

Intra-Industry Foreign Direct Investment

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In this paper, we use a unique firm-level dataset to characterize global patterns of multinational activity. Traditionally, the literature has distinguished between two forms of, and motivations for, multinational firms locating activities abroad. “Horizontal” foreign investment is understood to mean situating production facilities so as to avoid trade costs (James R. Markusen 1984; S. Lael Brainard 1993) and “vertical” investment represents firms’ attempts to take advantage of cross-border factor cost differences (Elhanan Helpman 1984; Helpman and Paul Krugman 1985). Most research has found the bulk of foreign direct investment (FDI) to be horizontal. Our results suggest that data limitations have led the literature to systematically underestimate vertical FDI, which our dataset reveals to be far more prevalent than previously thought.

To date, the central challenge for the literature has been the absence of a global source of firm-level data on the basis of which to distinguish between horizontal and vertical FDI. The requisite data would ideally include location, ownership, and intrafirm trading status of multinational enterprises at the plant level.¹ Researchers have instead used multinational corporation (MNC) activity at the industry level or aggregate FDI flows from balance-of-payments statistics as a proxy for foreign firm activity. Empirical tests based on such consistently reject models that assume low transport costs and comparative advantage in favor of models in which market access issues arise (see Brainard 1993, 1997; David L. Carr, Markusen, and Keith E. Maskus 2001, 2003; Markusen and Maskus 2001, 2002; Bruce A. Blonigen, Ronald B. Davies, and Keith Head 2003).

A new firm-level dataset provided by Dun & Bradstreet (D&B) enables us to present a much more comprehensive and nuanced picture of global multinational activity. The dataset includes location, ownership, and detailed sector (at the four-digit level) for each of more than 650,000 multinational subsidiaries in 400 industries and 90 countries. This remarkable picture of global investment patterns is, to our knowledge, the first detailed characterization of global, firm-level multinational activity. Because we do not observe interplant trade within multinational firms, a limitation of our dataset, we use a combination of four-digit sector-level information and input-output tables to distinguish horizontal and vertical FDI. We classify a horizontal subsidiary as a

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¹ From this data, horizontal FDI could be identified as establishments owned by a foreign parent that produce the same products as the parent but sell them in the local market, and vertical FDI as establishments owned by a foreign parent that produce intermediate inputs to the parent’s production and export those inputs to the parent country. This is a lot to expect of any dataset, especially in the context of multinational activity. Databases of foreign investment at the firm level tend to be almost exclusively national (for example, the Bureau of Economic Analysis (BEA) confidential compilation of data on US multinationals).

plant in the same sector code as the foreign owner parent, and a vertical subsidiary as a plant that produces in sectors that are inputs to the foreign parent's product. We verify the accuracy of this method in a number of ways.

Some of our plant-level findings require that we significantly reconsider the conventional wisdom. Consistent with the existing literature, we find that the bulk of multinational activity occurs among the rich nations of the world. Additionally, at the two-digit industry level, we observe considerably more horizontal (subsidiaries in the same industry as their parents) than vertical (subsidiaries that supply their parents with inputs) FDI. However, disaggregating to the four-digit level reveals that many of the foreign subsidiaries in the same two-digit industry as their parents are, in fact, located in sectors that produce highly specialized inputs to their parents' production. Thus, contrary to the conventional wisdom, we find the number of vertical multinational subsidiaries to be larger than commonly thought.² We find important vertical activity in terms both of number of subsidiaries (112,939 vertical versus 104,057 horizontal subsidiaries) and number of employees (15.8 million versus 11.9 million, respectively).³ These patterns prevail even within developed countries.

The most striking empirical finding is that a significant amount of vertical FDI might have been previously misclassified as horizontal FDI for three reasons. First, because most vertical FDI is north-north, it has been assumed to be market seeking (horizontal) when, in fact, firm-level data indicate that these are vertical relationships (i.e., parent firms sourcing inputs from their subsidiaries in other developed countries). Second, skill differences between parent and subsidiaries are small (even within vertical FDI), which also lends support to horizontal motivations for foreign activity.⁴ Third, the vertical nature of these relationships is missed at the two-digit level (and visible only at the four-digit level, for example) because many subsidiaries that supply goods to their parents are located in sectors in which both the input and final good are in the same two-digit Standard Industrial Classification (SIC) code.

We call these subsidiaries unveiled at higher levels of disaggregation "*intra*-industry vertical FDI" and show them to be qualitatively different from vertical subsidiaries that cross two-digit industry codes ("*inter*industry vertical FDI"). Intra-industry vertical subsidiaries are generally located in sectors that produce high-skill inputs to their parent firms, and a large proportion of these firms are located in high-skill countries. Although both inter- and intra-industry subsidiaries are vertical in the sense that they are in sectors that provide inputs to their parent firms, intra-industry FDI is much harder to explain with the standard theories of vertical FDI, which emphasize factor cost differences as the primary motivation for fragmentation. Using a sample of subsidiaries identified as being vertical suppliers to their parents at the two-digit level, we find strong evidence that vertical FDI is driven by comparative advantage; that is, low-skill activities tend to be located in low-skill countries. But when we examine intra-industry foreign-owned subsidiaries that are in the same two- and three-digit industry as their parents, but in a four-digit

² We build on other recent findings that challenge the conventional wisdom about the dominance of horizontal FDI (see Gordon H. Hanson, Raymond J. Mataloni, and Matthew J. Slaughter 2002, 2005; Stephen R. Yeaple 2003). Our results are consistent with firm-level trade data for the United States that shows the proportion of intrafirm trade to be higher between rich countries than between rich and poor countries, further evidence of important multinational vertical activity between rich countries (see Andrew B. Bernard, J. B. Jensen, and Peter K. Schott 2006). This literature is discussed in the next section.

³ The dataset is at the plant level for all industries. In the regression analysis we use only manufacturing subsidiaries in order to compare our findings with those reported in the literature. Section II and Appendix A describe the data in detail.

⁴ Empirical tests in frameworks that encompass both types of investment (such as Markusens' knowledge-capital model) generally show the location of foreign subsidiaries to be driven mostly by factors consistent with the horizontal model, such as size of the host market and similarity between host and home factor endowments.

industry that is an input to their parents' production, we find significantly less evidence that vertical FDI is driven by comparative advantage.

The utility of distinguishing among industries at this level of detail when characterizing the type of, and motivation for, FDI is illustrated by the case of General Motors Corporation. We observe in our data 2,248 entities that report to General Motors Corporation as their "global ultimate parent."⁵ Of these, 455 are subsidiaries outside the United States and 123 are in manufacturing industries.⁶ We find 68 of these foreign manufacturing subsidiaries to be "horizontal" according to our classification (i.e., in the same primary four-digit SIC code as the parent firm, GM SIC 3711 Motor Vehicles and Passenger Car Bodies). Using the US input-output matrix, we classify 42 as being "vertical" (i.e., in industries that are inputs to the parent industry). These include inputs such as vehicle engines (SIC 3519) produced by Powertrain-Kaiserslautern in Germany and specialized auto parts (SIC 3714), including the air bags produced by Delphi Interior Systems company in Mexico (and other parts of the world), diesel engine parts produced by GMI Engineering in Japan, and carburetors, pistons, rings, and valves produced by GM Strasbourg in France. Skill intensity in the industries of GM subsidiaries, on average, does not differ significantly between rich and poor countries.⁷ Strikingly, GM's foreign subsidiaries do not include any firms producing what might be called the "raw materials" for, or "low-skill inputs" to, the production of automobiles. These are produced outside the boundaries of GM's multinational network. If the production of automobiles is fragmented into "stages of production" from raw materials to intermediate inputs to final goods, then GM's "vertical FDI" is focused on the penultimate stages in the vertical production chain.

Our findings document a substantial amount of intrafirm FDI between rich countries in high-skill sectors involving products that are at stages close to the parent firm's final stage of production, which raises the question of why parent firms in rich countries choose to own their foreign suppliers rather than outsource the inputs. Vertical FDI is the result of two decisions by a parent firm: whether to source an input from abroad, and whether to source it from within the boundaries of the firm or purchase it from an unaffiliated foreign firm. Recent contributions to the theory of boundaries of the firm relate these decisions to the characteristics of the countries involved and products being produced (in addition to firm characteristics).⁸ That rich country multinationals are operating in close stages of production to final firms (supplying inputs) and that skill differences between parent and subsidiary are small suggest that the main motivation to locate abroad is not wage differentials.

