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Firm Heterogeneity, Intra-Firm Trade, and the Role of Central Locations

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7.1 Introduction

Multinational enterprises, those firms that produce in more than one country, play a key role in the conduct of international commerce. According to UNCTAD (2004) the volume of sales of the foreign affiliates of multinational enterprises are more than twice the volume of global exports. Further, multinational enterprises (MNE) account for much of international trade (Hanson, Mataloni, and Slaughter 2005). Although the empirical trade literature has accumulated a wealth of facts concerning the behavior of multinational enterprises, most empirical work has been motivated by two-country models that cannot capture the rich pattern of multinational investments across countries (Blonigen 2005).

A firm that has decided to invest abroad faces a wide array of complex problems. In which of the world's countries will a firm's good be sold? What configuration of production locations will minimize the cost of serving these markets? Since a good that is sold to final customers might require hundreds or even thousands of different types of intermediate inputs, the logistics of acquiring components represents a daunting problem.

Even without considering arm's-length transactions, the extent of vertical specialization within multinational production networks is substantial and is becoming increasingly important. Table 7.1 shows data for various aggregate measures of the level of the activity of the manufacturing affiliates of U.S. multinationals in 1989 and 1999 and their growth rate as reported in the benchmark surveys of the U.S. Bureau of Economic Analysis. The total values for the sales of these affiliates are shown in the first row, and the destinations of these sales are shown in the next three rows. The data show that while sales to local customers are still the largest component of total affiliate sales, the fast-growing components are exports to countries other than

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Table 7.1 U.S. MNE activity in manufacturing industries, 1989–1999

	1989 $Billion	1999 $Billion	Growth, % 1989–1999
Sales	509	1,107	117
Local	334	652	89
Export to other, affiliated	79	180	128
Export to other, unaffiliated	43	110	159
Value added	207	316	54

Source: BEA Benchmark surveys (SCB 2002).
Note: 1989–1999 change in U.S. CPI = 35%.
Total U.S. exports of goods in 1999 = $696 billion.
Numbers for 1989 slightly understate all values as they omit some petroleum refining.

the United States. Exports to affiliates in other countries (not including the United States) grew at a rate of 128% over the period, while sales to local customers grew by merely 89%, and the total sales of U.S. multinationals to all locations grew at a rate of only 117%. Although these data partially reflect changes in composition across firms, they are highly suggestive of an increasing importance of vertical specialization across countries within the multinationals' networks. Perhaps the most stark evidence of the increased vertical specialization of the foreign affiliates of U.S. multinationals can be seen in the final row: the value added of U.S. manufacturing grew by a paltry 54%, which is less than half the growth in total sales.

Further complicating our ability to understand the structure of international production is the substantial degree of heterogeneity across firms in terms of their international organization. To get an idea of the extent of this heterogeneity, consider the data for 1994 from the U.S. Bureau of Economic Analysis that is shown in Figure 7.1. This figure shows the number of countries in which each of approximately 1,500 U.S. MNEs in manufacturing industries owns a foreign affiliate. The height of each bar corresponds to the number of firms in the size categories (number of countries per firm) shown on the horizontal axis. Few multinationals own affiliates in more than a handful of foreign locations: more than a third of all U.S. multinationals produce in only one foreign country, and the median number of foreign locations is two.

Given the tradition in the international trade literature of analyzing the motives for and consequences of international commerce in a two-country

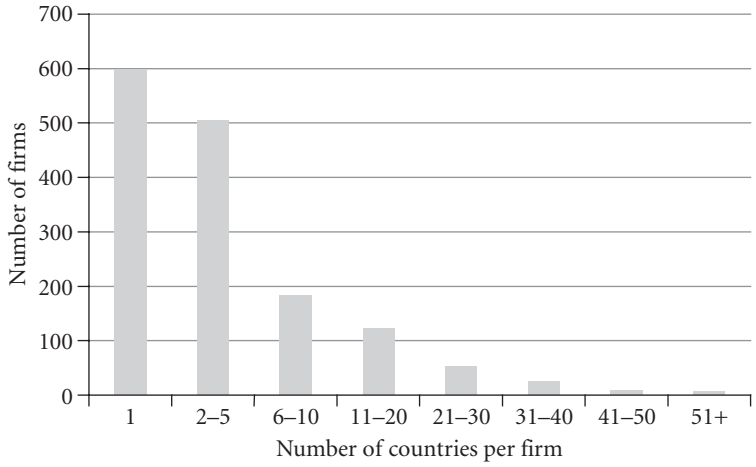

Figure 7.1 Number of countries in which manufacturing firms have affiliates.

framework in which all firms are identical, it is not surprising that existing work falls far short of explaining the structure of multinational production. This chapter presents a framework that makes the analysis of many of the complex logistical problems facing multinational enterprises tractable. The model has three key features. First, the world is composed of two regions, one of which is composed of many countries arrayed in a "hub and spokes" configuration. Geography matters in this framework because there are both interregional and intraregional transport costs. Transport costs within the region are lowest between the hub, which we refer to as the *central location,* and each of the spokes, which we refer to as the *peripheral countries.* Second, the model features a production technology in which final goods are assembled from a continuum of tradable intermediate inputs. There are fixed costs to opening each assembly plant and to opening a plant to produce a specific intermediate input. Third, firms are heterogeneous.

Firms maximize their profits by (1) choosing the set of countries in which they will assemble their final product, and (2) choosing from which countries they will source their intermediate inputs. Hence, the model endogenizes not only a firm's choice of which countries to own an affiliate but also the value-added at each location and the volume and direction of intrafirm trade. Since firms are heterogeneous, they each organize their international operations differently. Thus, the aggregate structure of foreign direct invest-

ment (FDI) across countries features both an *extensive* margin (the number of active firms) and an *intensive* margin (the volume of activity at the average firm).

We use the model to develop a rich set of predictions over the relationship between a firm's characteristics and the structure of its international operations. We show that small multinationals concentrate their foreign operations exclusively in central locations and source their intermediate inputs either from local plants or from their parent firms, while larger multinationals open assembly facilities in many foreign countries and source intermediates both from plants located in central locations and from their U.S. parents. For all but the largest multinationals, the central location plays a key role in the structure of a firm's international operations by acting either as an *export platform* for shipping final goods or as a primary location for producing intermediates that are in turn shipped to assembly plants elsewhere. These predictions are consistent with several empirical facts that we highlight below and are also consistent with recent empirical studies that explore the relationship between a country's *foreign market potential,* as measured by its geographic location, and its ability to attract multinational enterprises (see, for instance, Blonigen et al. 2005; Lai and Zhu 2006).

The comparative statics of the model highlight the importance of accounting for firm heterogeneity and regional geography. For instance, an increase in the distance between regions induces a larger set of firms to concentrate their foreign production in the single, central location. This result obtains because firms that centralize production optimally source a smaller percentage of their intermediates from their parent firm and so are less affected by the larger shipping costs associated with greater interregional distance. This mechanism provides a plausible explanation for why empirical studies typically find that greater distance between countries predicts smaller volumes of both exports and FDI between them.

Changes in regional characteristics, such as the level of intraregional transport costs or the number of countries within the region, are shown to have an effect on the structure of the international organization that operates through two channels. First, holding fixed the location of a firm's foreign assembly plants, a change in regional characteristics affects the manner in which that firm sources its intermediate inputs, thereby altering the local content of foreign production and the volume of interfirm trade in intermediates. Second, a change in regional characteristics induces some firms to alter the structure of their networks of foreign assembly plants. Since the

optimal sourcing of intermediate inputs depends on this configuration, the volume of intrafirm trade is further altered.

