Intra-Industry Foreign Direct Investment

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We use a new firm-level data set that establishes the location, ownership, and activity of 650,000 multinational subsidiaries. Using a combination of four-digit level information and input-output tables, we find the share of vertical FDI (subsidiaries that provide inputs to their parent firms) to be larger than commonly thought, even within developed countries. Most subsidiaries are not readily explained by the comparative advantage considerations whereby multinationals locate activities abroad to take advantage of factor cost differences Instead, multinationals tend to own the stages of production proximate to their final production, giving rise to a class of high-skill, intra-industry vertical FDI.

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Key words: Multinational Activity, Foreign Direct Investment, Horizontal FDI, Vertical FDI, Stages of Production.

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In this paper, we use a unique firm-level data set 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 to represent firms' attempts to take advantage of cross-border factor cost differences (Elhanan Helpman, 1984; Elhanan 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 intra-firm trading status of multinational enterprises at the plant level.[1] Researchers have instead used multinational (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, James R. Markusen, and Keith E. Maskus, 2001, 2003; James R. Markusen and Keith E. Maskus, 2001, 2002; Bruce A. Blonigen, Ronald B. Davies, and Keith Head, 2003).

A new firm-level dataset provided by Dun & Bradstreet 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 inter-plant 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 plant in the same sector code as the foreign owner parent, 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 between the rich nations of the world. Additionally, at the two-digit industry level, we observe

[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, 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's confidential compilation of data on U.S. multinationals).

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 indicates 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 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-

[2] We build on other recent findings that challenge the conventional wisdom about the dominance of horizontal FDI (see Hanson, Mataloni, and Slaughter, 2001, 2005; and Yeaple, 2003). Our results are consistent with firm-level trade data for the United States that shows the proportion of intra-firm trade to be higher between rich countries than between rich and poor countries, further evidence of important multinational vertical activity between rich countries (see Bernard, Jensen, and Schott, 2006). This literature is discussed in the next section.

[3] The data set 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.

digit industry as their parents, but in a four-digit 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 U.S. 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 airbags 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 intra-firm 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, (1) whether to source an input from abroad, and (2) 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

[5] The Dun & Bradstreet 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 GPD per capita of less than ten thousand U.S. dollars), respectively.
[8] Helpman (2006) and Barbara J. Spencer (2005) provide recent overviews of this emerging literature.

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 arms-length transactions for lower-skill inputs and processes. Although our data does not allow for a complete analysis of a firm's decision to undertake arms-length transactions (via outsourcing) versus FDI, our evidence, and that in the literature, suggests that early stages of production associated with raw/unskilled products are undertaken via trade (see Andrew B. Bernard, J. Bradford Jensen, and Peter K. 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 have also 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.

[9] There might be, for example, information or monitoring advantages associated with ownership over arms-length transactions of high-skill/later 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).

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 multi-plant 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 James R. 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 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 Stephen R. Yeaple (2003) and Gordon H. Hanson, Raymond J. Mataloni, and Matthew J. Slaughter (2001, 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]

[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.

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, intra-firm trade should be higher between rich and poor countries than between rich countries. This conclusion, however, is inconsistent with recent findings in the empirical trade literature, which documents large flows of intra-industry and intra-firm trade in intermediate inputs between rich countries. Bernard, Jensen, and Schott (2006) find that, in general, the share of intra-firm 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 intra-firm imports tends to be low for raw materials, early stage products, and labor-intensive goods such as apparel and footwear, high for capital and technology intensive products such as nuclear reactors, electrical machinery, and organic chemicals.[11] The implication of the intra-firm 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 further evidence of the importance of international vertical specialization.[12]

As noted by Elhanan 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 characteristics 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 roadmap 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.

Hanson, Mataloni, and Slaughter's (2003) detailed information on U.S. operations reveals an increasing fraction of FDI flows to be related to exports of intermediate inputs to foreign affiliates for further processing.

[11] Antràs (2003) and Stephen R. Yeaple (2006) find positive relationships between intra-firm trade shares and industry capital intensity and R&D intensity, and no effect of human capital on intra-firm trade shares.

[12] José Manuel Campa and Linda S. Golberg (1997) document these trends for U.S., U.K. and Canada; Hummels, Ishii and Yi (2001) for OECD countries. See also findings for U.S. MNCs and Canadian affiliates in Susan E. Feinberg and Michael P. Keane (2006)

[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, intra-firm trade is heavily concentrated in capital-intensive industries and flows mostly between capital abundant countries.

II. Multinational Activity: The WorldBase Data Base

We use data from WorldBase, a database of more than 43 million plant-level observations in more than 205 countries and territories compiled by Dun & Bradstreet (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. Appendix A, available online, provides further information on the data set.

We describe an establishment as foreign-owned if it satisfies two criteria, (1) it reports to a global parent firm, and (2) 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 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 data set and the UNCTAD's data is that ours is at the plant level, theirs at the firm level. For the United States, the number of firms is thus similar, but our data shows more plants, and the analysis we undertake requires plant-level data. Also, UNCTAD data is inflated by a huge number of Chinese

[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' (1975) comparisons of size and diversification patterns of Canadian and U.S. domestic firms as well as subsidiaries of U.S. 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. McMillian (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 (2005) 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.

[16] This data is primarily from national sources.