Our strongest stylized fact is that parent firms own the stage in the production process closest to their own. The empirical findings serve as the inspiration for a novel explanation of patterns of FDI that, before the availability of these data, were misclassified and therefore mischaracterized. We argue that a coexistent and correlated motivation for bringing an input inside the boundaries of a firm relates not only to its characteristics or the characteristics of the country in which it is produced, but also to its position in the production chain. Multinational firms have tended to embrace vertical FDI for high-skill and later stages of production, and arm's-length transactions for lower-skill inputs and processes. Although our data do not allow for a complete analysis of a firm's decision to undertake arm's-length transactions (via outsourcing) versus FDI, our

⁵ The D&B data has detailed ownership information. Each firm reports a local owner ("domestic ultimate") as well as a global parent ("global ultimate") that is the highest entity in the multinational network.

⁶ Non-manufacturing subsidiaries are primarily dealerships and credit and insurance institutions. Note that this information is as of 1999.

⁷ Skill intensity is measured as the ratio of non-production to production workers: 0.17 and 0.16 in rich and poor countries (defined as countries with GDP per capita of less than ten thousand US dollars), respectively.

⁸ Helpman (2006) and Barbara J. Spencer (2005) provide recent overviews of this emerging literature.

evidence, and that in the literature, suggests that early stages of production associated with raw/unskilled products are undertaken via trade (see Bernard, Jensen, and Schott 2006).

Different rationales might explain why firms choose to own these proximate stages of production in rich countries.⁹ Although data limitations impede a full explanation of why firms choose to own the proximate stages of production, we present evidence that the patterns of vertical FDI might relate to the positions of various inputs in the production process. We define a new variable that captures the proximity of two four-digit sectors in a vertical production chain using the proportion of the intermediate product used directly in the final good (i.e., raw materials have low proximity variables). We find that the proximity between two vertically related firms is, on average, significantly higher than proximity between two randomly selected firms. We also show that the position of intermediate inputs in the chain of production explains the pattern of intra-industry FDI, goods closer to raw materials being less likely to be the subject of FDI than intermediate goods proximate to the final good.

Firms' motivations to undertake multinational activity have long been recognized to be complex. This debate matters as the different motivations bear on how multinational activity affects factor incomes within and across countries. If FDI is sensitive to relative factor prices it could exert downward pressure on wages. That is, because vertical FDI operates as a complement to trade, multinational activity might reduce absolute wage differences across countries and alter relative wages within countries. On the other hand, as horizontal FDI substitutes for trade, multinational activity might raise income in each country without necessarily changing its distribution. Our findings suggest that intra-industry FDI could also have more subtle effects on income distribution, as it seems to be driven by proximity considerations.

The rest of the paper is organized as follows. Section I discusses the related theoretical and empirical research on patterns of FDI and trade. Section II describes the data. Section III presents the patterns. Section IV discusses our findings and their implications against the background of the existing literature. The last section concludes.

I. Related Literature

A firm becomes multinational when, through FDI, it establishes in two or more countries business enterprises over which it exercises some minimum level of ownership control. Although patterns of foreign investments have long been recognized to be complex, for analytical simplicity, multinational activity has usually been classified into horizontal and vertical FDI.

A firm engages in horizontal FDI when it replicates a subset of its activities or production process in another country, in other words, when the same (horizontal) state of the production process is duplicated. These multiplant firms often are motivated by the potential to save on transaction and trading costs, a substitute for exports. In the models developed by Markusen (1984), Brainard (1997), and Markusen and Anthony J. Venables (2000), for example, firms with headquarters in a home country produce final output in plants that serve consumers in each of two national markets. In contrast, firms engage in vertical FDI when production is by function, that is, when they break the value-added chain. The geographical fragmentation of the production process is often motivated by cost considerations arising from factor cost differences associated, for example, with the abundance of unskilled labor in (primarily) developing countries. Helpman's (1984) model of multinational firms that maintain their headquarters in one country

⁹ There might be, for example, information or monitoring advantages associated with ownership over arms-length transactions of high-skill/late stages of production activities. In addition, most trade is among rich countries, a fact that has been addressed via intra-industry theories of trade that consider imperfect competition and increasing returns (see Helpman and Krugman 1995).

and manufacture elsewhere predicts the size of multinational activity to be increasing in relative factor endowment differences.

Empirical investigations of patterns of FDI activity generally give strong support to the predictions of the horizontal model. The literature, as noted above, is replete with findings where models that assume low transport costs and comparative advantage (consistent with vertical activity) are rejected by the data in favor of models in which market access issues arise (consistent with horizontal investments). Brainard (1997), for example, finds little evidence that the pattern of factor abundance is related to FDI in a way that suggests that firms are exploiting comparative advantage. Instead, she finds that FDI is high in industry-country pairs in which transport costs are high and plant scale economies low (the market access motive). Carr, Markusen, and Maskus (2001) report similar findings. The consensus that the overwhelming proportion of FDI is horizontal is reflected in Markusen and Maskus (2002), who conclude that “horizontal investment is much more important in the world economy than vertical investment, or at least vertical investments motivated by factor-endowment differences.”

Recent evidence by Yeaple (2003) and Hanson, Mataloni, and Slaughter (2002, 2005), however, supports the view that MNCs’ location decisions are affected by comparative advantage considerations, that is, by the desire to shift production activities to countries in which factors are relatively cheap.¹⁰

The standard vertical explanation, at least in the models of Helpman (1984) and Helpman and Krugman (1985), predicts that multinational subsidiaries that supply their parents with intermediate goods will tend to locate in poorer countries to take advantage of low factor costs. Hence, intrafirm trade should be higher between rich and poor countries than between rich countries. This conclusion is inconsistent, however, with recent findings in the empirical trade literature, which documents large flows of intra-industry and intrafirm trade in intermediate inputs among rich countries. Bernard, Jensen, and Schott (2006) find that, in general, the share of intrafirm exports to the United States is low for low-income countries and above average for high-income countries (as seen also in Figure 4). In addition, the share of intrafirm imports tends to be low for raw materials, early stage products, and labor-intensive goods such as apparel and footwear, and high for capital- and technology-intensive products such as nuclear reactors, electrical machinery, and organic chemicals.¹¹ The implication of the intrafirm trade data is that there is a lot of vertical FDI between rich countries. In addition, the documented flow of inputs across countries for further processing and final assembly in rich countries provides more evidence of the importance of international vertical specialization.¹²

As noted by Helpman (2006), these trends are related to the growing fragmentation of production, where multinational corporations play a central role. The growing importance of trade in intermediate products, either through outsourcing or within the boundaries of the firm (though FDI), has led to the emergence of new theories that combine aspects of trade and international organization (such as property rights, transaction costs, incentive systems, and delegation of authority). Papers in the recent literature speak of the positive correlation between the charac-

¹⁰ Yeaple (2003) argues that the evidence against vertical FDI is a consequence of using data aggregated across industries to the country level, and shows FDI flows in skilled-labor-scarce host countries to be concentrated in low-skill industries, and in skilled-labor-abundant host countries to be concentrated in high-skill industries. Hanson, Mataloni, and Slaughter’s (2002) detailed information on US operations reveals an increasing fraction of FDI flows related to exports of intermediate inputs to foreign affiliates for further processing.

¹¹ Pol Antràs (2003) and Yeaple (2006) find positive relationships between intrafirm trade shares and industry capital intensity and R&D intensity, and no effect of human capital on intrafirm trade shares.

¹² José Manuel Campa and Linda S. Golberg (1997) document these trends for the United States, United Kingdom, and Canada; David Hummels, Jun Ishii, and Kei-Mu Yi (2001) do so for OECD countries. See also findings for US MNCs and Canadian affiliates in Susan E. Feinberg and Michael P. Keane (2006).

teristics of rich countries and vertical FDI activity.¹³ More generally, explanations of why rich country multinationals source inputs from other rich countries relate to the fact that most trade is among rich countries, a fact that has been addressed by the intra-industry theories of trade.

The foregoing discussion provides a simple road map for understanding the different strands of the literature related to our findings. Our empirical results address some of the puzzling findings in several of these strands, but we also find strong patterns that cannot be fully explained by product or country differences.

II. Multinational Activity: The WorldBase Database

We use data from WorldBase, a database of more than 43 million plant-level observations in more than 205 countries and territories compiled by D&B for 2005.¹⁴ The unit of observation in WorldBase is the establishment rather than the firm. Establishments, which we also refer to as plants, like firms, have their own addresses, business names, and managers, but might be partly or wholly owned by other firms. We are therefore able to observe new enterprises spawned from existing firms, or, by aggregating to the firm level, examine only independent new firms.

For each establishment, we use data that WorldBase records on:

- (i) Industry information, including the four-digit SIC code of the primary industry in which each establishment operates and, for most countries, the SIC codes of up to five secondary industries, listed in descending order of importance;¹⁵
- (ii) Ownership, including information about firms' family members (number of family members, domestic parent, and global parent), status (joint venture, corporation, partnership), and position in the hierarchy (branch, division, headquarters);
- (iii) Location information, including the country, state, city, and street address of each family member; and
- (iv) Operational information, including sales, employment, and year. Web Appendix A (available at <http://www.aeaweb.org/articles.php?doi=10.1257/aer.99.5.2096>), provides further information on the dataset.