This chapter is unique in endogenizing (1) the location of multinational affiliates, (2) the sourcing of intermediates from parent firms, and (3) the export of both final goods and intermediate inputs by foreign affiliates within a framework of firm heterogeneity. Nevertheless, it is related to several papers in the literature. Its closest relative is Helpman, Melitz, and Yeaple (2004), which analyzes the trade-off between exporting and FDI in serving any given foreign market. This chapter goes further than Helpman, Melitz, and Yeaple in incorporating key features of problems facing multinational enterprises. In particular, the analysis in this chapter considers a regional geography in which there are "central locations" and allows for a rich pattern of intrafirm trade.

Our analysis is also related to the work on export platform FDI by Ekholm, Forslid, and Markusen (2003) and models of "complex" FDI as presented in Yeaple (2003) and in Grossman, Helpman, and Szeidl (2006).[1] However, our focus differs in that it is on regional geography and not on factor prices as the motive for export platform and complex FDI strategies. Moreover, the production structure considered in our framework allows for a richer pattern of intermediate sourcing.

The remainder of the chapter is organized into six sections. In Section 7.2, we introduce a simple analytical framework in which central locations play a key role. In Section 7.3, we characterize the optimal structure of a firm's international operation as a function of its size. Comparative statics on the model's key variables are conducted in Section 7.4. Section 7.5 presents an extension of the model to a more complex regional geography and considers an application of the framework to a policy question: rules of origin in a regional trade agreement. Several of the model's key predictions are evaluated empirically in Section 7.6. In Section 7.7, we discuss the results and suggest extensions.

7.2 The Model

The analytical framework introduced in this section has three key components. First, to analyze the sourcing of intermediates, we specify a technology in which a final good is assembled from a continuum of inputs. Second, to analyze the role of regional geography, we consider a multiple-country, hub-and-spokes setting in which countries differ in their relative foreign-

market access. Finally, to introduce an extensive margin of foreign direct investment, we allow for firm heterogeneity so that firms sort into mode of foreign-market access.

A final good is produced according to a Leontief technology with a continuum of inputs indexed by ω on the unit interval. If the marginal cost of producing intermediate ω is $c(\omega)$, then the cost of producing one unit of the final good is

$$C = \int_0^1 c(\omega)d\omega. \tag{7.1}$$

The advantage of a Leontief technology is that the marginal cost of supplying the final good is linear in the marginal cost of each intermediate input. Any number of alternative technologies would deliver similar results.

The production of intermediate inputs involves both fixed and variable costs. Intermediates vary in terms of the size of the fixed cost required to open a plant. The fixed cost to build a plant that is specific to intermediate ω is

$$f(\omega) = f\omega. \tag{7.2}$$

Once a plant has been built to assemble the final good from intermediates, assembly requires no additional inputs. To build an assembly plant requires a firm to incur a fixed cost F_A. To keep the analysis simple, we assume that a firm produces all the intermediates itself rather than outsource their production to outside contractors.

There are two regions. One region is composed of a country called Home. The other region is composed of $M + 1$ countries. M of these countries are identical and called peripheral. The other country is called Center. Factor prices are the same in all countries. To ship a final good internationally incurs per-unit (specific) transport costs. The cost of shipping an assembled final good between Home and any of the countries in the other region is τ. Within a region, final goods can be shipped between the central country and any of the M countries in the periphery but incur a specific transport cost t. For simplicity assume that shipping costs between countries in the periphery are sufficiently large that it does not occur.[2] Goods are more costly to ship between regions than within region so that $\tau > t$.

Intermediate inputs are also costly to ship between regions and countries within a region. The cost of shipping a unit of an intermediate input between regions is $\alpha\tau$ while the cost of shipping an intermediate input

between the central country and a peripheral country is αt, where $\alpha \in [0, 1]$ measures differences in the transportability of intermediates relative to final goods. Note that these transport costs are independent of ω.

Firms differ in terms of the demand for their product. In each foreign country there are φ consumers each willing to pay no more than p for each unit of a firm of type-φ's output. This formulation of firm heterogeneity differs from other formulations found in the literature, such as Melitz (2003) or Helpman, Melitz, and Yeaple (2004), where firms vary in terms of their productivity. What induces sorting of firms into modes of foreign-market access in Helpman, Melitz, and Yeaple (2004) is not productivity differences per se, however, but the fact that more-productive firms sell a larger number of units in any given market. By assuming that firms differ in the number of customers rather than their productivity, we capture the key implications of firm heterogeneity in productivity in a simple and notationally clean way. Many of the results derived below would also obtain in a more complicated general equilibrium setting with monopolistically competitive firms and heterogeneity in terms of productivity.[3]

To serve the foreign market, a firm can either export the good from the home country or engage in FDI in the foreign region. Firms are assumed to be endowed with an assembly plant and a plant to produce each intermediate in the home country, so that there are no fixed costs associated with exporting to a foreign market. Once they have chosen in which of the $M + 1$ foreign countries they wish to assemble their final good, they organize their international production of intermediate inputs so as to minimize its total cost. Should intermediates be produced in the country of assembly, should they be imported from Home, or should their production be concentrated in the country called Center and exported to affiliates within the region?

7.3 Analysis

Firms can choose from three broad strategies for serving the foreign region that are defined by the location of assembly plants. First, they could assemble the final good exclusively in the home country and then export it to each foreign market. Second, they could open a single assembly plant in the central country and then serve the remaining M markets in the region by exporting the final good from the central country. This option corresponds to *export platform* FDI, which has received an increasing amount of attention in the literature. Since this mode involves complete centraliza-

tion of foreign activity in one country, we refer to this option as *centralized* FDI. Third, they could open an assembly plant in each of the foreign markets and avoid shipping the final good across any borders. This type of firm may still concentrate the production of some of the intermediate inputs in the centralized country and so engage in intrafirm trade in intermediates within region. We refer to this strategy as *decentralized* FDI.

In our analysis, we characterize the optimal intermediate-input sourcing behavior of firms choosing each of these strategies and the profits associated with these strategies in turn. We then turn to sorting of firms into strategies on the basis of their type.

7.3.1 Exporting

Consider first the profits associated with exporting the final good from the home country to each of the $M + 1$ markets of the foreign region. Clearly, a firm that assembles the final good in its home country will also produce all of its intermediates there as well. Hence, such a firm incurs no fixed costs or shipping costs associated with the intermediate inputs. Since each final good shipped is subject to the interregional transport cost of τ, the profits associated with exporting for a firm of type φ are

$$\Pi_X(\varphi) = (M + 1)\varphi(p - \tau). \tag{7.3}$$

To make exporting a viable option, we assume that $p > \tau$.

7.3.2 Centralized FDI

Now consider the behavior and profits of a firm that engages in centralized FDI. A firm that has opened an assembly plant in the central country can then export the good to the M peripheral countries and incur a transport cost $t < \tau$ on final goods. The firm must then decide from where to obtain intermediates. A firm following a centralized FDI strategy will never produce the intermediates in a peripheral country because doing so will incur the fixed cost of building an additional plant and the transport cost of shipping the intermediate to Center. This transport cost could be avoided by simply producing the intermediate in Center.

