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Abstract

Most multinational firms today operate multilateral production networks. Most existing empirical analyses, however, have focused on the choice between producing at home and investing overseas and assumed firms' decisions to invest in foreign countries to be independent of their locations in third countries. This paper uses detailed French multinational subsidiary level data to examine the effect of existing production networks on multinationals' entry decisions. The paper finds strong evidence of horizontal and vertical interdependence across multinationals' foreign production locations, but little evidence of interdependence between home-country production and foreign investment when third-country effects are taken into account. This result constitutes a sharp contrast to the conventional emphasis, and highlights the importance of investigating the causes and effects of foreign direct investment in the context of multinational production networks.

Key words: multinational firm, production network, interdependence, entry decision, trade cost, input-output linkage

JEL codes: F23, D21

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1 Introduction

Most multinational corporations (MNCs) today operate multilateral production networks. French multinationals, for example, invested in, on average, 3.8 foreign countries in 2007, an increase of 0.9 country per firm compared to 2005. Yet the vast empirical literature of multinational firms has largely ignored the multilateral nature of MNC production, focusing instead on the relationship between home-country production and foreign investment. Most studies in the literature assume that multinational firms' decisions to invest in foreign countries are independent of their existing production networks in third countries, an assumption increasingly at odds as multinationals expand production around the world.

This paper examines the effect of third-country production networks on multinationals' entry decisions using a rich dataset that provides detailed location, ownership, and production information for French manufacturing firms' foreign subsidiaries in 2005 and 2007. These data are used to identify the structure of individual firms' production networks around the world and the change of the networks over time. They are also used to establish intra-firm linkages, in particular, the input-output relationships of subsidiaries' production activities, thereby making it possible to distinguish the nature of interdependence among multinationals' foreign subsidiaries.

Figure 1, for example, plots the geographic distribution of Renault's global production network in 2007. Two observations emerge in this figure. First, Renault owns subsidiaries in more than 10 countries outside of France. Second, Renault segments production across foreign production locations, producing components in countries like Argentina, South Korea, and Spain (represented by the darker area) and performing end processes in countries like Russia and Colombia (represented by the lighter area). These observations are not exclusive to Renault. French multinationals had abroad in 2007, on average, 0.72 intermediate production subsidiaries (producing intermediate inputs required for final-good production) and 2.49 final-good production subsidiaries (producing final products). It is clear that multinationals' investment decisions can no longer be viewed as a choice between producing at home and investing abroad, but involve, instead, networks of vertically linked subsidiaries.

[Figure 1 about here]

Econometric evidence in this study suggests strong interdependence in multinationals' foreign production networks. Third-country subsidiaries exert a significant effect on multinationals' expansion decisions with respect to both final-good and intermediate production. First, MNCs are more likely to locate final-good production in countries to which it would be relatively costly to import final goods from existing foreign subsidiaries. This result, referred to in the paper as horizontal interdependence, reflects MNCs' market access motive. Second, multinationals tend to produce final products in countries that offer better access to large markets. This finding, labeled in the paper as the market potential effect, captures the importance of host-country

market potential. Finally, the paper finds significant interdependence between intermediate and final-good production subsidiaries. Specifically, multinationals tend to locate final-good production so as to minimize the cost of importing intermediate inputs from existing intermediate production subsidiaries. Similarly, MNCs are more likely to select countries with better access to existing final-good production subsidiaries as intermediate production locations. This type of interaction, referred to here as vertical interdependence, is shown to increase in the extent of input-output linkages between subsidiaries.

The strong interdependence between MNCs' foreign production locations contrasts sharply with the little evidence of interdependence found between multinationals' production at home and new investments abroad. The estimated relationship between foreign investment and home-country production becomes insignificant in the paper when third-country network factors are taken into account. This result is robust to the various specifications and sensitivity analyses used to address omitted variable bias and potential endogeneity of network factors. In a departure from the existing literature, the result suggests that assuming away the interdependence of foreign production locations is likely to yield biased estimates of the relationship between home-economy performance and FDI activities, and calls for reconsideration of the conventional specification to take into account the effect of third-country networks.

Findings in this study also convey important messages to host-country policy makers. First, given the vertical interdependence between intermediate and final-good production, trade policies like lower import tariffs on intermediate inputs can affect countries' attractiveness as final-good production locations. Second, FDI flows to third countries can mediate the ability to attract multinationals. This cross-country spillover can be either positive or negative depending on the linkages of FDI flows.

This paper is closely related to a growing theoretical literature led by Yeaple (2003a), Ekholm, Forslid and Markusen (2007), and Bergstrand and Egger (2008) that applies FDI modeling to a three-country framework. The existing literature on FDI, including the seminal work of Markusen (1984) and Helpman (1984), and influential empirical contributions by Brainard (1997), Carr, Markusen and Maskus (2001), Yeaple (2003b), Helpman, Melitz and Yeaple (2004), and Hanson, Mataloni and Slaughter (2005), stresses the importance of market access and comparative advantage in multinationals' incentives to invest abroad.[1] Yeaple (2003a), Ekholm, Forslid and Markusen (2007), and Bergstrand and Egger (2008) show that the combination of market-access and comparative-advantage motives can lead to export-platform FDI whereby multinational firms adopt a host country as a platform from which to serve third nations. This prediction suggests that multinationals' investment decisions cannot be viewed as a binary choice between exporting from home and investing abroad, but rather engages other, third nations.

Most of the empirical literature has not taken into account the third-country effect, much

[1] See Blonigen (2005) for an excellent survey of this literature.

less the interdependence between multinationals' foreign production locations. The following few studies took the step of examining the determinants of export-platform FDI. Head and Mayer (2004) show that third-country market demand plays a significant role in countries' ability to attract multinational firms. They find that Japanese multinationals are more likely to locate in regions proximate to large markets. Baltagi, Egger and Pfaffermayr (2007) consider a broader set of third-country characteristics and find most of the characteristics exert a significant effect on the level of U.S. outbound FDI. Chen (2009) examines how a host country's preferential trade agreements with third nations can affect its receipt of FDI, and finds that countries integrated with large markets tend to experience an increase in total and export-platform investment.

Blonigen *et al.* (2007, 2008) were among the first to investigate cross-country interdependence in FDI. 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 the results to be sensitive to the sample of host countries: the third-country effect can be either insignificant or of reverse signs. Evidence of negative interdependence across proximate host countries, a result consistent with export-platform FDI theory, is found mainly among European OECD members. The authors further find that including third-country FDI does not alter the estimated effects of traditional FDI determinants. 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. The effect of third-country FDI in host countries is negative when the sample is restricted to European countries.

This paper examines the cross-country interdependence in individual multinationals' production networks using subsidiary-level data. The dataset employed here offers two distinct advantages relative to the aggregate data used previously in the literature. First, it makes it possible to distinguish horizontal and vertical linkages for each pair of subsidiaries at a disaggregate industry level (NACE 4-digit), following the methodology introduced in Alfaro and Charlton (2009). These linkages cannot be distinguished at the aggregate industry level considered in previous studies because, as Alfaro and Charlton (2009) note, a large percentage of vertical FDI is intra-industry. This might explain, to some extent, the ambiguity of the evidence reported in Blonigen *et al.* (2007, 2008), whose estimates likely reflect a mix of horizontal and vertical interactions. Second, the subsidiary-level dataset supports the examination of individual multinational firms' entry decisions, thereby making it possible to compare the effect of traditional FDI determinants with the effect of third-country networks. Evidence in the present study shows that the ability to focus on intra-firm interdependence results in sharply different findings from those reported in previous studies. Specifically, the estimated interdependence between FDI and home-country production disappears when third-country network variables are included.

The rest of the paper is organized as follows. Section 2 examines attributes of French MNC production networks. A simple, three-country theoretical framework to motivate the

empirical analysis is presented in Section 3, and the econometric methodology and data sources are described in Sections 4 and 5, respectively. The main econometric results are presented in Section 6, the sensitivity analyses in Section 7. Section 8 concludes.

