Intrafirm trade and vertical fragmentation in U.S. multinational corporations☆

Natalia Ramondo [a,b], Veronica Rappoport [c,d], Kim J. Ruhl [e,*]

[a] University of California at San Diego, United States
[b] NBER, United States
[c] London School of Economics, United Kingdom
[d] CEP and CEPR, United Kingdom
[e] New York University Stern School of Business, United States

A B S T R A C T

Using firm-level data, we document two new facts regarding intrafirm trade and the activities of the foreign affiliates of U.S. multinational corporations. First, intrafirm trade is concentrated among a small number of large affiliates within large multinational corporations; the median affiliate ships nothing to the rest of the corporation. Second, we find that the input–output coefficient linking the parent's and affiliate's industries of operation — a characteristic commonly associated with production fragmentation — is not related to a corresponding intrafirm flow of goods.

© 2015 Elsevier B.V. All rights reserved.

1. Introduction

Over the last 30 years, the global fragmentation of production grew dramatically, as did the trade in final and intermediate goods that it entails.[1] Multinational corporations (MNC) are at the center of this phenomenon, as they account for the vast majority of trade across countries. An extensive literature has developed that studies the international trade that takes place within the multinational corporation as a means to better understand the underlying patterns of production fragmentation.[2] We add to this literature by documenting two new sets of facts on the intra-corporation trade of U.S. multinational corporations.

First, we show that, although intra-MNC trade represents an important fraction of aggregate U.S. exports and imports, the median manufacturing foreign affiliate ships nothing to — and receives nothing from — its parent in the United States. Intra-MNC trade is concentrated in a small group of large affiliates and large corporations: The largest five percent of affiliates accounts for around half of the total trade to and from the parent, while the largest five percent of corporations accounts for almost two thirds of total intra-MNC trade. This skewness is also observed within the corporation: Intra-MNC trade tends to be concentrated in a small number of an MNC's largest foreign affiliates.

The lack of intra-MNC cross-border trade that we find for foreign affiliates of U.S. multinationals is more surprising than the similar finding in (Atalay et al., 2014) for intrafirm trade within the United States. Factor price differences — the theoretical motivation for vertical fragmentation and the intrafirm trade that accompanies it — are much larger across countries than across U.S. cities. In this regard, (Brainard, 1993) first documented the weak relationship between factor endowments and intra-MNC trade across borders.

The skewness of intra-MNC trade towards large affiliates and corporations in our first finding is reminiscent of the skewness in the distributions of other international activities. Manufacturing exports are concentrated in large firms (Bernard and Jensen, 1995), and even larger firms own foreign affiliates (Helpman et al., 2004). These patterns are consistent with theories of the firm that are based on economies of scale in production. In (Grossman et al., 2006), for example, the production of inputs for the entire multinational corporation is concentrated into a few large affiliates, which exploit the strong economies of scale

[1] See (Baldwin and Lopez-Gonzalez, 2013) for a recent survey.
[2] Working at the affiliate level, for example, (Borga and Zeile, 2004), (Hanson et al., 2005), (Feinberg and Keane, 2006), and (Bilir et al., 2013) analyze the country-and industry-level determinants of intra-MNC trade. (Carr et al., 2001), (Antras, 2003), (Yeaple, 2006), (Nunn and Trefler, 2008), (Bernard et al., 2009), and (Costinot et al., 2011) analyze intra-MNC trade using data aggregated to the country-industry level.

in production. Affiliates created to supply a foreign market — as an alternative to exporting, in order to avoid transportation costs — are relatively small. The model predicts that a small number of large affiliates ship goods within the corporation, while numerous smaller affiliates serve local markets. The concentration of intra-MNC trade in the largest firms is also consistent with the contract theory of the multinational firm proposed by (Antras and Helpman, 2004): In their framework with heterogeneous firms, only the largest firms choose to integrate offshore activities.

Our second set of facts relates intra-MNC trade to the upstream and downstream links between the industries of the parent and affiliate, as defined by the U.S. input–output table. As previously shown in (Alfaro and Charlton, 2009), we find that multinational corporations own affiliates in industries that are vertically linked to the parent's industry. The input–output coefficient between the affiliate's and the parent's industries of operation, however, is not related to the existence and the magnitude of the trade in goods between the two. These findings are similar to those in (Atalay et al., 2014), who study multi-establishment firms within the United States: The ownership of vertically linked affiliates is *not* related to the transfer of goods within the boundaries of the firm.

Our analysis is made possible by U.S. Bureau of Economic Analysis (BEA) data, in which each affiliate's sales are broken down by destination (the United States, the host country, or a third country) and by transaction type (the parent, another affiliate, or an unaffiliated party). The richness of the data allows us to identify production chains inside the boundaries of the MNC, but the data are unable to capture a vertical production chain once the intermediate goods leave the multinational corporation. We cannot capture, for example, MNC configurations that involve unrelated parties in some stages of production interacting with different affiliates of the same firm, possibly in different countries and industries. While the data have limitations, the BEA benchmark surveys offer the most complete description of multinational activity available, allowing us to characterize, in depth, several aspects of these global production chains.

The remainder of the paper is organized as follows. Sections 2 and 3 describe the data and broad patterns of intra-MNC trade, and Section 4 analyzes the relationship between input–output links and intra-MNC trade. Section 5 concludes.

2. Data

Our firm-level data are collected by the U.S. Bureau of Economic Analysis for the purpose of producing aggregate statistics on the operations of multinational companies.[3] These data cover the universe of U.S. parents and their foreign affiliates in the benchmark year 2004.

Our sample consists of the majority-owned foreign affiliates (MOFAs: affiliates with parents that own more than 50% of the affiliate's voting stock or equivalent), that have sales, assets, or net income (loss) of more than $25 million, and that operate — and are owned by a parent that operates — in a manufacturing industry. The 4,901 affiliates in our MOFA25 sample account for almost 80% of total reported affiliate sales, 90% of total reported affiliate sales to the parent, and almost 80% of total reported parent exports to affiliates.