We describe an establishment as foreign-owned if it satisfies two criteria: it reports to a global parent firm; and the parent firm is located in a different country. Parents are defined in the data as entities that have legal and financial responsibility for another firm. Combining the location

¹³ Antràs (2003), for example, develops a Helpman-Krugman model of trade with an incomplete-contracting, property-rights view of the boundaries of the firm to explain why, relative to trade, intrafirm trade is heavily concentrated in capital-intensive industries and flows mostly between capital-abundant countries.

¹⁴ The dataset is not publicly available, but was released to us by D&B. Early uses of the D&B data include Richard E. Caves's (1975) comparisons of size and diversification patterns of Canadian and US domestic firms, as well as subsidiaries of US multinationals in Canada, and Robert E. Lipsey's (1978) comparisons of the D&B data with existing public sources. More recently, Anne E. Harrison, Inessa Love, and Margaret S. McMillan (2004) used D&B's cross-country foreign ownership information. Other research uses include Sandra E. Black and Philip E. Strahan's (2002) study of entrepreneurial firm activity in the United States, and Daron Acemoglu, Simon Johnson, and Todd Mitton's (2009) cross-country study of concentration and vertical integration.

¹⁵ D&B uses the United States Government Department of Commerce, Office of Management and Budget, Standard Industrial Classification Manual 1987 edition to classify business establishments. In 1963, the firm introduced the Data Universal Numbering System—The D&B D-U-N-S® Number—used to identify businesses numerically for data-processing purposes. The system supports the linking of plants and firms across countries.

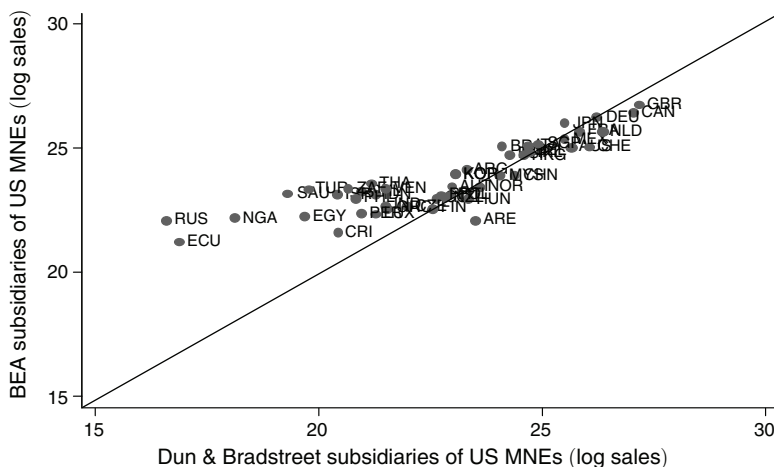


FIGURE 1A. COMPARISON OF US MULTINATIONALS – BEA VERSUS DUN & BRADSTREET SALES OF US MULTINATIONALS

and ownership information, it is possible to identify 625,427 affiliates in foreign countries that report to 72,978 parent firms.

To give some sense of the coverage of the D&B WorldBase, we compare our results to UNCTAD's data on multinational firms.¹⁶ UNCTAD's World Investment Report 2004 identifies 61,582 parent firms with 926,948 affiliates operating worldwide. Among the differences between our dataset and that of UNCTAD is that ours is at the plant level, and theirs is at the firm level. For the United States, the number of firms is thus similar, but our data show more plants, and the analysis we undertake requires plant-level data. Also, UNCTAD data are inflated by a huge number of Chinese observations (424,196), which represent all approved FDI projects registered by the Chinese, but overestimate the number of actual foreign firms.

We also compare the US-owned subsidiaries in the WorldBase data with information on US-owned firms maintained by the US BEA (see Figures 1A and 1B). The BEA *US Direct Investment Abroad: Benchmark Survey* is a legally mandated confidential survey conducted every five years, which covers virtually the entire population of US MNCs.¹⁷ Firm-level data are not readily available, but the BEA reports aggregate and industry-level information. The BEA reported in 2004 that sales (employment) by foreign affiliates of US MNCs totaled \$3,238 billion (10.02 million employees); according to the D&B data for 2005, the sum of all sales (employment) by foreign establishments reporting US parents was \$2,795 billion (10.07 million employees).¹⁸ Not only are the totals similar, but the distribution across countries is also consistent.

Figure 1A plots total sales (by country) of the foreign affiliates of US MNCs as reported in the BEA *Benchmark Survey 2004* against total sales (by country) of all firms in the D&B data that report a US-based parent.¹⁹ The correlation is striking, suggesting that the cross-country distribution of multinational activity in the D&B data matches that in the BEA benchmark survey.

¹⁶ These data are primarily from national sources.

¹⁷ Firm-level data, however, are not readily available to researchers. It can also be argued that the uniqueness of the US economy might imply different patterns from those observed in other countries.

¹⁸ See Mataloni and Daniel R. Yorgason (2006) or the tables at http://bea.gov/bea/di/usdop/all_affiliate_centry.xls.

¹⁹ http://bea.gov/bea/di/usdop/all_affiliate_centry.xls

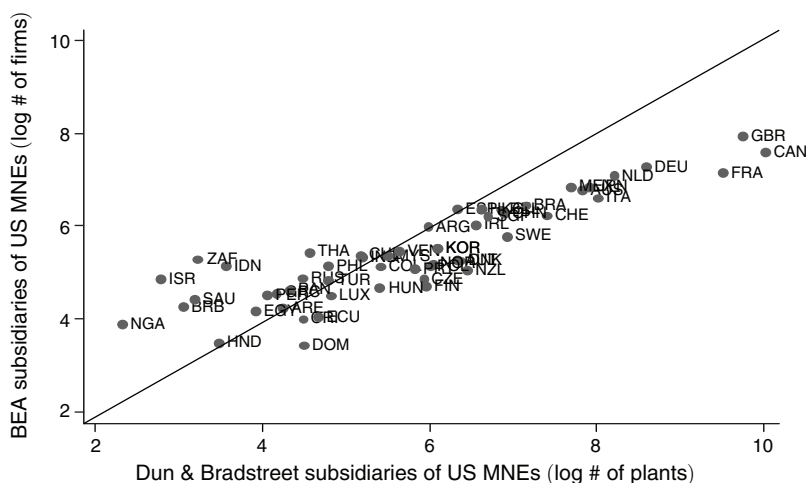


FIGURE 1B. COMPARISON OF US MULTATIONALS – BEA VERSUS DUN & BRADSTREET NUMBER OF US SUBSIDIARIES

These comparisons suggest that the D&B sample of multinational firms constitutes possibly the best estimate of the global population of multinational firms. Given the way the D&B data are collected, this is perhaps not surprising. D&B searches for firms using family networks. When their researchers enter one firm in the database, they also immediately look for all firms in its ownership hierarchy, increasing the likelihood that globally connected firms will enter the database.

III. Global Multinational Activity

Consistent with the literature, Figure 2 indicates that less than 2 percent of foreign subsidiaries are in agriculture (SIC00–10), almost 30 percent in manufacturing (SIC20–40), and the remainder in basic services (SIC 40–50), trade (SIC 50–60), finance (SIC 60–70), and business and professional services (SIC 70–80). Figure 3 indicates that the vast majority of our foreign-owned subsidiaries are in richer countries. There are 550,857 subsidiaries in rich countries and 53,089 in poor countries.²⁰

A. Vertical and Horizontal Foreign Activity: Measuring Vertical and Horizontal FDI

To study the patterns and determinants of FDI, the data would ideally be separated into horizontal and vertical activities. This distinction is difficult, however, as it is not always clear-cut (not all division of production can be neatly packaged as horizontal and vertical), and the exercise is, practically speaking, highly demanding of the data, requiring firm-level information on the sales and purchases of inputs by foreign subsidiaries. Sales need to be classified according to their destination (sales to local market, exports to home country, exports to other countries), and inputs according to whether they are used for further reprocessing or for resale in the local market. Such data are generally not directly available.²¹

²⁰ The bulk of FDI flows are among rich countries, nearly 85 percent in 2001 (UNCTAD).