There are two viable options for sourcing intermediate inputs. First, the firm may produce the intermediates in Home and then ship them to Center. This option avoids fixed costs but incurs interregional transport costs.

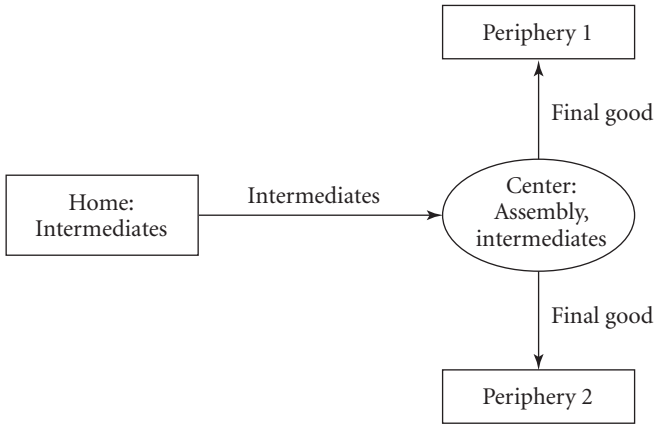

Figure 7.2 Centralized FDI strategy.

Second, a firm may produce the intermediate locally in Center, thereby avoiding transport costs but incurring the fixed cost of building local plants. Figure 7.2 provides a schematic of the location of production and implied trade patterns for a firm following a centralized FDI strategy. Since intermediates share the same transport cost between Home and Center ($\alpha\tau$) and since intermediates with a lower index of ω involve a lower fixed cost, the profitability of moving the production of an intermediate offshore is decreasing in ω. It follows that there is a threshold ω^* such that for $\omega < \omega^*$, intermediates are produced in Center while the remaining intermediates are imported from Home by the assembly affiliate in Center.

Since the final good must be shipped from the center to the periphery, incurring transport cost t while the measure $(1 - \omega^*)$ of intermediates incurs transport cost $\alpha\tau$, it follows from (7.1) that the marginal cost of serving a peripheral country for a firm that chooses cutoff intermediate ω^* is

$$t + (1 - \omega^*)\alpha\tau,$$

while the marginal cost of serving the central country is

$$(1 - \omega^*)\alpha\tau.$$

The total fixed cost for a firm that opens a single foreign assembly plant and an intermediate input plant for all $\omega < \omega^*$ is

$$F_A + f \int_0^{\omega^*} \omega d\omega = F_A + \frac{f}{2}(\omega^*)^2.$$

It follows that the profits of a firm of type φ with investment threshold ω^* are

$$\Pi_{CI}(\omega^*, \varphi) = (M+1)\varphi p - \left\{M\varphi t + F_A\right\} - \left\{(M+1)\varphi(1-\omega^*)\alpha\tau + \frac{f}{2}(\omega^*)^2\right\}. \tag{7.4}$$

The profits of a firm following a centralized FDI strategy have three components. The first component is the revenue of the firm, which is given by the first term on the right-hand side of (7.4). The second term in (7.4) is the cost associated with assembly and moving the final good to foreign locations, which we refer to as the *downstream costs*. The last term is the cost associated with providing intermediates to assembly plants, which we refer to as the *upstream costs*.

A firm that has chosen a centralized FDI strategy minimizes its upstream costs by choosing ω^*. The first-order condition is

$$(M+1)\varphi\alpha\tau - f\omega^* = 0,$$

which implies the following solution for the optimal cutoff between building an intermediate in Home and building it in the central location:

$$\omega^*(\varphi) = \begin{cases} \frac{(M+1)\alpha\tau}{f}\varphi & \text{if } \varphi \le \varphi^* \\ 1 & \text{otherwise} \end{cases} \tag{7.5}$$

where

$$\varphi^* = \frac{f}{(M+1)\alpha\tau}. \tag{7.6}$$

The sourcing of intermediate inputs by a centralized multinational across firms with different market sizes is depicted in Figure 7.3. As a firm's market size becomes larger, the goal of reducing total costs induces the firm to source an increasing share of its intermediates from plants within the central country. As such, the share of intrafirm imports of intermediate inputs from the home country in total value-added is decreasing in a firm's foreign output.

Note that as a firm's market size becomes larger, its marginal costs of serving a foreign market fall endogenously as the firm reorganizes production to avoid transport costs. The observation is interesting because the predictions of standard models of firm heterogeneity run from lower marginal costs to higher market size and not the reverse.

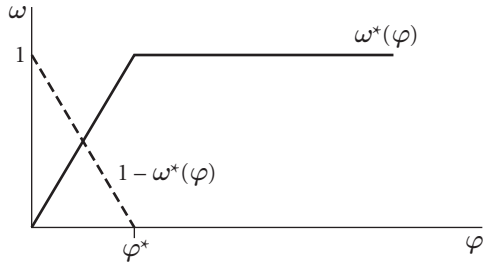

Figure 7.3 The sourcing of intermediate inputs by centralized multinationals.

Combining equations (7.4) and (7.5) yields the expression for the maximum profits that a firm of type φ can earn by engaging in centralized FDI:

$$\Pi_{CI}(\varphi) = \begin{cases} (M+1)\varphi p - \left(M\varphi t + F_A\right) & \\ \quad - \left((M+1)\varphi\alpha\tau - \frac{((M+1)\alpha\tau\varphi)^2}{2f}\right) & \text{if } \varphi \leq \varphi^* \\ (M+1)\varphi p - \left(M\varphi t + F_A\right) - \frac{f}{2} & \text{otherwise.} \end{cases} \tag{7.7}$$

A few features of this profit function are notable. First, notice that while the function is continuous in φ, its first derivative is discontinuous at φ^* as a firm with this market share has moved the production of all its intermediate inputs offshore. Second, as a firm's market share φ rises, its upstream costs rise, but at a slower rate than if it could not adjust the sourcing of its intermediate inputs. This makes the profit function strictly convex for $\varphi \leq \varphi^*$.

7.3.3 Decentralized FDI

A firm that follows a decentralized FDI strategy opens an assembly plant in each foreign country. This firm incurs the fixed cost $(M+1)F_A$ and pays no shipping costs on the final good. The firm must then decide where to produce each intermediate input. There are three options for sourcing a given intermediate. If an intermediate ω is imported from Home, then no additional fixed costs are incurred and the marginal cost of serving any foreign plant is $c(\omega) = \alpha\tau$. If the production of intermediate ω is concentrated in Center, then the additional fixed cost $f\omega$ is incurred in Center and the marginal cost of serving an assembly plant in Center is zero and is $c(\omega) = \alpha t$ in a peripheral country. Finally, if a firm opens a plant to produce intermediate ω in each of the $M+1$ foreign markets, then the fixed cost associated

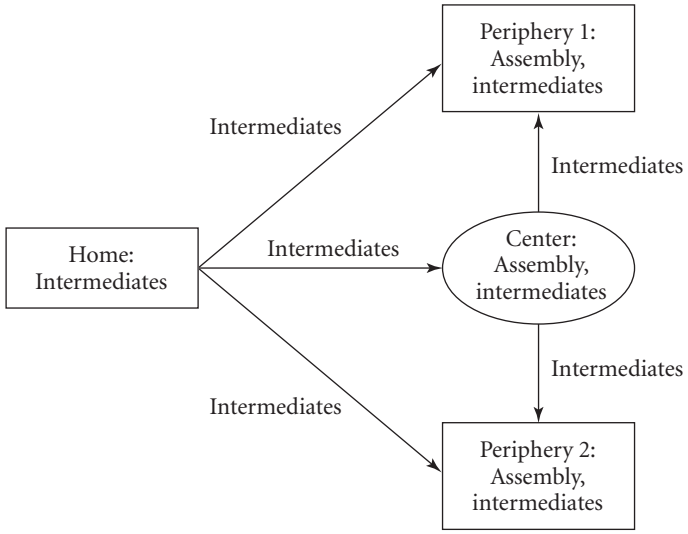

Figure 7.4 Decentralized FDI strategy.

with this intermediate is $(M + 1) f\omega$ and the marginal cost of serving an assembly plant in any foreign country is $c(\omega) = 0$. Figure 7.4 provides a schematic for the structure of production and implied trade patterns of a firm following a decentralized FDI strategy.