Two features of the BEA data, only available for the MOFA25 sample of affiliates, make our analysis possible. The first is a classification of affiliate sales broken down by transaction type. In the data, an affiliate's sales can be directed to: (i) the parent; (ii) unaffiliated U.S. parties; (iii) local affiliates; (iv) local unaffiliated parties; (v) affiliated parties in neither the U.S. nor the host country (what we call *third countries*); and (vi) unaffiliated parties in third countries. These affiliates also

report shipments received from their parents.[4] The second feature of the data is a breakdown of parents' and affiliates' sales in each of their seven largest industries, as classified by the International Surveys Industry (ISI) classification, which is roughly equivalent to the 2002 North American Industry Classification System (NAICS). We focus our baseline analysis on the affiliate's and parent's primary industries of operation, which are typically the industries with the largest shares of total sales.[5] There are 77 four-digit manufacturing industries in the ISI classification. In our sample, affiliates are present in all 77 industries and parent firms are present in 74 industries.

Further details regarding the data and the sample construction are in online appendix A.

3. Patterns of intra-MNC trade

In our data, intra-MNC trade makes up the majority of affiliate exports: 70% of total affiliate sales made outside of the host country were directed to other affiliates within the corporation. This aggregate statistic, however, masks substantial heterogeneity across affiliates.

3.1. The skewness of intra-MNC trade

Panel 1 in Table 1 shows that while, on average, 27% of an affiliate's sales are to other parties within the corporation (column 1) and seven percent are to the parent (column 1), the median affiliate reports only nine percent of its sales to be intra-MNC and reports no trade with its parent (column 3).[6] The corollary is that the majority of affiliates sell their output to unaffiliated parties: The median affiliate's shipments to unaffiliated parties accounts for 91% of its sales and consists mainly of sales in its country of operation (column 3). These statistics point to a very skewed distribution of the share of intra-MNC trade across affiliates: As column 5 shows, a small group of affiliates in the 95th percentile are devoted exclusively to shipping within the corporation, and an even smaller group engages in trade only with their parents.

In panel 2, we report shipments of goods from the parent to the foreign affiliate, as a share of the affiliate's total cost of goods sold (cogs). The median affiliate receives nothing from its parent (column 3), while affiliates in the 95th percentile receive 38% of their inputs from their parents (column 5), indicating that only a handful of affiliates receive most of their inputs from their parents.[7]

In panel 3, rather than focusing on the affiliate as the unit of analysis, we aggregate the data to the corporation level to see — in an admittedly simple way — how intra-MNC trade varies across MNCs. For each MNC, we construct *MNC-wide sales* and *intra-MNC sales* by aggregating total sales and total shipments to related parties, respectively, of each foreign affiliate and the parent. The patterns found for individual affiliates in

---

[3] The other source of U.S. affiliated-party trade data is the U.S. Census Bureau's related-party trade database, which is based on transaction-level data at the country-industry level. (Ruhl, 2015) shows that the two datasets are broadly consistent at the aggregate level.

[4] Both shipments from and to the parent refer to all goods. The sub-sample of affiliates with sales, assets, or net income (loss) of more than $150 millions (MOFA150) has to report shipments from the parent broken down by goods for resale and goods for further processing or assembly. As Table A1 in the online appendix shows, goods for processing accounts for more than 85 percent of the total goods shipped to the affiliate by the parent. A similar break-down by type of good is not available for shipments from the affiliate to the parent.

[5] The median foreign affiliate operates in only one four-digit manufacturing industry, and the employment-weighted average share of its total sales accounted for by the primary industry is 0.92. The median parent operates in two industries, and the employment-weighted average share of its total sales accounted for by the primary industry is 0.74.

[6] Note that the median affiliate changes as we change the sorting variable. From now on, we refer to "the median affiliate" with the understanding that it is the median affiliate with respect to the variable being studied.

[7] The group of affiliates located in the North American motor vehicles sector is often held up as an example of the importance of intrafirm trade. Indeed, the median shares of intra-MNC sales for this group are the highest across all industry and country groups (30, 18, and 2% for trade to all affiliated parties, to the parent, and from the parent, respectively — not shown). Even so, more than 50% of affiliates in this group sell more than 95% of their output to unaffiliated parties, while almost 10% of them direct more than 95% of their sales to affiliated parties (not shown).

Table 1
Intra-MNC trade, summary.

	Mean	Std	p50	p75	p95	Emp > p50	Emp > p75	Emp > p95
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel 1: Share of affiliate sales								
To any unaffiliated parties	0.73	0.34	0.91	1.00	1.00	0.70	0.68	0.64
To local unaffiliated parties	0.57	0.39	0.66	0.97	1.00	0.55	0.54	0.51
To non-local unaffiliated	0.17	0.27	0.00	0.24	0.84	0.15	0.13	0.12
To any affiliated party	0.27	0.34	0.09	0.41	1.00	0.30	0.32	0.36
To parent	0.07	0.19	0.00	0.02	0.49	0.09	0.11	0.14
Panel 2: Share of affiliate cogs								
From parent	0.06	0.15	0.00	0.04	0.38	0.05	0.05	0.06
Panel 3: Share of total MNC sales								
To any unaffiliated party	0.89	0.13	0.93	0.98	1.00	0.89	0.88	0.86
To any affiliated party	0.10	0.11	0.06	0.15	0.31	0.11	0.12	0.16

Notes: Columns 3–5 report the average of the 11 firms around the indicated percentile. Columns 6–8 report the average values for the firms (or MNCs) with employment greater than the indicated percentile employment. In panel 3, statistics correspond to the aggregate at the corporate level, which includes the parent and its reporting foreign affiliates.

panel 1 are also present at the corporation level: For the median corporation, intra-MNC sales account for six percent of total sales (column 3).

Fig. 1 further describes the distribution of the share of intra-MNC trade in affiliate sales across affiliates. Fig. 1a shows the distribution of affiliates by their shares of sales to the parent and their shares of cogs received from their parents. Almost 80% of affiliates direct less than five percent of their sales to the parent — and receive a similar share of goods from it. Fig. 1b shows the distribution of intra-MNC trade shares: About 55% of affiliates — and almost 70% of MNCs — sell less than ten percent of their output to affiliated parties, while about 10% of affiliates are almost exclusively dedicated to supplying other parties in the corporation.

The skewness of intra-MNC trade towards a few affiliates and a few corporations is clearly shown in Fig. 2: Five percent of affiliates account for 88% of affiliate-to-parent trade, 82% of parent-to-affiliate trade, and 75% of affiliate trade to other affiliates. In the opposite tail of the distribution, 50% of affiliates ship nothing to — and receive nothing from — their parents, while almost 25% ship nothing to any related party. The concentration is markedly less dramatic when we look at the corporation level. The five percent of corporations with the largest intra-MNC trade flows account for 23% of total intra-MNC trade, while the bottom 50% account for 9% of total intra-MNC trade.