²¹ As Giorgio Barba-Navaretti and Venables (2004) note, detailed firm-level data with which to analyze the activities of MNCs are not generally available, restricting firm-level studies to a few countries such as the United States. Note,

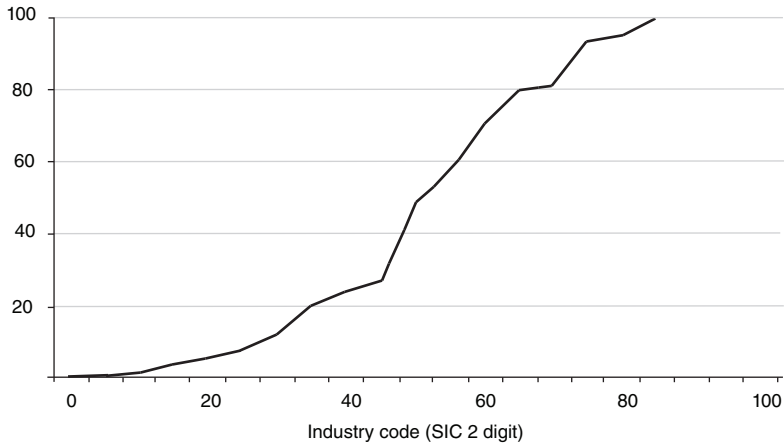


FIGURE 2. FOREIGN SUBSIDIARIES ACROSS INDUSTRIES

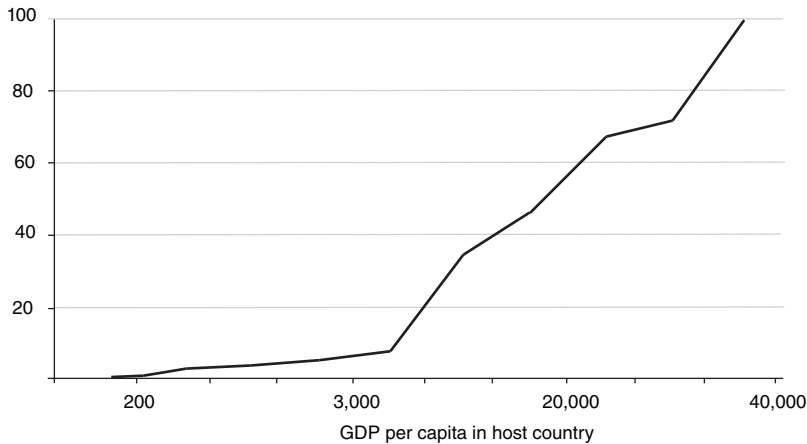


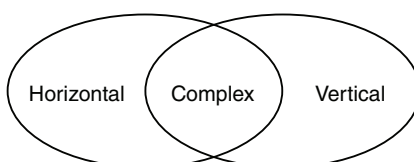
FIGURE 3. FOREIGN SUBSIDIARIES ACROSS COUNTRIES

Hummels, Ishii, and Yi (2001) describe a concept of vertical specialization that captures a country's role in the fragmentation of production into multiple stages in multiple locations. The authors use input-output tables to measure a country's vertical specialization as its exports weighted by the share of imported inputs in its total output. Hanson, Mataloni, and Slaughter (2002, 2005) analyze vertical production using firm-level data from the BEA, which records information about subsidiaries of US parent firms, including the volume of intermediate goods imported from their parents. Characterizing vertical production as intrafirm flows of inputs observed flowing from parents in the United States to subsidiaries in other countries enables the BEA to observe one-way US bilateral intrafirm trade.

however, that the BEA data do not track transactions between foreign affiliates of a given parent or production networks involving arms-length interfirm transactions. Thus, the data do not support observing the processing of trade between foreign affiliates or between US parents and foreign entities that they do not own.

We combine elements of both definitions and calculate bilateral horizontal and vertical FDI using firm ownership data and an input-output matrix. For the purposes of analyzing the D&B dataset, we define horizontal FDI as the activity of foreign-owned subsidiaries in the same industry as their parent, and vertical FDI as the activity of foreign-owned subsidiaries in industries upstream from the parent industry (according to the US input-output matrix). Foreign-owned subsidiaries are neither vertical nor horizontal if they satisfy neither of these criteria, and if they satisfy both we call them complex FDI.

As noted, each firm reports up to six SIC codes for itself and its parent.²² Let S be the set of SIC codes of the subsidiary and P be the set of SIC codes of the parent. We use notation $x \rightarrow z$ to denote any element x being an input to an element z where $x \in S$ and $z \in P$. We define $x \rightarrow z$ if the input-output coefficient from the US input-output matrix is greater than a threshold level, which we vary. We define an owned establishment as:



- (i) Horizontal if S and P share any element (if $\exists x | x \in S \vee x \in P$) or if the sets are identical (if $S = P$);
- (ii) Vertical if any element of S is an input to any element of P ($\exists x | x \rightarrow z$, where $x \in S$ and $z \in P$) and the sets are not identical (if $S \neq P$);
- (iii) Complex if they share any element (if $\exists x | x \in S \vee x \in P$) and any element of S is an input to any element of P ($\exists x | x \rightarrow z$, where $x \in S$ and $z \in P$) and the sets are not identical (if $S \neq P$);
- (iv) Neither if none of these connections exists.

Our approach for identifying vertical FDI suffers from the data limitation that we do not observe intrafirm trade. Instead, we infer it from information about the goods produced in each of the firm's establishments and the aggregate input-output relationship between those goods. The advantage of our method is that we have a large amount of data for many countries and industries and do not have to worry about the value of intrafirm trade being affected by transfer pricing. Hummels, Ishii, and Yi (2001) argue that another advantage of using I-O tables is that they avoid the arbitrariness of classification schemes that divide goods into "intermediate" and other categories. The disadvantage of our approach is that our identification of vertical subsidiaries as those that supply inputs to their parents relies on a number of assumptions. First, we use an input-output matrix to determine related industries. Given the difficulty of finding input and output matrices for all the countries in our data, we follow Acemoglu, Johnson, and Mitton (2009) and use US input and output matrices and industry codes to describe firms. The input-output data come from the BEA 1987 Benchmark I-O Tables, which contain the make table, use table, and direct and total requirements coefficients table. This information is provided using the

²² We also classified the data using only the primary SIC, and observed similar patterns. We prefer to report results using all of the information available to us.

BEA's six-digit industry codes. These were matched to the four-digit 1987 SIC codes assigned by D&B using BEA concordances.²³

The input-output matrix gives us a vector of coefficients with which we can determine which industries are connected via an input relationship. We select a threshold to determine the strength of the relationship required to assume that a subsidiary is a supplier to its parent. For the main results, we use a threshold of 0.05 for the "total requirements" coefficient (i.e., the use of a commodity directly and indirectly by an industry). We vary this between 0.01 and 0.1 and find that our results are robust. In addition, we use an alternative vector of input-output coefficients based on the "direct requirements" coefficient (i.e., the use of a commodity directly by an industry), which we use with a threshold of zero, and again find that our results are robust. Web Appendix B discusses the sensitivity of the results to our assumptions.

B. *Patterns of Vertical and Horizontal FDI*

Using these definitions, we can describe the most frequent manufacturing parent-subsidiary combinations.²⁴ Here and henceforth, we focus on manufacturing subsidiaries in order to compare our findings with those reported in the existing literature. Of the manufacturing subsidiaries in the data, 112,939 are vertical and 104,057 horizontal. The summary statistics for multinational activity presented in Tables 1A–1C show vertical activity to be much higher than presumed in the existing literature.

Web Appendix Table 1 shows that the most common horizontal pairs are Motor Vehicle Parts and Accessories (SIC 3714) and parent firms that own foreign subsidiaries that also produce Motor Vehicle Parts and Accessories.²⁵ Web Appendix Table 2 similarly reports the most common vertical industry pairs identified by our method, these being 122 Medicinal Chemicals and Botanical Products firms (SIC 2833) supplied by 475 of their foreign subsidiaries producing Pharmaceutical Preparations (subsidiary industry SIC 2834). The second most common pairs are 79 Speciality Cleaning, Polishing, and Sanitary Preparations firms (SIC 2834) supplied by 278 of their subsidiaries producing Soaps and Other Detergents, Except Speciality Cleaners (SIC 2833). Casual observation indicates that the subsidiary industries in Appendix Table 2 are, without exception, clearly suppliers of inputs to the industries with which our method pairs them. This gives us some initial confidence that our approach is capturing supply chain relationships.

In addition, we look at our firm-level results for several families of firms. For example, General Motors Corporation has 123 subsidiaries outside the United States in manufacturing industries.²⁶ Of these, 68 are "horizontal" subsidiaries according to our classification (i.e., in the same primary four-digit SIC code as the parent firm, GM SIC 3711 Motor Vehicles and Passenger Car Bodies), and using the US input-output matrix we classify another 42 as "vertical" FDI (i.e., in industries that are inputs to the parent industry). In descending order of frequency, the top five industries in which these vertical subsidiaries were identified were: Specialized Auto Parts (SIC 3714) (e.g., GM Strasbourg, which produces carburetors, pistons, rings, and valves in France); Vehicle Engines (SIC 3519) (e.g., Powertrain-Kaiserslautern in Germany); Electrical Equipment for Internal Combustion Engines (SIC 3694) (e.g., Hughes Network Systems in Germany);

²³ This concordance is available upon request. The BEA matches its six-digit industry codes to 1987 US SIC codes (<http://www.bea.gov/industry/exe/ndn0017.exe>).