Since the fixed cost is increasing in ω, it follows that if any intermediates are produced exclusively in Home, then it is those with the largest ω, and the intermediates that are produced in each of the $(M + 1)$ countries will be those intermediates with the smallest ω. Therefore, two thresholds, ω_1 and ω_2, exist such that intermediates $\omega \geq \omega_2$ are produced in Home and imported by assembly plants, intermediates $\omega \in (\omega_1, \omega_2)$ are produced in Center and imported by assembly plants within the region, and intermediates $\omega \leq \omega_1$ are produced in each foreign country. Using (7.1), the marginal-cost equation for serving peripheral countries can be written

$$(\omega_2 - \omega_1)\alpha t + (1 - \omega_2)\alpha\tau.$$

The term on the left-hand side is the cost of procuring intermediates from Center, and the term on the right-hand side is the cost of procuring intermediates from Home. The marginal-cost equation for serving Center is

$$(1 - \omega_2)\alpha\tau.$$

Note that the local content of production is higher in Center than it is in the periphery. The total fixed cost is

$$(M+1)\left[F_A + f\int_0^{\omega_1} \omega d\omega\right] + f\int_{\omega_1}^{\omega_2} \omega d\omega$$
$$= (M+1)F_A + \frac{f}{2}\omega_2^2 + M\frac{f}{2}\omega_1^2.$$

It follows immediately that the profits that a firm of type φ with investment thresholds ω_2 and ω_1 are

$$\Pi_{DI}(\omega_1, \omega_2; \varphi) = (M+1)\varphi p - (M+1)F_A \tag{7.8}$$
$$- \left\{\varphi\alpha\left[(M+1)\tau(1-\omega_2) - Mt(\omega_2 - \omega_1)\right]\right.$$
$$\left. + \frac{f}{2}\omega_2^2 + M\frac{f}{2}\omega_1^2\right\}.$$

The three terms in (7.8) correspond to revenue, downstream costs, and upstream costs respectively.

Assuming an interior solution, the first-order condition for profit maximization with respect to ω_2 is

$$\varphi\alpha[\tau(M+1) - Mt] - f\omega_2 = 0,$$

which implies the following solution for the optimal cutoff ω_2 between building an intermediate in Home and building it in the central location:

$$\omega_2(\varphi) = \begin{cases} \frac{\alpha[\tau(M+1)-Mt]}{f}\varphi & \text{if } \varphi \le \varphi' \\ 1 & \text{otherwise} \end{cases} \tag{7.9}$$

where

$$\varphi' = \frac{f}{\alpha\left[\tau(M+1) - Mt\right]}. \tag{7.10}$$

Assuming an interior solution, the first-order condition for profit maximization with respect to ω_1 is

$$\alpha\varphi t - f\omega_1 = 0,$$

which implies the following solution for the optimal cutoff ω_1 between building an intermediate in each country and building it exclusively in Center:

$$\omega_1(\varphi) = \begin{cases} \frac{\alpha t}{f}\varphi & \text{if } \varphi \le \varphi'' \\ 1 & \text{otherwise} \end{cases} \tag{7.11}$$

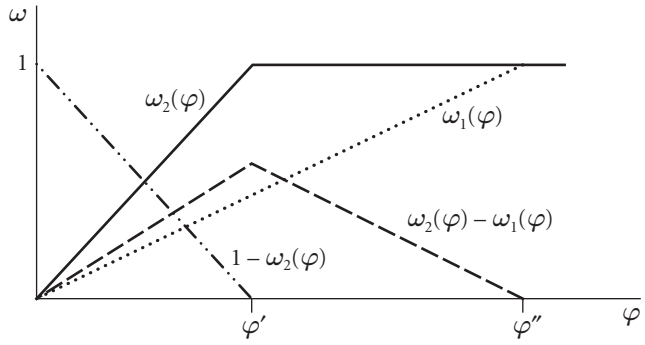

Figure 7.5 The sourcing of intermediate inputs by decentralized multinationals.

where

$$\varphi'' = \frac{f}{\alpha t}. \tag{7.12}$$

Note that the assumption that $\tau > t$ guarantees that $\omega_2 > \omega_1$ and that $\varphi'' > \varphi'$.

This simple framework predicts a rich pattern of intrafirm trade across firms following decentralized FDI strategies as shown in Figure 7.5. As a firm's market size φ increases, the share of intermediates that it sources from home is decreasing (the dotted and dashed line), the share of intermediates that it produces in each peripheral country is increasing (the small dotted line), and the share of intermediates that its affiliates in peripheral countries source from the central country is first increasing, as centrally produced intermediates substitute for imports from the home country, and then decreasing, as locally produced intermediates substitute for centrally produced intermediates. The solid line corresponds to the share of intermediates produced within the region.

Combining equations (7.8)–(7.12) yields the expression for the maximum profits that a firm of type φ can earn by engaging in decentralized foreign investment:

$$\Pi_{DI}(\varphi)\begin{cases} (M+1)\left(\varphi p - F_A\right) & \\ \quad -\left\{(M+1)\varphi\alpha\tau - \frac{(\tau(M+1)-Mt)^2\alpha^2}{2f}\varphi^2\right. & \\ \quad \left. -\frac{M(\alpha t)^2}{2f}\varphi^2\right\} & \text{if } \varphi \le \varphi' \\ (M+1)\left(\varphi p - F_A\right) - \left\{M\varphi\alpha t + \frac{f}{2} - M\frac{(\alpha t)^2}{2f}\varphi^2\right\} & \text{if } \varphi \in (\varphi', \varphi'') \\ (M+1)(\varphi p - F_A - \frac{f}{2}) & \text{otherwise.} \end{cases} \tag{7.13}$$

As was the case with centralized FDI, the profits of decentralized FDI are convex in a firm's market size as a firm adjusts its upstream costs. While upstream costs are strictly increasing in φ, they are bounded above by $(M+1)f/2$—the cost of opening plants to produce each intermediate input in each country.

7.3.4 The Structure of International Commerce

The analysis of the selection of firms into modes of serving foreign markets involves comparing the profit functions (7.3), (7.7), and (7.13). Since firms' revenues are independent of their mode choice, the decision between modes depends solely on which mode offers the lowest cost of supplying the market. Further, modes differ in the relative magnitudes of their upstream and downstream costs. Our analysis of mode choice will depend on the relative importance of these two types of costs, which is governed at least in part by the cost of transporting intermediates relative to the cost of transporting final goods (α).

