Global Sourcing and Multinational Activity: A Unified Approach*

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Abstract

Multinational firms (MNEs) accounted for 42 percent of US manufacturing employment, 87 percent of US imports, and 84 of US exports in 2007. Despite their disproportionate share of global trade, MNEs' input sourcing and final-good production decisions are often studied separately. Using newly merged data on firms' trade and FDI activity by country, we show that US MNEs are more likely to import not only from the countries in which they have affiliates, but also from other countries within their affiliates' region. We rationalize these patterns in a unified framework in which firms jointly determine the countries in which to produce final goods, and the countries from which to source inputs. The model generates a new source of scale economies that arises because a firm incurs a country-specific fixed cost that allows all its assembly plants to source inputs from that country. This shared fixed cost across plants creates interdependencies between firms' assembly and sourcing locations, and leads to non-monotonic responses in third markets to bilateral trade cost changes.

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1 Introduction

Firms increasingly organize production using global value chains, with different stages of production located in different countries (Antràs and Chor, 2022). Recent disruptions to these global value chains, such as the US-China trade war and the COVID pandemic, highlight just how interdependent countries have become in the production of goods. For example, car manufacturers in the United States stand idle as they await semiconductors from foreign suppliers, with these effects rippling across the globe as US car producers reduce demand for other domestic and foreign inputs.[1]

This interrelated nature of global supply chains complicates domestic policy and poses challenges for existing trade models. Take as an example the anti-dumping duties placed on US washing machine imports from Korea in 2012. While standard trade models would predict an increase in US prices, prices instead fell as the Korean manufacturers relocated production to China. This relocation was accompanied by rising exports of washing machine parts from Korea to China, also highlighting the importance of multinational firms' use of imported inputs in their affiliate locations (Flaaen et al., 2020).

Although firms' incentives to import inputs and locate assembly plants abroad are well understood, the literature tends to study each activity in isolation. Most work on horizontal or export platform FDI assumes that assembly only uses local factors of production, while most work on global sourcing or vertical FDI often has final goods that are either nontradable or perfectly tradable. This dichotomy is driven by theoretical considerations – the desire to isolate the determinants of either global sourcing or export-platform FDI – and empirical limitations – detailed data on FDI generally lack country-level information on the full range of firms' import and export activities.

In this paper, we develop a unified framework to study how changes in trade costs, productivity, or demand affect firms' global production *and* trade decisions in other countries. We overcome prior data limitations by combining US data on firms' detailed trade transactions with country-level information on multinationals' affiliates and ownership. These new data show that MNEs account for the vast majority of manufacturers' imports and exports, and that their extensive-margin import and export decisions across countries are oriented not only towards countries in which they have foreign affiliates, but also towards other countries in their affiliates' region. We rationalize these patterns in a framework in which firms jointly determine not only the locations of their various assembly plants, but also the countries from which those plants import inputs. The model features a new source of scale economies that arises because firms incur a single, country-specific fixed cost that allows all their assembly plants to import inputs from that country. This firm-level fixed cost also generates an interdependence between firms' extensive-margin decisions about the countries from which to source inputs and in which to locate production. Since the benefits of importing inputs are decreasing in bilateral trade costs between the input-source country and final-assembly country, shocks to bilateral trade costs between one set of locations affects firm sourcing and production in other countries.

Our first contribution is to construct and analyze a comprehensive new dataset that captures the

[1] The WSJ reported that Ford and GM's US plants faced chip shortages and shut downs, even as Toyota did not (Colias and Naughton, 2021).

domestic and foreign activities of all firms with US operations. We use the Census Bureau's 2007 Longitudinal Business Database and Economic Censuses to build a firm-level dataset with detailed industry, employment, and sales information for all private, non-farm employer establishments in the United States. We augment this dataset with firms' imports and exports by country from the Longitudinal Firm Trade Transactions Database. Building on extensive work by Kamal et al. (2021), we merge the Census data with information on US firms' foreign affiliate operations by country using the Bureau of Economic Analysis (BEA) outward direct investment surveys, and identify firms with foreign-ownership shares using the BEA's inward direct investment survey. We use the combined data to classify firms as US multinationals (US MNEs) if they are majority owners of foreign affiliates and their ultimate parent is a US firm. We classify firms as foreign MNEs if they are majority owned by a foreign firm.[2]