²⁴ We exclude complex subsidiaries from the analysis that describes motives for FDI. We have also excluded "neither" subsidiaries from the analysis. There were 21,725 "neither" for a total 188,721 manufacturing subsidiaries. The overlap between categories is 50,000, that is, there are 50,000 "complex" subsidiaries.

²⁵ Appendix tables available at <http://www.aeaweb.org/articles.php?doi=10.1257/aer.99.5.2096>.

²⁶ The nonmanufacturing subsidiaries are primarily dealerships and credit and insurance institutions.

TABLE 1A—PATTERNS OF MULTINATIONAL ACTIVITY

	Four-digit	Three-digit	Two-digit	One-digit
Total	216,996	216,996	216,996	216,996
Horizontal	104,057	123,828	151,446	174,213
Vertical	112,939	93,168	65,550	42,783
Vertical inter	65,550	65,550	65,550	
Vertical intra	47,389	27,618		
<i>Percentage</i>				
Horizontal	48	57	70	80
Vertical	52	43	30	20
Vertical inter	30	30	30	
Vertical intra	22	13		

Note: Authors' calculation using D&B data.

TABLE 1B—SHARE OF VERTICAL AND HORIZONTAL FDI

	Firms percent	Sales percent	Employment percent
Horizontal	48%	54%	51%
Vertical	52%	46%	49%

Note: Authors' calculation using D&B data.

TABLE 1C—LOCATION OF VERTICAL FDI

	High-income countries	Low-income countries	Low-income countries (percent)
Firms	104,230	8,709	9%
Employees ('000)	14,062	1,738	11%

Note: Authors' calculation using D&B data.

Vehicular Lighting Equipment (SIC 3647) (e.g., General Motors Do Brasil LTDA); and Steel Springs, Except Wire (SIC 3493) (e.g., GM Canada).

C. Robustness and Comparisons of Results

An important concern with our method is that affiliates might be shipping their products not to their parents' country but to another plant in the same country or to a third country. In terms of third-country exports, there are reasons to include these "export platform" subsidiaries in a study of vertical FDI, inasmuch as they are to some degree motivated by the same comparative advantage considerations. But they are not strictly vertical FDI and our method would overestimate vertical activity if we did not exclude them. To account for within-country shipping, we performed the additional robustness exercise of eliminating any subsidiary that satisfies the foregoing definition of vertical FDI if the product produced by that subsidiary is an input to any product produced by another subsidiary of the same parent firm in the same host country. For example, if a GM subsidiary is producing specialized auto parts (SIC 3714) in Germany and there is also a GM assembly factory in Germany (SIC 3711), we exclude the parts maker from our vertical sample on the assumption that it might be providing inputs to the German assembler

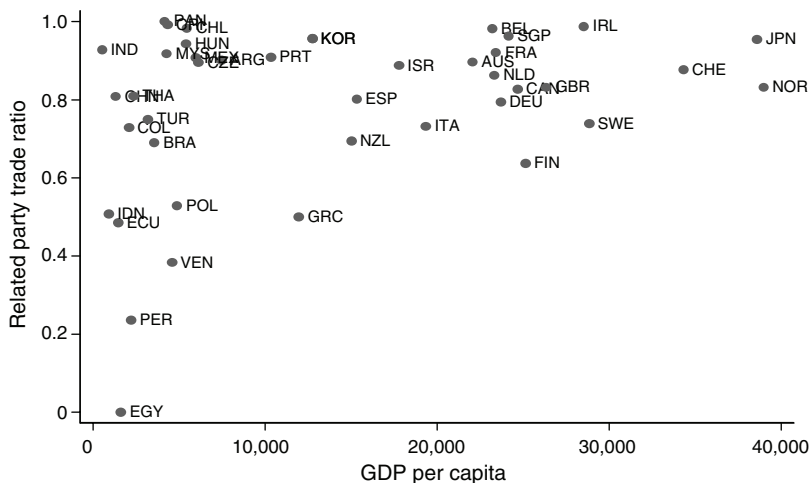


FIGURE 5. BEA DATA: SHARE OF INTRAFIRM US IMPORTS AND GDP PER CAPITA—US (2004)

this approach is identifying, with a reasonable degree of accuracy, multinational parents and the foreign-owned subsidiaries that supply them.

IV. Results

A. Patterns of Horizontal and Vertical FDI

In contrast to the previous literature, we find substantial vertical activity in rich countries. Our classification as vertical of a significant amount of FDI previously misclassified as horizontal accounts for the discrepancy between our results and those reported in the previous FDI literature. There are two reasons for this. First, as seen in Table 1C, a large number of our vertical FDIs are located in high-income countries, with just 9 percent located in poor countries. Because much vertical FDI is North-North, it has been assumed to be market-seeking (horizontal) when, in fact, firm-level data indicate that these are vertical relationships (i.e., parent firms sourcing inputs from their subsidiaries in other northern countries).

Second, the vertical nature of these relationships is missed at the two-digit level because, in the case of many subsidiaries supplying goods to their parents, both the input and final good are in the same two-digit SIC code.²⁸ Figure 6, which shows that at two digits much of the vertical FDI we observe appears to be horizontal, as it is in the same two-digit industry code as its parent, highlights the number of observations that can be lost when observing at smaller levels of aggregation (see also Table 1A). Figure 6 also indicates that about half the vertical FDI we observe is not visible at the two-digit level because only at finer levels of disaggregation is it clear that these subsidiaries are in sectors that produce inputs to their parents' products. Because at finer levels of disaggregation some of the FDI we label horizontal at the four-digit level might, in fact, be vertical, we think of our results as an upper bound on the number of horizontal subsidiaries. We argue that the distinction between vertical investments visible at the two- and four-digit level is

²⁸ In many cases, the vertical relationship is visible only at the four-digit level, that is, owned subsidiaries supplying intermediate inputs to their parents.

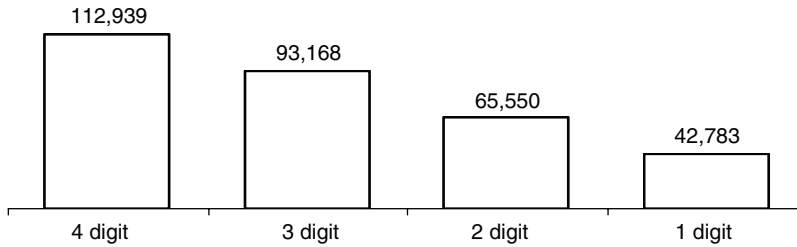


FIGURE 6. VERTICAL FDI OBSERVED WHEN AGGREGATING AT THE ONE-, TWO-, THREE-, OR FOUR-DIGIT STANDARD

more than one of labelling; there are in fact different products, one being an input to the other (as evidenced by Appendix Table 1).

We label vertical FDI that operates across two-digit industry codes as “interindustry vertical FDI,” and argue that its motivations, product characteristics, and location determinants are quite different from those of “intra-industry vertical FDI,” which is observable only across four-digit industry codes. To continue with our example from General Motors, the parent SIC code is 3711 (Motor Vehicles and Passenger Car Bodies). Whereas owned subsidiaries in Specialized Auto Parts (SIC 3714) are intra-industry vertical subsidiaries because they share the same three-digit SIC code, owned-subsiaries in 3011 Tires, or, further down the production chain, 3061 Molded, Extruded Rubber Goods, being in different two-digit industry codes, are classified as interindustry FDI.

The top panel of Figure 7 shows the parent-subsidiary industry combinations for both intra- and interindustry vertical FDI in the manufacturing sector (SIC 2000–3999). Taken as a whole, it is striking how much vertical FDI is characterized by parents and subsidiaries in quite similar industries as determined by their SIC codes. In the lower panels, we observe that intra-industry subsidiaries are, by construction, bunched close to, but not on, the 45-degree line, whereas interindustry FDI is more widely distributed.

Industry characteristics differ between interindustry and intra-industry FDI. Intra-industry vertical subsidiaries are predominantly in industries with lower absolute-skill levels, lower-skill levels relative to their parents’ industry, and greater variance in parent-subsidiary skill differences (see Figure 8 and Table 2). Host country characteristics of inter- and intra-industry vertical FDI also differ, interindustry subsidiaries, on average, being more likely to be found in poorer and smaller countries.