2 Attributes of French MNC Production Networks

French multinational firms' production networks exhibit a number of notable attributes. Consider first the distribution of French multinationals by the number of countries in which investment occurs (Figure 2). In 2007, most French MNCs concentrated foreign production in three or more countries, with some spreading to as many as 63. Comparing 2007 with 2005, the average size of production networks increased by 0.93. Second, final-good production subsidiaries accounted for a large fraction of French MNCs' foreign production locations.[2] The average number of countries in which firms perform final-good production, 2.49, is significantly greater than the average number of countries in which firms engage in intermediate production.

[Figure 2 about here]

Now consider the geographic density of French MNCs' production networks. Based on the distance data obtained for each pair of subsidiaries (owned by the same French MNC), the closest two (in Austria and Slovakia) are 66 kilometers apart, the most distant pair (in Estonia and New Zealand) 19,845 kilometers apart. Most subsidiaries are within 6,126 kilometers of one another, the mean distance being around 6,000 kilometers. At the firm level, while a significant percentage of French MNCs operate relatively dispersed networks with subsidiaries located distant from one another, many MNCs concentrate their subsidiaries geographically, clustered in neighboring countries such as EU members.

Comparing the distance of final-good production locations with that of vertically linked subsidiaries suggests that the geographic density of production networks varies significantly with the input-output linkages between subsidiaries. Subsidiaries with input-output production relationships tend to be located closer to each other than subsidiaries that perform duplicate final-good production. The average distance between vertically linked subsidiaries is around 5,159 kilometers, significantly less than the average distance between final-good production subsidiaries.

The above observations apply as well to tariffs, which are obtained for each pair of subsidiaries owned by the same French MNC. For more than 30 percent of French MNC subsidiary pairs, the tariff rates between the subsidiary countries are zero. For more than 50 percent, the tariff rates are 7 percent or lower. At the firm level, more than 15 percent of French MNCs do not need to pay tariffs when exporting from one subsidiary country to another, and 50 percent face

[2] Section 4 describes how final-good and intermediate production subsidiaries are identified for purposes of the analysis.

an average of 6 percent or lower tariffs. This suggests that French MNCs' choice of foreign production locations are not always driven by the tariff-jumping motive; a large percentage can trade freely within their production networks.

Tariff rates, like distance, tend to be less between vertically linked subsidiaries than between final-good production locations. The average tariff rates for French MNCs to import intermediate inputs to final-good production subsidiaries are 1.5 percentage points lower than the 4.5 percent average tariff rates between final-good production subsidiaries.

3 Theoretical Motivation

As a prelude to the econometric analysis, a stylized theoretical framework is adopted in this section to motivate the empirical hypotheses.

3.1 General setup

Suppose the world consists of N countries $\mathcal{N} = \{1, 2, ..., N\}$. In each country, a certain amount of the representative consumer's expenditure, denoted as I_j ($j \in \mathcal{N}$), is allocated to the industry of differentiated products, within which the consumer has a utility function with constant elasticity of substitution (CES). Maximizing the CES utility function subject to the consumer's expenditure level yields the demand function for each representative variety: $q_{ij} = Y_j p_{ij}^{-\sigma}$, where q_{ij} denotes the quantity of the differentiated product produced by firms in country i and sold to destination country j, $Y_j \equiv I_j / \sum_r p_{rj}^{1-\sigma}$ denotes the demand level in country j with r representing the set of varieties, p_{ij} denotes the product price, and σ the constant elasticity of substitution. Note that $p_{ij} = \tau_{ij} \cdot p_i$, where p_i is country i's product market price and $\tau_{ij} \geqslant 1$ is the iceberg trade cost of exporting from country i to country j (with $\tau_{ii} = 1$).

Each firm produces a different brand of the differentiated product. Given the interest of the present study, it is assumed that country 1's firms can produce final goods in any country and firms in the other countries produce only at home and serve foreign markets via exports. Firms must pay a plant-level fixed cost F for each final-good production location and produce one unit of intermediate input for each unit of final good.[3] Country 1's firms can produce the intermediate input, as they can the final product, in any country. For simplicity, the plant-level fixed cost for intermediate-input production, denoted by G, is assumed to be sufficiently large that firms choose to perform intermediate production in only one location.[4] Intermediate

[3] Given this paper's focus on intra-firm linkages, the option of purchasing intermediate inputs from unaffiliated suppliers is not explored here. The effect of this option on firms' location decisions is a promising area for future empirical research. For theoretical studies in this area see, for example, Krugman and Venables (1996), Venables (1996), and Puga and Venables (1997). The empirical analysis undertaken in this paper attempts to control for these factors using firm fixed effect, as firm-level data that identify intermediate-input suppliers are largely missing.

[4] Although roughly in alignment with the observation that French multinationals have, on average, fewer intermediate production subsidiaries than final-good production locations, this assumption is not crucial for

production subsidiaries are assumed to sell inputs to final-good production subsidiaries at $m_k\tau_{ki}$, where m_k is the marginal cost of producing intermediate inputs and τ_{ki} is the cost of exporting intermediate inputs from country k to country i.

The goal of this model is to examine firms' decisions to invest in final-good and intermediate production given an existing production network. Let d_i be an indicator variable that equals 1 if a firm has final-good production in country i and similarly u_i be an indicator variable that identifies the existence of intermediate production in country i. Each firm's production network can then be characterized as $g \equiv \{d_i, u_i\}$ where $i \in \mathcal{N}$. A firm is defined as a national firm if it has no subsidiary abroad, and a multinational if it has at least one foreign subsidiary. The set of countries in which a firm performs final-good production is denoted by $\mathcal{N}_d(g) = \{i \in \mathcal{N} : d_i = 1\}$ and the set of countries with intermediate production is represented by $\mathcal{N}_u(g) = \{i \in \mathcal{N} : u_i = 1\}$. The numbers of countries in which firms perform final-good and intermediate production are denoted, respectively, by $n_d(g)$ and $n_u(g)$.

The profit-maximizing price is given by:

$$p_i = \frac{\sigma(c_i + m_k\tau_{ki})}{(\sigma - 1)}, \tag{1}$$

where c_i is the marginal cost of producing the final good in country i. Given equation (1), the operating profit a firm will earn by producing the intermediate input in country k and final good in country i and selling to destination country j, that is, $g = \{d_i = 1, u_k = 1\}$, is

$$\pi_{ij}(g) = \frac{1}{\sigma}\left(\frac{1}{c_i + m_k\tau_{ki}}\right)^{\sigma-1} {\tau_{ij}}^{-\sigma} Y_j. \tag{2}$$

It is clear that π_{ij} is an increasing function of country j's demand (Y_j) and a decreasing function of the final good marginal cost (c_i) and the trade cost to ship the final good from country i to country j (τ_{ij}). Moreover, π_{ij} decreases in the marginal cost of producing the intermediate input (m_k) and the trade cost of shipping the input to the final-good production location (τ_{ki}).

Suppose the firm has chosen $\mathcal{N}_d(g)$ as the set of locations in which to produce the final good and country k as the location in which to produce the intermediate input, that is, $\mathcal{N}_u(g) = \{k\}$. The total profit function will then be given by:

$$\begin{aligned}\Pi(g) = &\sum_{i \in \mathcal{N}_d(g)} \frac{1}{\sigma}\left(\frac{1}{c_i + m_k\tau_{ki}}\right)^{\sigma-1} Y_i \\ &+ \sum_{j \in \mathcal{N}\setminus\mathcal{N}_d(g)} \max_{i \in \mathcal{N}_d(g)} \left[\frac{1}{\sigma}\left(\frac{1}{c_i + m_k\tau_{ki}}\right)^{\sigma-1} {\tau_{ij}}^{-\sigma} Y_j\right] - n_d(g)F - G.\end{aligned} \tag{3}$$

purposes of the comparative analysis undertaken in the paper.