Tables B1 and B2 in online appendix B report statistics by sector and geographic region.

3.2. The role of firm size

We have documented that intra-MNC trade is concentrated in a small group of affiliates and corporations. Here, we explore the characteristics

of those firms. In particular, we focus on the relationship between affiliate and corporation size and the presence and magnitude of intra-MNC sales. Columns 6–8 in Table 1 report the average share of affiliate sales by destination for firms that are above the 50th, 75th, and 95th percentile of the employment size distribution. The average share of affiliate output sold within the corporation increases from 27% for the full sample to 36% for the firms above the 95th size percentile (columns 1 and 8 in panel 1). This largest five percent of affiliates accounts for 40% of all trade to affiliated parties and for about half of all shipments made to and from parents (not shown). A similar pattern, though with smaller quantitative differences, describes the importance of intra-MNC trade when aggregating to the MNC-wide level (columns 1 and 8 in panel 3). The largest five percent of corporations accounts for almost two thirds of total intra-MNC trade (not shown).

Next, we explore the relationship between firm size and intra-MNC trade more formally by analyzing the presence and magnitude of intra-MNC trade across affiliates and MNCs, while controlling for affiliate-industry and destination-country fixed effects, as well as MNC characteristics. We estimate, by Ordinary Least Squares (OLS),

$$D(X_{ij}) = \beta \log emp_a + Z_c + F_d + F_x + \varepsilon_{ij}, \tag{1}$$

$$\log(X_{ij}) = \gamma \log emp_a + Z_c + F_d + F_x + \varepsilon_{ij}. \tag{2}$$

In (1), the dependent variable, $D(X_{ij})$, equals one if the corresponding intra-MNC trade flow is positive and zero otherwise. The specification in (2) considers only those affiliates with positive intrafirm trade. We analyze four types of intra-MNC trade: (i) for $ij = ap$, shipments

(a) Affiliate-parent trade
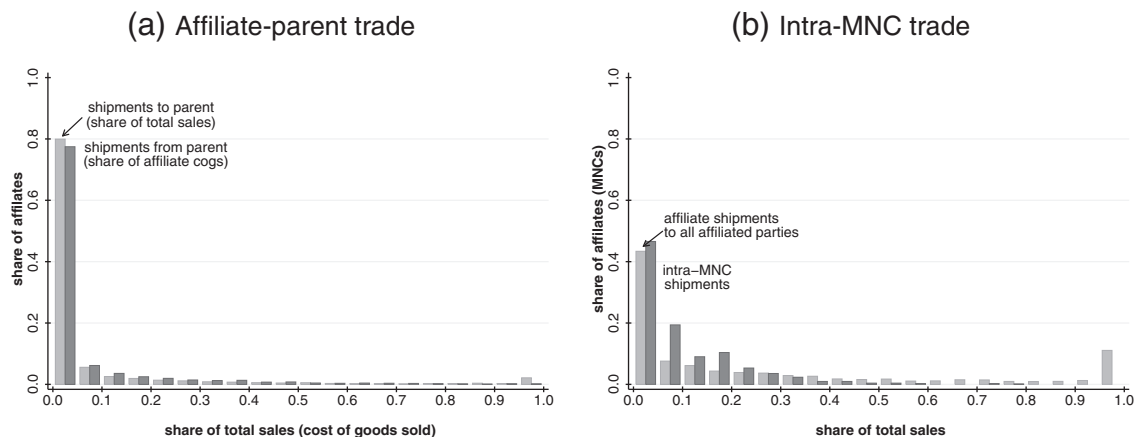

(b) Intra-MNC trade

Fig. 1. Distribution of affiliates and MNCs by share of sales to affiliated parties. Notes: In panel a, observations are at the affiliate level. In panel b, intra-MNC shipments are the sum over all of the foreign affiliates and the parent of the MNC, and shipments to all affiliated parties are total shipments from an affiliate to other parties in the MNC.

(a) Affiliate-parent trade

(b) Intra-MNC trade

Fig. 2. Distribution of intra-MNC trade across affiliates and MNCs. Notes: In panel a, observations are at the affiliate level. In panel b, intra-MNC shipments are the sum over all of the foreign affiliates and the parent of the MNC, and shipments to all affiliated parties are total shipm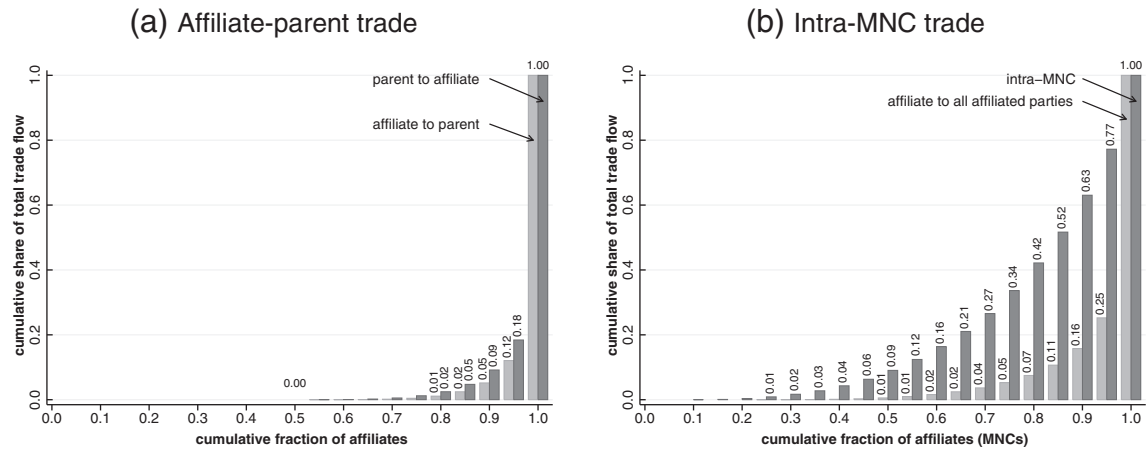ents from an affiliate to other parties in the MNC. In panel (a), the 55th percentile is the first non-zero entry for both parent-to-affiliate and affiliate-to-parent trade. In panel (b), the 25th (10th) percentile is the first non-zero entry for affiliate–affiliated-party (intra-MNC) trade.

from the affiliate to the parent as a share of the affiliate's total sales (X_{ap}); (ii) for $ij = ac$, shipments from the affiliate to any affiliated party as a share of the affiliate's total sales (X_{ac}); (iii) for $ij = pa$, shipments from the parent to the affiliate as a share of the affiliate's cogs (X_{pa}); and (iv) for $ij = cc$, intra-MNC trade as a share of the MNC's total sales (X_{cc}).