B. Intra-Industry Vertical FDI, Comparative Advantage, and Proximity

Following Brainard’s (1997), Yeaple’s (2003), and Carr, Markusen, and Maskus’s (2001) studies of the determinants of FDI, we assess the importance of comparative advantage considerations in the determination of vertical FDI patterns by running the following specification:

$$\begin{aligned}
 (1) \quad FDI_{ijs} = & \beta_2 SumMktSize_{ij} + \beta_3 Distance_{ij} + \beta_4 CountrySkill_i \\
 & + \beta_5 CountrySkill_i \times IndustrySkillInt_s \\
 & + \beta_5 IndustrySkillInt_s + \varepsilon_{ijs},
 \end{aligned}$$

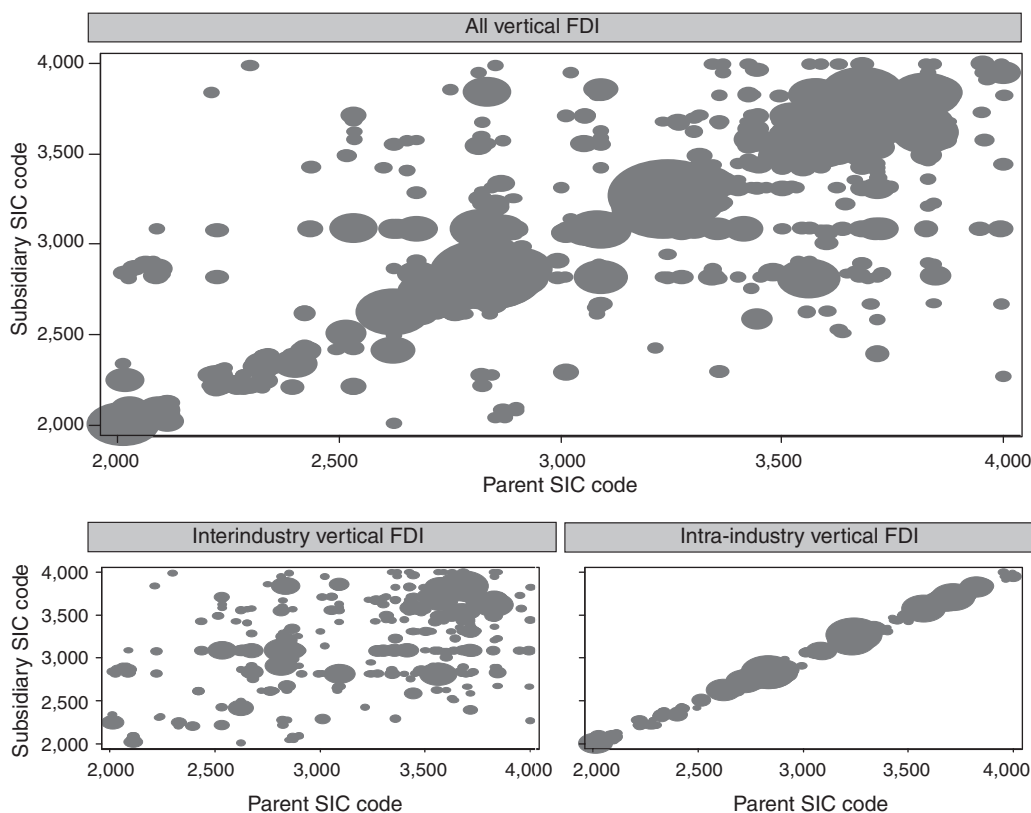


FIGURE 7. INTER- AND INTRA-INDUSTRY VERTICAL FDI
(Size of marker is proportional to number of subsidiaries, manufacturing SIC 2000–4000)

where subscript i and j index host and parent country and the subscript s the industry of the subsidiary. *FDI* is a measure of the bilateral multinational activity in an industry, for which we use the number of subsidiaries and total sales or total employment. Due to bilateral data limitations at four digits, we restrict the analysis to a few main variables. Freight and tariff data, for example, are not available for all the countries in our sample at the digit level we require.²⁹ We proxy trade costs using bilateral distance between home and host country, $Distance_{ij}$. Market size is the sum of the GDPs of the host and parent economies, $SumMktSize$. The comparative advantage motive enters into equation (1) via proxy variables for a host country's unit cost of production given by $\beta_5 CountrySkill_i + \beta_6 CountrySkill_i \times IndustrySkillInt_s + \beta_7 IndustrySkillInt_s$, where $CountrySkill_i$ proxies the human capital abundance of the host country, and $IndustrySkillInt_s$ is the skilled labor–intensity of sectors. Standard errors are heteroskedastic consistent and allow for clustering at the industry level. All variables are in logs except as noted. *Country-skill* is average years of schooling from the World Bank *World Development Indicators* (WDI); and *industry-skill* intensity is the ratio of nonproduction to total workers. Web Appendix A explains the data

²⁹ Given our sample of countries, it is difficult to find industry trade costs by bilateral pair (such as those cited in the literature using US data). Our objective is to present evidence of the facts we have uncovered, not to undertake a full-fledged analysis of the determinants of FDI.

TABLE 2—CHARACTERISTICS OF INTRA-AND INTERINDUSTRY VERTICAL FDI
(*Manufacturing only*)

	Inter-industry (1)	Intra-industry (2)
Average industry-skill intensity of subsidiary	0.28 [0.27–0.30]	0.37 [0.35–0.38]
Average difference between parent and subsidiary industry-skill intensity level	0.03 [0.025–0.036]	0.00 [–0.001–0.002]
Average GDP of subsidiary country (billion US dollars)	1,270 [1,191–1,280]	1,440 [1,430–1,445]
Average difference in GDP per capita of parent and subsidiary country (billion US dollars)	9,494 [7,493–11,724]	7,752 [6,258–9,736]

Notes: 95% confidence interval in brackets. Industry-skill intensity level is the ratio of non-production to total workers. See Appendix B for detailed definition of variables.

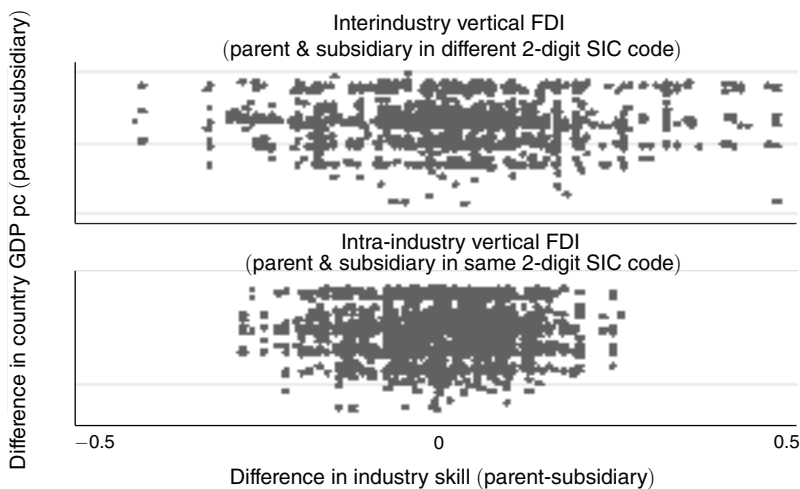


FIGURE 8. SKILL DIFFERENCE FOR VERTICAL FDI
(*Difference between parent and subsidiary industry skill*)

and sources in detail. We restrict analysis to the manufacturing sector in order to compare ours with the results reported in the literature.³⁰

We follow Yeaple (2003) in focusing on the interaction between the relative skilled-labor abundance of countries and skilled-labor intensity of industries to determine whether less-skilled products tend to be produced in low-skill countries. The market access motive should vary with country-industry pair characteristics as well as with country characteristics such as market size. Comparative advantage also varies across countries and industries, depending on the importance of factor price differentials given an industry's production technology.

³⁰ We follow this approach in order to compare our results with previous findings reported in the literature. These results should be interpreted with caution, as there are concerns regarding the use of reduced-form specifications.