We first use the newly merged data to document MNEs' significant size premia and their disproportionate role in international trade. MNEs comprise only 0.23 percent of all firms in the United States, yet employ one quarter of the workforce, account for 44 percent of aggregate sales, 69 percent of US imports, and 72 percent of US exports. MNEs' dominance of trade flows is even more salient among manufacturers.[3] MNEs constitute only 1.5 percent of all manufacturing firms in the United States, yet account for 87 percent of their imports and 84 percent of their exports.

MNEs' contribution to trade flows is due not only to their large size, but also to their higher trade intensities. US MNEs' ratio of imports to sales is 0.11, almost double the 0.06 ratio for domestic importers. Similarly, US MNEs' ratio of export to sales is 0.10, while domestic importers' ratio is only 0.05. MNEs also engage with more countries. US MNEs import from an average of 21 countries and export to an average of 40. By contrast, multi-country domestic importers source from an average of 4, while multi-country domestic exports sell to 8 markets.

Despite their greater trade intensity and outsized role in US exports, US MNEs' predominantly serve foreign markets from their foreign affiliates. Foreign affiliate sales by US MNEs with foreign manufacturing are 74 percent of their total US establishments' sales, and four times larger than their US merchandise exports. In sum, understanding MNEs' trade motives is crucial for explaining aggregate trade flows, with their foreign assembly decisions playing a key role in their global involvement.

To understand the relationship between MNEs' trade and FDI decisions, we assess how cross-country variation in their extensive and intensive margins of trade relate to their foreign affiliate or foreign headquarter locations. Focusing first on imports, we find that US MNEs are 53.6 percentage points more likely to import from countries in which they have foreign affiliates, and 7.4 points more likely to import from other countries in the same region as their affiliates. By contrast, the amount a US MNE imports from a country (conditional on any imports from that country), has no statistically

[2]The BEA outward survey includes foreign-owned firms. For example, a foreign MNE may locate its North American headquarters in the United States and directly own foreign affiliates, such as subsidiaries in Mexico or Canada. Distinguishing US versus foreign MNEs is difficult in practice because the Census Bureau firm identifier sometimes spans multiple BEA firms with conflicting ownership status. To resolve these conflicts, we use ownership and voting share information from the BEA data, along with the Census Bureau's Company Organization Survey (COS).

[3]We follow Fort, Pierce and Schott (2018) and classify all firms with one or more manufacturing plants as manufacturers. This ensures that our sample covers all US manufacturing activity.

significant relationship with the presence of an affiliate elsewhere in the region. Foreign MNEs are disproportionately oriented towards their headquarter country. They are 67.8 percentage points more likely to import from their headquarter country, and 9.0 points more likely to import from other countries in their headquarter's region. Foreign firms' intensive margin of imports is also larger, both for its headquarter country and for other countries in the same region. These results thus provide new evidence that firms' global sourcing strategies are oriented towards those regions in which they have multinational activity, and that for US MNEs, this reorientation is driven solely by variation in their extensive-margin import decisions.

US MNEs' exports are also oriented towards their foreign affiliate locations: they are 46.3 percentage points more likely to export to a country in which they have an affiliate, and 8.7 points more likely to export to another country in their affiliate's region. Their intensive margin of exports is also higher, both to countries with affiliates, and to other countries in their affiliate's region. This evidence seems at odds with canonical models of horizontal FDI, in which firms decide whether to serve a foreign market using exports versus foreign affiliates. While increased exports to their affiliates' countries might consist of inputs for their foreign affiliates, (e.g., as in Keller and Yeaple, 2013), that explanation cannot explain MNEs' higher exports to proximate countries in their affiliates' region. Instead, exporting and FDI seem to be complementary activities. These positive cross-country correlations between an MNE's trade and FDI decisions are key features of the data, yet absent from most models of input sourcing and FDI that consider each activity separately.

