006). Accordingly, countries with adequate port and airport infrastructures should be attractive locations for MNCs that are seeking to locate part of their production processes abroad while minimizing transportation costs and potential disruptions of the chain.

The second infrastructure dimension is related to the logistics that facilitates the coordination of production across space. As mentioned before, the ICT infrastructure is a crucial platform that provides firms the possibility to move information over long distances in fast, cheap and reliable ways lowering the costs of coordinating production blocks across borders. Therefore, countries with adequate ICT infrastructures should also be appealing destinations for corporations fragmenting production internationally.

Detailed data on port and airport efficiency are hard to find. The literature on the determinants of transport costs sometimes relies on econometric estimations to recover a parameter that proxy the efficiency of the port or the airport (Blonigen and Wilson, 2008) but this approach is hindered by the scarcity of freights data at a cross-country basis. In this paper we employ a combination of hard data and survey indicators of infrastructure. First, we obtain hard micro data on port and airport characteristics to construct measures of port and airport availability at the country level. Specifically, we follow the work in Clark, Dollar and Micco (2004) and construct a measure of seaport infrastructure that captures the availability of ports with adequate leverage capacity. The port infrastructure variable consists of the number of ports in the country that have lifts with leverage capacity of at least 50 tons (squared) normalized by the country's population. Similarly, we construct a measure of the adequacy of airport infrastructure following the work in Micco and Serebrisky (2006). The measure consists of the number of airports with paved runways of at least 2000 meters long and 40 meters wide (squared) divided by the population of the country. According to the authors, this choice of runway dimension is based on the minimum requirements for aircrafts typically used in the air cargo industry. [11] The data on ports come from the World Port Index, 2011, prepared by the US National Geospatial-Intelligence Agency and the data on airport characteristics come from the ST3400 Database, 2011, of Sandel Avionics. These port and airport infrastructure variables are subsequently transformed into indexes that take values between 1 and 100.

With respect to ICT infrastructure, we combine a series of hard indicators following the core measures on ICT infrastructure suggested by The Partnership on Measuring ICT for Development.[12] The core indicators

[11] We follow these authors in using the country's population for normalizing the port and the airport infrastructure measures. Alternatively, we also employ the number of employees which could be argue is more closely related to the level of economic activity. The results, available from the authors upon request, do no change in any significant way.

[12] This partnership was created in 2003 by ITU, OECD, UNCTAD, UNESCO Institute for Statistics, UNECA, UNECLAC, UNESCAP, UNESCWA, the UN ICT Task Force and the World Bank, to work towards defining and collecting a set of common ICT indicators and assisting developing countries in their efforts to produce information society statistics

are: fixed telephone lines per 100 inhabitants, mobile cellular telephone subscriptions per 100 inhabitants, terrestrial mobile wireless subscriptions per 100 inhabitants, dedicated mobile data subscriptions per 100 inhabitants, fixed (wired) Internet subscriptions per 100 inhabitants, fixed (wired) broadband Internet subscriptions per 100 inhabitants and the international Internet bandwidth per Internet user. Our ICT infrastructure index consists of the linear average of all these variables after they are normalized to take values between 1 and 100.

As mentioned before, we combine the hard data on logistics infrastructure with survey indicators. The latter are obtained from the Global Competitiveness Index, 2011, of the World Economic Forum. In particular we take three sub-indexes, the "quality of port infrastructure", "quality of air transport infrastructure" and "quality of ICT infrastructure". Each of these sub-indexes is normalized to take values between 1 and 100 as with the previous sub-indexes. Our port infrastructure index, then consist of the average of the port index constructed with the hard data and the port index based on the survey information. Similarly, the airport infrastructure index and the ICT infrastructure index are constructed by combining their corresponding hard data index and survey indicator.

Finally, it is important to mention that the resulting port, airport and ICT indexes are highly correlated among themselves. All the correlations are higher than 0.7 and statistically significant at the 1% This precludes identifying the individual impact of each index on the location of vertical FDI. Therefore, we construct a final overall logistics index per country that consists of the average of these three indexes.

We insert the logistics index in the gravity equation by combining the logistics indexes of both the parent and the host country. The rationale is that having adequate access to good logistics infrastructure is important not only in the host country from which the components are shipped to the headquarters but also in the parent country that receives the components. Thus, our logistics measure consists of the product of the logistic measures of both countries.