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 U.S. owned subsidiaries in the WorldBase data with information on U.S. owned firms maintained by the U.S. Bureau of Economic Analysis (see Figures 1a and 1b). The BEA's *U.S. Direct Investment Abroad: Benchmark Survey* is a legally mandated confidential survey conducted every five years that covers virtually the entire population of U.S. MNCs.[18] Firm-level data is not readily available, but the BEA reports aggregate and industry-level information. The BEA reported in 2004 that sales (employment) by foreign affiliates of U.S. 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 U.S. parents was $2,795 billion (10.07 million employees).[19] 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 U.S. MNCs as reported in the BEA's Benchmark Survey 2004 against total sales (by country) of all firms in the D&B data that report a U.S.-based parent.[20] The correlation is striking, suggesting that the cross-country distribution of multinational activity in the D&B data matches that in the U.S. BEA's benchmark survey.

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 is 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.

Comparison U.S. Multinationals — BEA versus Dun and Bradstreet

Figure 1a: Sales of U.S. Multinationals

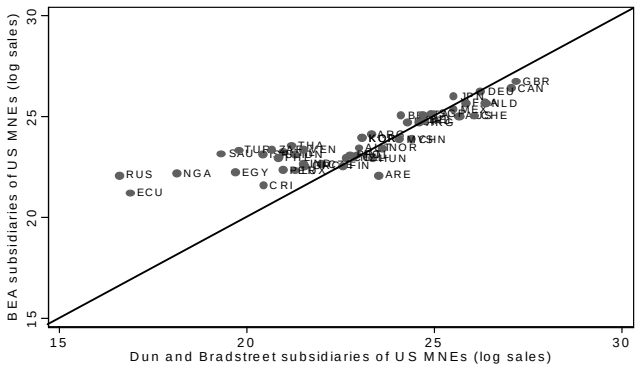
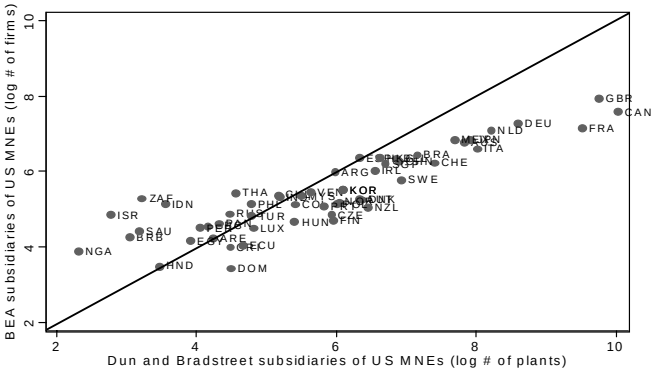


Figure 1b: Number of U.S. Subsidiaries



[18] Firm-level data, however, is not readily available to researchers. It can also be argued that the uniqueness of the U.S. economy might imply different patterns from those observed in other countries.

[19] See Raymond J. Mataloni and Daniel R. Yorgason (2006) or the tables http://bea.gov/bea/di/usdop/all_affiliate_cntry.xls.

[20] http://bea.gov/bea/di/usdop/all_affiliate_cntry.xls

III. Global Multinational Activity

Consistent with the literature, Figure 2 indicates that less than 2% of foreign subsidiaries are in agriculture (SIC00-10), almost 30% 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, 53,089 in poor countries.[21]

Figure 2: Foreign Subsidiaries Across Industries

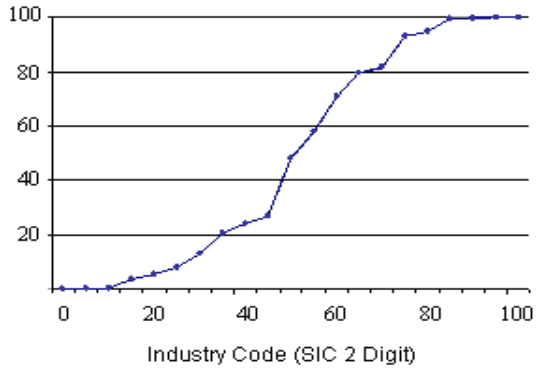
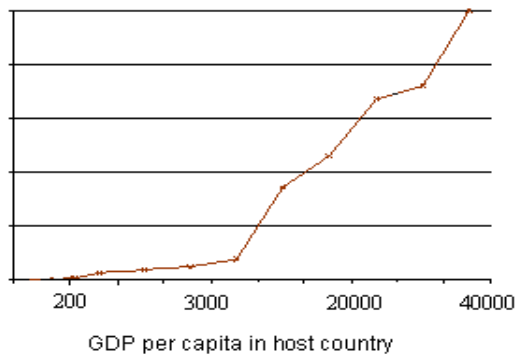


Figure 3: Foreign Subsidiaries Across Countries



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, however, is difficult 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), inputs according to whether they are used for further reprocessing or for resale in the local market. Such data are generally not directly available.[22]

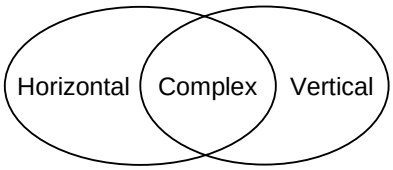
David Hummels, Jun Ishii, and Kie-Mu Yi (2001) describe a concept of vertical specialization that captures a country's role in the fragmentation of production into multiple stages involving value-added in multiple locations. The authors use input-output tables to measure a country's vertical specialization as its exports weighted by the share of imported inputs in its total output. Hanson, Mataloni, and Slaughter (2001, 2005) analyze vertical production using firm-level data from the U.S.

[21] The bulk of FDI flows are among rich countries (nearly 85% in 2001, UNCTAD).