Our second contribution is to develop a unified framework in which firms jointly determine their optimal global input sourcing and final-good production across countries. To do so, we combine the export-platform model of FDI from Tintelnot (2017) with the global sourcing framework in Antràs, Fort and Tintelnot (2017). Consumers across J countries have nested constant-elasticity-of-substitution (CES) preferences over differentiated varieties, which are produced by firms in a monopolistically competitive manufacturing sector with free entry. As in Melitz (2003), each firm pays a fixed entry cost to learn its core productivity. Firms then decide whether to exit, or instead to pay country-specific fixed costs to open assembly plants in one or more countries, and whether to incur country-specific fixed costs to source inputs from one or more countries. Crucially, we assume that the country-specific fixed costs of sourcing are incurred *at the firm level*, such that all assembly plants in the firm may source inputs from its 'activated' input-source countries.

After choosing its optimal sets of assembly and input-source countries, each firm combines a continuum of inputs to produce a continuum of differentiated manufactured final-good varieties. By invoking the probabilistic approach to productivity in Eaton and Kortum (2002) for both final-good production (as in Tintelnot, 2017) and for inputs (as in Antràs et al., 2017), we derive simple, gravity-style formulas for firm-level bilateral shipments of consumer goods from each of the firm's assembly countries, and for intermediate-input purchases from each of the firms activated input-source countries to each of its assembly locations.

Firms' intensive-margin gravity formulas provide a new lens through which to analyze short- and medium-run responses to trade and other cost shocks in which firms hold their extensive margin decisions fixed, but may shift input sourcing and final-good production across countries.[4] For example, we show that a bilateral reduction in input-trade costs between China and Japan affects the domestic sales of a US MNE that sources inputs from China and has an affiliate in Japan. If consumers are relatively sensitive to price (i.e., demand is elastic) and comparative advantage gains are large (i.e., high assembly productivity dispersion), a firm's affiliate sales across countries are complementary, such that the increased productivity of its Japanese affiliate (due to cheaper Chinese inputs) raises sales by its US plants. Alternatively, if a firm's plants cannibalize sales from each other, the firm's US sales would decline as consumers substitute towards the now cheaper Japanese variety. We provide similar comparative statics analyses for firms' input purchases in response to changes in potential cost savings from final-good production in a particular country.

The probabilistic approach to productivities also delivers a simple, closed-form solution for firm profits as a function of both its set of activated input-source countries, and its set of activated assembly locations. Although solving for these optimal country sets is complicated, we use this profit function to characterize the firm's decision under different parameter values. First, the marginal benefit of opening an assembly plant in one country will be decreasing in the plants in the firm's active set when plants cannibalize sales each other, as in Tintelnot (2017), or increasing in other the plants when they complementary.[5] Second, the marginal benefit of adding a new input-source country may similarly be increasing or decreasing in the set of countries from which the firm imports. As in Antràs et al. (2017), input-source countries are complements when the scale effects from adding a new country outweigh the substitution effects of a new input source, though this result may be overturned when assembly plants cannibalize sales from each other.

Our framework also delivers a novel interdependency between a firm's optimal set of assembly locations and input-source countries. We show that when assembly plants are complements, the extensive-margin assembly and sourcing decisions are also complementary. Sourcing from more countries reduces marginal costs, increases optimal firm scale, and thus raises the appeal of producing final goods in more countries. Similarly, having assembly plants in more countries increases overall firm sales and thus makes a more expansive sourcing strategy more profitable. On the other hand, when assembly plants cannibalize sales from each other, the marginal benefit of activating certain input countries may be diminished by activating certain assembly locations, for example if those location pairs face high bilateral trade costs.

Our third contribution is to demonstrate the empirical and policy relevance of the model's predicted interdependence in firms' sourcing and assembly decisions. The positive correlations we document between MNEs' extensive-margin sourcing and final-good production locations are precisely in line with this interdependence, and with the key role of bilateral trade costs between assembly and sourcing locations in shaping a firm's extensive-margin choices in the theory. Consider two US MNEs, one with an affiliate in Japan and the other with an affiliate in Germany. Because the Japanese affiliate has relatively lower costs to source inputs from China (since it is closer than the German one), that firm is

[4] The WSJ reports on car plants, "Often, it takes years for such plants to be made and approved..." (Boston, 2018).