We begin our analysis with the case in which $\alpha = 0$ so that intermediates can be costlessly shipped and upstream costs are zero for all modes. When intermediates can be costlessly shipped, firms face a simple tradeoff between the marginal costs associated with shipping the final good and the fixed costs of building assembly plants. Since the fixed costs are greatest for decentralized FDI, lowest for exports, and

$$\frac{\partial \pi_{DI}(\varphi)}{\partial \varphi} > \frac{\partial \pi_{CI}(\varphi)}{\partial \varphi} > \frac{\partial \pi_{X}(\varphi)}{\partial \varphi}, \tag{7.14}$$

it follows that the firms with the largest market sizes will opt for decentralized FDI, firms with moderate market sizes will opt for centralized FDI, and the least-productive firms will export. This sorting is akin to the type found in Helpman, Melitz, and Yeaple (2004). The main difference is that the structure of FDI here features a geography that gives rise to centralized FDI.

Complications arise for the case in which $\alpha > 0$. To see why, note that the upstream costs associated with obtaining components are highest for firms following a decentralized FDI strategy and are zero for firms choosing to export the final good from the home country to the foreign region. Since upstream costs differ across modes in terms of their responsiveness to a

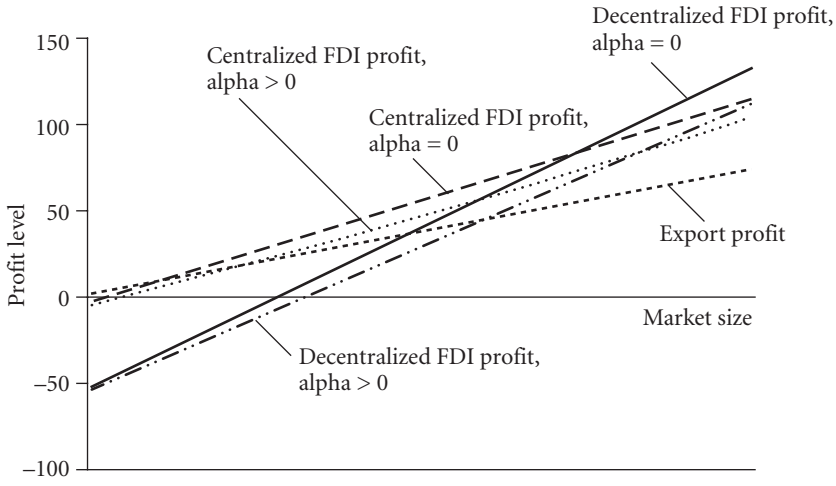

Figure 7.6 Profits as a function of market size and mode choice.

firm's market size, it is not generally possible to establish an ordering akin to (7.14) that holds for all values of φ.

To make progress, we consider the case in which α is so small that upstream costs are small relative to downstream costs. In particular, it can be shown that if

$$\alpha < \alpha^* \equiv \min\left\{\frac{\tau - t\frac{M}{M+1}}{\tau}, \frac{\tau}{\tau + (\tau - t)}\right\},$$

then the ordering given by (7.14) is preserved. To see the implication of transport costs for intermediates on the mapping from a firm's market size to its mode choice, consider Figure 7.6.[4] The solid lines in this figure correspond to the case in which $\alpha = 0$ while the dashed lines correspond to the case in which $\alpha^* > \alpha > 0$. In both cases, the profit associated with decentralized FDI is highest for firms with the largest market shares, the profit associated with exports is highest for the smallest firms, while the profit for centralized FDI is highest for firms in between these extremes. Because exporters have the lowest upstream costs (they are zero) and because decentralized FDI has the highest upstream costs, an increase in α expands the range of market sizes for which export is the favored mode and shrinks the range of market sizes for which firms opt for decentralized FDI.

Let the cutoff market size between exporting and centralized FDI be given by φ_1 and let the cutoff market size between centralized FDI and decentralized FDI be given by φ_2. Choosing parameter values[5] such that these cutoffs fall below φ^* (that is, at these cutoffs, firms import some intermediates from their parent firms), the threshold φ_1 is implicitly defined by the function

$$\Psi(\varphi_1) = (M+1)\left[\frac{(M+1)(\alpha\tau\varphi_1)^2}{2f} - \tau\varphi_1(1-\alpha)\right] - M\varphi_1 t - F_A = 0, \tag{7.15}$$

and the threshold φ_2 is implicitly defined by the function

$$\Omega(\varphi_2) = M\left\{\varphi_2 t - \alpha^2\frac{(\varphi_2)^2}{2f}(M+1)\,(2\tau - t)\,t - F_A\right\} = 0. \tag{7.16}$$

Note that α^* can be derived from these expressions and the definition of an interior equilibrium. In summary, firms with size $\varphi < \varphi_1$ engage exclusively in export and own no foreign affiliates, firms with size $\varphi \in (\varphi_1, \varphi_2)$ invest exclusively in the central country, and firms with market size $\varphi > \varphi_2$ invest in all M markets in the foreign region.

Now consider the pattern of intrafirm trade between parent and affiliate as a function of a firm's type. The share of intermediates that are imported from the parent is given by $(1 - \widehat{\omega})$. For firms pursuing a centralized FDI strategy; $\widehat{\omega}$ is given by (7.5) while for firms pursuing a decentralized FDI strategy, $\widehat{\omega}$ is given by (7.9). Notice that the threshold intermediate cutoff given by (7.5) exceeds the threshold intermediate cutoff given by (7.9). For a given φ, the affiliates of firms pursuing a centralized FDI strategy import a smaller share of their intermediate inputs from the parent firm than the affiliates of firms that pursue a decentralized FDI strategy.

Firms that concentrate their assembly in one location can lower their cost of delivering a unit of intermediate input to the assembly plant by $\alpha\tau$. Firms that concentrate the marginal intermediate's production in Center must still export that intermediate plant to affiliates located in the periphery, and so, moving the production of an intermediate to Center reduces the cost by only $\alpha(\tau - t)$. Since, on the margin, firms face the same fixed cost of moving the production of an intermediate offshore, it follows that firms that concentrate assembly in Center have a stronger incentive to re-

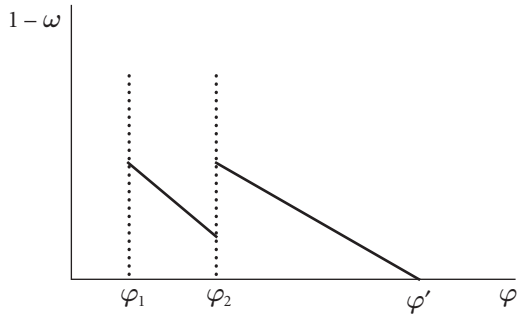

Figure 7.7 Imports from parent firms and firm size.

duce their imports from their parent firm. Hence, local content tends to be higher for centralized firms. This has the implication that the relationship between the share of intermediates imported from the parent and a firm's size is nonmonotonic and discontinuous at φ_2, the cutoff threshold firm size between those firms that pursue a centralized FDI strategy and those that pursue a decentralized FDI strategy, as shown in Figure 7.7.

Figure 7.7 has important implications for empirical work. Suppose that a researcher is interested in understanding the relationship between a firm's characteristics and the extent of intrafirm trade. A regression of the share of trade between a parent firm and an affiliate on firm size could yield a positive, negative, or zero coefficient depending on the distribution of firm sizes in the sample. Holding fixed a mode choice, however, the relationship between firm size and propensity to import intermediates is clearly negative.