[22] As Giorgio Barba-Navaretti and Anthony Venables (2004) note, detailed firm-level data with which to analyze the activities of MNCs is not generally available, restricting firm-level studies to a few countries such as the Unites States. Note, however, that the BEA data do not track transactions between foreign affiliates of a given parent or production networks involving arms-length inter-firm transactions. Thus, the data do not support observing the processing of trade between foreign affiliates or between U.S. parents and foreign entities that they do not own.

Bureau of Economic Analysis (BEA). The BEA records information about subsidiaries of U.S. parent firms including the volume of intermediate goods imported from their parents. Characterizing vertical production as intra-firm flows of inputs observed flowing from parents in the United States to subsidiaries in other countries enables the BEA to observe one-way U.S. bilateral intra-firm trade.

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, vertical FDI as the activity of foreign-owned subsidiaries in industries upstream from the parent industry (according to the U.S. 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.[23] 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 U.S. 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 $\exists x \mid x \in S \vee x \in P$) or if the sets are identical (if S=P).

ii. Vertical if any element of S is an input to any element of P ($\exists x \mid x \rightarrow z$, where $x \in S$ and $z \in P$) and the sets are not identical (if $S \neq P$).

i. Complex if they share any element (if $\exists x \mid x \in S \vee x \in P$) and any element of S is an input to any element of P ($\exists x \mid x \rightarrow z$, where $x \in S$ and $z \in P$) and the sets are not identical (if $S \neq P$).

ii. Neither if none of these connections exist.

Our approach for identifying vertical FDI suffers from the data limitation that we do not observe intra-firm 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 intra-firm 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

[23] 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.

industries. Given the difficulty of finding input and output matrices for all the countries in our data, we follow Daron Acemoglu, Simon Johnson, and Todd Mitton (2008) and use U.S. input and output matrices and industry codes to describe firms. The input-output data comes from the Bureau of Economic Analysis, 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 BEA's six-digit industry codes. These were matched to the four-digit 1987 SIC codes assigned by D&B using BEA concordances.[24]

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. Appendix B, available online, 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.[25] 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.

Appendix Table 1 shows that the most common horizontal pairs are Motor Vehicle Parts and Accessories (SIC 3714), parent firms that own foreign subsidiaries that also produce Motor Vehicle Parts and Accessories.[26] 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

[24] This concordance is available upon request. The BEA matches its six-digit industry codes to 1987 U.S. SIC codes http://www.bea.gov/industry/exe/ndn0017.exe.

[25] 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.

[26] Appendix Tables available online at AER website.

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.[27] 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 U.S. 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); 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

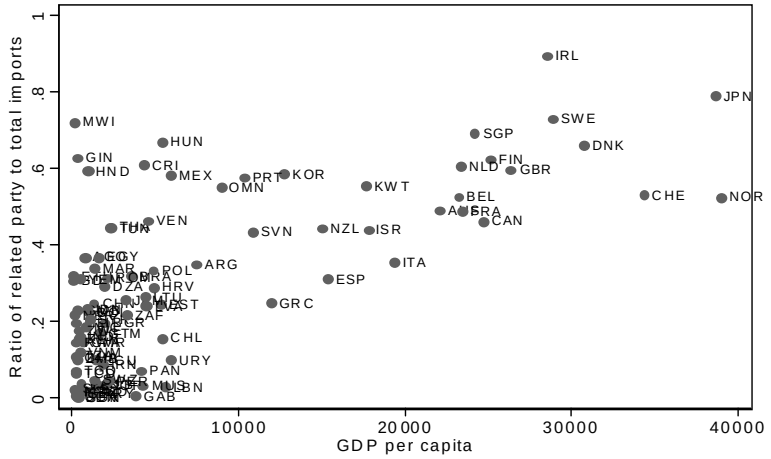
An important concern with our method is that affiliates might be shipping their products not to their parents' country but to another plant in the same country or to a third country. In terms of third country exports, there are reasons to include these "export platform" subsidiaries in a study of vertical 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 over-estimate 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 rather than shipping its output back to the United States. This exercise results in the elimination of 4,378 vertical subsidiaries, but does not materially change our results.

We use the U.S. Census Bureau Data as a cross-check on the D&B data. We compared the patterns of vertical and horizontal activity of U.S. affiliates in the latter against patterns of trade and

[27] The non-manufacturing subsidiaries are primarily dealerships and credit and insurance institutions

related-party trade from the U.S. Census Bureau.[28] Figure 4 supports our contention that there is a large share of vertical FDI between rich countries, and a positive relationship between the level of development of each country and the proportion of goods exported to the United States in the form of intra-firm (or related-party) trade. We find the correlation between the total value of U.S. imports from related entities reported by the U.S. Census Bureau and aggregated sales of all U.S. vertical affiliates in the D&B data to be 0.68, indicating that the two data sources are similar. To control for size effects, we also calculated the ratio of vertical and horizontal sales of U.S. parents in the D&B data versus the ratio of related-party imports to total imports in the U.S. data (correlation 0.71).