TABLE 3A—DETERMINANTS OF MULTINATIONAL BILATERAL ACTIVITY
(Dependent variable: Multinational activity in each bilateral industry pair)

Dependent variable	Level of aggregation: Two digits			
	Number of firms (US parents only) (1)	Number of firms (2)	Sales (3)	Number of employees (4)
LogDistance _{ij}	-27.006 [2.527]***	-11.528 [1.602]***	-0.409 [0.054]***	-0.820 [0.164]***
LogSumofMarketSize _{ij}	296.998 [30.897]***	42.555 [2.252]***	1.520 [0.073]***	3.236 [0.223]***
CountrySkill _j	-13.611 [1.782]***	-7.383 [1.224]***	-0.059 [0.038]	-0.547 [0.117]***
CountrySkill × IndustrySkillInt _{js}	20.582 [1.567]***	16.710 [1.295]***	0.246 [0.037]***	0.597 [0.114]***
IndustrySkillInt _s	-320.695 [38.900]***	-36.906 [25.677]	-3.328 [0.860]***	-2.348 [2.616]
Observations	5,668	13,553	13,553	13,553

Notes: All regressions are estimated by Tobit. Robust standard errors clustered by industry are in brackets. The dependent variable is multinational activity defined as the number of firms with US parent in column 1; number of firms in 2; sales in 3; and number of employees in 4. Country skill is average years of schooling from World Bank WDI; industry-skill intensity is the ratio of nonproduction to total workers. See Web Appendix for detailed description of the data.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

Comparative Advantage.—Table 3A presents the main results following equation (1), where we use a Tobit regression to account for the bilateral country-industry observations where no FDI is observed. In column 1 we present results of the estimation of equation (1) using data observable at the two-digit level of aggregation (19 two-digit manufacturing industries) and information on the number of firms with a US parent only. This is the specification that best approximates Yeaple's (2003) studies.

Overall, the results are in line with the literature. The GDP variable is positive and significant. The variable bilateral distance, which proxies costs, is associated with less multinational activity (which is not consistent with the market access motive, but similar results are obtained in the literature; see Carr, Markusen, and Maskus 2001). In terms of the comparative advantage variables, the interaction terms of country-skill and industry-skill intensity are positive and significant; column 2 presents results for the entire sample of 94 countries using number of firms; columns 3 and 4 use sales and employment, respectively, as dependent variables. In all cases, the results are similar. The interaction term of country-skill abundance and industry-skill intensity is positive and significant. In terms of economic significance, estimates in column 2 imply that an increase in the distance between parent and subsidiary countries has a negative effect on the level of bilateral multinational activity; a movement from the twenty-fifth percentile (e.g., the United Kingdom and Norway) to the seventy-fifth percentile (e.g., the United Kingdom and Mexico) of the distribution of distances is associated with a reduction in the number of subsidiaries equivalent to 32 percent of the mean number of subsidiaries. An increase in the subsidiary country-skill level has a negative effect on the level of multinational activity; a movement from the twenty-fifth percentile (e.g., Slovenia) to the seventy-fifth percentile (e.g., Germany) of the distribution of skills is associated with a decrease of 80 percent in the number of subsidiaries below the mean. An increase in the difference between parent and subsidiary country-skill levels has a negative

TABLE 3B—DETERMINANTS OF MULTINATIONAL BILATERAL ACTIVITY
(Dependent variable: Multinational activity in each bilateral industry pair)

Dependent variable	Level of aggregation: Four digits								
	Number of firms (1)	Sales (2)	Number of employees (3)	Number of firms (4)	Number of firms (5)	Sales (6)	Sales (7)	Number of employees (8)	Number of employees (9)
LogDistance _{ij}	-1.900 [0.139]***	-7.175 [0.630]***	-2.152 [0.162]***	-1.909 [0.139]***	-1.908 [0.139]***	-7.193 [0.631]***	-7.174 [0.629]***	-2.158 [0.162]***	-2.150 [0.162]***
LogSumof MarketSize _{ij}	5.096 [0.187]***	18.222 [0.903]***	5.294 [0.235]***	5.099 [0.187]***	5.116 [0.188]***	18.221 [0.903]***	18.222 [0.901]***	5.291 [0.235]***	5.292 [0.234]***
CountrySkill _j	-0.303 [0.163]*	-0.676 [0.715]	0.005 [0.186]	-0.305 [0.163]*	-0.309 [0.160]*	-0.680 [0.718]	-0.697 [0.702]	0.007 [0.187]	-0.009 [0.183]
CountrySkill × IndustrySkillInt _{js}	0.302 [0.403]	0.812 [1.755]	0.117 [0.457]	0.305 [0.405]	0.315 [0.397]	0.818 [1.761]	0.856 [1.721]	0.108 [0.459]	0.140 [0.449]
IndustrySkillInt _s	10.079 [3.707]***	39.982 [16.293]**	11.916 [4.292]***	10.322 [3.726]***	9.323 [3.650]**	40.791 [16.363]**	37.082 [15.967]**	12.264 [4.311]***	11.052 [4.208]***
Proximity _{ps} (direct/total IO coefficient)				2.094 [0.559]***		6.660 [2.469]***		1.980 [0.631]***	
Closeness _{ps} (Abs. difference in 1987 4 digit SIC)					-0.009 [0.001]***		-0.033 [0.004]***		-0.009 [0.001]***
Observations	106,914	106,914	106,914	106,914	106,914	106,914	106,914	106,914	106,914

Notes: All regressions are estimated by Tobit. Robust standard errors clustered by industry are in brackets. The dependent variable is multinational activity defined as the number of firms in columns 1, 4, and 5; sales in 2, 6, and 7; and number of employees in 3, 8, and 9. Country skill is average years of schooling from World Bank WDI; industry-skill intensity is the ratio of nonproduction to total workers. The proximity coefficient is a ratio of the direct to the total inputs used by the firm. Closeness is the absolute difference in four-digit SIC between parent and subsidiary. See Web Appendix for detailed description of the data.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

effect on the level of bilateral multinational activity; a movement from the twenty-fifth percentile (e.g., the difference between the United Kingdom and Finland) to the seventy-fifth percentile (e.g., the difference between the United Kingdom and Brazil) of the distribution of bilateral-skill differences is associated with a decrease of 28 percent in the number of subsidiaries below the mean.

Columns 1–3 of Table 3 present results using the four-digit level of aggregation data to reveal intra-industry vertical FDI. That the GDP variable remains positive and significant is again explained by the fact that most FDI is in rich countries. But the interaction term is no longer significant. Is this vertical FDI attracted by factor differences, as recent work that finds evidence of vertical motivations seems to suggest? At the two-digit level (interindustry vertical FDI), we find results similar to Yeaple's (2003), that is, at two digits, there is an important component of FDI that is driven by comparative advantage. But the effect is much weaker at the four-digit level (where firms are sourcing intermediate inputs). When we replicate the analysis at the four-digit level, we find that the comparative advantage variables become insignificant. This is because four-digit FDI is more proximate (therefore higher skill and in richer countries). At four digits, we find that FDI that is misclassified is not being driven by comparative advantage considerations.

Proximity.—We introduce to the literature two new variables that measure the proximity of two products in a vertical production chain. The first, which we call “proximity,” is constructed for each pair of four-digit SIC codes using the US Input-Output matrix. For each pair of codes,

TABLE 4—PROXIMITY AND CLOSENESS: MEAN AND STANDARD DEVIATION

	All industry pairs	Parent-subsidiary industry pairs
Proximity (direct/total requirements coefficient)	0.062 [0.108]	0.584 [0.338]
Closeness (absolute difference in four-digit SIC)	695.9 [520.1]	54.1 [124.4]

Notes: Standard deviation in brackets. The proximity coefficient is a ratio of the direct to the total inputs used by the firm. Closeness is the absolute difference in four-digit SIC between parent and subsidiary. See Web Appendix B for detailed definition of variables.

we identify two input-output coefficients: the *Direct Requirements Coefficient* (i.e., the amount of the output of industry i used directly as an input to industry j); and the *Total Requirements Coefficient* (i.e., the total amount of output of industry i used either directly or indirectly in the production of industry j). Our measure of proximity is the ratio of the direct and total requirements coefficients. The more of the intermediate product used directly in the final good, the higher is the proximity variable (i.e., raw materials have low proximity variables). This variable might not effectively distinguish between two early stages of production if neither produces any direct inputs to the final good (i.e., the proximity of both will be zero). For this reason, we also create an alternative variable, “closeness,” which is simply the absolute difference between the four-digit SIC codes of the two products. For example, Motor Vehicles and Passenger Car Bodies (SIC 3711) has a closeness of 3 to Motor Vehicle Parts and Accessories (SIC 3714) and a closeness of 246 to Stamped Body Parts for Passenger Cars (SIC 3465). This closeness variable merely takes advantage of the fact that the 1987 SIC groups similar industries together.

We test whether the average proximity variable is higher for parent-subsidiary pairs. As seen in Table 4, the ratio across all industries is, on average, 0.06, and for the average parent-subsidiary pair, 0.58, indicating that parents are more likely to own their proximate inputs. We also find a positive correlation between the proximity variable and industry-skill level (0.25), suggesting, as expected, that raw materials are, on average, associated with lower-skilled levels. We also find the average proximity variable of subsidiaries to be higher in rich than in poor countries, suggesting, again as expected, that rich countries specialize in intermediate inputs relative to raw materials.