[5] Pairs of assembly location may be complements when varieties are more substitutable across firms than within firms. Tintelnot (2017) restricts his analysis to symmetric CES preferences with a common elasticity across all varieties.

more likely to find it profitable to incur the fixed cost of sourcing from China. The US MNE with the Japanese affiliate is thus more likely to source from China, though its Japanese affiliate will have higher Chinese input shares than its US plants. In an extension, we show how a firm-level fixed cost to sell goods in a particular country can generate a similar, positive correlation between a firm's FDI and export locations, consistent with the patterns we document for exports. These correlations between MNEs' affiliate locations and their sourcing and exporting markets are absent in most models of FDI, yet we show they imply very different responses to policy changes or other shocks.[6]

To illustrate the policy-relevance of our framework, we conclude with two simple illustrations of how firm responses to bilateral trade cost shocks differ under firm- versus plant-level sourcing fixed costs. In a first example, we show that a rising US input tariff on imports from China can eventually lead to the closure of an assembly plant in a third market (e.g., Mexico) under firm-level sourcing fixed costs, whereas Mexican exports to the US are always rising under plant-level fixed costs. This distinction can arise if the decreasing productivity of the firm's US plants leads it to drop China from its optimal set of source countries (if the fixed sourcing cost is not sunk), thus also lowering the Mexican plant's productivity. In a second example, we show that under firm-level fixed costs, a unilateral tariff increase on Chinese final goods can ultimately decrease the firm's US sales and exports. This surprising result occurs if the final-good tariffs lead the firm to close its Chinese assembly plant, and then to drop China as a source of intermediate inputs. This loss of scale and cheap source of inputs in turn lowers the firm's US productivity, thus leading those sales to drop as well. For both of these examples, a model in which the fixed costs to source inputs are incurred at the plant level (e.g., as in Bernard et al., 2018) does not generate these non-monotonicities.

Our paper contributes to three strands of literature. First, we add to a large literature on the motives for FDI. Horizontal FDI has long been modeled as a 'proximity-concentration tradeoff,' in which firms decide whether to serve a foreign market with local assembly plants or via exporting (Markusen, 1984; Brainard, 1997; Helpman et al., 2004; Tintelnot, 2017; Gumpert et al., 2020; Garetto et al., 2019).[7] While those papers tend to treat exports versus FDI as substitutes, we exploit comprehensive new data to show that MNEs export more, not only to their affiliates' countries, but also to other countries in their affiliates' region. Related work suggests that, at least some, of these exports may contain inputs from the parent firm to its affiliates (Helpman, 1985; Boehm et al., 2019; Irarrazabal et al., 2013; Keller and Yeaple, 2013; Ramondo and Rodríguez-Clare, 2013; Wang, 2019; Li, 2021), with 'headquarter' gravity potentially influencing firms' optimal affiliate locations. We expand the analysis to allow affiliates to source from any country, which allows for new interdependencies in trade flows and production across countries. Yeaple (2003a) and Grossman, Helpman and Szeidl (2006) discuss potential complementarities between global sourcing and global assembly, but in models with at most three countries and two inputs. Conconi et al. (2022) show that firms acquired by foreign MNEs begin trading with the MNE's headquarter country and other countries in which it has affiliates. We provide

[6] For instance, the WSJ reports that firm responses to the US-China trade-war tariffs include relocation to other Asian countries for many industries, similarly to the washing-machine example above (Smith, 2019). Our framework can rationalize these patterns due to the importance of input access for final-good production.

[7] Firms also use exports to learn about foreign demand before opening an affiliate (Conconi et al., 2016).

a new framework in which a firm's decisions to import inputs across multiple countries influences where it locates its horizontal affiliates and how much to produce in each one.