Figure 4: Ratio of Related-Party Trade to Total Imports—U.S. (2005)

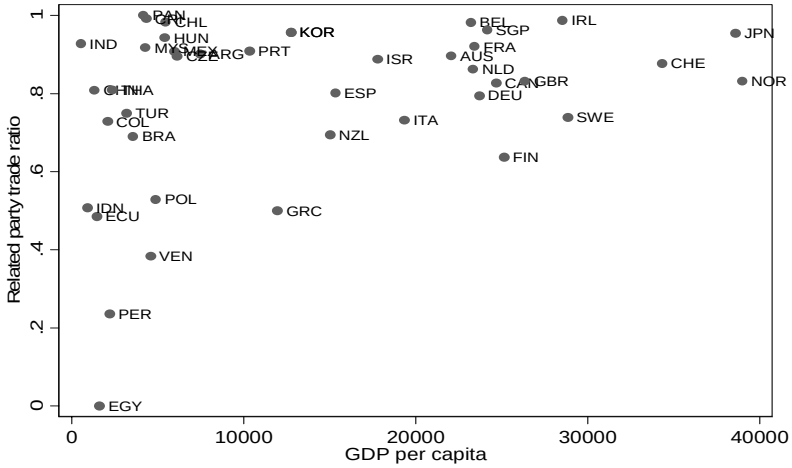


We also compared our results against data publicly available from the Bureau of Economic Analysis. Its 2004 Direct Investment Statistics, "Table III.I 1. U.S. Trade in Goods with Affiliates, by Country of Affiliate" presents information on the ratio of imports of goods shipped by foreign affiliates of U.S. firms to their parent firm in the United States to the total exports of those affiliates to the United States. As seen in Figure 5, 86% of what U.S. affiliates in richer countries ship back to the United States is for their U.S. parent company (and 14% is to other firms in the United States). Countries with below median GDP per capita had average ratios of 74%. Thus, U.S. affiliates in richer countries ship a larger fraction back to their parents.

An additional concern is that our results might be subject to measurement bias in the assigning of SIC codes. D&B is an official source of SIC codes, and careful analysis of the the firm- and industry-level results of our horizontal and vertical classifications, together with comparisons with other data sets, gives us considerable confidence that this approach is identifying, with a reasonable degree of accuracy, multinational parents and the foreign-owned subsidiaries that supply them.

[28] Related-party trade includes import transactions between parties with various types of relationships including "any person directly or indirectly, owning, controlling or holding power to vote, 6% of the outstanding voting stock or shares of any organization." See the Data Appendix for further details.

Figure 5: BEA data: Share of Intra-firm U.S. Imports and GDP per capita—U.S. (2004)



IV. Results

A. Patterns of Horizontal and Vertical FDI

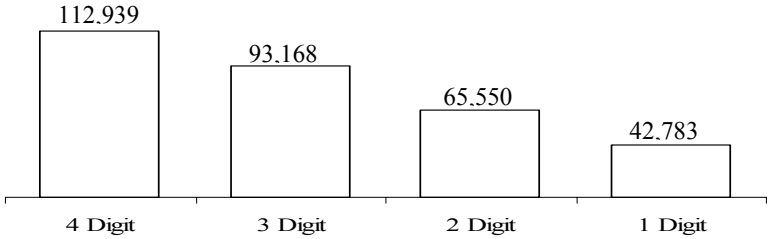
In contrast to the previous literature, we find substantial vertical activity in rich countries. Misclassification of a significant amount of vertical FDI as horizontal accounts for the discrepancy between our results and those reported in previous FDI literature. There are two reasons for this. First, as seen in Table 1c, a large number of our vertical FDIs are located in high-income countries and just 9% 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 indicates 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.[29] 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 more than one of labelling; they are in fact different products, one being an input to the other (as evidenced by Appendix Table 1).

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

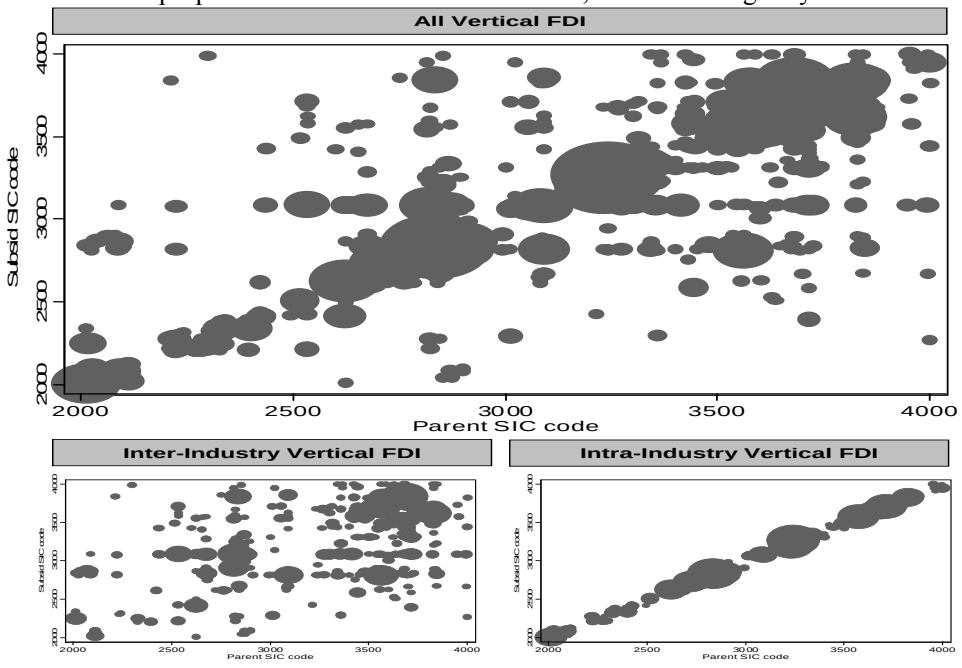
We label vertical FDI that operates across two-digit industry codes as "inter-industry vertical FDI," and argue that its motivations, product characteristics, and location determinants are quite different from those of "intra-industry vertical FDI," which is only observable across four-digit industry 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-subsidiaries in 3011 Tires, or, further down the production chain, 3061 Molded, Extruded Rubber Goods, being in different two-digit industry codes, are classified as inter-industry FDI.