Sources of additional variables

The data on country skills come from the Barro-Lee Education Attainment Dataset. The dummy variable for the economic integration agreements is constructed using a dataset assembled by Scott Baier and Jeffrey Bergstrand.[13] Finally, our proxy for the industry dependence on logistics services is a measure of industry sensitivity to shipping times constructed by Hummels and Schaur (2012). The rationale is based on the idea that rapid delivery require good logistics infrastructure; therefore, industries that are sensitive to shipping times are also sensitive to good logistics. The advantage of using Hummels and Schaur measure is that it is

[13]The data can be obtained in the following site: http://www.nd.edu/~jbergstr/

constructed in a way that it is agnostic regarding why speed is important.[14] Accordingly, the measure can be capturing sensitivity to logistics services for an array of different reasons. The most obvious one is that adequate logistics infrastructure is important because swift delivery is necessary to meet uncertainty from the demand side of the supply chain. Hummmels and Schaur (2010) and Evans and Harrigan (2005), for example, examine the link between speed of delivery and uncertainty due to rapid fluctuations in demand. Another reason is that speed might be the outcome of an effort to avoid unreliability in the supply side of the chain. For instance, Clark, Schaur and Kozlova (2012) show that firms tend to switch to more expensive air shipping when uncertainty in ocean shipping increases.[15] Therefore, we can reasonably argue that the measure of time sensitivity is capturing the dependence of the industry on good logistics infrastructure because there are industries that require rapid deliveries but also because there are industries for which it is vital to minimize uncertainty and potential disruptions in the delivery of the good.

3. Empirical results

Table 1 shows key descriptive statistics of the dependent variable. The first three rows of the table report summary statistics aggregated at the country level. For example, on average, a host country has vertically-integrated subsidiaries from 33 different parent countries; the typical parent country owns subsidiaries in 47 different countries, and the average number of subsidiaries of a parent country in a host country is 31. There is large variation in the data. For instance, the standard deviation of the number of subsidiaries of a parent country in a host country is 119. The last three rows of the table report the summary statistics across pairs of countries and sectors (2-digit SIC level). There is also significant variation in the data at this level of aggregation. This variation already suggests that the patterns of vertical FDI flows across countries are far from being homogenous with some countries and sectors capturing a considerable amount of subsidiaries while others attract much smaller quantities. Table 2 shows a summary of our main explanatory variable, the logistics infrastructure index. As expected, the quality of logistics infrastructure is higher for the most advanced nations and lower for countries with low incomes.

We start our estimations by running the simplest form of the gravity equation, as in equation 1. Column 1 from table 3 shows least square estimates while columns 2 and 3 show two quasi-maximum likelihood estimations (QMLE), the poisson model and the negative binomial model, respectively. The QMLE regressions have the advantage of incorporating the zero value observations that are dropped in the least

[14] Specifically, the measure reflects the premium for air shipping that firms in an industry are willing to pay to avoid an additional day of ocean transport. In particular, the measure is calculated for over 1000 products at the 4-digit level of the Harmonized System (HS).

[15] Harrigan and Venables (2006) examine the issue of uncertainty in shipping goods in a theoretical framework. They model uncertainty as a function of distance. In the equilibrium, companies tend to locate close to each other to assure timely delivery of all the components. In our gravity framework, this uncertainty associated to distance is controlled by the bilateral distance variable.

squares because of the linear-in-logs specification.[16, 17] The three estimations show somewhat similar results. In general, vertical FDI is larger for countries with common border and common language. Distance affects vertical FDI negatively confirming previous results in the literature. The role of common colonial ties and trade agreements is positive and significant in the QMLE estimations but insignificant in the least square model, and the coefficient for differences in human capital, while positive and significant in the least squares model is insignificant in the QMLE estimations. This latter result is consistent with Alfaro and Charlton (2008) who also control for zero value observations and find that human capital does not have a significant effect on the number of vertical subsidiaries.[18] Most importantly for the purposes of this paper, we find in all the regressions a positive relationship between vertical FDI and the measure of logistics infrastructure. A 10% improvement in the quality of the logistics infrastructure induces an increase of around 8% in the number of vertically-linked affiliates. Note that the relation is statistically significant even after controlling for distance suggesting that both variables have separate effects on the location of vertical FDI. Given the advantage of incorporating the zero value observations, we will continue using the QMLE model. Specifically, we will show the results when we employ the negative binomial estimation as this model is more general than the Poisson. Nevertheless, the results with the Poisson estimation do not change in any significant way.[19]