We repeat the previous exercise at the four-digit level, running an appended equation that includes our proximity variables:

$$\begin{aligned}
 (2) \quad FDI_{ijsk} = & \beta_2 SumMktSize_{ij} + \beta_3 Distance_{ij} + \beta_4 CountrySkill_i \\
 & + \beta_5 CountrySkill_i \times IndustrySkillInt_s + \beta_5 IndustrySkillInt_s \\
 & + \beta_6 Proximity_{sk} + \varepsilon_{ijsk},
 \end{aligned}$$

where subscript i and j index host and parent country, and the subscripts s and k the industry of the subsidiary and parent. We used as proximity variables both the ratio of *Direct Requirements/Total Requirements* and the absolute difference in the four-digit SIC code between the parent and the subsidiary (closeness).

Columns 4 to 9 of Table 3B present the main results. The proximity variables are highly positive and significant, and the market access and distance variables remain significant with the

expected sign. We thus find proximity to be a significant determinant of vertical FDI; multinational firms are more likely to own the stages of production closest to the final good they supply.³¹ In terms of economic significance, estimates in column 4 imply that an increase in the ratio of direct to total I-O coefficients between two industries has a positive effect on the level of vertical multinational activity observed between those industries; a movement from the twenty-fifth percentile to the seventy-fifth percentile of the distribution of ratios of I-O coefficients is associated with an increase in the number of vertical subsidiaries between those industries equivalent to 36 percent of the number of subsidiaries in the average industry pair. When measuring proximity as the difference between SIC codes, estimates in column 9 imply that the farther apart two SIC codes, the less vertical multinational activity is observed between them. For every two-digit SIC code farther apart a parent and subsidiary are, the number of subsidiaries in that bilateral-industry pair decreases by 17 percent below the mean.

C. Discussion

The distinction between intra- and interindustry vertical FDI resolves a puzzling contradiction between the FDI and recent trade literatures. The conclusion that, owing to comparative advantage motivations, most subsidiaries that provide inputs to their parents will be located in poorer countries is inconsistent with the documented high shares of intrafirm trade in rich countries. Analyzing FDI using data with industry information at the two-digit level will reveal only interindustry FDI, and will miss intra-industry vertical FDI. Consistent with the stylized facts above, firms that engage in interindustry FDI are more likely to be sourcing low-skill inputs from low-skill countries, validating the results of FDI studies at the two-digit level. Including intra-industry vertical FDI, which is predominantly between rich countries, enables us to account for the high share of intrafirm trade flows between rich countries observed in the trade data, as documented by Bernard, Jensen, and Schott (2006).

Although advancing a theoretical model explaining these facts is beyond the scope of this paper, our evidence suggests that models in which FDI comes about because firms seek to match their technology with low factor costs in poor countries are less able to explain overall patterns. Comparative advantage might, instead, be achieved through outsourcing.³² We argue the patterns of intra-industry North-North vertical FDI reflect firms' decision to outsource versus own the production of intermediate inputs. Overwhelmingly, multinationals source raw materials and inputs in early stages of production from outside the firm, but tend to own the stages of production proximate to their final production, giving rise to a class of high-skill, intra-industry vertical FDI.

Our evidence is consistent with contracting models such as Antràs (2003) that involve a correlation between rich countries and firm ownership. The evidence is also consistent with models that, building on intra-industry trade patterns, consider incentive system approaches and theories of boundaries of the firm involving quality control or delegation of authority. We believe these additional motivations to be of importance as we uncover proximity patterns in which firms control the penultimate stage of production.

³¹ As an additional robustness test, we controlled for the industry's capital intensity using data from the NBER Manufacturing Industry Productivity Database. The most recent data available to us are from 1996. The proximity variables, however, remained significant with the expected sign.

³² Antràs (2003) argues that Helpman's (1984) model might be the right model for understanding the recent trend of increasing fragmentation in the production process, but it is far less clear that predictions will show up in MNC activity and the intrafirm component of trade. Instead, a substantial part of the recent fragmentation of the production process has occurred at arm's length.

Several existing theories provide rationales for why firms choose to own these proximate stages of production. Because the production of a final good has more in common with the activities involved in producing proximate inputs than with the activities involved in the production of raw materials, there might be information advantages associated with co-ownership of the latter stages.³³ A multinational might find it difficult to protect its firm-specific assets and difficult or expensive to motivate independent local firms to act in its best interest. As proximate goods get closer to the final good, concerns, for example, about intellectual property might increase, as might costs associated with monitoring employees when firms expand their activities internationally (sources of information asymmetry are likely to multiply and agency problems worsen). Ownership of the penultimate stages of the production process also affords parent firms a monitoring advantage over arms-length transactions. Firms intent on maximizing quality control are also more likely to want to control stages of production that produce intermediate inputs than those that process raw materials that will be further transformed in later stages.³⁴ Quality control might be more important for some inputs and goods (especially proximate/high-skilled ones, and particularly in the final stages of production) and quality, like technology sharing, is better controlled within the boundaries of the owner firm. Because higher-quality and higher-tech inputs are more likely to be produced in rich countries, we expect more ownership in those countries.

The results are also in line with recent arguments that the quality of contracting institutions affects patterns of trade (comparative advantage). Nathan Nunn (2007) shows that countries with a poor contractual environment tend to specialize in (standardized) industries in which relationship-specific investments are not important.³⁵ Countries with better governance are also more likely to have FDI (Alfaro, Sebnem Kalemli-Ozcan, and Vadym Volosovych 2008). One can think of firms in weak institution countries engaging in mostly arm's-length trade, and firms in high institution countries that specialize in relationship-specific activities (sophisticated inputs) engaging in FDI. Again, this pattern curtails vertical FDI in rich countries.

V. Conclusion

The firm-level data in this paper afford a comprehensive view of the location, ownership, and activity of global multinational subsidiaries. Among the patterns that emerge from the data are that most FDI occurs between rich countries; and, contrary to the existing FDI literature, the share of vertical FDI is larger than commonly thought, even within developed countries.

We explain the discrepancy between our results and those reported in the previous literature by showing that a significant amount of vertical FDI was misclassified as horizontal FDI because (1) much of it is North-North FDI between parent and subsidiaries in similarly skilled activities; and (2) more than half of all vertical subsidiaries are observable only at the four-digit level because the inputs they are supplying are so proximate to the parent firms' final goods that they appear identical at the two-digit level. Because intra-industry vertical subsidiaries generally produce

³³ Bernard, Stephen J. Redding, and Schott (2006) model firm productivity as the combination of firm-level "ability" and firm-product-level "expertise." The authors find that liberalization pressures firms to focus on their "core competencies." See also Phillippe Aghion and Jean Tirole (1997).

³⁴ This argument assumes that low quality in later stages is more costly than low quality in earlier stages. More generally, the argument relates to the proximate process in the last stages of production. As noted, data on intrafirm trade is consistent with our findings.

³⁵ Antràs and Helpman (2008) generalize the model to accommodate varying degrees of contractual frictions. The paper shows how the relative prevalence of alternative organization forms depends not only on cross-country differences in contractibility, but also on the degree to which contractual institutions are biased toward inputs controlled by the final good producer or other suppliers. Gene M. Grossman and Helpman (2003, 2005) also emphasize the role of contract enforcement in the host country.

inputs similar in skill intensity to the parent-produced final goods, and because they overwhelmingly do so in high-skill countries, their production and location are not readily explained by the comparative advantage considerations of traditional models of vertical FDI. That multinationals tend to own the stages of production proximate to their final production gives rise to a class of high-skill, intra-industry vertical FDI.

Our results have several important implications. One is associated with the level of aggregation. Important elements of the pattern of foreign direct investment are missed at the two-digit level and not observable without industry data. This evidence suggests that conventional tests of MNC location theory using country- or industry-level data are problematic and, echoing results by Schott (2004) for trade, highlight the importance of shifting away from industry analysis toward more disaggregated data to understand firms' location decisions. Second, our analysis suggests that intrafirm trade and foreign investment activity might be better explained by complex production processes involving several stages and decisions about not only where to source inputs, but also whether to source them from inside or outside the firm.³⁶

Our evidence is consistent with organizational motivations (contractual, incentive system, or delegation of authority rationales) imbedded in intratrade models (increasing returns and specialization motives) that involve a correlation between rich countries' characteristics and ownership (e.g., high capital intensity, high technology, specialization in contractual-intensive goods). Exploring these possibilities further is an important topic for future research.

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³⁶ Equipment manufacturing, for example, involves production stage design, component production, and final assembly, which are physically separable. Production stages exhibit different factor intensities, design activities being more skill intensive and other activities more labor intensive (see Hanson, Mataloni, and Slaughter, 2002).

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