Figure 6: Vertical FDI Observed when Aggregating at the 1-, 2-, 3- or 4-Digit Standard Industry Code



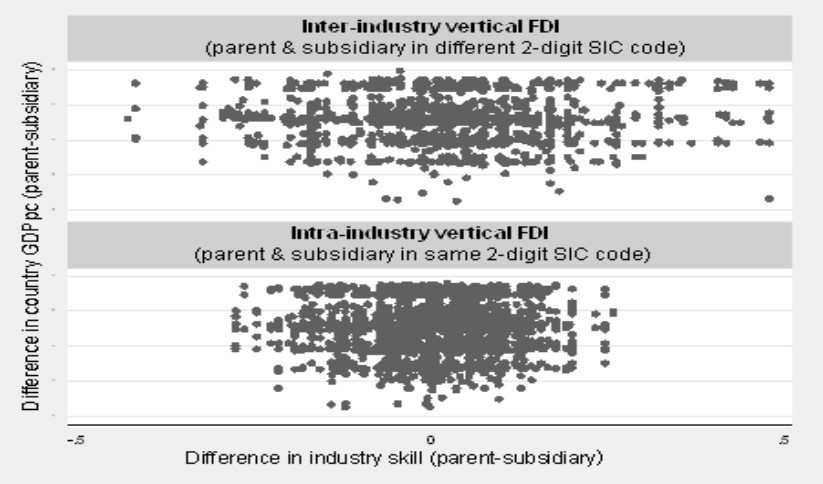
The top panel of Figure 7 shows the parent-subsidiary industry combinations for both intra- and inter-industry vertical FDI in the manufacturing sector (SIC 2000-3999). Taken as a whole, it is striking how much vertical FDI is characterized by parents and subsidiaries in quite similar industries as determined 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 inter-industry FDI is more widely distributed.

Figure 7: Inter- and Intra-Industry Vertical FDI
(size of marker is proportional to number of subsidiaries, manufacturing only SIC 2000-4000)



Industry characteristics differ between inter-industry and intra-industry FDI. Intra-industry vertical subsidiaries are predominatly 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, inter-industry subsidiaries, on average, being more likely to be found in poorer and smaller countries.

Figure 8: Skill Difference for Vertical FDI
(difference between parent and subsidiary industry-skill)



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:

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

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.[30] 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 $\beta_5 CountrySkill_i$

[30] Given our sample of countries, it is difficult to find industry trade costs by bilateral pair (such as those cited in the literature using U.S 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.

$+\beta_6 CountrySkill_i * IndustrySkillInt_s + \beta_7 IndustrySkillInt_s$, 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 World Bank, WDI; industry-skill intensity the ratio of non-production to total workers. Appendix A explains the data and sources in detail. We restrict analysis to the manufacturing sector in order to compare ours with the results reported in the literature.[31]

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 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.

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 U.S. 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 25th percentile (e.g., the United Kingdom and Norway) to the 75th 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% of the mean number of subsidiaries. An increase in the subsidiary country-skill level has a negative effect on the level of multinational

[31] 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.

activity; a movement from the 25th percentile (e.g., Slovenia) to the 75th percentile (e.g., Germany) of the distribution of skills is associated with a decrease of 80% in the number of subsidiaries below the mean. An increase in the difference between parent and subsidiary country-skill levels has a negative effect on the level of bilateral multinational activity; a movement from the 25th percentile (e.g., the difference between the United Kingdom and Finland) to the 75th 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% in the number of subsidiaries below the mean.

Table 3b, columns (1)-(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 (inter-industry 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 U.S. Input-Output matrix. For each pair of codes 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 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 from Motor Vehicle Parts and Accessories (SIC 3714) and a closeness of 246 from Stamped Body Parts for Passenger Cars (SIC 3465). This closeness variable merely takes advantage of the fact that the 1987 Standard Industrial Classification (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.

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

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).

Table 3b, columns (4) to (9) 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.[32] 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 25th percentile to the 75th 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% 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 further apart two SIC codes, the less vertical multinational activity is observed between them. For every two-digit SIC code further apart a parent and subsidiary are, the number of subsidiaries in that bilateral-industry pair decreases by 17% below the mean.

C. Discussion

The distinction between intra- and inter-industry 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

[32] 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 was 1996. The proximity variables, however, remained significant with the expected sign.

countries is inconsistent with the documented high shares of intra-firm trade in rich countries. Analyzing FDI using data with industry information at the two-digit level will reveal only inter-industry FDI and miss intra-industry vertical FDI. Consistent with the stylized facts above, firms that engage in inter-industry 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 intra-firm trade flows between rich countries observed in the trade data, as documented by Bernard, Jensen, and Schott (2006). Hence, 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.

Although advancing a theoretical model explaining these facts is beyond the scope of this paper, 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 then consistent with contracting models such as Pol 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.

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

[33] Andrew B. Bernard, Stephen J. Redding, and Peter K. 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).

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 (Laura Alfaro, Sebnem Kalemli-Ozcan, and Vadym Volosovych 2008). One can think of firms in weak institution countries engaging in mostly arms-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 affords 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 results 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 only observable 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 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.

[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 intra-firm trade is consistent with our findings.

[35] Pol Antràs and Elhanan 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 towards inputs controlled by the final good producer or other suppliers. Gene M. Grossman and Elhanan Helpman (2003, 2005) also emphasize the role of contract enforcement in the host country.