The key regressor in both specifications is affiliate size, as measured by employment (emp_a). The variable Z_c is a vector of MNC characteristics (size of the parent, log emp_p; size of the corporation, log emp_c; and the number of foreign affiliates in the corporation, log N_c). We also include affiliate industry and affiliate destination country fixed effects, F_x and F_d, respectively. In some specifications, we replace the vector Z_c with an MNC fixed effect.

Table 2 reports the results. Larger affiliates are substantially more likely to ship goods to — and from — the parent and to related parties (columns 1, 5, and 9). This result holds when we include corporation fixed effects: The largest affiliates in the corporation are more likely to trade within it (columns 2, 6, and 10). The intensive margin also increases with the affiliate's size when we consider flows from the affiliate to the parent: For larger affiliates, shipments to the parent represent a larger fraction of their sales. When shipments from the parent to the affiliate are considered (column 11), their share in the cost of goods sold by the affiliate decreases with the affiliate size and increases with the parent's size. Within the same MNC, smaller affiliates are also the ones for which goods shipped from the parent represent a larger share of the costs of goods sold (column 12). Finally, larger MNCs, in terms of number of foreign affiliates, have a higher likelihood (column 13) and higher share (column 14) of intra-MNC trade in total sales, and larger MNCs, in terms of employment, also have larger intra-MNC shares of sales. Even though larger corporations are typically headed by a larger parent firm, once we account for the size of the corporation, in terms of both the number of affiliates and aggregate employment, the size of the parent firm, in terms of employment, decreases the share of intra-MNC trade in total corporation sales.

4. Input–output links and intra-MNC trade

In the existing literature, country and industry characteristics have been used to explain the observed patterns of intra-MNC trade. Our focus, in contrast, is on variables that characterize the parent-affiliate pair and determine the potential for trade between the two, after controlling for country- and industry-level characteristics. Specifically, we are interested in what the input–output relationship between the parent's industry and the affiliate's industry can tell us about the presence and magnitude of intra-MNC trade.

We begin by characterizing the input–output relationship between the affiliate's and parent's industries using the direct requirements coefficients from the 2002 U.S. input–output (I–O) table, which reflects the observed inter-industry trade pattern in the United States.[8],[9] An observation in the I–O table is a commodity–industry pair, and the direct requirements coefficient, dr_{ij}, is the value of inputs from industry i needed to produce one dollar of output in industry j. We map the commodity and industry classification used in the I–O table into the NAICS-based ISI classification used by the BEA, yielding 77 manufacturing industries.

The classical theory on the boundaries of the firm would predict that our measure — by indicating the existence of an affiliate (parent) in an industry that produces goods used as inputs by the parent's (affiliate's) industry — should signal the existence of shipments of goods between the affiliate to the parent.[10] Here, having data on both the affiliate's and parent's industries and on intra-MNC trade, we can test whether the purpose of owning I–O linked affiliates is the transfer of goods within the firm. Our data allow us to observe only firm characteristics for trade between parents and affiliates, so we restrict our analysis to these transactions.

In Fig. 3a, we summarize the characteristics of the direct requirements table, and in Fig. 3b, we plot the distribution of industry pairs for the parent–affiliate pairs in our data. The x-axis in Fig. 3a is the ISI code of the using (downstream) industry, and the y-axis is the ISI code of the producing (upstream) industry. In Fig. 3a, the bubble's size is proportional to the size of the direct requirements coefficient of the industry pair. In Fig. 3b, the bubble's size is proportional to the number of parent–affiliate observations in that industry pair. It is clear from Fig. 3a that most industries require inputs from similar industries: The entries in the direct requirements table tend to be largest on or near the diagonal.

Combining Fig. 3a and b suggests that parents own affiliates in similar industries, and these industries are important producers of intermediate inputs for each other. In fact, more than 90% of the manufacturing affiliates operate in an industry with a positive direct requirement

---

[8] Papers that use the I–O table to construct a proxy for vertical production fragmentation between two firms in different countries are, among others, (Acemoglu et al., 2009), (Alfaro and Charlton, 2009), and (Fajgelbaum et al., 2015).

[9] While (Antras et al., 2012) construct a measure of "upstreamness" that characterizes an industry's position along the entire production chain, our goal is to characterize the amount of trade we would expect to see between two industries — a task for which the direct requirements coefficient is the relevant measure.

[10] This is the assumption underlying the findings in (Alfaro and Charlton, 2009), who use the presence of I–O links to infer vertical FDI (defined as "subsidiaries which provide inputs to their parent firms"), and (Fajgelbaum et al., 2015), who use these links to distinguish between vertical and horizontal affiliates.

Table 2
Intra-MNC trade and firm size.

	$D(X_{ap})$		$\log(X_{ap})$		$D(X_{ac})$		$\log(X_{ac})$		$D(X_{pa})$		$\log(X_{pa})$		$D(X_{cc})$	$\log(X_{cc})$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
$\log emp_a$	0.085***	0.090***	0.113*	0.222***	0.068***	0.073***	0.103***	0.150***	0.051***	0.053***	−0.261***	−0.168***		
	(0.007)	(0.007)	(0.062)	(0.078)	(0.007)	(0.007)	(0.037)	(0.043)	(0.008)	(0.008)	(0.045)	(0.058)		
$\log emp_p$	−0.017		−0.033		−0.026		−0.106		0.007		0.505***		−0.003	−0.919***
	(0.040)		(0.179)		(0.039)		(0.169)		(0.048)		(0.172)		(0.023)	(0.183)
$\log N_c$	0.011		−0.217*		0.064***		−0.091		0.007		−0.120		0.069***	0.726***
	(0.020)		(0.112)		(0.020)		(0.106)		(0.026)		(0.093)		(0.013)	(0.095)
$\log emp_c$	−0.027		0.088		−0.027		0.242		−0.068		−0.442*		−0.018	0.560**
	(0.051)		(0.234)		(0.051)		(0.214)		(0.060)		(0.215)		(0.027)	(0.223)
Aff industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Aff country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
MNC FE	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	No
Observations	4731	4738	2176	2177	4731	4738	3673	3674	4731	4738	2380	2381	728	668
R-squared	0.223	0.480	0.241	0.507	0.160	0.475	0.134	0.392	0.178	0.495	0.281	0.528	0.051	0.233