The positive correlation that we have found in table 3 between logistics infrastructure and vertical FDI does not necessarily imply causality. As mentioned before, improvements in logistics infrastructure might attract vertical FDI but logistics infrastructure investments might also be shaped by existing FDI trends. To address this potential endogeneity issue, we rely on a difference-in-difference specification that examines whether countries with adequate logistics infrastructure attract more vertical subsidiaries in industries that are more dependent on logistics services. As mentioned in the previous section, our proxy for the industry dependence on logistics services is a measure of industry sensitivity to shipping times from Hummels and Schaur (2012). The measure, constructed using data on air and maritime freight rates, reflects the premium for air shipping that firms are willing to pay to avoid an additional day of ocean transport. We can expect, for instance, that highly perishable goods might be time sensitive. But this is not only about the perishability of a good. Other goods, like computer chips, might also require fast shipments because they enter just-in-time production

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16 The QMLE has the additional advantage of imposing much weaker conditions on the error term than those imposed by the least square estimation. As mentioned by Santos Silva and Tenreyro (2006), the least square estimation yields consistent estimates of the parameters if the error term is homoskedastic and normally distributed. These requirements are relaxed in the QMLE.

17 Santos Silva and Tenreyro (2006) propose the Poisson model. The Poisson model is a special case of the more general negative binomial model. The advantage of the negative binomial model is that it does not impose the mean equals variance restriction of the Poisson model and thus it can accommodate overdispersion.

18 The authors show that human capital have a significant impact but only when vertical linkages are defined at the 2-digit SIC level of aggregation; at the 4-digit SIC level, the impact disappears. Indeed, one of the major contributions of this work is to show that there is a significant amount of vertical FDI occurring across countries with similar comparative advantages which might have been previously misclassified as horizontal FDI. In this study we define vertical linkages at the 4-digit SIC level as in Alfaro and Charlton (2008)

19 Results from the Poisson model are available from the authors upon request

processes and thus they are expected to have high values of this measure. Also, as mentioned before, the indicator is likely to capture the sensitivity to logistics infrastructure because of other factors, like reliability of delivery.

The time sensitivity measure is calculated originally at the 4-digit level of the Harmonized System and we convert it to the 4-digit SIC level using a concordance table taken from the World Integrated Trade Solution. We then aggregate the measure at the 2-digit SIC level by taking simple averages of the index within each 2-digit SIC category. Table 6 shows the values by sectors ordered from the largest to the smallest. In general, the ranking seems to make intuitive sense. For instance, shipments of livestock are the most time-sensitive while shipments of coal are the least time-sensitive. Generally, mineral commodities and light manufactures like textile or tobacco tend to have low time-sensitivity values while shipments of more complex manufactures like machinery or scientific and professional instruments tend to have larger time-sensitivity values.

The first column of Table 4 shows the difference-in-difference estimation. The key result in this regression is the positive and significant coefficient of the interaction term between the measure of time-sensitivity and the logistics infrastructure index. The positive coefficient implies that countries with better logistics infrastructure attract more vertical subsidiaries in industries that are more dependent on logistics services. The result is economically significant. The value of the coefficient implies, for example, that if Philippines, a country at the first quartile of the distribution of logistics infrastructure were to improve the quality of its infrastructure system to the level of the third quartile (Israel), the number of vertically-integrated subsidiaries would increase by an average of 15 percent. The change is different for different sectors. For instance, the number of vertical subsidiaries in the chemicals sector, which is highly time sensitive (4th quartile of the distribution of time-sensitiveness) would increase by 30 percent while the number of vertical subsidiaries in the textile sector (low time-sensitive, 1st quartile) would increase by 11 percent, a 19 percentage points difference.