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 Peter K. Schott (2003) for trade, highlight the importance of shifting away from industry analysis towards more disaggregated data to understand firms' location decisions.

Second, our analysis suggests that intra-firm 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 suggests that comparative advantage (deriving from labor cost differences) might not be the main motivation to engage in FDI. Comparative advantage might instead be achieved through outsourcing.[37]

Our evidence is consistent with organizational motivations (contractual, incentive system or delegation of authority rationales) imbedded in intra-trade 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.

VI. References

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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, 2001).

[37] Antràs (2003) argues that Helpman's (1984) 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 intra-firm component of trade. Instead, a substantial part of the recent fragmentation of the production process has occurred at arm's length.

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Appendix A: Data and Sources for Regression Analysis

Firm-Level Data: We use data from WorldBase, a database of more than 43 million plant-level observations in more than 205 countries and territories compiled by Dun & Bradstreet (D&B) from the 2004/2005 file. WorldBase is the core database from which D&B populates its commercial data products including Who Owns Whom™, Risk Management Solutions™, Sales & Marketing Solutions™, and Supply Management Solutions™.[38] These products provide information about the "activities, decision makers, finances, operations and markets" of potential customers, competitors, and suppliers of D&B clients. Whereas other databases draw primarily from national firm registries, D&B compiles its data from a wide range of sources with a view to providing its clients with contact details and basic operating information about potential customers, competitors, and suppliers. Sources include partner firms in dozens of countries, telephone directory records, websites, and self-registering firms. All information is verified centrally via a variety of manual and automated checks. Information from local insolvency authorities and merger and acquisition records are used to track changes in ownership and operations.

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. We use four categories of data that WorldBase records for each establishment.

i. Detailed 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. 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.

ii. Detailed ownership information 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).

[38] D&B has been the leading U.S. source of commercial credit and marketing information since approximately 1845. Presently, it operates in 205 countries and territories, directly or through affiliates, agents, and associated business partners. For more information about the quality control process see: http://www.dnb.com/us/about/db_database/ dnbinfoquality.html.

iii. Detailed location information including the country, state, city, and street address of each family member.

iv. Basic operational information including sales, employment, year of establishment, and an indicator of import and export activity for each establishment (less coverage).

U.S. Trade Data: From Foreign Trade Division, U.S. Census Bureau, for 2005.

U.S. Related-Party Trade: Data includes import transactions between parties with various types of relationships including "any person directly or indirectly, owning, controlling or holding power to vote, 6 percent of the outstanding voting stock or shares of any organization," from Foreign Trade Division, U.S. Census Bureau, for 2005.

Market Size: GDP, from World Development Indicators.

Human Capital: High school enrollment years of schooling per worker, from World Bank.

Trade and Investment Costs: Bilateral distance.

Skill Intensity: Non-production workers (e.g., managers and engineers) as a proportion of total employment. The higher the proportion, the higher the skill level presumed to be embodied in the production processes and product offerings.

Proximity: For each pair of codes, we identify two different 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 direct/total requirements coefficients.

Closeness: Absolute difference between the four-digit SIC codes of two products.

Appendix B: Sensitivity of Results to the I-O Analysis

How sensitive are these results to the I-O analysis? We initially use a coefficient cutoff of 0.05 and vary this to test the robustness of our results to different coefficients. If we raise the cutoff coefficient to 0.075, we lose only one of the top 10 vertical pairs in Appendix Table 1. All of the others have coefficients greater than 0.075. The pair we lose is Orthopedic, Prosthetic, and Surgical Appliances and Supplies (SIC 3842) (parent firms) and Surgical and Medical Instruments and Apparatus (SIC 3841) (subsidiaries). The I-O coefficient is 0.063 and there are 201 such pairs. We are reluctant to cut this pair because it appears to be a bone-fide vertical relationship.

Altering the cutoff coefficient in this way, we lose only three pairs in the top 50 most frequent parent-subsidiary industry combinations, and each of those industry pairs seems to make sense as a vertical relationship: Railroad Equipment (parent), Switchgear and Switchboard Apparatus (subsidiary); Telephone and Telegraph Apparatus (parent), Radio and Television Broadcasting and Communications Equipment (subsidiary); Chocolate and Cocoa Products (parent), Candy and Other Confectionery Products (subsidiary).

Table 1a: Patterns of Multinational Activity

	4-digit	3-digit	2-digit	1-digit
Total	216996	216996	216996	216996
Horizontal	104057	123828	151446	174213
Vertical	112939	93168	65550	42783
Vertical Inter	65550	65550	65550	
Vertical Intra	47389	27618		
Percentage				
Horizontal	48%	57%	70%	80%
Vertical	52%	43%	30%	20%
Vertical Inter	30%	30%	30%	
Vertical Intra	22%	13%		

Notes: Authors calculation using D&B Data.

Table 1b: Share of Vertical and Horizontal FDI

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

Notes: Authors calculation using D&B Data.

Table 1c: Location of Vertical FDI

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

Notes: Authors calculation using D&B Data.

Table 2: Characteristics of Intra and Inter industry Vertical FDI (Manufacturing Only)

	Inter-industry (1)	Intra-industry (2)
Average Skill Level of Subsidiary Industry	0.28 [0.27-0.30]	0.37 [0.35-0.38]
Average Difference Between Parent and Subsidiary Skill	0.03 [0.025-0.036]	0.00 [-0.001-0.002]
Average GDP of Subsidiary Country (Billion U.S. Dollars)	1270 [1,191-1,280]	1440 [1,430-1,445]
Average difference in GDP per capita of Parent and (Billion U.S. Dollars)	9494 [7,493-11,724]	7752 [6,258-9,736]

Notes: 95% confidence interval in parenthesis. Country skill is high school enrollment from WB, WDI; industry Intensity is the ratio of non-production to total workers. See Appendix B for detailed definition of variables.