In this equation, the first term represents the operating profit from domestic sales (in countries with final-good production), the second term the operating profit from export sales (in markets without final-good production), and the last two the fixed costs of final-good and intermediate production (which increase as firms increase the number of production locations). Note that export profit depends on the choice of export-platform countries, that is, the final-good production locations in $\mathcal{N}_d(g)$ from which the firm chooses to export to each market. Firms will strictly prefer location configuration g^* to g if and only if

$$\Pi(g^*) > \Pi(g). \tag{4}$$

3.2 Final-good production location decision

Given the goal of examining firms' investment decisions in a given production network, suppose the current production network consists of a final-good production subsidiary in country $\widetilde{i}$ and an intermediate production subsidiary in country $\widetilde{k}$, that is, $g_0 = \{d_{\widetilde{i}} = 1, u_{\widetilde{k}} = 1\}$.

First, consider the decision to establish a new final-good production subsidiary in country i, denoted by Δd_i. If $\Delta d_i = 1$, the production network will change from g_0 to $g_1 = \{d_i = d_{\widetilde{i}} = 1, u_{\widetilde{k}} = 1\}$. Firms will establish a final-good production subsidiary in i if and only if

$$\Pi(g_1) > \Pi(g_0). \tag{5}$$

Given equation (3), the above condition implies

$$(c_i + m_{\widetilde{k}}\tau_{\widetilde{k}i})^{1-\sigma} M_i > (c_{\widetilde{i}} + m_{\widetilde{k}}\tau_{\widetilde{k}\widetilde{i}})^{1-\sigma}(\tau_{\widetilde{i}i}{}^{-\sigma} Y_i + M_{\widetilde{i}}^e) + \sigma F, \tag{6}$$

where $M_i \equiv Y_i + M_i^e \equiv Y_i + \sum_{j \in \mathcal{N}\setminus\mathcal{N}_d(g_1)}(\tau_{ij}{}^{-\sigma} Y_j)$ represents country i's market potential, which includes country i's domestic market size Y_i and the (trade-cost weighted) aggregate size of export markets, denoted by M_i^e, in which the firm does not have final-good production.[5] Letting $\rho_{\widetilde{k}i} \equiv m_{\widetilde{k}}/c_i$ denote the extent of vertical linkage between intermediate input and final good, the above expression can be re-written as:

$$c_i^{1-\sigma}(1 + \rho_{\widetilde{k}i}\tau_{\widetilde{k}i})^{1-\sigma} M_i > (c_{\widetilde{i}} + m_{\widetilde{k}}\tau_{\widetilde{k}\widetilde{i}})^{1-\sigma}(\tau_{\widetilde{i}i}{}^{-\sigma} Y_i + M_{\widetilde{i}}^e) + \sigma F. \tag{7}$$

As monotonic transformations and terms such as $c_{\widetilde{i}}$, $m_{\widetilde{k}}$, $\tau_{\widetilde{k}\widetilde{i}}$, $M_{\widetilde{i}}^e$ and F do not affect the ordering of host countries i, condition (7) is simplified (and taken natural logs) to obtain a

[5] The above condition assumes that firms will choose the new final-good production subsidiary as the export platform, and takes into account all potential export markets when measuring each country's market potential. This assumption is made to keep the theoretical analysis tractable, and also because supply strategy information is rarely observable at the firm-market level.

simple empirical specification:

$$\Pr\left[\Delta d_i = 1 | g_0\right] = \tag{8}$$
$$\Phi[\beta_{d1} \ln c_i + \beta_{d2} \ln Y_i + \underbrace{\lambda_d^u \ln(1 + \rho_{\widetilde{ki}} \tau_{\widetilde{ki}})}_{vertical} + \underbrace{\lambda_d^m \ln M_i}_{market\ potential} + \underbrace{\lambda_d^d \ln \tau_{\widetilde{ii}}}_{horizontal} + \varepsilon].$$

In this specification, $\Pr\left[\Delta d_i = 1 | g_0\right]$ represents the probability of each firm establishing a new final-good production location in country i given its existing production network g_0 and $\Phi[.]$ is the cumulative probability function. The terms $\ln(1 + \rho_{\widetilde{ki}} \tau_{\widetilde{ki}})$ and $\ln \tau_{\widetilde{ii}}$ represent, respectively, the trade costs to import from the firm's existing intermediate and final-good production locations, and capture the vertical and horizontal interdependence in the network. The variable $\ln M_i$ represents country i's market potential given the firm's final-good production network. The residual ε captures all the remaining factors such as $c_{\widetilde{i}}$, $m_{\widetilde{k}}$, $\tau_{\widetilde{ki}}$, and $M_{\widetilde{i}}^e$, attributes of existing production locations that are invariant with country i's attributes.

The model predicts that $\beta_{d1} < 0$ and $\beta_{d2} > 0$. The effect of existing production networks is expected to vary with the nature of subsidiaries. The effect of vertically linked subsidiaries is expected to satisfy $\lambda_d^u < 0$, that is, firms have a greater incentive to establish final-good production subsidiaries in countries with lower costs of importing intermediate inputs, especially when there is a strong vertical linkage between intermediate inputs and final goods (i.e., a large $\rho_{\widetilde{ki}}$). The expected effect of existing final-good production networks is $\lambda_d^d > 0$, that is, firms are more likely to expand horizontally in countries with higher costs of importing final goods. Finally, the host-country market potential is predicted to have a positive effect, that is, $\lambda_d^m > 0$.

3.3 Intermediate production location decision

Now consider the intermediate production location decision. Given network g_0 (where $d_{\widetilde{i}} = 1, u_{\widetilde{k}} = 1$), firms will establish an intermediate production subsidiary in country i and move to network $g_2 = \{d_{\widetilde{i}} = 1, u_i = 1\}$ if and only if

$$\Pi\left(g_2\right) > \Pi\left(g_0\right). \tag{9}$$

Given equation (3), this is equivalent to

$$m_{\widetilde{k}} \tau_{\widetilde{ki}} > m_i \tau_{\widetilde{ii}}. \tag{10}$$

Taking natural logs of the above condition yields the following empirical specification:

$$\Pr\left[\Delta u_i = 1 | g_0\right] = \Phi[\beta_u \ln m_i + \underbrace{\lambda_u^d \ln \tau_{\widetilde{ii}}}_{vertical} + \underbrace{\lambda_u^u \ln \tau_{\widetilde{ki}}}_{horizontal} + \varepsilon]. \tag{11}$$

In this expression, $\Pr[\Delta u_k = 1|g_0]$ denotes the probability of a firm establishing an intermediate production location in country i given its existing production network g_0. The model predicts $\beta_u < 0$, $\lambda_u^d < 0$ (incentives to produce intermediate inputs are greater in countries with lower costs of exporting to firms' existing final-good production locations, i.e., a lower $\tau_{\widetilde{ii}}$), and $\lambda_u^u > 0$ (firms are more likely to invest in intermediate production when existing intermediate production subsidiaries have relatively high costs of exporting to final-good production locations). The residual ε captures remaining factors such as $m_{\widetilde{k}}$.

4 Econometric Framework and Methodology

Based on the theoretical section, an econometric framework that examines firms' investment decisions as a function of existing production networks is employed for the empirical analysis.

4.1 Econometric framework

4.1.1 Final-good production location decision

The decision of individual firms to invest in final-good production is examined using a specification that follows directly equation (5):

$$\begin{aligned} final\ good \quad : \quad & \Pr[\Delta d_i = 1] = \Phi[\beta_d X_i + \\ & \underbrace{(\lambda_{d,0}^d + \lambda_{d,1}^d W_{d,i}^d \cdot d) I_d}_{horizontal} + \underbrace{(\lambda_{d,0}^u + \lambda_{d,1}^u W_{d,i}^u \cdot u) I_u}_{vertical} + \underbrace{\lambda_d^m \ln M_i}_{market\ potential} + \varepsilon_{d,i}]. \end{aligned} \tag{12}$$

In the above equation, Δd_i represents each firm's decision to establish a new final-good production subsidiary in country i in 2007, and X_i represents a vector of country i's characteristics in 2005 including, for example, domestic market size Y_i and marginal production costs c_i.