7.4 Comparative Statics

We now consider the effect of changes in key exogenous variables on two components of the structure of FDI. First, a change in an exogenous variable will alter the mode choice of firms. These effects can be obtained by differentiating the threshold conditions (7.15) and (7.16). Second, holding fixed a firm's mode choice, a change in an exogenous variable will alter the structure of FDI within modes by inducing firms to change their intermediate-input sourcing policies. These effects can be obtained by

differentiating equations (7.5), (7.11), and (7.9). Since the sourcing of intermediate inputs depends in part on mode choice, the total change in the location of intermediate-input production depends upon both effects.

First, consider an increase in the interregional transport cost. An increase in τ induces a decrease in φ_1 and an increase in φ_2. Higher interregional transport costs are therefore associated with a smaller share of firms engaged in exporting *and* a smaller share of firms engaged in decentralized FDI. The decrease in φ_1 is a straightforward result of the proximity-concentration trade-off built into the model.

The increase in φ_2 requires more explanation. This result obtains because the upstream costs of firms engaged in centralized FDI are more sensitive to interregional trade costs than the upstream costs of firms engaged in decentralized FDI (see Figure 7.7). The result has the interesting implication that for any peripheral country, higher interregional transport costs are associated with a smaller number of foreign investors entering the country. This might help explain why many studies find that FDI is actually decreasing on average in distance between the host and the source country. Moreover, it has the interesting implication that the effect of distance on the volume of FDI to a country interacts with that country's centrality: distance between a source and host country increases the volume of FDI in central locations and reduces it in peripheral locations.

Second, consider the effect of an increase in interregional trade costs on the sourcing of intermediates. Differentiating equations (7.5), (7.11), and (7.9) establishes that an increase in inter-regional trade costs induces a decrease in the share of intermediates sourced from the home country. This result is consistent with the finding in Hanson, Mataloni, and Slaughter (2005) who show that imports of intermediate inputs by the affiliates of U.S. multinational enterprises is decreasing in trade costs between the United States and the host country. Interaffiliate trade in the aggregate also falls because of the decrease in φ_2: firms engaged in centralized FDI demand fewer inputs from Home.

Third, consider the effect of an increase in intraregional trade costs. Total differentiation of (7.15) establishes that an increase in t results in an increase in the threshold φ_1. Hence, a reduction in intraregional trade costs, such as might occur with a preferential trade agreement, reduces the volume of final good imports from Home and increases the number of firms conducting FDI in the foreign region. An increase in t also leads to a decrease in the threshold φ_2 so that a reduction in intraregional trade costs

is associated with a tendency for firms to centralize their foreign production. These results are consistent with recent empirical work presented in Chen (2006). She finds that the introduction of a preferential trade agreement within a region tends to increase U.S. FDI to that region but that FDI becomes more concentrated in particularly attractive countries within the region.

With respect to the effect of an increase in intraregional transport costs on the sourcing of intermediates, intermediate imports from Home increase for two reasons. First, as firms switch from a centralized to a decentralized FDI strategy, they increase their intermediates imports from Home because local content is higher among centralized multinationals. Second, holding fixed a firm's mode choice, an increase in intraregional trade costs induces firms to substitute the production of inputs away from Center toward Home.

Finally, an increase in the size of the foreign region, as measured by the number of markets in which there is demand M, has very similar implications to a reduction in intraregional transport costs. First, there is an increase in φ_1 and a decrease in φ_2: the number of firms engaged in centralized FDI expands at the expense of both exporters and firms engaged in decentralized FDI. Second, local content increases as centralized FDI expands at the expense of decentralized FDI and as a larger regional market induces firms to incur the additional fixed costs associated with moving production offshore.

7.5 An Extension and an Application

To illustrate the usefulness of this simple model, we consider an extension of the model to a more complex geography and an application of the model to the analysis of rules of origin in a regional trade agreement.[6]

7.5.1 Multiple Foreign Regions

Suppose that there are two identical foreign regions that firms from Home wish to serve. A firm that locates an assembly plant in the center country of one region can serve any market in the other foreign region at transport cost δ, where $\tau > \delta > t$. In this sense, an affiliate located in the central country of one region is "nearer" to another region than is Home and so can act as

an export platform to that region. For simplicity, assume that $\alpha = 0$ so that the complications created by the cost-of-components effect do not arise.

This specification introduces a second kind of centralization strategy. In the first centralization strategy, a firm opens a single affiliate in one of the two foreign regions and then exports to all foreign countries from that region. In the second centralization strategy, the firm opens an affiliate in both central countries and ships its final good to each country within its region only.

The pattern of specialization is very similar to the one derived above. The larger a firm's market size φ, the more affiliates the firm has. The firms with the smallest φ export from home, while the firms with the highest φ own an affiliate in each foreign country. Among the intermediate ranges of φ, the firms with relatively smaller φ open a single affiliate in the center country of one region and that affiliate exports its final good both within and across foreign regions, while firms with relatively higher values of φ open an affiliate in each central country and each affiliate then exports final goods within its region.

This pattern of affiliate ownership across firms is intuitively sensible. As a firm's market size grows, its international production network first expands *across* regions. As it becomes even larger, it then begins to expand its affiliate network *within* regions.

The case in which intermediate inputs are costly to trade introduces additional complications, and there are many possible cases that can arise depending on the relative magnitudes of the parameters. For instance, it is possible that a firm opens an assembly affiliate in both central countries but continues to concentrate its production of some of its intermediates (those with relatively high fixed costs) in one of the two central locations and then ships those intermediates to the other foreign country.

7.5.2 Rules of Origin

To illustrate how the framework can be used for policy analysis, consider the following reinterpretation of the model. Suppose that the difference in trade costs $\tau - t$ reflects the size of the tariff on outside goods in a regional trade agreement. Once one has reinterpreted the difference in trade costs within a region relative to between regions in this way, there is no need to think of a central location. It is still true, however, that a firm choosing

a "centralized" FDI strategy will assemble the final good in one location and any intermediates produced within that region will be produced in the country of assembly.

Suppose that for the intraregional exports of a multinational affiliate to enjoy this tariff reduction, the firm must have a minimum local content with region of $\underline{\omega}$. What impact does this policy have on the structure of FDI? Since only the final good uses intermediate inputs, rules of origin only directly affect the profits of firms choosing a centralized FDI strategy. Consider $\underline{\omega} = \omega^*(\underline{\varphi})$, where the function $\omega^*(\cdot)$ is given by equation (7.5) and $\underline{\varphi} \in (\varphi_1, \varphi_2)$, where φ_1 is the smallest market size of a firm that follows a centralized FDI strategy and φ_2 is the largest market size of a firm that follows a centralized FDI strategy when there are no rules of origin. For the firm with market size φ_1, the rules of origin lower the profit associated with centralized FDI relative to export and so induce that firm to export rather than engage in FDI within the region. For firms with higher market size φ_2, the rules of origin do not bind and so they do not affect the firm's choice of FDI strategy. This implies that there exists a new cutoff market-size threshold $\widetilde{\varphi}_1 \in (\varphi_1, \underline{\varphi})$ that is implicitly defined by

$$\Pi_{CI}(\widetilde{\varphi}_1 : \omega = \underline{\omega}) = \Pi_X(\widetilde{\varphi}_1),$$

where the profit of centralized FDI $\Pi_{CI}(\cdot)$ is given by (7.4) and the profit of exporting $\Pi_X(\cdot)$ is given by (7.3). Rules of origin have opposing effects on the size of local affiliate production. Firms with $\varphi \in (\varphi_1, \widetilde{\varphi}_1)$ cease to produce in the country at all, while firms $\varphi \in (\widetilde{\varphi}_1, \underline{\varphi})$ are induced to increase the share of intermediate inputs that they produce within the region.