Table 3a: Determinants of Multinational Bilateral Activity
Dependent Variable: Multinational Activity in Each Bilateral Industry Pair

Dependent Variable	Level of Aggregation: 2 Digits			
	# Firms (US parents only)	# Firms	Sales	Empl.
	(1)	(2)	(3)	(4)
Log Distance$_{ij}$	-27.006	-11.528	-0.409	-0.820
	[2.527]***	[1.602]***	[0.054]***	[0.164]***
Log Sum of Market Size$_{ij}$	296.998	42.555	1.520	3.236
	[30.897]***	[2.252]***	[0.073]***	[0.223]***
Country Skill$_{j}$	-13.611	-7.383	-0.059	-0.547
	[1.782]***	[1.224]***	[0.038]	[0.117]***
Country Skill x Industry Skill$_{js}$	20.582	16.710	0.246	0.597
	[1.567]***	[1.295]***	[0.037]***	[0.114]***
Industry Skill$_{s}$	-320.695	-36.906	-3.328	-2.348
	[38.900]***	[25.677]	[0.860]***	[2.616]
# Observations	5668	13553	13553	13553

Notes: All regressions are estimated by Tobit. Robust standard errors clustered by industry are in parentheses denoting *** 1%, **5%, and *10% significance. The dependent variable is multinational activy defined as the number of firms with U.S. parent in (1); number of firms in (2); sales in (3); and number of employees in (4). Country skill is high school enrollment from WB, WDI; industry Intensity is the ratio of non-production to total workers. See Appendix for detailed description of the data.

Table 3b: Determinants of Multinational Bilateral Activity
Dependent Variable: Multinational Activity in Each Bilateral Industry Pair

	Level of Aggregation: 4 Digits								
Dependent Variable	# Firms	Sales	Empl.	# Firms	# Firms	Sales	Sales	Empl	Empl
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Log Distance$_{ij}$	-1.900	-7.175	-2.152	-1.909	-1.908	-7.193	-7.174	-2.158	-2.150
	[0.139]***	[0.630]***	[0.162]***	[0.139]***	[0.139]***	[0.631]***	[0.629]***	[0.162]***	[0.162]***
Log Sum of Market Size$_{ij}$	5.096	18.222	5.294	5.099	5.116	18.221	18.222	5.291	5.292
	[0.187]***	[0.903]***	[0.235]***	[0.187]***	[0.188]***	[0.903]***	[0.901]***	[0.235]***	[0.234]***
Country Skill$_{j}$	-0.303	-0.676	0.005	-0.305	-0.309	-0.680	-0.697	0.007	-0.009
	[0.163]*	[0.715]	[0.186]	[0.163]*	[0.160]*	[0.718]	[0.702]	[0.187]	[0.183]
Country Skill x Industry Skill$_{js}$	0.302	0.812	0.117	0.305	0.315	0.818	0.856	0.108	0.140
	[0.403]	[1.755]	[0.457]	[0.405]	[0.397]	[1.761]	[1.721]	[0.459]	[0.449]
Industry Skill$_{s}$	10.079	39.982	11.916	10.322	9.323	40.791	37.082	12.264	11.052
	[3.707]***	[16.293]**	[4.292]***	[3.726]***	[3.650]**	[16.363]**	[15.967]**	[4.311]***	[4.208]***
Proximity$_{ps}$				2.094		6.660		1.980	
(Direct/Total IO Coefficient)				[0.559]***		[2.469]***		[0.631]***	
Closeness$_{ps}$					-0.009		-0.033		-0.009
(Abs. Difference in 1987 4 digit SIC)					[0.001]***		[0.004]***		[0.001]***
# Observations	106914	106914	106914	106914	106914	106914	106914	106914	106914

Notes: All regressions are estimated by Tobit. Robust standard errors clustered by industry are in parentheses denoting *** 1%, **5%, and *10% significance. The dependent variable is multinational activy defined as the number of firms in (1), (4) and (5); sales in (2), (6) and (7); and number of employees in (3), (8) and (9). Country skill is high school enrollment from WB, WDI; industry Intensity is the ratio of non-production 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 4 digit SIC between parent and subsidiary. See Appendix for detailed description of the data.

Table 4: Proximity and Closeness: Mean and Standard Deviation.

	All Industry Pairs	Parent-Subsidiary Industry Pairs
Proximity	0.062	0.584
(Direct/total requirements coefficient)	[0.108]	[0.338]
Closeness	695.9	54.1
(Absolute difference in 4 digit SIC)	[520.1]	[124.4]

Notes. Standard Deviation in parenthesis. The proximity coefficient is a ratio of the direct to the total inputs used by the firm. Closeness is the absolute difference in 4 digit SIC between parent and subsidiary.See Appendix B for detailed definition of variables.