We now present a series of additional regressions to test the robustness of the results. We start by including additional covariates to control for factors that even though are not explicitly integrated into the fragmentation framework mentioned above, might still play a role in the location decisions of multinational companies. The first variable is derived from the recent work in Alfaro and Charlton (2008). The main idea is that the position in the supply chain is an important factor behind the decision of a multinational to bring blocks of production inside the boundaries of the firm. More specifically, the authors argue that inputs closer to the multinational's core business are more likely to be sourced via subsidiaries while inputs far from the core business are more likely to be sourced through external suppliers. The immediate consequence of this is that a larger number of vertically-integrated subsidiaries across pair of countries would be observed the closer the industry of the subsidiary to the industry of the parent. The authors present empirical evidence supporting this argument. It seems then important to control for this factor, particularly given the similarities between the datasets employed in both papers. We do this by including in our specification a measure similar to what these authors call "proximity" which is based on the idea that for any given input employed in the production of any given product, the ratio of the direct requirements to the total requirements coefficients (both obtained from the BEA input-output tables) provides a measure of how close is a particular input to the production of the good. For instance, raw materials tend to have low proximity values while main inputs tend to have higher values. Following the authors, we construct proximity values for each pair of four-digit SIC codes. Then we introduce them in our specification by taking the average of across all pairs of products between country *i* and *j*. We should expect a positive coefficient for this variable.

The second covariate has to do with barriers to firm entry. Remember that in this study the dependent variable is the number of subsidiaries from a multinational in parent country *i* successfully opened in host country *j*. Therefore, one could expect that this variable might be sensitive to existing regulatory barriers to firm entry. For instance, in the two-stage procedure for estimating trade flows, Helpman, Melitz and Rubinstein (2008) use firm entry costs for their first stage estimation of selection into exporting. The authors argue that the fixed costs of entering export markets are associated with the costs of starting a business in that market. In our case, the dependent variable is precisely the number of subsidiaries that have started operations in a particular market; therefore, we should expect that this variable is affected by the costs of starting a business. To deal with this issue in the gravity framework that already incorporates country fixed effects, we follow the specification used in Helpman, Melitz and Rubinstein (2008) by combining entry barriers for both partner countries. According to these authors, entry costs are likely to be magnified when both partner countries impose high regulatory hurdles. Following this study, we construct a dummy variable for high fixed-costs of entry that consist of country pairs in which both the parent and the host country have entry regulation measures above the cross-country median, where the measures are the sum of the number of days and the number of procedures needed to legally start operating a business. The data are taken form the Doing Business dataset of the World Bank.

Our third covariate seeks to control for the quality of contracting institutions. Antràs (2011), for example, argue that uncertain and ambiguous practices in contract enforcement can undermine international transactions particular those involving intermediate inputs in supply chains. Consistent with this view, Bernard, Jensen, Redding and Schott (2010), show that the quality of the legal contractual system is positively related with the extensive margin of intra-firm trade. To include this aspect in the model we proceed in a similar way as with the previous factor and construct a dummy variable for the quality of contracting institutions that is equal to one when both the parent and the host country have measures above the cross-country median. The measure that we employ is the rule of law index constructed by Kaufmann, Kraay and Mastruzzi (2006).

Columns 2 to 5 of table 4 show the results of including these additional covariates. The coefficient on proximity is significant at the 1% supporting the findings in Alfaro and Charlton (2008). The coefficients for barriers to entry and for the quality of the contracting institutions are also significant and show the right signs. Most importantly, the results regarding the effects of logistics infrastructure on vertical FDI do not change in any significant way. The coefficients for the logistics infrastructure index and for the interaction term remain positive and significant at conventional levels. Note that these results are also robust to alternative specifications of the dependent variable in which the vertical relationship between a parent and its subsidiary is defined under alternative input-output thresholds (see Table B.2 in Appendix B).

While we have introduced additional covariates to the baseline model to check for the robustness of the results, there are many other factors that have been shown to affect the location of FDI, including financial deepening (di Giovanni, 2005), creditor's rights (Loungani et al., 2003), time zones (Stein and Daude, 2007), property rights protection (Bénassy-Quéré et al., 2007), taxes (Mutti and Grubert, 2004), corruption (Wei, 2000), and government instability (Daude and Stein, 2007) among others. We could tackle this issue by adding several of these variables in the regression; however, as the list of potential factors is large, we could still run into an omitted variables problem. Our preferred strategy is to use a more stringent set of fixed effects to capture many potential factors that may influence the decision of a multinational in country *i* to establish a subsidiary in country *j*. In particular, we add a parent-host country fixed effect in addition to the previous fixed effects and examine whether our variable of interest, the interaction term, remains robust. One problem with this specification, however, is that the set of fixed effects is too demanding for the QMLE iterative techniques to converge. Accordingly, we show the results using the more traditional least-squares estimation. While we are fully aware that the exclusion of the zero-value observations might result in a biased coefficient, our main interest in this exercise is on the significance of the interaction term. The results are shown in column 1 of table 5. The coefficient for the interaction term remains positive and significant after the more demanding set of controls are imposed.