Notes: The variable X_{ap} is the share of affiliate a's total sales shipped to the parent; X_{ac} is the share of affiliate a's total sales shipped to all affiliated parties; X_{pa} is the share of shipments from the parent in affiliate a's input cost; and X_{cc} is the share of corporation c's total sales shipped within its boundaries. The operator $D(X)$ is equal to 1 if $X > 0$ and 0 otherwise. emp_a, emp_p, and emp_c are the employment in the affiliate, parent, and the aggregate employment of the multinational corporation, respectively. N_c is the number of foreign affiliates of the corporation. Robust standard errors, clustered by MNC, are in parentheses. Levels of significance are denoted ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$.

coefficient with the parent's industry — what we call an Input–Output (I–O) link.[11] We further explore this relationship by estimating (OLS).

$$D(N_{xzd}) = \beta_U dr_{xz} + \beta_D dr_{zx} + F_{xd} + \varepsilon_{xzd} \qquad (3)$$

$$\log(N_{xzd}) = \alpha_U \log dr_{xz} + \alpha_D \log dr_{zx} + F_{xd} + \varepsilon_{xzd}. \qquad (4)$$

Let x be the primary industry of the affiliate, z be the primary industry of the parent, and d be the affiliate host country. We aggregate the firm-level data so that the unit of observation is a triplet, xzd, that refers to the affiliate's primary industry, the parent's primary industry, and the affiliate's country of operation. N_{xzd} is the number of affiliates in the triplet, and $D(N_{xzd})$ is equal to one if we observe at least one affiliate in the triplet xzd and zero otherwise. F_{xd} are affiliate industry-destination country fixed effects. We report the estimates of (3) and (4) in columns 1 and 2 of Table 3. Consistent with (Alfaro and Charlton, 2009), the direct requirements coefficients are significant predictors of multinational investment. For example, a 10% increase in both the upstream and downstream average direct requirements coefficients implies a 90% increase in the probability of observing FDI activity in an xzd triplet. The impact of the direct requirements coefficients on the number of affiliates in xzd triplets with positive observations can also be observed in the *adjusted variable plots* in Fig. 4a and b. The affiliate industry-destination fixed effects explain most of the variation in the number of observations, but there is still a clear positive relationship between (the residuals of) the number of affiliates and the direct requirements coefficients between a parent's and its affiliate's primary industries.

Even though multinational corporations own affiliates that operate in industries with strong I–O links to their parents' industries, we are left with the question: Are input–output links associated with trade in goods between the parent and affiliate? We explore this question formally by estimating (OLS).

$$D(X_{ap}) = \beta dr_{xz} + F_d + F_x + \varepsilon_{xz}, \qquad (5)$$

$$\log(X_{ap}) = \alpha \log dr_{xz} + F_d + F_x + \varepsilon_{xz}. \qquad (6)$$

The variable X_{ap} is shipments from affiliate a to parent p, as a share of total affiliate sales, and $D(X_{ap})$ equals one if $X_{ap} > 0$ and zero otherwise. Note that the direct requirements coefficient has the affiliate's industry in the upstream position. F_d and F_x are affiliate-industry and destination-country fixed effects, and in some specifications, we also include MNC fixed effects. We estimate an analogous set of equations for shipments from the parent to the affiliate, as a share of the affiliate's cogs, X_{pa}, using the direct requirement coefficient with the affiliate's industry in the downstream position, dr_{zx}. Note that the linear probability model provides a check that transfer pricing is not driving our results. Any measure of intra-MNC trade may be contaminated by the non-market prices used to value within-firm transactions. The concern is that if transfer prices are biased downward, this could bias our estimates of the intensive margin towards zero. The linear probability model avoids this issue since it is unlikely that a firm with positive intra-MNC trade could report zero trade.

We report the estimates from (5) and (6) in columns 3–10 in Table 3. The coefficients on dr_{xz} and dr_{zx} are insignificant: The I–O link between the parent's and the affiliate's industries are not informative about the existence and the magnitude of shipments between the affiliate and the parent.

Fig. 4c and d report the adjusted variable plots for parent–affiliate trade and the corresponding direct requirements coefficient. Compared to the plots in Fig. 4a and b, the fixed effects explain less of the parent–

---

[11] The average direct requirements coefficient in the I–O table is 0.005, and 49% of the industry pairs have a direct requirements coefficient equal to zero. In the parent–affiliate data, however, the average direct requirements coefficient jumps to 0.072 when we consider the parent to be upstream, and 0.069 when we consider the affiliate to be upstream. The share of parent–affiliate industry pairs whose direct requirements coefficient is zero is less than ten percent.
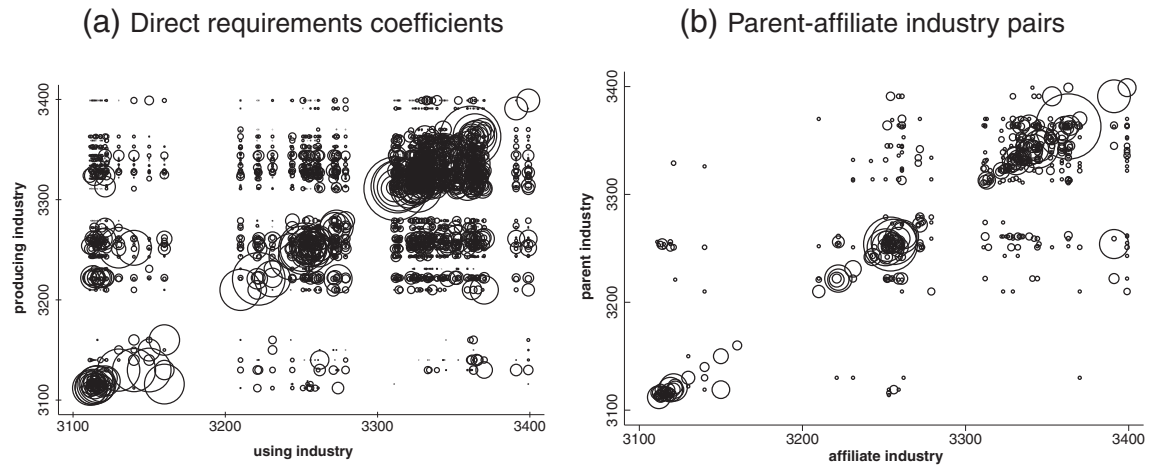
(a) Direct requirements coefficients

(b) Parent-affiliate industry pairs

Fig. 3. Direct requirements coefficients and parent–affiliate activity. Left panel: Direct requirements coefficients for industry pairs in 2002; bubbles are proportional to the size of the direct requirement coefficient. The direct requirement coefficient is the value of goods needed from the producing (upstream) industry in order to produce one dollar of output in the using (downstream) industry. Manufacturing industries only (ISI codes 3111–3399). Right panel: Frequency of the (primary) industries of parent–affiliate pairs; bubbles are proportional to the number of parent–affiliate pairs in a given industry pair.