The total effect of the rules of origin on the volume of local production is ambiguous. On the one hand, local production falls on the *extensive* margin as fewer firms produce in the region, while on the other hand, local production rises on the *intensive* margin as some firms are induced to open plants for the production of intermediates. The relative size of these two effects depends in part on the empirical distribution of φ, which is a variable that likely varies across industries (see Helpman, Melitz, and Yeaple 2004). For a high enough floor on local content, no firm would choose a strategy of centralized FDI, and the volume of within-region trade in final goods would collapse. Note that in this framework, rules of origin induce firms that stay in the market to lower their marginal costs.

7.6 Firm Heterogeneity and Central Locations: Empirics

In this section, we conduct two analyses of the data on U.S. multinational enterprises (MNE). First, we ask whether the assumptions of the model are consistent with the behavior of U.S. MNE. Do the multinationals that enter centrally located countries tend to export final goods and intermediates more than other countries? Second, we test the model's sorting prediction. Is the composition of multinationals that enter centrally located countries skewed toward those firms that produce in relatively few locations?

Our analysis relies on firm-level data from the 1999 Benchmark Survey of U.S. Direct Investment Abroad, conducted by the U.S. Bureau of Economic Analysis (BEA). In benchmark years, the BEA requires all U.S. firms with direct investment abroad to list all of the countries in which they own foreign affiliates. This requirement is independent of the affiliate's size so that the scope of this data is comprehensive. As an affiliate becomes larger, the BEA requires the U.S. parent to provide an increasingly larger set of information concerning the affiliate's operations, including the volume of its affiliate's exports to both related and unrelated customers in other foreign countries. From this database we consider all U.S. MNE, whose main line of business is in manufacturing, and their manufacturing affiliates.

7.6.1 Exports and Central Locations

We begin the analysis by asking whether there is in fact a tendency for affiliates located in centrally located countries to export heavily to third countries. We consider regressions of the form

$$EX_{ik} = \eta_i + \beta \cdot FMA_k + \alpha \cdot Z_k + e_{ik},$$

where EX_{ik} is a measure of the logarithm of affiliate i's exports from country k. There are two measures of exports. The first is the affiliate's exports to related affiliates located in other countries other than the United States. The second is the affiliate's exports to unrelated parties located in other countries other than the United States. Exports to related parties is a measure of cross-border vertical specialization, while exports to unrelated parties is a measure of the extent of export-platform FDI.

The other variables are defined as follows: η_i is a fixed effect by firm, FMA_k is a proxy for the centrality of country k, and Z_k is a vector of controls for other characteristics of country k. The key variable of interest is foreign

market access (FMA). This variable is a proxy for the centrality of a country's location. We follow Redding and Venables (2004) in our construction of our measure of foreign-market access. The variable is defined as

$$FMA_k = \sum_{j \neq k} \exp(ptn_j)^{\widehat{\lambda}_j} dist_{kj}^{\widehat{\delta}_1} border_{kj}^{\widehat{\delta}_2} lang_{kj}^{\widehat{\delta}_3} RTA_{kj}^{\widehat{\delta}_4}, \tag{7.17}$$

where j indexes other countries, ptn_j is an indicator variable for country j, $dist_{kj}$ is the distance between country j and country k, $border_{kj}$ is an indicator variable that is equal to one when countries j and k share a common border, $lang_{kj}$ is an indicator variable that is equal to one when countries j and k share a common language, RTA_{kj} is an indicator variable that is equal to one if countries k and j are partners in the same regional free trade agreement, and $\widehat{\lambda}_j$, $\widehat{\delta}_1$, $\widehat{\delta}_2$, $\widehat{\delta}_3$, and $\widehat{\delta}_4$ are coefficients estimated from a gravity equation.[7] Note that since our interest is on exports to third countries and not to the United States, *FMA* does not include the United States as a partner country.

The variables in Z_k are standard controls from gravity equations. The gravity variables include GDP_k, the logarithm of the host country's GDP; $ENGLISH_k$, which is the share of the population that speaks English; $DIST_k$, which is the logarithm of the distance between the United States and the country in question; ADJ_k, which is a dummy for Mexico and Canada; and $GDPPC_k$, which is the logarithm of a country's GDP per capita. Descriptive statistics for these variables are shown in Table 7.2.

Table 7.2 Descriptive statistics

	Mean	Std deviation
Number	1.21	1.15
Median locations	2.57	0.85
FMA	15.92	0.78
GDP	25.76	1.77
GDPPC	9.26	0.79
DIST	8.87	0.61
ENGFRAC	0.16	0.34
ADJ	0.05	0.22

Note: All variables except *ENGFRAC* and *ADJ* are in logarithms.

Table 7.3 Exports and central locations

	Logarithm of intrafirm exports (1)	Logarithm of other exports (2)
FMA	0.820	0.827
	(0.096)	(0.108)
GDP	−0.373	−0.529
	(0.089)	(0.099)
GDPPC	0.149	0.524
	(0.148)	(0.141)
DIST	−0.301	−0.077
	(0.234)	(0.185)
ENGLISH	0.211	0.151
	(0.190)	(0.141)
ADJ	−1.594	−1.142
	(0.602)	(0.542)
N	1,536	1,354
R-squared	0.174	0.222

Note: Both specifications include fixed effects by firm. All variables except *ENGLISH* and *ADJ* are in logarithms. Standard errors shown in parentheses are adjusted for heteroskedasticity and clustering by country.

The results of these regressions are shown in Table 7.3. The coefficient estimates corresponding to intrafirm trade are in column 1, and the results corresponding to unrelated-party exports are shown in column 2. Of particular interest is the result shown in the first row. Affiliates located in central locations export substantially more to both related and unrelated parties than to affiliates located elsewhere. Interestingly, the volume of both types of exports is decreasing in a country's GDP. The coefficient on *GDPPC* is positive for both types of exports but is statistically insignificant for related party exports while larger and statistically significant for unrelated party exports. Pure export-platform FDI is more common among developed countries while there is greater heterogeneity with respect to related party trade.

7.6.2 Central Locations and the Sorting of Multinationals

We now consider the tendency for multinationals to sort into countries based on their degree of centrality. We consider two measures of U.S. MNE

activity to assess whether central locations attract a large number of U.S. multinationals with small international production networks. The first measure VOL_{jk} gauges the volume of activity of U.S. MNE in country k and industry j as captured by the number of U.S. multinationals that own an affiliate in the country k and industry j. The second measure $COMP_{jk}$ gauges the composition of U.S. MNE entrants into country k and industry j. This variable is the number of countries in which the median U.S. multinational entrant into country k owns affiliates. As this variable becomes smaller, the composition of investors is becoming skewed toward firms with smaller multinational networks.