Our last set of regressions consists on an exercise that tests the consistency of our identification strategy. As mentioned before, this strategy relies on the notion that industries differ in their sensitivity to logistics services which we proxy using Hummels and Schaur's measure of time sensitivity. According to this, the more sensitive the industry to these services the more important is to source from countries with adequate logistics infrastructure. One can reasonably think, however, that time sensitivity is also a function of the distance between the countries. For instance, differences in time sensitivity across industries might be less relevant for very close countries because everything can be deliver fast, but when countries are far apart, these differences should matter more. This implies that our interaction term between the quality of logistics infrastructure and the time sensitivity measure might have a non-linear relationship with distance. To explore this issue we re-estimate the regression in column 1 across two groups of countries which we define by the median distance between the parent and the host country. The results are shown in columns 2 and 3 of table 5. The coefficient for the pair of countries whose distance is below the median is lower than the coefficient for the pair of countries with distance above the median, a result that is consistent with the idea that the importance of logistics infrastructure particularly for time sensitive industries tends to decrease with proximity.

4. Concluding remarks

Production processes have been increasingly fragmented worldwide and the emergence of international production networks has opened up new opportunities for countries to participate in ever finer international divisions of labor. By allowing countries to join global supply chains rather than building them entirely domestically, the surge in international fragmentation of production is providing nations with new paths of industrialization (Baldwin, 2011). As developing countries scramble to get a piece of the action, it is important to understand the main drivers behind these international supply chains. A prominent group of papers has emerged in recent years precisely with this objective (Yeaple, 2003; Hanson, Mataloni, Salughter, 2005; Alfaro and Charlton, 2009). The present paper contributes to this literature by analyzing empirically the specific determinants of cross-border production sharing and in particular by examining the role of logistics infrastructure on the location of vertical FDI. The rich dataset employed in this study based on corporate linkages at the plant level and the empirical strategy used allow us to capture the vertical specialization phenomenon globally and estimate in a precise manner its responsiveness to the quality of logistics infrastructure while properly controlling for other factors. Our results fill a gap between the lack of systematic evidence in this area and mounting casual observation arising from case studies indicating that multinational corporations are increasingly searching for places with adequate transport and logistics infrastructure to locate affiliates.

Our results have important policy implications. While distance is found to be an important factor providing support to the common perception that international production networks tend to be regional (Hummels, Rapoport and Yi, 1998) there is a policy venue with respect to transportation and coordination costs via the quality of logistics infrastructure. Conditioned to other factors, the results show that improvements in the quality of logistics infrastructure -including transport-related infrastructure and information and communication-related infrastructure- have important effects in the attraction of vertical FDI particularly in industries that are highly dependent on logistics services.

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Table 1: Descriptive statistics of foreign-own vertically integrated subsidiaries

Variable \ Statistics	Mean	St. Dev	Min	Max
No. of parent countries that own subsidiaries in host country i	33	17	1	68
No. of host countries in which a parent country j own subsidiaries	47	27	1	92
No. of subsidiaries in host country i from parent country j	31	119	1	2226
By sector k (2-dig SIC)				
No. of parent countries that own subsidiaries in host country i in sector k	15	10	1	45
No. of host countries in which parent country j own subsidiaries in sector k	20	14	1	58
No. of subsidiaries in host country i from parent country j in sector k	6	17	1	528

Notes: The table summarizes the variation in the ownership of vertically integrated subsidiaries across 178 countries and 32 sectors. All summary statistics are for the sample of positive values. A sector is defines at the 2-digit level in the SIC industry classification. The first three rows of the table report summary statistics across pairs of countries; specifically, the number of parent countries that own subsidiaries in a host country; the number of host countries in which a parent country own subsidiaries, and the number of subsidiaries in a host country from a parent country. The last three rows report summary statistics across pairs of countries and by sector; specifically, the number of parent countries that own subsidiaries in a host country in each sector; the number of host countries in which a parent country own subsidiaries in each sector, and the number of subsidiaries in a host country from a parent country in each sector.