Table 3
I–O links, FDI activity, and intra-MNC trade.

	$D\,(N_{xzd})$	$\log\,(N_{xzd})$	$D\,(X_{ap})$		$\log\,(X_{ap})$		$D\,(X_{pa})$		$\log\,(X_{pa})$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
dr_{xz}	0.338***		0.008	−0.135						
	(0.015)		(0.215)	(0.227)						
dr_{zx}	0.296***						0.313	−0.170		
	(0.015)						(0.197)	(0.212)		
$\log\,(dr_{xz})$		0.093***			0.004	−0.059				
		(0.023)			(0.042)	(0.075)				
$\log\,(dr_{zx})$		0.136***							0.039	−0.019
		(0.030)							(0.030)	(0.059)
Aff ind-ctry FE	Yes	Yes	No	No	No	No	No	No	No	No
Aff industry FE	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Aff country FE	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
MNC FE	No	No	No	Yes	No	Yes	No	Yes	No	Yes
Observations	616,616	1922	4901	4901	2072	2072	4901	4901	2201	2201
R-squared	0.055	0.716	0.177	0.442	0.238	0.506	0.153	0.480	0.253	0.528

Notes: The operator $D\,(X)$ is equal to 1 if $X > 0$ and 0 otherwise. N_{xzc} refers to the number of affiliates operating in industry x in country d owned by parents in industry z. X_{ap} is the share of affiliate $a\,'\,s$ total sales shipped to the parent p. X_{pa} is the share of affiliate $a\,'\,s$ total input costs shipped from the parent p. dr_{xz} is the direct requirement coefficient from the affiliate's primary industry into the production of the parent's primary industry. dr_{zx} is the direct requirements coefficient from the parent's industry into the production of the affiliate's industry. Our sample contains 104 host countries and 77×77 possible industry pairs, for a total of 616,616 possible combinations, of which only 2523 display any multinational activity, measured as the existence of at least one affiliate. For columns 3–10, robust standard errors, clustered by MNC, are in parentheses. In columns 1–2, standard errors are clustered by affiliate industry-country. Levels of significance are denoted ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$.

affiliate trade variation, and there is no relationship between the magnitude of the trade flow between the affiliate and the parent and the corresponding I–O link between the two firms' industries of operation.

To summarize, we find that multinational corporations tend to own affiliates that operate in industries downstream or upstream of the parent firm's industry; however, I–O links between parents' and affiliates' industries do not predict the existence and magnitude of trade between the two. These results lead to the obvious question: Why do multinationals own affiliates in industries downstream or upstream of those of the parent, if not for the shipment of goods along the vertical production chain? (Atalay et al., 2014), who find similar results when studying the flow of goods between related establishments in the United States, suggest that the firm's boundaries are determined by the transfer of capabilities and not by the transfer of goods. Strong input–output links between two industries may signal the use of a common set of intangible inputs, knowledge, and expertise; this may be the case internationally, as well. Sharing these intangibles can be an advantage in the production of I–O linked goods, even in the absence of physical shipments between affiliates. In the international trade and multinational firm literature, this commonly required knowledge has been formalized as the capacity to solve related problems,

as in (Garicano and Rossi-Hansberg, 2006); the stock of technology capital — specific to goods of similar characteristics — as in (McGrattan and Prescott, 2010); managerial ability, as in (Bloom and Van Reenen, 2007); core capabilities, as in (Bernard et al., 2011); and the stock of knowledge capital that is a public good within the corporation, as in the seminal work of (Markusen, 1984). If this is the case, the multinational corporation may have comparative advantages in producing goods that are linked by I–O relationships without any trade in goods within its boundaries.

4.1. Robustness

We now present two robustness tests of our results in Table 3 — that I–O links between a parent's and an affiliate's industries do not predict the existence and the importance of trade between the two.[12]

---

[12] We have also checked the robustness of our results to the coarseness of the industry classification, a discrete classification of I–O links as in (Alfaro and Charlton, 2009), and the sub-sample of large majority-owned affiliates with sales, assets, or net income (loss) of more than $150 million (available upon request). The lack of a positive, significant relationship between I–O links and shipments between the parent and the affiliate survives.
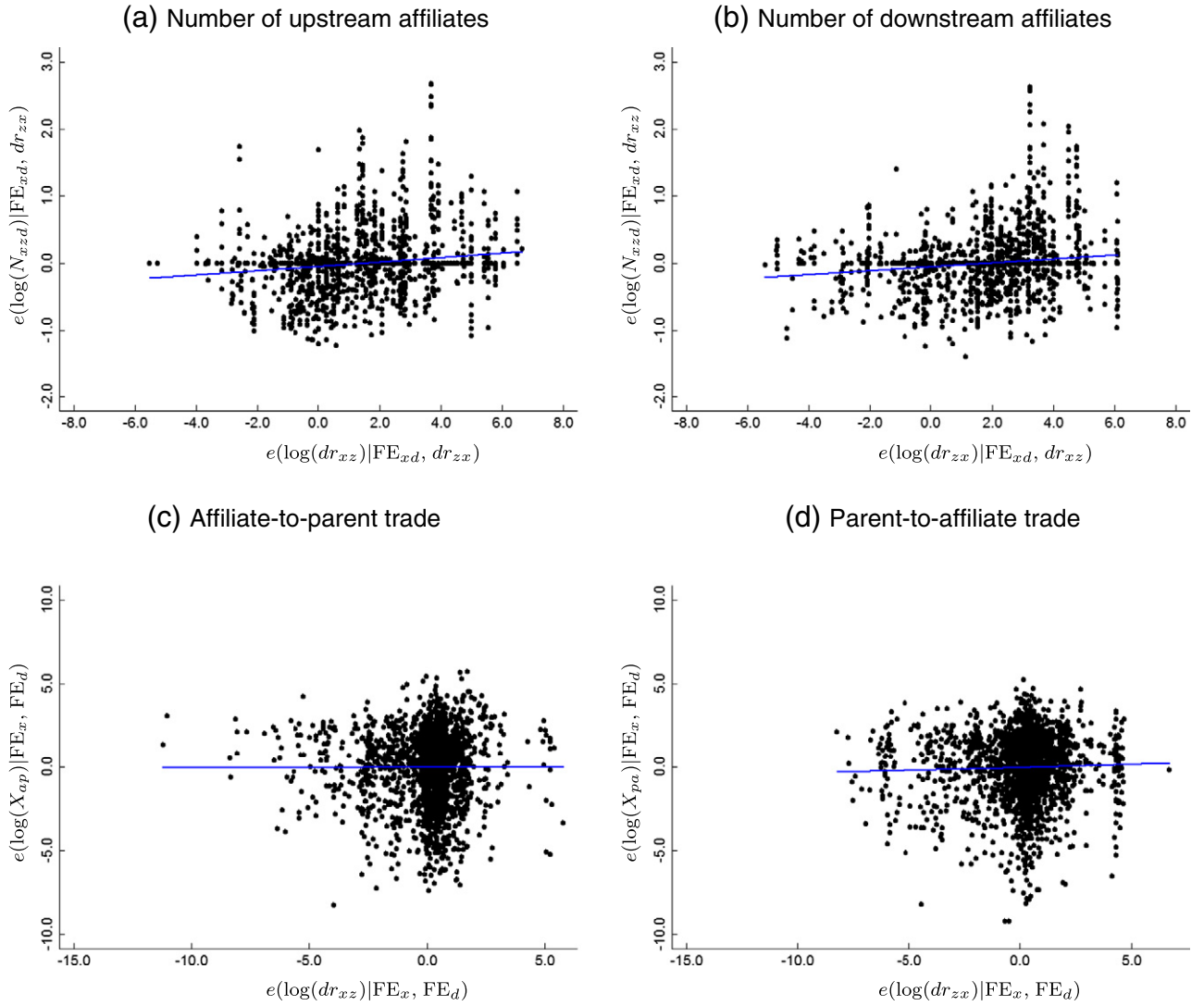
(a) Number of upstream affiliates