We also add to an active literature on input sourcing and global value chains (GVCs). A long line of work considers the importance of factor price differences and trade costs in firms' decisions to fragment production across countries (Helpman, 1984; Jones and Kierzkowski, 2001; Yeaple, 2003b; Hanson et al., 2005; Grossman and Rossi-Hansberg, 2008; Fort, 2017; Arkolakis et al., 2018; Bernard et al., 2020).[8] Related papers document productivity gains from importing inputs (Halperen et al., 2015; Blaum et al., 2018), with shocks to one input market affecting input purchases in other markets (Antràs et al., 2017; Boehm et al., 2020). Relative to those papers, we exploit novel data to show that firms' input-sourcing decisions are geographically correlated with their final-good assembly locations. Prior work shows how geography shapes firms' responses to falling trade or communication costs (Antràs and De Gortari, 2020), which can lead to an 'overshooting' phenomenon in GVCs (Baldwin and Venables, 2013; Costinot et al., 2013). Geography also plays a key role in our framework because of the variation it generates in bilateral trade costs between the firm's input-source countries and assembly plants. This type of interdependence can explain why FDI responds to trade policy shocks (as documented in McCaig et al., 2022), with potential spillovers in markets that undergo no policy changes (Head and Mayer, 2019). Our contribution is to analyze how interdependencies between assembly and sourcing locations due to firm-level fixed costs in sourcing can generate non-monotonic responses to policy shocks, not only in the countries that experienced the policy change, but also in other markets.

Finally, we build on studies that document the role of scale economies in international trade. Early evidence on exporters' size premia (Bernard and Jensen, 1999) spawned a new focus on how trade liberalization affects aggregate productivity via selection effects (Melitz, 2003) and technology upgrading (Lileeva and Trefler, 2010; Bustos, 2011). Within-firm productivity gains arise from a natural complementarity between two activities that each entail fixed costs and increase firm scale, such as imported inputs and R&D (Boler et al., 2015), and more generally (Bernard et al., 2018). Fixed costs and selection are also well-established features of FDI (Yeaple, 2009; Ramondo, 2014). We propose a new source of 'global' scale economies that arises because firms incur a single, country-specific fixed cost that allows all their assembly plants to import inputs from that country. This interaction between foreign final-good production and input purchases leads globalization to magnify initial differences in firm productivity beyond the predictions of models with importing, exporting, or FDI.

The rest of the paper is structured as follows. Section 2 introduces our novel, linked dataset and documents MNEs' significant size premia and disproportionate role in international trade. Section 3 reports the strong, positive correlation between firms' sourcing and assembly decisions. We present the model assumptions and solve for its equilibrium holding firms' extensive-margin sourcing and assembly decisions fixed in section 4, and discuss those optimal margins in section 5. In section 6, we relate the interdependence between assembly and sourcing to the evidence in Section 3. Section 7 concludes.

[8] A strand of this work focuses on firms' optimal integration decisions (e.g., Antràs and Helpman, 2004; Antràs and Chor, 2013), which we do not analyze here.

2 New Data and Facts on US Multinational Activity

In this section, we analyze newly linked, comprehensive data on all firms in the United States, and their domestic and foreign activities. We first describe the data sources and explain how we merge them. We then present a series of new facts on (i) the aggregate importance of both US and foreign multinationals in terms of total US sales, employment, and trade flows, as well as the share of these measures accounted for by the sample of US manufacturing firms we use in this paper; (ii) MNEs' relative propensity to engage in exporting and global sourcing; and (iii) the extent to which MNEs use foreign production plants to serve foreign consumers.

2.1 Data Description

An important contribution of this paper is to advance the construction and analysis of a new dataset that links the Bureau of Economic Analysis (BEA) data on multinational firm activity in the United States to the universe of private, non-farm employer establishments provided by the US Census Bureau. While numerous studies have used the BEA or the Census Bureau data separately, ours is one of the first to use both.

A crucial benefit of the combined data is that they provide the full set of countries from which US MNEs' import goods, as well as all their export destinations, regardless of whether those transactions occur at arm's length or within the boundary of the firm. They also enable us to measure the complete range US MNEs' domestic activities, and compare them to those of domestic-only importers. We focus on 2007 so that we can employ the most detailed Census data from the Economic Censuses, while avoiding contamination from the Great Recession.