Table 2: Summary of logistics infrastructure index

	High income countries	Middle income countries	Low income countries
Average	56.7	28.9	14.8

Notes: The table presents the average of the logistics infrastructure index for the countries according to income groups. The index goes from 1 (inadequate infrastructure) to 100 (adequate infrastructure). Income groups are taken from the World Bank classification

Table 3: Baseline estimations

	OLS	Poisson	Negative Binomial
Regressor	**(1)**	**(2)**	**(3)**
Contiguity	0.3018***	0.3848***	0.4850***
	(0.0789)	(0.1256)	(0.1705)
Common language	0.1902***	0.4304***	0.5386***
	(0.0626)	(0.1267)	(0.1069)
Colonial ties	0.1087	0.5867***	0.5276***
	(0.0793)	(0.1435)	(0.1138)
Skill difference	2.0785***	-1.3112	-1.4017
	(0.3683)	(2.1089)	(3.9276)
PTA	-0.0415	0.4963***	0.3280**
	(0.0746)	(0.1897)	(0.1439)
Distance	-0.3098***	-0.4401***	-0.7392***
	(0.0313)	(0.0645)	(0.0582)
Logistics infrastructure	0.7532***	0.5975***	0.5922***
	(0.1148)	(0.2818)	(0.2061)
Parent country fixed effect	yes	yes	yes
Host country fixed effect	yes	yes	yes
Sector fixed effect	yes	yes	yes
Observations	8611	305760	305760
R^2	0.49	--	--

Notes: The dependent variable in the column (1) is the log of the number of subsidiaries in country i from country j in sector k. The dependent variable in the columns (2) and (3) is the number of subsidiaries in country i from country j in sector k. Robust standard errors clustered by country pairs reported in parentheses.

*** ; ** ; * significant at the 1%, 5% and 10% level respectively

Table 4: Difference-in-difference estimation

Regressor	(1)	(2)	(3)	(4)	(5)
Contiguity	0.4861***	0.3759***	0.4877***	0.4934***	0.3871***
	(0.1704)	(0.1200)	(0.1704)	(0.1693)	(0.1196)
Common language	0.5404***	0.5352***	0.5385***	0.5452***	0.5291***
	(0.1069)	(0.1165)	(0.1070)	(0.1073)	(0.1165)
Colonial ties	0.5284***	0.2118*	0.5291***	0.5304***	0.2169*
	(0.1140)	(0.1228)	(0.1140)	(0.1149)	(0.1225)
Skill difference	-1.4130	-1.3982	-0.8467	-1.7277	-0.6381
	(3.9196)	(3.0533)	(3.9570)	(4.0096)	(3.1277)
PTA	0.3282**	0.0772	0.3304**	0.3523**	0.1098
	(0.1436)	(0.1134)	(0.1438)	(0.1432)	(0.1137)
Distance	-0.7400***	-0.6036***	-0.7397***	-0.7354***	-0.5971***
	(0.0581)	(0.0535)	(0.0581)	(0.0576)	(0.0531)
Logistics infrastructure	0.5476***	0.5389**	0.5535***	0.7038***	0.7017***
	(0.2057)	(0.2377)	(0.2053)	(0.2006)	(0.2211)
x Time-sensitiveness	0.0568***	0.0627***	0.0569***	0.0578***	0.0639***
	(0.0210)	(0.0198)	(0.0210)	(0.0209)	(0.0198)
Proximity		7.3277***			7.3299***
		(0.1117)			(0.1111)
Barriers to firm entry			-1.0636**		-2.7098***
			(0.4006)		(0.9512)
Rule of law				0.6723***	0.6051**
				(0.2444)	(0.2678)
Parent country fixed effect	yes	yes	yes	yes	yes
Host country fixed effect	yes	yes	yes	yes	yes
Sector fixed effect	yes	yes	yes	yes	yes
Observations	305760	305760	305760	305760	305760

Notes: The dependent variable in all columns is the number of subsidiaries in country i from country j in sector k. All the regressions are estimated with the negative binomial model. Robust standard errors clustered by country pairs reported in parentheses.