(b) Number of downstream affiliates

(c) Affiliate-to-parent trade

(d) Parent-to-affiliate trade

Fig. 4. Adjusted variable plots for I–O links, multinational activity, and intra-MNC trade. Notes: Panel a plots the residuals of $\log(N_{xzd})$ and dr_{xz}, after projecting them onto the affiliate industry-destination fixed effects and dr_{zx}. Panel b plots the residuals of $\log(N_{xzd})$ and dr_{zx}, after projecting them onto the affiliate industry-destination fixed effects and dr_{xz}. Panel c plots the residuals of $\log(X_{ap})$ and dr_{xz}, after projecting them onto the affiliate industry-destination fixed effects. Finally, panel d plots the residuals of $\log(X_{pa})$ and dr_{zx}, after projecting them onto the affiliate industry-destination fixed effects. N_{xzd} is the number of foreign affiliates in the triplet given by affiliate's industry x, parent's industry z, and destination country d. X_{ap} is affiliate-to-parent trade as a share of affiliate's sales, and X_{pa} is parent-to-affiliate trade as a share of affiliate's cogs. dr_{xz} (resp. dr_{zx}) is the direct requirements coefficient from the affiliate's (resp. parent's) primary industry into the production of the parent's (resp. affiliate's) primary industry.

4.1.1. Off-diagonal industry pairs

Industries are very heterogeneous in the direct requirements coefficient with itself, possibly reflecting I–O links between sub-industries. Affiliates and parents operating in the same ISI code could be producing an input for a downstream sub-industry that we do not observe due to the coarseness of the industry classification.

To confirm that our results are not driven by same-industry pairs, we estimate (5) and (6) including the interaction between the direct requirements coefficient and a dummy variable that equals one for observations in which the affiliate and the parent operate in the same (primary) industry, and equals zero otherwise. The robustness specification also tests whether trade between a parent and an affiliate operating in the same industry is larger for an industry with a larger direct requirements coefficient with itself. The coefficient on the interaction term represents this possibility.

Columns 1, 3, 5, and 7 in Table 4 report the estimates of the augmented regression. The probability of observing intra-MNC trade increases for parent and affiliate pairs operating in the same industry (columns 1 and 5). Again, we find that the I–O link between the parent

and the affiliate is not a significant predictor of trade between the affiliate and the parent, neither on nor off the diagonal of the I–O table.

4.1.2. Alternative measures of I–O links

Our baseline I–O link measure is the direct requirements coefficient between the primary industries of the parent and the affiliate. As an alternative, we construct a measure of the I–O link between the parent and the affiliate that includes each party's seven most important industries of operation. We restrict the analysis to all four-digit industries in the manufacturing sector to compute a sales-weighted average of the direct requirements coefficients of all the possible combinations of parent and affiliate industries. Let P be the set of industries in which the parent operates, and let A be the set of industries in which the affiliate operates. Our new measure of the I–O link between the industries of the affiliate and of the parent, v_{ap} and v_{pa}, are:

$$v_{ap} \equiv \frac{\sum_{x \in A, z \in p} dr_{xz} \times sales_p^z}{total\ sales_a} \qquad v_{ap} \equiv \frac{\sum_{x \in A, z \in p} dr_{zx} \times sales_a^z}{total\ sales_p}, \qquad (7)$$

Table 4
Robustness.

	$D(X_{ap})$		$\log(X_{ap})$		$D(X_{pa})$		$\log(X_{pa})$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
dr_{xz}	−0.306							
	(0.190)							
$I(x=z$	0.089**		0.856		0.107**		0.167	
	(0.037)		(0.589)		(0.048)		(0.512)	
$dr_{xz} \times (x=z)$	−0.249							
	(0.339)							
v_{ap}		−6.3e−07***						
		(2.14e−07)						
$\log(dr_{xz})$			−0.070					
			(0.058)					
$\log(dr_{xz}) \times I(x=z)$			0.171					
			(0.187)					
$\log(v_{ap})$				0.051				
				(0.059)				
dr_{zx}					0.389			
					(0.297)			
$dr_{zx} \times I(x=z)$					−0.733			
					(0.526)			
v_{pa}						−0.019		
						(0.035)		
$\log(dr_{zx})$							0.0632	
							(0.039)	
$\log(dr_{zx}) \times I(x=z)$							0.152	
							(0.141)	
$\log(v_{pa})$								0.025
								(0.028)
Aff industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Aff country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4901	2951	2072	1257	4901	2951	2201	1395
R-squared	0.180	0.187	0.240	0.252	0.156	0.165	0.255	0.303