In addition to host-country characteristics, the right-hand side of equation (12) includes three terms that capture firms' existing production networks in 2005. The first measures horizontal interdependence between final-good production locations. In this term, I_d is an indicator variable that identifies whether the firm already has final-good production locations abroad, $W_{d,i}^d \equiv \{\ln \tau_{1i}, ..., \ln \tau_{\widetilde{ii}}, ..., \ln \tau_{Ni}\}$ is a weighting matrix composed of the trade costs of exporting firms' final goods from a given country to country i, $d \equiv \{d_1, ..., d_{\widetilde{i}}, ..., d_N\}'$ is a vector that identifies the existence of final-good production in each country, and $\lambda_{d,0}^d$ and $\lambda_{d,1}^d$ are constants. Two types of trade costs, including transport costs and tariffs, are taken into consideration in constructing $W_{d,i}^d$. Distance is used as a proxy for transport costs. Tariffs are obtained for each country pair and the final good industry. To measure the average trade costs between final-good production locations, the vector d is scaled by each firm's total number of final-good production locations, that is, n_d. Section 3.2 predicts that $\lambda_{d,0}^d < 0$, and $\lambda_{d1}^d > 0$, that is, the probability of

firms investing in final-good production in a given country increases in that country's costs of importing final goods from those firms' existing final-good production locations.

The second network term in equation (12) captures vertical interdependence between intermediate and final-good production. In this term, I_u is an indicator variable that identifies whether firms already have intermediate production locations abroad, $W^u_{d,i} \equiv \{\ln(1+\rho\tau_{1i}), ..., \ln(1+\rho\tau_{\widetilde{k}i}), ..., \ln(1+\rho\tau_{Ni})\}$ is a weighting matrix composed of the trade costs of exporting intermediate inputs from firms' foreign subsidiaries to country i, weighted by the input-output coefficient between the intermediate inputs and the firms' final goods, $u \equiv \{u_1, ..., u_{\widetilde{k}}, ..., u_N\}'$ is a vector that identifies the existence of intermediate production in each country, and $\lambda^u_{d,0}$ and $\lambda^u_{d,1}$ are constants. As for final goods, both transport costs and tariffs are taken into account in measuring the trade costs of shipping intermediate inputs. The vector u is scaled by each firm's total number of intermediate production locations, that is, n_u, to obtain average trade costs. Section 3.2 predicts that $\lambda^u_{d0} > 0$ and $\lambda^u_{d1} < 0$, that is, the probability of firms investing in final-good production in a given country decreases in that country's costs of importing intermediate inputs from those firms' existing intermediate production locations.

Finally, equation (12) takes into account each host country's market potential, that is, $\ln M_i \equiv \ln[W^m_{d,i} \cdot (I-d)]$ where $W^m_{d,i} \equiv \{Y_1/\tau_{i1}, ..., Y_j/\tau_{i\widetilde{i}}, ..., Y_N/\tau_{iN}\}$ is a weighting matrix that consists of the market size of each country, weighted by the costs of exporting final goods from country i to that country, and $I-d \equiv \{1-d_1, ..., 1-d_{\widetilde{i}}, ..., 1-d_N\}$ is a vector that identifies all the countries in which firms do not already have final-good production. The effect of $\ln M_i$ is expected to be positive, that is, $\lambda^m_d > 0$.

4.1.2 Intermediate production location decision

Now consider the decision of each firm to invest in intermediate production. The following specification is adopted based on equation (11):

$$\begin{aligned} intermediate \quad : \quad & \Pr[\Delta u_i = 1] = \Phi[\beta_u X_i \\ & + \underbrace{(\lambda^d_{u0} + \lambda^d_{u1} W^d_{u,i} \cdot d) I_d}_{vertical} + \underbrace{(\lambda^u_{u0} + \lambda^u_{u1} W^u_{u,i} \cdot u) I_u}_{horizontal} + \varepsilon_{u,i}]. \end{aligned} \tag{13}$$

In the above equation, Δu_i represents each firm's decision to establish an intermediate production subsidiary in country i in 2007, and X_i represents a vector of country i's characteristics in 2005 including, for example, marginal production costs.

In addition to host-country characteristics, the right-hand side of equation (13) includes two network terms measured in 2005. The first captures vertical interdependence between intermediate and final-good production locations. In this variable, $W^d_{u,i} \equiv \{\ln\tau_{i1}, ..., \ln\tau_{i\widetilde{i}}, ..., \ln\tau_{iN}\}$ is a weighting matrix composed of the trade costs of exporting intermediate inputs from country i to

other countries, I_d and d are as defined in Section 4.1.1, and λ_{u0}^d and λ_{u1}^d are constants. Section 3 predicts that $\lambda_{u0}^d > 0$ and $\lambda_{u1}^d < 0$, that is, the probability of firms investing in intermediate production in a given country decreases in that country's costs of exporting intermediate inputs to those firms' existing final-good production subsidiaries.

The second network term in equation (13) captures the substituting relationship between existing and potential intermediate production locations. In this term, $W_{u,i}^u \equiv \{\ln \tau_{1\mathcal{N}_d}, ..., \ln \tau_{\widetilde{k}\mathcal{N}_d}, ..., \ln \tau_{N\mathcal{N}_d}\}$ is a weighting matrix composed of the trade costs of exporting intermediate inputs from each country to firms' existing final-good production locations denoted by $\mathcal{N}_d$, I_u and u are as defined in Section 4.1.1, and λ_{u0}^u and λ_{u1}^u are constants. It is expected that $\lambda_{u0}^u < 0$ and $\lambda_{u1}^u > 0$, that is, firms are more likely to invest in intermediate production when existing intermediate production subsidiaries incur a relatively high cost to export to final-good production locations.

4.2 Econometric methodology

Given the binary nature of the dependent variables, a probit model is used as a baseline specification for estimating equations (12) and (13). Three econometric issues can arise in the empirical analysis including (i) omitted variables, (ii) prevalence of zeros in the values of dependent variables, and (iii) endogeneity of network variables. To address these issues, a number of alternative estimating strategies are employed, as discussed below.

Omitted variables First, it is possible that, in addition to firm network variables, other firm-level characteristics, such as business connections in a given host country, also affect firms' location entry decisions. A firm-level fixed effect can be included in the baseline specification for equations (12) and (13) to control for the effect of potential omitted variables.[6] To avoid the potential incidental parameter problem associated with fixed-effect probit models, alternative estimators like fixed-effect linear probability and conditional logit models were also considered as a robustness check.

Prevalence of zeros A second issue concerns the prevalence of zeros in the values of dependent variables. This is determined by the nature of location entry data. Because, over a given period of time, a multinational may make no new entry, choosing instead to operate with existing production networks, the dependent variables can consist of a large fraction of zeros relative to the number of observations.

To address this issue, a Heckman selection procedure is considered. In this procedure, multinationals' decision of whether to enter any new host country given their existing production networks is first examined. A number of instrumental variables are used in this step including

[6] Note that the adoption of firm fixed effects in probit models means that all multinationals that did not make any entry, that is, firms for which d_i or u_i equals 0 for all i, will be dropped from the analysis.

the number of existing final-good and intermediate production locations and firm productivity growth. The choice of these instrumental variables, in particular, productivity growth, is motivated by an emerging literature, led by Helpman *et al.* (2004) and Yeaple (2009), that links firm productivity to the decision to invest abroad. This literature shows that firms with greater productivity are more likely to overcome the fixed cost of FDI in each host country and invest in larger numbers of countries. In a dynamic setting, firms that experienced productivity growth should be more likely to expand foreign production networks and enter new host countries. Controlling for the potential self-selection bias, firms' decisions regarding where to invest in final-good and intermediate production are then examined, following equations (12) and (13).

Endogeneity of network variables Another issue that can arise in the analysis is the potential endogeneity of network variables. Even though a time lag is included between firms' entry decisions and network characteristics, the network variables can still be endogenous when, for example, firms are sufficiently forward looking.