We use the Census Bureau's 2007 Longitudinal Business Database (LBD), which is based on administrative tax records and provides employment and industry for every private, non-farm employer establishment in the United States. An establishment is a single, physical location where business transactions take place and for which payroll and employment are recorded.[9] The LBD contains a firm identifier ($firmid$) that captures all establishments under common ownership or control in a given year. We use the $firmid$ to identify all establishments (and their corresponding Employer Identification Numbers (EINs)) under the same firm ownership. Although the BEA data also include a firm identifier, the BEA only collects information for up to two EINs from a firm, while the Census data indicate that some large firms have 100s of EINs. The Census $firmid$ is thus important for capturing the full range of activities at these large firms. Indeed, when merging the BEA and Census data, we find that Census $firmid$ may encompass one or more BEA firmids.

We supplement the LBD with additional information from the 2007 Economic Censuses (ECs) of Manufacturing (CMF), Wholesale Trade , Retail Trade, Construction, Mining (CMI), Transportation, Communications, and Utilities, and Services. The censuses are conducted in years that end in "2" and "7" and provide information on establishment sales, value added, and input usage.

[9]In practice, firms report these data at the employer identification number (EIN) level. The Census Bureau allocates this information across establishments using data for known multi-establishment firms from the Company Organization Survey (COS). See Jarmin and Miranda (2002) and Chow et al. (2021) for details on the LBD construction.

We also link the dataset to the 2007 Longitudinal Firm Trade Transaction Database (LFTTD). The trade data comprise the Customs Transactions of merchandise good shipments by firms in the United States. They contain information on the products, values, and countries of firms' imports and exports. They also include an indicator for whether a transaction between the US importer or exporter takes place with a related party in the foreign country.[10] We match these data at the firm level to the LBD and EC data, and follow Antràs, Fort and Tintelnot (2017) in dropping mineral trade (HS2=27) so that we exclude trade in oil from the analysis. These data allow us to characterize the complete picture of MNEs' importing and exporting behavior.

We combine the Census data with the annual BEA outward and Benchmark BEA inward foreign direct investment survey data. The BE-11 survey provides annual information on US-based firms' *outward* foreign affiliate employment, local sales, sales back to the United States (and whether these are intra-firm), and sales to third markets, by the affiliates' country and industry. These data are collected for all firms with establishments in the United States that have 10 percent or greater ownership shares in foreign affiliates with sales, assets, or net income greater than $60 million. While these US-based firms are often US MNEs, foreign MNEs may locate their North American headquarters in the United States and thus report outward foreign affiliate activity if their US establishments own those affiliates. Below, we describe how we distinguish these foreign MNEs in the outward survey from US MNEs. In this paper, we focus only on foreign affiliates in which the US entity has a 50 percent or higher ownership stake.

We also use data collected from the BE-12 survey, which identifies foreign MNEs with *inward* activity in the United States. Since this is a benchmark survey, all foreign firms with a 10 percent or higher voting ownership interest in a US affiliate are required to file the BE-12 form. We build on extensive work by Kamal, McCloskey and Ouyang (2021) to match the BEA outward and inward surveys to Census datasets using Employer Identification Numbers (EINs), and by name and address. We provide details on our matching algorithms in Appendix Section B.1.

An important element of our empirical analysis is distinguishing US versus foreign MNEs. Because the BEA outward data contain both types of firms, it is not sufficient to classify an MNE's US versus foreign ownership based solely on whether it appears in the outward or inward surveys.[11] In addition, we find that the Census firm identifier sometimes includes more US establishments than the BEA firm identifier, such that some firms that are unique to one survey using the BEA firm identifier appear in both surveys when using the Census $firmid$. Although these MNEs with conflicting country ownership information are small in number, they account for a large share of aggregate activity and thus cannot be ignored. To distinguish US versus foreign MNEs, we use the ownership and voting share information from the BEA data, along with questions on MNE activity in the Census Bureau's

[10]For exports, related-party transactions are those in which one of the trading entities owns, directly or indirectly, 10 percent or more of the other entity. For imports, related-party transactions are those between members of the same family, shared officers or directors, partners, employers and employees, or a 5 percent controlling interest. See Bernard et al. (2007) and Kamal and Ouyang (2020) for additional details on the LFTTD. The matched data cover about 80 percent of total exports and imports.