*** ; ** ; * significant at the 1%, 5% and 10% level respectively

Table 5: Additional estimations

Regressor	(1)	Proximate versus distant countries (2)	(3)
Logistics infrastructure x Time-sensitiveness	0.0712***	0.0568***	0.0795***
	(0.0141)	(0.0168)	(0.0165)
Parent country fixed effect	no	no	no
Host country fixed effect	no	no	no
Sector fixed effect	yes	yes	yes
Parent-host country fixed effect	yes	yes	yes
Observations	8708	4339	4369
R^2	0.50	0.50	0.50

Notes: Column (1) is estimated with all the sample. Columns (2) and (3) show the results for pairs of countries with distances below and above the median, respectively. Robust standard errors clustered by country pairs reported in parentheses.

*** ; ** ; * significant at the 1%, 5% and 10% level respectively

Table 6: Time sensitivity measure

SIC	Description	Time sensitivity
02	Livestock and livestock products	2.590
28	Chemicals and allied products	1.659
39	Miscellaneous manufactured products	1.257
32	Stone, clay, glass, and concrete products	1.224
38	Scientific and professional instruments	1.171
34	Fabricated metal products	1.100
14	Nonmetallic minerals	0.998
35	Machinery, except electrical	0.905
30	Rubber and plastic products	0.904
26	Paper and allied products	0.881
36	Electrical machinery	0.788
33	Primary metal products	0.743
27	Printing, publishing and allied products	0.703
23	Apparel	0.666
13	Crude petroleum and natural gas	0.665
37	Transportation equipment	0.654
20	Food and kindred products	0.591
25	Furniture	0.585
09	Fish, fresh or frozen and other marine products	0.577
24	Lumber and wood products	0.577
22	Textile	0.575
01	Agricultural products	0.433
29	Petroleum refining and related products	0.359
21	Tobacco	0.279
08	Forestry products	0.268
10	Metallic ores and concentrates	0.000
12	Coal and lignite	0.000

Appendix A

Alfaro and Charlton (2008) developed a methodology to identify horizontal and vertical FDI linkages between parent companies and their subsidiaries using firm ownership from the D&B dataset and input-output tables. We employ the same methodology in this paper. This appendix presents a brief sketch of the technique. For the interested reader, the full details of the methodology can be found in Alfaro and Charlton (2008).

In the D&B dataset each parent and each subsidiary reports up to six SIC codes. These codes are used to examine whether the parent company and its subsidiary are engaged in the same activities or whether the subsidiary is in industries that are upstream from the parent industry. The latter is determined using the industry codes in combination with the Bureau of Economic Analysis 1987 benchmark input-output table. An industry is considered upstream from another industry if the input-output total requirement coefficient is greater than a certain threshold (see Appendix B). The authors formalize four possible relationships that can be established between a parent and a subsidiary:

Horizontal relationship: if both establishments share any of the SIC codes, or if all the codes are the same

Vertical relationship: if any SIC code from the subsidiary is an input to any SIC code of the parent, and the sets of codes are not identical

Complex relationship: if both establishments share any of the SIC codes and if any SIC code from the subsidiary is an input to any SIC code of the parent, and the sets of codes are not identical

Neither: if none of the above linkages can be established

Appendix B

The input requirement coefficients from the I-O table are used to determine whether a firm in industry *i* provides an input to a firm in industry *j*. Alfaro and Charlton select a baseline threshold equal to 0.05 (meaning that 5 cents worth of industry *i* are required to produce a dollar's output in industry *j*) but also use alternative thresholds between 0.01 and 0.1.

The threshold aids in the identification strategy by filtering implausible vertical linkages between a subsidiary and its parent. Take, for instance, the case of Fujifilm Corporation, the Japan multinational company specialized in photographic equipment and supplies (sic: 3861). Two of the firm´s affiliates are Fujifilm Electronic Materials Taiwan Co., a Taiwan-based plant specialized in industrial chemicals manufacturing (sic: 2819) and Sericol LTD, a plant based in England that produces office, school and art supplies (sic: 3952). While the first affiliate can be reasonably identified as being vertically-linked to Fujifilm Corporation, the second one is much less plausible. The threshold helps to filter the second unlikely case.