An instrumental variable (IV) approach is employed to address this issue. Consider first the final-good production location decision. In the first stage, each weighted network variable is estimated using corresponding instrumental variables. For example, the variable $W^d_{d,i} \cdot d$ is estimated using country i's characteristics X_i and $W^d_{d,i} \cdot X$, a vector of instrumental variables formed by the weighting matrix $W^d_{d,i}$ (defined in Section 4.1) and the matrix of host-country characteristics X. The fitted values of $W^d_{d,i} \cdot d$ obtained from this stage are then taken into account in equation (12). Formally, the estimation strategy can be written as:

$$\begin{aligned} final\ good \quad : \quad & \Pr\left[\Delta d_i = 1\right] = \Phi[\beta_d X_i + \\ & \underbrace{(\lambda^d_{d,0} + \lambda^d_{d,1}\widehat{W^d_{d,i} \cdot d})I_d}_{horizontal} + \underbrace{(\lambda^u_{d,0} + \lambda^u_{d,1}\widehat{W^u_{d,i} \cdot u})I_u}_{vertical} + \underbrace{\lambda^m_d \ln \widehat{M_i}}_{market\ potential} + \varepsilon_{d,i}], \end{aligned} \tag{14}$$

where

$$\begin{aligned} \widehat{W^d_{d,i} \cdot d} &= E\left[W^d_{d,i} \cdot d | X_i, W^d_{d,i} \cdot X\right] \\ \widehat{W^u_{d,i} \cdot u} &= E\left[W^u_{d,i} \cdot u | X_i, W^u_{d,i} \cdot X\right] \\ \widehat{M_i} &= E[W^m_{d,i} \cdot (I - d) | X_i, W^m_{d,i} \cdot X]. \end{aligned} \tag{15}$$

Similarly, for the intermediate production location decision, each weighted network variable in equation (13), namely, $W^d_{u,i} \cdot d$ and $W^u_{u,i} \cdot u$, is estimated in the first stage using X_i and the vectors of instrumental variables $W^d_{u,i}X$ and $W^u_{u,i}X$, respectively. The fitted values of the network variables are then taken into account in equation (13) to estimate the effects of existing production networks. Formally, the procedure is given by:

$$
\begin{aligned}
intermediate \quad : \quad & \Pr\left[\Delta u_i = 1\right] = \Phi[\beta_u X_i \\
& + \underbrace{(\lambda^d_{u0} + \lambda^d_{u1}\widehat{W^d_{u,i} \cdot d})I_d}_{vertical} + \underbrace{(\lambda^u_{u0} + \lambda^u_{u1}\widehat{W^u_{u,i} \cdot u})I_u}_{horizontal} + \varepsilon_{u,i}].
\end{aligned} \tag{16}
$$

where

$$
\begin{aligned}
\widehat{W^d_{u,i} \cdot d} &= E\left[W^d_{u,i} \cdot d | X_i, W^d_{u,i} \cdot X\right] \\
\widehat{W^u_{u,i} \cdot u} &= E\left[W^u_{u,i} \cdot u | X_i, W^u_{u,i} \cdot X\right].
\end{aligned} \tag{17}
$$

5 Data

The dataset employed in this paper, obtained from BvDEP AMADEUS, contains comprehensive financial and subsidiary information for public and private French firms. AMADEUS combines data from specialist regional information providers around the world. Its coverage is particularly good for countries like France.

The dataset reports French multinationals' subsidiary activities in 99 host countries in 2005 and 2007.[7] It is compiled using two editions of AMADEUS published in 2006 and 2008.[8] For each multinational firm, the dataset reports not only subsidiary locations but also, for each location, the primary product and sales, asset, and employment information.[9] There are in total 1,698 French multinational firms in the dataset. These firms invested in, on average, 2.88 host countries in 2005 and 3.81 countries in 2007.[10]

Subsidiaries engaged in final-good and intermediate production are distinguished in the analysis using the methodology introduced by Alfaro and Charlton (2009). Final-good production subsidiaries are identified by comparing each subsidiary's primary product with the parent firm's primary and secondary products, all reported at the NACE 4-digit level.[11] If its primary product is listed as one of the parent firm's final products, the subsidiary is considered a final-good production location. Subsidiaries that engage in intermediate production are determined by examining the input-output relationship between the subsidiary's primary product and parent firm's final products. A subsidiary is considered an intermediate production location if the direct requirement for the subsidiary's primary product in the parent firm's final-product production exceeds a threshold value.[12] This identification of final-good and intermediate pro-

[7] The final sample is smaller in some specifications because of the missing values of explanatory variables.

[8] AMADEUS does not directly report time series information for subsidiary data. To obtain that information, it is necessary to acquire different editions of AMADEUS published in different years.

[9] The coverage of sales, assets, and employment data is not as complete as the location information.

[10] It is worth noting that there are very few exits (i.e., subsidiary shut-downs) in the data. Nearly all subsidiaries that existed in 2005 were active in 2007.

[11] AMADEUS reports both primary and secondary products of parent firms.

[12] Using different threshold values yielded similar results. The results presented in the following sections are

duction subsidiaries has been generally absent in the literature, with the exception of Alfaro and Charlton (2009), mainly because of lack of information on subsidiary-level activities.

In 2007, according to the above definitions, French multinationals owned, on average, final-good production subsidiaries in 2.49 countries and intermediate production subsidiaries in 0.72.[13] More than 75 percent of subsidiaries newly established between 2005 and 2007 were final-good production locations, suggesting a greater tendency for MNCs to expand horizontally than vertically.

As explained in Section 4.1, the two types of trade costs used to construct the network variables are (i) the distance between each pair of host countries (as a proxy for transport costs), and (ii) the tariff rates on parent firms' final products and intermediate inputs produced overseas between each pair of host countries. The input-output coefficient between the primary products of the parent firm and each subsidiary is also included. Distance data are taken from the CEPII distance database. Tariff data, consisting of applied tariff rates at the NACE 4-digit industry level, are obtained from TRAINS. The input-output coefficients are computed based on the 2002 U.S. Bureau of Economic Analysis (BEA) benchmark input-output accounts, a source with more disaggregated information than most alternative national input-output tables.

In addition to firm network characteristics, FDI determinants traditionally emphasized in the literature are also taken into account. First, several variables are used to capture the trade costs between home and host countries. For the final-good production, multinationals' incentives to invest in a foreign country are expected to increase in the trade costs of exporting final goods from home. This is the conventional market access motive of horizontal FDI shown in Markusen (1984) and following empirical studies by Carr et al. (2001), Brainard (1997), and Yeaple (2003b), and predicts a positive parameter for transport costs, proxied by distance, between home and host countries, and host-country tariffs on the home country in the final-good industry. Multinationals' incentives to invest in final-good production in a given country are also expected to decrease in the trade costs of exporting final goods back home. This follows directly the theory of vertical FDI established by Helpman (1984) and predicts a negative parameter for the distance between home and host countries, and home-country tariffs on firms' final goods produced overseas. A dummy variable that distinguishes EU members from the rest of the world is included to capture additional trade cost differences between EU and non-EU host countries. Like distance, the effect of the EU dummy hinges on the type of FDI undertaken by French MNCs. Finally, multinationals' incentives to invest intermediate production in a foreign country are expected to decrease in the trade costs of exporting intermediate inputs to final-good production locations, which are controlled for by the network variables.[14]

obtained based on the threshold value 0.1. The analysis also considered weighting each intermediate production subsidiary with its input-output coefficient to the final product, as explained in Section 6.

[13] Fewer than 20 percent of subsidiaries belong to neither category, and engage in activities such as wholesale distribution services. They were not included in the construction of network variables.

[14] Different from the case of final-good production, the market access motive, captured by the trade costs of

Host-country domestic market size, measured by real GDP, is included as well. Previous empirical studies, such as Carr et al. (2001), Brainard (1997), and Yeaple (2003b), show that multinationals tend to invest in countries with a larger domestic market size. Host countries' marginal costs of production, measured in the analysis using real unit labor costs computed with labor cost and output data from the World Bank Trade and Production Database, are expected to exert a negative effect on multinationals' investment incentives. Finally, as in Yeaple (2003b), various measures of investment costs are taken into account. First, host countries' tax policy is controlled for using maximum corporate tax rates available from the U.S. Office of Tax Policy Research.[15] Second, the costs of starting a business, taken from the World Development Indicators, are included as a proxy for entry costs. Third, the distance between France and each host country serves as a proxy for fixed costs of investment, the expectation being that the fixed cost of investment (for example, monitoring cost) will be greater for subsidiaries located in remote countries. Table A.1 provides sources and summary statistics for the variables.