Notes: The operator $D(X)$ is equal to 1 if $X > 0$ and 0 otherwise. The dependent variable X_{ap} is the share of affiliate a's total sales shipped to the parent, and X_{pa} is shipments from the parent as a share of affiliate a's cost of goods sold. dr_{xz} is the direct requirements coefficient from the affiliate's primary industry into the production of the parent's primary industry. dr_{zx} is the direct requirements coefficient from the parent's primary industry into the production of the affiliate's primary industry. $I(x=z)$ is a dummy equal to one if the parent and the affiliate operate in the same primary industry. v_{ap} and v_{pa} are defined in (7). Robust standard errors, clustered by MNC, are in parentheses. Levels of significance are denoted ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$.

where $sales_a^z$ ($sales_p^z$) is the affiliate's (parent's) sales in industry z. Columns 2, 4, 6, and 8 in Table 4 report the estimates of (5) and (6) using these alternative measures of I–O links. The patterns found using this more comprehensive measure are the same as the ones observed in Table 3.

5. Concluding remarks

We have presented two sets of facts related to the cross-country fragmentation of production within the boundaries of the corporation. First, we find that intra-MNC trade in goods is not the typical activity of the median affiliate of U.S. multinationals; rather, within-firm trade is concentrated in the largest affiliates of MNCs. Second, the input–output relationship between the parent's and the affiliate's operating industries, a commonly used measure for vertical fragmentation, is not associated with the presence and magnitude of intra-MNC trade.

Our finding that there is little cross-country fragmentation of the production chain *within* the boundaries of the corporation raises a new set of questions to be explored in future research. For example, how do multinational corporations use third-party suppliers? To what extent do these third-party suppliers interact with different parts of the same corporation? The challenge in answering these new questions is the need for even more detailed data on the activities of the multinational corporation.

Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.jinteco.2015.08.002.

References

Acemoglu, D., Johnson, S., Mitton, T., 2009. Determinants of vertical integration: financial development and contracting costs. J. Financ. 64, 1251–1290.
Alfaro, L., Charlton, A., 2009. Intra-industry foreign direct investment. Am. Econ. Rev. 99, 2096–2119.
Antras, P., 2003. Firms, contracts, and trade structure. Q. J. Econ. 118, 1375–1418.
Antras, P., Helpman, E., 2004. Global sourcing. J. Polit. Econ. 112, 552–580.
Antras, P., Chor, D., Fally, T., Hillberry, R., 2012. Measuring upstreamness of production and trade. Am. Econ. Rev. Pap. Proc. 112, 552–580.
Atalay, E., Hortacsu, A., Syverson, C., 2014. Vertical integration and input flows. Am. Econ. Rev. 104 (4), 1120–1148.
Baldwin, R., Lopez-Gonzalez, J., 2013. Supply-chain Trade: A Portrait of Global Patterns and Several Testable Hypotheses. NBER Working Paper 18957.
Bernard, A.B., Jensen, J.B., 1995. Exporters, jobs, and wages in U.S. manufacturing: 1976–1987. Brookings Papers on Economic ActivityMicroeconomics pp. 67–119.
Bernard, A.B., Jensen, J.B., Schott, P.K., 2009. Importers, exporters, and multinationals: a portrait of firms in the U.S. that trade goods. In: Dunne, T., Jensen, J.B., Roberts, M.J. (Eds.), Producer Dynamics: New Evidence from Micro Data. University of Chicago Press, pp. 513–552.
Bernard, A.B., Redding, S.J., Schott, P.K., 2011. Multi-product firms and trade liberalization. Q. J. Econ. 126, 1271–1318.
Bilir, K., Chor, D., Manova, K., 2013 . Host Country Financial Development and MNC Activity . Unpublished Manuscript
Bloom, N., Van Reenen, J., 2007. Measuring and explaining management practices across firms and countries. Q. J. Econ. 122, 1351–1408.
Borga, M., Zeile, W.J., 2004. International fragmentation of production and the intrafirm trade of U.S. multinational companies. BEA Working Paper 2004–02.
Brainard, S.L., 1993. An Empirical Assessment of the Factor Proportions Explanation of Multi-National Sales. NBER Working Paper 4583.
Carr, D.L., Markusen, J.R., Maskus, K.E., 2001. Estimating the knowledge-capital model of the multinational enterprise. Am. Econ. Rev. 91, 693–708.
Costinot, A., Oldensky, L., Rauch, J., 2011. Adaptation and the boundary of multinational firms. Rev. Econ. Stat. 93, 298–308.
Fajgelbaum, P., Grossman, G., Helpman, E., 2015. A linder hypothesis for foreign direct investment. Rev. Econ. Stud. 82 (1), 83–121.
Feinberg, S.E., Keane, M.P., 2006. Accounting for the growth of MNC-based trade using a structural model of U.S. MNCs. Am. Econ. Rev. 96, 1515–1558.
Garicano, L., Rossi-Hansberg, E., 2006. Organization and inequality in a knowledge economy. Q. J. Econ. 121, 1383–1435.

Grossman, G.M., Helpman, E., Szeidl, A., 2006. Optimal integration strategies for the multinational firm. J. Int. Econ. 70, 216–238.

Hanson, G.H., Mataloni Jr., R.J., Slaughter, M.J., 2005. Vertical production networks in multinational firms. Rev. Econ. Stat. 87, 664–678.

Helpman, E., Melitz, M.J., Yeaple, S.R., 2004. Export versus FDI with heterogeneous firms. Am. Econ. Rev. 94, 300–316.

Markusen, J.R., 1984. Multinationals, multi-plant economies, and the gains from trade. J. Int. Econ. 16, 205–226.

McGrattan, E., Prescott, E.C., 2010. Technology capital and the U.S. current account. Am. Econ. Rev. 100, 1493–1522.

Nunn, N., Trefler, D., 2008. The boundaries of the multinational firm: an empirical analysis. In: Helpman, E., Marin, D., Verdier, T. (Eds.), The Organization of Firms in a Global Economy. Harvard University Press, pp. 55–83.

Ruhl, K.J., 2015. How well is U.S. intrafirm tade measured? Am. Econ. Rev. 105, 524–529.

Yeaple, S.R., 2006. Offshoring, foreign direct investment, and the structure of U.S. trade. J. Eur. Econ. Assoc. 4, 602–611.