Setting a threshold is admittedly an arbitrary choice. A threshold that is too high can result in failing to detect a vertical linkage that may indeed be present. A threshold that is too low may mistakenly imply the existence of a vertical link when in reality there is not a supplier-buyer relationship. In this paper we set our baseline threshold at 0.001 after a series of checks with the BEA I-O matrix. Table B.1 presents one of those checks. The table specifically shows a hypothetical case for the motor vehicles industry (sic: 3711). The table depicts the production required of a selection of industries for one dollar of motor vehicles according to the BEA I-O accounts. The first industry, internal combustion engines (sic: 3519), has a coefficient of 0.0207 while the rest of the industries have coefficients lower than 0.01. Setting a threshold equal to 0.01 would induce the methodology to identify companies in the first industry as having vertical links with a company in motor vehicles but would fail to do so for any company in the other industries even though they are all obvious inputs to cars. Additional checks with other sectors confirm that a threshold equal to 0.001 produces reasonable outcomes. Nevertheless, in section 3 we present estimates with higher (more conservative) thresholds as well as with lower thresholds. The tests show that the results do no change in any qualitative way.

Table B.1: Selected input requirements for motor vehicles and car bodies (3711)

	I-O coefficient
1. Internal combustion engines (3519)	0.0207
2. Carburetors, pistons, piston rings and valves (3592)	0.0099
3. Ball and roller bearings (3562)	0.0054
4. Steel pipe and tubes (3317)	0.0050
5. Vehicular lighting equipment (3647)	0.0049
6. Electrical motors and generators (3521)	0.0034
7. Switchgear and switchboard apparatus (3613)	0.0016
8. Pumps and pumping equipment (3561)	0.0010

Note: the table provides the total input requirements from selected industries (in the rows) to the motor vehicles and car bodies industry (3711). Specifically, the values show the production required, both directly and indirectly, of the industry in the row per dollar of delivery to final use of motor vehicles and car bodies. The information is taken from the 1987 Bureau of Economic Analysis (BEA) input-output accounts

Table B.2: Estimations with alternative thresholds for the input-output coefficient

Thresholds	> 0.01	> 0.005	> 0.0005	> 0
Regressor	**(1)**	**(2)**	**(3)**	**(4)**
Contiguity	0.5785***	0.3780***	0.3734***	0.3747***
	(0.1486)	(0.1253)	(0.1228)	(0.1153)
Common language	0.3852***	0.4485***	0.5476***	0.5741***
	(0.1076)	(0.1014)	(0.1241)	(0.1131)
Colonial ties	0.4000***	0.3011***	0.1934	0.1936
	(0.1081)	(0.1097)	(0.1309)	(0.1179)
Skill difference	-1.6866	-1.6339	-0.8323	-0.6224
	(2.6441)	(2.9257)	(2.9904)	(3.1674)
PTA	0.1643	0.0504	0.0572	0.1302
	(0.1481)	(0.1185)	(0.1088)	(0.1120)
Distance	-0.5135***	-0.6561***	-0.6518***	-0.5851***
	(0.0658)	(0.0545)	(0.0540)	(0.0541)
Logistics infrastructure	0.9042***	1.0407***	0.7595***	0.7150***
	(0.2090)	(0.2112)	(0.2228)	(0.2132)
x Time-sensitiveness	0.0448***	0.0661***	0.0662***	0.0645***
	(0.0187)	(0.0209)	(0.0198)	(0.0192)
Proximity	6.1470***	7.4457***	7.1603***	7.5076***
	(0.1347)	(0.1307)	(0.1148)	(0.1121)
Barriers to firm entry	-0.6981	-1.7919***	-2.2504***	-2.7540***
	(0.5992)	(0.4328)	(0.8398)	(0.9619)
Rule of law	0.3022	0.6134**	0.6484**	0.5820**
	(0.2758)	(0.2480)	(0.2517)	(0.2510)
Parent country fixed effect	yes	yes	yes	yes
Host country fixed effect	yes	yes	yes	yes
Sector fixed effect	yes	yes	yes	yes
Observations	305760	305760	305760	305760

Notes: The dependent variable in all columns is the number of subsidiaries in country i from country j in sector k. All the regressions are estimated with the negative binomial model. Robust standard errors clustered by country pairs reported in parentheses.

*** ; ** ; * significant at the 1%, 5% and 10% level respectively