Appendix Table 1: Most Frequent Parent-Subsid Horizontal Industry Combinations in DNB Data

Parent industry	No. of Subsidiarys	SIC
Motor Vehicle Parts and Accessories	1080	3714
Pharmaceutical Preparations	1042	2834
Industrial Gases	1018	2813
Plastics Products, NEC	576	3089
Motor Vehicles and Passenger Car Bodies	541	3711
Computer Peripheral Equipment, NEC	394	3577
Perfumes, Cosmetics, and Other Toilet Preparations	386	2844
Periodicals: Publishing, or Publishing and Printing	349	2721
Paints, Varnishes, Lacquers, Enamels, and Allied Products	325	2851
Newspapers: Publishing, or Publishing and Printing	319	2711
Books: Publishing, or Publishing and Printing	279	2731
Printing Ink	278	2893
Plastics Material and Synthetic Resins, and Nonvulcanizable	260	2821
Surgical and Medical Instruments and Apparatus	245	3841
Elevators and Moving Stairways	237	3534
Flat Glass	220	3211
Petroleum Refining	220	2911
Pumps and Pumping Equipment	219	3561
Telephone and Telegraph Apparatus	213	3661
Air-Conditioning and Warm Air Heating Equipment and Commerci	209	3585
Semiconductors and Related Devices	209	3674
Electronic Components, NEC	204	3679
Tires and Inner Tubes	200	3011
Steel Works, Blast Furnaces (Including Coke Ovens), and Roll	198	3312
Plastics Products, NEC	195	3089
Industrial Inorganic Chemicals, NEC	190	2819
Electronic Computers	190	3571
Ophthalmic Goods	185	3851
Bottled and Canned Soft Drinks and Carbonated Waters	182	2086
Paper Mills	182	2621
General Industrial Machinery and Equipment, NEC	175	3569
Industrial Gases	168	2813
Chemicals and Chemical Preparations, NEC	165	2899
Radio and Television Broadcasting and Communications Equipme	160	3663
Motor Vehicles and Passenger Car Bodies	142	3711
Power, Distribution, and Specialty Transformers	142	3612

Appendix Table 2: Most Frequent Parent-Subsid Upstream Vertical Industry Combinations in DNB Data

Parent industry	Subsidiary industry	parent sic	subsid sic	No. of firms
Medicinal Chemicals and Botanical Products	Pharmaceutical Preparations	2833	2834	475
Speciality Cleaning, Polishing, and Sanitary Prep.	Soaps and Other Detergents, Except Speciality Cleaners	2842	2841	228
Orthopedic, Prosthetic, and Surgical App. and Supplies	Surgical and Medical Instruments and Apparatus	3842	3841	201
Biological Products, Except Diagnostic Substances	Pharmaceutical Preparations	2836	2834	201
Computer Storage Devices	Computer Peripheral Equipment, NEC	3572	3577	167
Computer Peripheral Equipment, NEC	Electronic Computers	3577	3571	165
Computer Terminals	Computer Peripheral Equipment, NEC	3575	3577	154
Pressed and Blown Glass and Glassware, NEC	Flat Glass	3229	3211	146
In Vitro and In Vivo Diagnostic Substances	Pharmaceutical Preparations	2835	2834	143
Motor Vehicles and Passenger Car Bodies	Motor Vehicle Parts and Accessories	3711	3714	134
Periodicals: Publishing, or Publishing and Printing	Books: Publishing, or Publishing and Printing	2721	2731	128
Industrial Instruments for Meas., Display, and Control	Measuring and Controlling Devices, NEC	3823	3829	128
Railroad Equipment	Switchgear and Switchboard Apparatus	3743	3613	122
Periodicals: Publishing, or Publishing and Printing	Books: Publishing, or Publishing and Printing	2721	2731	118
Paper Mills	Paperboard Mills	2621	2631	109
Commercial Printing, Lithographic	Commercial Printing, NEC	2752	2759	107
Industrial Organic Chemicals, NEC	Industrial Gases	2869	2813	103
Unsupported Plastics Film and Sheet	Plastics Products, NEC	3081	3089	102
Electronic Components, NEC	Electronic Connectors	3679	3678	101
Radio and Television Broadcasting and Com. Equip.	Communications Equipment, NEC	3663	3669	94
Printed Circuit Boards	Electronic Components, NEC	3672	3679	88
Paints, Varnishes, Lacquers, Enamels, and Allied Products	Plastics Material and Synthetic Resins, and Nonvulcaniza	2851	2821	87
Telephone and Telegraph Apparatus	Radio and Television Broadcasting and Com. Equip.	3661	3663	86
Plastics Foam Products	Plastics Products, NEC	3086	3089	84
Plastics Products, NEC	Plastics Material and Synthetic Resins, and Nonvulcaniza	3089	2821	78
Concrete Products, Except Block and Brick	Cement, Hydraulic	3272	3241	74
Flat Glass	Glass Products, Made of Purchased Glass	3211	3231	69
Meat Packing Plants	Sausages and Other Prepared Meats	2011	2013	68
Surgical and Medical Instruments and Apparatus	Orthopedic, Prosthetic, and Surgical App. and Supplies	3841	3842	66
Cyclic Organic Crudes and Int. and Organic Dyes	Industrial Inorganic Chemicals, NEC	2865	2819	65
Plastics Material and Synthetic Resins, and Nonvulcanizab	Industrial Inorganic Chemicals, NEC	2821	2819	65
Surface Active Agents, Finishing Agents, Sulfonated Oils	Industrial Organic Chemicals, NEC	2843	2869	64
Truck and Bus Bodies	Motor Vehicles and Passenger Car Bodies	3713	3711	61
Poultry Slaughtering and Processing	Prepared Feed and Feed Ingredients for Animals and Fow	2015	2048	58
Industrial Valves	Valves and Pipe Fittings, NEC	3491	3494	57
Radio and Television Broadcasting and Com. Equip.	Electronic Components, NEC	3663	3679	57
Aircraft	Aircraft Parts and Auxiliary Equipment, NEC	3721	3728	56