We estimate the following specification:

$$y_{jk} = \eta_j + \beta \cdot FMA_k + \alpha \cdot Z'_k + e_{jk},$$

where $y_{jk} \in \{VOL_{jk}, COMP_{jk}\}$, FMA_k is the logarithm of the measure of country k's foreign-market access as calculated in (7.17), Z'_k is a vector of controls considered in the previous section, and η_j is a fixed effect for three-digit NAICs industry j. The variables in Z'_k are standard controls from gravity equations that were described in Section 7.6.1 plus a set of indicator variables for a country's region. These indicators have the effect of normalizing values of FMA_k for a country's neighborhood in order to better capture centrality. The model predicts that the coefficient on FMA_k should be positive when the dependent variable is VOL_{jk} and negative when the dependent variable is $COMP_{jk}$: central locations attract more firms than peripheral locations, and these additional firms are those that concentrate their production in a few offshore sites. The equation is estimated via ordinary least squares.

The results are shown in Table 7.4. Column 1 corresponds to coefficient estimates when the dependent variable is VOL_{ik}, and column 2 reports the coefficient estimates when the dependent variable is $COMP_{ik}$. Standard errors are heteroskedasticity consistent and allow for clustering by country and are shown in parentheses below their coefficient estimates.

Looking first at column 1, we see that all the coefficient estimates are positive and statistically different from zero at standard levels. U.S. multinationals are more likely to enter countries in central locations (*FMA*), that have large domestic demands (*GDP*), that have relatively high GDP per capital (*GDPPC*), that are relatively distant from the United States (*DIST*), and that speak English (*ENGLISH*). Canada and Mexico receive a

Table 7.4 Volume and composition as a function of country characteristics

	VOL (Number of entrants) (1)	*COMP* (Median locations) (2)
FMA	0.327	−0.213
	(0.084)	(0.057)
GDP	0.291	−0.092
	(0.026)	(0.023)
GDPPC	0.336	−0.108
	(0.074)	(0.047)
DIST	0.282	−0.025
	(0.144)	(0.113)
ENGLISH	0.565	−0.604
	(0.118)	(0.093)
ADJ	0.909	−0.493
	(0.112)	(0.102)
N	678	678
R-squared	0.739	0.654

Note: All variables except *ENGFRAC* and *ADJ* are in logarithms. Coefficients on three-digit industry dummies and regional dummies are suppressed. Standard errors are robust to heteroskedasticity and allow for clustering by country and are shown in parentheses below the coefficient estimates.

disproportionate amount of U.S. foreign direct investment as indicated by the positive coefficient on *ADJ*.

The positive coefficient on *FMA* confirms our hypothesis that geography is an important determinant of foreign direct investment patterns. This result is reminiscent of Blonigen et al. (2005). Interestingly, when *FMA* is dropped from the regression, the coefficient on *DIST* becomes zero (specification not shown), suggesting that it is important to control for regional geography to understand the impact of distance on FDI volumes.

Now consider the coefficient estimates in column 2. The first key observation is that the country characteristics that predict greater volume of U.S. multinational entry also predict a different composition of entrants into that country. Of key interest to our study is the negative and statistically significant coefficient estimate on *FMA*: countries with greater foreign-market potential tend to attract U.S. multinationals that are active in fewer

locations than countries with lower foreign-market potential. This result is consistent with a key prediction of the model: firms whose international production is limited in scope concentrate their production in central locations.

7.7 Conclusion

This chapter makes the case that it is important to account for firm heterogeneity and the geography of regions to understand the structure of multinational enterprises. We analyzed a model that allows for both vertical and horizontally integrated multinationals in a multicountry setting. The model captures in the simplest possible way the complex logistical problems facing multinationals. Firms can choose between three broad strategies for assembling their final goods for foreign markets: home assembly followed by interregional trade, assembly in a central foreign region followed by intraregional trade, and assembly in each foreign location thereby avoiding all trade. Once a firm has chosen where to assemble its product, it must then decide where to produce intermediate inputs. Intermediates are costly to ship and since they vary in their transport costs, the optimal production location may vary over intermediates.

The analysis shows that firms with more popular products, and hence bigger market shares in any given foreign country, will organize their production within foreign regions in a very different fashion than firms with smaller market shares. Smaller multinationals centralize their production in central locations, while larger firms open assembly affiliates in many countries while centralizing the production of many components in central locations. These results are consistent with our empirical finding that countries with large market potential attract a disproportionate number of multinational firms and that these firms are on average less well represented in less centralized locations.

The model also has a number of interesting comparative statics. For instance, because centralized firms optimally concentrate a larger fraction of their intermediate-inputs production within a foreign region, an increase in interregional transport costs reduces the FDI in peripheral countries as firms substitute a centralized FDI strategy for a decentralized FDI strategy. This result may help us to understand why, as transport costs have fallen, the value of foreign sales of the affiliates of U.S. multinationals has been

increasing faster than their value-added but more slowly than their volumes of trade to both affiliated and unaffiliated customers.

The key role played by central locations also suggests that regions that are not integrated attract fewer multinationals. This result may suggest why certain regions, such as Latin America, continue to attract relatively little FDI. The model has other empirical implications that would be worthwhile to test. For instance, as affiliates become larger, their local content should be increasing, while their participation in interaffiliate trade relative to value-added should exhibit an inverted U-shape in affiliate size.

Finally, the framework has been kept as simple as possible for the purpose of exposition but could be extended in many dimensions. For instance, it is conceptually straightforward to introduce product market competition and heterogeneity in productivity to generate heterogeneity in market shares. Doing so would introduce the types of complementarities that have been identified in the recent work of Yeaple (2003) and Grossman, Helpman, and Szeidl (2006). Allowing free entry by country would considerably complicate the model but would endogenize demand levels in each location, a possibly important extension. The assumptions that all intermediates use no inputs and are costlessly assembled into final output is also restrictive. Many intermediates require many stages of production in their own right, and a technology that captured the sequential nature of production might offer additional insights into the effect of geography on foreign direct investment. The current formulation abstracts from factor price differences across countries on vertical specialization in order to focus purely on the role of geography, but factor price differences are surely important determinants of FDI patterns in their own right and may also interact with geography. Finally, while we assumed away the possibility of outsourcing for simplicity, the framework could be applied to situations in which some intermediates are produced by the firm and others obtained arm's length on markets.

ACKNOWLEDGMENTS

The statistical analysis of firm-level data on U.S. multinational corporations reported in this chapter was conducted at the International Investment Division, U.S. Bureau of Economic Analysis, under arrangements that maintained legal confidentiality requirements. Views expressed are those of the author and do not necessarily

reflect those of the U.S. Bureau of Economic Analysis. The author would like to thank the editors of this volume and Maurice Kugler for helpful comments and suggestions.

NOTES

1. Also see Neary (2007).
2. This formulation is consistent with the hub-and-spokes framework that occasionally appears in economic geography models.
3. In the case of monopolistic competition with CES preferences, a firm's revenues are monotonically decreasing in its marginal cost, which in turn is decreasing in a firm's productivity. What this specification rules out are certain types of "complementarities" that can arise when the reduction of a firm's marginal cost raises the volume of its sales. See, for instance, Grossman, Helpman, and Szeidl (2006).
4. Note that parameter values have been chosen so that the cutoff market sizes between the three modes occur for values of φ such that at these thresholds, firms engaged in FDI import at least some intermediates from their parent firms.
5. To obtain such an interior solution, one only need assume that F_A is sufficiently small.
6. The author would like to thank Elhanan Helpman and Thierry Verdier for inspiring this section.
7. The gravity data is from Andrew Rose's website (corrected in places using CEPII data), and the trade data is from Feenstra et al. (2005).

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