6 Empirical Evidence

In this section, the econometric framework outlined in Section 4 is evaluated to establish the effects of MNC production networks. Multinationals' entry decisions are estimated by first assuming away the interdependence in production networks. The results are then compared to the estimates that take into account production network effects. This comparison helps to assess the role of existing production networks in MNCs' entry decisions and, further, how accounting for third-country production networks affects the estimated effects of conventional host-country characteristics.

6.1 Excluding network effects

Table 1 reports estimates of equation (12) excluding the network variables. The estimated effects of host-country characteristics are largely consistent with the existing literature for all empirical specifications. Consider first the baseline results reported in column (1). French MNCs exhibit a significant market-access motive that is in alignment with previous findings. Firms are more likely to establish final-good production in countries with higher GDP. They also have greater incentives to enter countries that set higher tariffs on final-product exports from France. The parameter of EU membership is negative, suggesting that firms are more likely to choose FDI instead of exports in countries outside the EU. All of these results suggest a horizontal interdependence between MNCs' home and foreign production: MNCs are motivated to replace final-good exports from home with FDI when foreign markets are large and trade costs high. As

exporting intermediate inputs from home to host countries, is not expected to play a significant role in the decision to invest in intermediate production.

[15] Ideally, applied corporate tax rates should be included instead of the maximum, but the former data have a large number of missing values.

found in previous studies, the effect of distance is negative, consistent with the role of distance in raising fixed costs of investment.

[Table 1 about here]

Table 1 also implies a significant comparative advantage motive for French MNCs. Multinationals looking to establish final-good production subsidiaries are attracted to countries with a lower unit labor cost. Investment costs also exert a significant effect on the entry decision. A higher cost of starting a business is associated with a lower probability of attracting multinational firms. The sign of the corporate tax parameter is inconsistent with the expectation. This can be a result of the tax data used here, which report each host country's maximum corporate tax rate and do not necessarily capture the rates applied to multinational firms. Because the latter information is not systematically available, to include it would reduce the sample size substantially.

The estimated effects of host-country characteristics remain similar when firm dummies are included in column (2) to control for potential omitted variables. The parameter of home-country tariffs also becomes significant, suggesting a negative relationship between French final-good tariffs and multinationals' incentives to produce the final good abroad. This result lends further support to the comparative advantage motive hypothesis: some French multinationals serve their home country from foreign production locations and are adversely affected by home-country tariffs. The Heckman selection procedure adopted to address the prevalence of zeros in the dependent variables yields similar results.

Table 2 reports estimates of equation (13), excluding the network variables, for MNCs' intermediate production location decisions. As shown in the table, the estimated effects of host-country characteristics are largely similar to those reported in Table 1. Countries with a higher GDP have a greater probability of attracting multinationals. Countries relatively proximate to France are also more likely to become intermediate production locations. A higher real unit labor cost or higher entry cost lowers multinationals' incentives to establish intermediate production subsidiaries in a given country. As expected, host-country tariffs do not play a significant role in intermediate production location decisions. A result not expected analytically is the positive effect of French tariffs. Home-country tariffs are found to be positively associated with the probability of French firms investing in intermediate production overseas. Again, controlling for unobserved firm attributes and prevalence of zeros in the dependent variable does not change the estimated effects of host-country characteristics.

[Table 2 about here]

6.2 Accounting for network effects

6.2.1 Final-good production location decision

The effects of existing production networks are considered next. Table 3 reports estimates of equation (12), for the final-good production location decisions, taking into account potential network effects. The results provide strong evidence of horizontal and vertical interdependence in multinationals' production networks. First, multinationals are significantly more likely to invest in countries relatively distant from existing final-good production locations. As shown in column (1), a 100-percent increase in third-country distance increases the probability of entry by one percentage point or, equivalently, 100 percent given that the average fitted probability of entry is 0.01. This result applies as well to tariffs. The incentive to enter a host country increases in the level of tariffs on final-good imports from existing production locations. Market potential also plays a significant role. Multinationals have a greater probability of producing final goods in countries with greater market potential. This points to the significance of export-platform FDI, whereby multinationals use host countries as the platform from which to supply third countries, in particular, third countries in which the MNCs do not already have final-good production activities.

[Table 3 about here]

The effect of trade costs is reversed when there is a vertical production linkage between foreign production locations. Table 3 considers the average trade costs of importing intermediate inputs from existing intermediate production locations, unweighted by input-output coefficients. The results suggest that French multinationals are motivated to cluster vertically linked subsidiaries in proximate countries. For example, the probability of being selected as a final-good production location is 0.4 percentage point lower for countries 100-percent farther from multinationals' existing upstream locations. This result suggests that FDI activities in neighboring countries and vertically linked intermediate industries can trigger an increase in the flow of FDI to a host country in the final good industry.

These findings remain robust to the adoption of firm dummies and the Heckman procedure in columns (2) and (3), respectively.[16] Addressing the endogeneity of network variables also does not change the results qualitatively. As shown in column (4), most network variables continue to exert a significant effect on French MNCs' entry decisions.

The effect of the conventional market access variables is affected, however, by the consideration of production networks. As seen in Table 3, the parameters of both host-country tariffs on France and French tariffs on host countries become statistically insignificant when the network variables are taken into account. This constitutes a sharp contrast with Table 1, in which the

[16] Note that when the firm fixed effect is included, the firm-specific network dummy variables drop out of the estimations.

evidence suggests significant interdependence and, in particular, a substituting relationship between foreign and home-country final-good production. This change in the results suggests that it is not adequate to focus exclusively on the interdependence between home and host countries. Interdependence across foreign production locations increases as multinationals' production networks expand over time. The FDI decision is no longer a binary choice between investing in a foreign country and exporting from home; it has become significantly more complex, involving third nations. Ignoring third-country network effects is likely to give rise to biased estimates of the relationship of home economy and FDI activities and, more generally, the true causes and effects of FDI.

In Table 4, the extent of vertical production linkages is taken into account in constructing the intermediate production network variables, following the description in Section 4.1.1. The results are largely similar to those reported in Table 3. The incentive to cluster vertically linked subsidiaries in countries with lower trade costs increases in the extent of vertical linkages. Intermediate production locations with a stronger input-output linkage to firms' final-good production play a more important role in the choice of final-good production locations. Again, these results are not sensitive to the various estimation strategies employed in the analysis.

[Table 4 about here]

6.2.2 Intermediate production location decision

The effects of production networks on MNCs' intermediate production location decisions are examined in this sub-section. Table 5 reports estimates of equation (13), taking into account production network effects. Consider first the baseline estimates reported in column (1). The results indicate significant vertical interdependence between final-good and intermediate production locations. French multinationals tend to establish intermediate production locations in countries relatively proximate to existing final-good production locations. A 100-percent increase in distance to MNCs' final production subsidiaries decreases the probability of MNCs investing in intermediate production by 0.1 percentage point. This effect increases to 0.7 percentage point in columns (3) and (4) with the use of the Heckman and IV approaches, respectively. The effect of intermediate-input tariffs is weaker and significant only in columns (1) and (4).

There is also a substituting effect between existing and potential intermediate production locations. The probability of investing in new intermediate production subsidiaries increases in the trade costs for existing subsidiaries to reach final-good production locations. For example, a 100-percent increase in distance between MNCs' existing intermediate and final production subsidiaries increases the probability of MNCs establishing new intermediate production locations by one percentage point according to column (3).[17] This result is not robust, however, to the adoption of the IV approach.

[17] Because these variables only vary across firms, they are controlled for in column (2) by firm dummies.

[Table 5 about here]

7 Conclusion

This study is one of the first attempts to estimate interdependence in multinationals' global production networks. Using a detailed French multinational subsidiary dataset, the paper finds, for the first time, strong evidence of horizontal and vertical interactions between MNCs' foreign production locations. These results complement existing contributions in which evidence of interdependence, obtained using aggregate FDI data, has been mixed. Here, third-country subsidiaries are shown to exert a significant effect on French multinationals' entry decisions with respect to both final-good and intermediate production. But the effect varies systematically with the nature of production linkages between subsidiaries. Multinationals are more likely to expand horizontally when the trade cost of importing final goods from existing final-good production subsidiaries is relatively high, but tend to locate vertically linked subsidiaries in countries with low intra-firm trade costs, especially when there is a strong input-output relationship. These results are robust to the control of omitted variables, prevalence of zeros in the values of dependent variables, and potential endogeneity of network variables.

Strikingly, there is little evidence of interdependence between multinationals' production at home and new investment abroad when third-country network effects are taken into account. The estimated effects of conventional market access variables measuring the trade costs between home and host countries become insignificant after the consideration of production networks. This sharp contrast with the existing literature can be explained by the assumption made in most previous studies that firms' decisions to invest in foreign countries are independent of their locations in third nations, even though the majority of multinationals today operate multilateral production networks.

This paper conveys important policy implications for both FDI home and host countries. It is crucial to analyze the causes and effects of FDI in the context of global production networks. As shown in the paper, assuming away the interdependence of foreign production locations is likely to over-estimate the relationship between home-country production and foreign investments, and also fail to account for spillovers among FDI flows including, for example, the effect of FDI inflows to third countries on a host country's ability to attract multinational firms.

This paper is a step towards examining interdependence in multinational production networks, but more research is needed in this area. For example, future work might investigate the heterogeneity of multinationals' production networks and role of firm characteristics, such as productivity and production technologies, in explaining network attributes. This type of analysis will provide additional useful insights into the global organization of firms.

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Table 1: Estimating final-good production location decisions without network factors

Dependent variable: Final-good production location decision	Expected sign	(1) Baseline	(2) Firm FE	(3) Heckman selection
Host-country GDP	+	0.01***	0.01***	0.02***
		(0.000)	(0.000)	(0.001)
Host-country product tariff	+	0.002***	0.002***	0.003***
		(0.000)	(0.000)	(0.000)
EU membership	+/-	-0.02***	-0.04***	-0.05***
		(0.002)	(0.003)	(0.004)
Distance to home	+/-	-0.02***	-0.03***	-0.04***
		(0.001)	(0.001)	(0.002)
Real unit labor cost	-	-0.02***	-0.03***	-0.05***
		(0.002)	(0.003)	(0.006)
Home-country product tariff	-	-0.001	-0.003**	-0.004**
		(0.001)	(0.001)	(0.002)
Corporate tax	-	0.01***	0.02***	0.03***
		(0.003)	(0.004)	(0.007)
Entry cost	-	-0.003***	-0.01***	-0.01***
		(0.000)	(0.000)	(0.001)
No. of observations		102,162	59,950	59,950
Log likelihood		-4880.5	-3384.1	-4034.9
Prob>F		0.00	0.00	0.00

Notes: Marginal effects are reported in the table. Standard errors clustered at the country-industry level are included in the parentheses. *** p<0.01, ** p<0.05, * p<0.1. See text for a detailed description of the variables.

Table 2: Estimating intermediate production location decisions without network factors

Dependent variable: Intermediate production location decision	Expected sign	(1) Baseline	(2) Firm FE	(3) Heckman selection
Host-country GDP	+	0.002***	0.007***	0.01***
		(0.000)	(0.001)	(0.002)
Host-country product tariff		-0.001	-0.001	-0.002
		(0.001)	(0.002)	(0.003)
EU membership	+/-	-0.01***	-0.02***	-0.03***
		(0.003)	(0.006)	(0.008)
Distance to home	+/-	-0.01***	-0.02***	-0.04***
		(0.000)	(0.001)	(0.003)
Real unit labor cost	-	-0.02***	-0.06***	-0.09***
		(0.006)	(0.02)	(0.03)
Home-country product tariff	-	0.001***	0.007***	0.01***
		(0.000)	(0.003)	(0.004)
Corporate tax	-	0.01***	0.05***	0.08***
		(0.003)	(0.01)	(0.02)
Entry cost	-	-0.002***	-0.006***	-0.01***
		(0.000)	(0.001)	(0.002)
No. of observations		102,162	26,370	26,370
Log likelihood		-1735.5	-844.1	-981.5
Prob>F		0.00	0.00	0.00

Notes: Marginal effects are reported in the table. Standard errors clustered at the country-industry level are included in the parentheses. *** p<0.01, ** p<0.05, * p<0.1. See text for a detailed description of the variables.

Table 3: Estimating final-good production location decisions with network factors

Dependent variable: Final-good production location decision	Expected sign	(1) Baseline	(2) Firm FE	(3) Heckman selection	(4) IV
Horizontal network dummy	-	-0.01***	-	-0.07***	-0.04***
		(0.000)		(0.01)	(0.01)
(a) distance weighted	+	0.01***	0.02***	0.04***	0.01***
		(0.001)	(0.002)	(0.01)	(0.001)
(b) tariff weighted	+	0.001***	0.005***	0.01***	0.004***
		(0.000)	(0.000)	(0.002)	(0.002)
Vertical network dummy	+	0.08***	-	0.35***	0.01***
		(0.02)		(0.05)	(0.004)
(a) distance weighted	-	-0.004***	-0.01***	-0.02***	-0.001***
		(0.001)	(0.002)	(0.004)	(0.000)
(b) tariff weighted	-	-0.006***	-0.003	-0.03**	0.001
		(0.002)	(0.004)	(0.01)	(0.001)
Market potential					
(a) distance weighted	+	0.01***	0.02***	0.06***	-0.01
		(0.001)	(0.003)	(0.01)	(0.01)
(b) tariff weighted	+	0.002**	0.09***	0.01**	0.02***
		(0.001)	(0.02)	(0.005)	(0.006)
Host-country GDP	+	0.01***	0.01***	0.03***	0.01***
		(0.000)	(0.001)	(0.003)	(0.003)
Host-country product tariff	+	-0.001	-0.002	-0.002	0.001
		(0.000)	(0.001)	(0.002)	(0.003)
EU membership	+/-	-0.02***	-0.03***	-0.06***	-0.03***
		(0.002)	(0.002)	(0.007)	(0.01)
Distance to home	+/-	-0.02***	-0.03***	-0.08***	-0.02***
		(0.001)	(0.001)	(0.01)	(0.01)
Real unit labor cost	-	-0.01***	-0.02***	-0.05***	-0.04***
		(0.002)	(0.003)	(0.01)	(0.01)
Home-country product tariff	-	0.000	-0.000	0.001	-0.001
		(0.001)	(0.000)	(0.003)	(0.003)
Corporate tax	-	0.01***	0.02***	0.06***	0.03
		(0.003)	(0.004)	(0.01)	(0.02)
Entry cost	-	-0.002***	-0.01***	-0.01***	-0.01***
		(0.000)	(0.000)	(0.002)	(0.005)
No. of observations		102,162	59,950	59,950	59,950
Log likelihood		-3963.2	-2581.5	-3170.3	-3805.2
Prob>F		0.00	0.00	0.00	0.00

Notes: Marginal effects are reported in the table. Standard errors clustered at the country-industry level are included in the parentheses. *** p<0.01, ** p<0.05, * p<0.1. See text for a detailed description of the variables.

Table 4: Estimating final-good production location decisions with network factors - IO weighted

Dependent variable: Final-good production location decision	Expected sign	(1) Baseline	(2) Firm FE	(3) Heckman selection	(4) IV
Horizontal network dummy	-	-0.01***	-	-0.04***	-0.04***
		(0.000)		(0.01)	(0.01)
(a) distance weighted	+	0.01***	0.02***	0.03***	0.01***
		(0.001)	(0.002)	(0.01)	(0.001)
(b) tariff weighted	+	0.002***	0.004***	0.01***	0.005***
		(0.000)	(0.001)	(0.002)	(0.002)
Vertical network dummy	+	0.004***	-	0.03***	0.01***
		(0.01)		(0.01)	(0.004)
(a) distance and IO-coef. weighted	-	-0.006***	-0.76***	-0.02**	-0.01***
		(0.002)	(0.16)	(0.01)	(0.005)
(b) tariff and IO-coef. weighted	-	-0.02***	-0.09***	-0.05***	-0.01*
		(0.004)	(0.01)	(0.01)	(0.007)
Market potential					
(a) distance weighted	+	0.01***	0.02***	0.04***	-0.01
		(0.001)	(0.003)	(0.01)	(0.01)
(b) tariff weighted	+	0.002**	0.10***	0.01**	0.02***
		(0.001)	(0.02)	(0.004)	(0.007)
Host-country GDP	+	0.01***	0.01***	0.02***	0.01***
		(0.000)	(0.001)	(0.003)	(0.003)
Host-country product tariff	+	-0.001	-0.002	-0.001	0.001
		(0.000)	(0.001)	(0.001)	(0.003)
EU membership	+/-	-0.02***	-0.03***	-0.05***	-0.04***
		(0.002)	(0.002)	(0.007)	(0.01)
Distance to home	+/-	-0.02***	-0.03***	-0.06***	-0.02***
		(0.001)	(0.001)	(0.01)	(0.01)
Real unit labor cost	-	-0.01***	-0.02***	-0.04***	-0.04***
		(0.002)	(0.003)	(0.01)	(0.01)
Home-country product tariff	-	0.000	-0.000	0.001	-0.001
		(0.001)	(0.000)	(0.002)	(0.003)
Corporate tax	-	0.01***	0.02***	0.04***	0.03
		(0.003)	(0.004)	(0.01)	(0.02)
Entry cost	-	-0.002***	-0.004***	-0.01***	-0.006
		(0.000)	(0.000)	(0.002)	(0.005)
No. of observations		102,162	59,950	59,950	59,950
R square		-4085.0	-2614.5	-3282.7	-3807.2
Prob>F		0.00	0.00	0.00	0.00

Notes: Marginal effects are reported in the table. Standard errors clustered at the country-industry level are included in the parentheses. *** p<0.01, ** p<0.05, * p<0.1. See text for a detailed description of the variables.

Table 5: Estimating intermediate production location decisions with network factors

Dependent variable: Intermediate production location decision	Expected sign	(1) Baseline	(2) Firm FE	(3) Heckman selection	(4) IV
Horizontal network dummy	-	-0.004***		-0.03***	-0.003
		(0.001)		(0.01)	(0.005)
(a) distance weighted	+	0.003***		0.01***	-0.001
		(0.001)		(0.004)	(0.001)
(b) tariff weighted	+	0.007***		0.003	0.003*
		(0.002)		(0.01)	(0.002)
Vertical network dummy	+	-0.000		0.01***	0.002
		(0.000)		(0.003)	(0.002)
(a) distance weighted	-	-0.001***	-0.001***	-0.007***	-0.007***
		(0.000)	(0.000)	(0.003)	(0.003)
(b) tariff weighted	-	-0.002*	0.000	0.01	-0.002*
		(0.001)	(0.000)	(0.01)	(0.001)
Host-country GDP	+	0.002***	0.005***	0.01***	0.01***
		(0.000)	(0.001)	(0.002)	(0.003)
Host-country product tariff		-0.001	-0.002	-0.003	0.001
		(0.000)	(0.002)	(0.004)	(0.003)
EU membership	+/-	-0.006***	-0.01***	-0.02***	-0.01*
		(0.002)	(0.005)	(0.01)	(0.007)
Distance to home	+/-	-0.006***	-0.02***	-0.04***	-0.01***
		(0.000)	(0.001)	(0.01)	(0.002)
Real unit labor cost	-	-0.01***	-0.05***	-0.09***	-0.07***
		(0.004)	(0.01)	(0.03)	(0.02)
Home-country product tariff	-	0.001**	0.008***	0.01***	0.01***
		(0.000)	(0.002)	(0.004)	(0.003)
Corporate tax	-	0.01***	0.04***	0.08***	0.05***
		(0.003)	(0.01)	(0.02)	(0.01)
Entry cost	-	-0.001***	-0.006***	-0.01***	-0.003*
		(0.000)	(0.000)	(0.002)	(0.002)
No. of observations		102,162	26,370	26,370	26,370
Log likelihood		-1658.2	-767.5	-903.6	-886.2
Prob>F		0.00	0.00	0.00	0.00

Notes: Marginal effects are reported in the table. Standard errors clustered at the country-industry level are included in the parentheses. *** p<0.01, ** p<0.05, * p<0.1. See text for a detailed description of the variables.

Table A.1: Summary statistics

Variables	Source	Mean	Std. dev.	Min	Max
final-good production location entry	AMADEUS	0.007	0.08	0	1
intermediate production location entry	AMADEUS	0.002	0.04	0	1
GDP	WDI	26.24	1.35	23.85	30.00
real unit labor cost	World Bank Trade and Production Database	-2.17	2.17	-15.08	0.18
corporate tax	Office of Tax Policy Research	-1.25	0.29	-2.40	-0.91
distance to home	CEPII Distance Database	7.81	1.19	5.57	9.73
between-host distance	CEPII Distance Database	8.42	1.01	0	9.87
EU membership	—	0.45	0.49	0	1
host-country product tariff	TRAINS	0.04	0.06	0	0.85
home-country product tariff	TRAINS	0.01	0.02	0	0.42
I-O coefficient	BEA	0.06	0.06	0	0.33

Note: All variables except entry variables, EU membership and I-O coefficient are measured in natural logs.

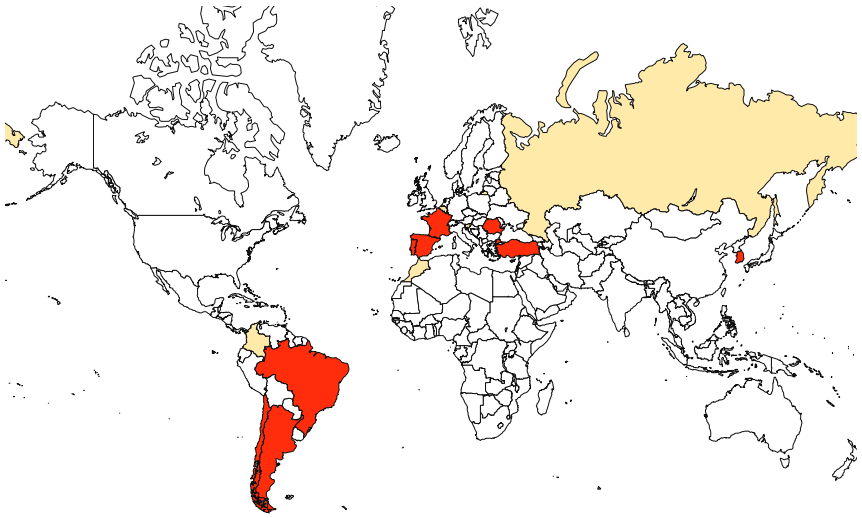

Figure 1: Renault's global production network (the darker and lighter areas represent upstream and downstream production locations, respectively)

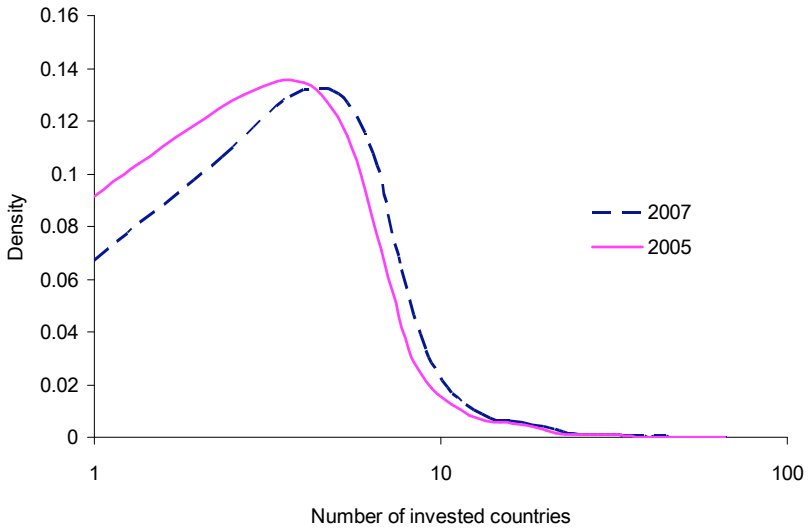

Figure 2: The distribution of French MNCs by the number of invested countries