[11]Many of the public BEA data products based on the outward FDI surveys contain both US *and* foreign MNEs. The aggregate numbers we present below are thus not directly comparable to the published statistics.

Company Organization Survey (COS). We provide details on our method to identify firm ownership in Appendix Section B.2.

The merged dataset improves upon independent use of the various underlying data sources in two ways. First, access to the Customs trade transactions data allows us to document US MNEs' imports and exports across source and destination markets, regardless of whether those transactions involve foreign affiliates. By contrast, BEA's BE-11 survey includes related-party trade between US parents and their foreign affiliates by country, but arm's-length imports by US parents are aggregated across countries. For foreign MNEs' affiliates in the United States, we can similarly measure all of their imports and exports by country, whereas the data collected in BEA's BE-12 survey are aggregated across countries. Furthermore, the LFTTD contains detailed product information on imports and exports, while BEA only reports these flows at the entity (parent or affiliate) level.[12]

Second, access to the BEA surveys augments our understanding of how firms' trade patterns relate to their foreign affiliate activity and headquarter country. Early work inferred traders' MNE status by flagging all firms with related-party import or export transactions as MNEs (e.g., Bernard, Jensen and Schott, 2009), but this approach cannot distinguish US MNEs from foreign MNEs, has low thresholds of 5 and 10 percent for importing and exporting related-party status, respectively, and provides no information on the affiliate countries of the firm. While Boehm et al. (2020) made a significant data contribution by merging the Census data to directories of international corporate structure, those authors focused solely on US firms' manufacturing activity, and did not have the detailed information of foreign affiliate activity available in the BEA data. By contrast, we distinguish US from foreign MNEs, focus only on firms with majority-ownership shares, include firms' US manufacturing and non-manufacturing employment and sales, and provide a comprehensive assessment of US-MNEs' foreign affiliate locations and how they relate to their export and import countries.

Despite the advantages provided by our newly merged dataset, we note an important limitation. While the BEA outward survey and Customs trade transactions should provide a complete and accurate portrait of US MNEs' global operations, the same is not true for foreign MNEs in the United States. Although we observe all the Customs trade transactions made by their US establishments, we lack any information on foreign MNEs' headquarter-firm activities, as well as any information on their foreign affiliates that are not majority owned by their US establishments. As such, our merged dataset likely misses a significant share of the foreign parent group global sales, employment, and trade flows.

2.2 Aggregate Importance of MNEs and Manufacturing Firm Sample

We first use the newly linked BEA-Census data to document the aggregate importance in the United States of global firms. To do so, we define four mutually-exclusive firm types: US multinational enterprises (US MNEs), foreign-owned multinationals (foreign MNEs), US importers that are not multinationals (Importers), and all other domestic firms (Domestic). We define foreign-MNEs as Census firms that are majority owned by a foreign entity, using the firm's ultimate owner to make this designation. We define US MNEs as firms that have majority-owned foreign affiliate activity and are

[12] In this paper, we only exploit the product-level information to exclude mineral trade (HS2=27), as mentioned above.

majority owned by a US firm, again using the firm's ultimate owner to make this designation. We classify all remaining firms as domestic, and separate them into firms that do or do not import.

Table 1 presents aggregate information on the number of firms, workers, sales, and trade flows conducted by US establishments, by firm type. The first column shows that although there are only about 2,800 US MNEs, which account for less than 0.06 percent of all US firms, they employ about 20 percent of US workers and account for one third of aggregate US sales. US MNEs are even more important in terms of trade, mediating over one third of total US merchandise imports and almost half of all US merchandise exports.[13] Foreign MNEs are also disproportionately involved in trade, accounting for 6 percent of aggregate US employment, but one third of US imports and a quarter of US exports. MNEs thus account for 69 percent of imports and 72 percent of exports.[14] Finally, (non-MNE) US importers are also important in the aggregate. They account for about a quarter of US employment, sales, and exports, and one third of imports. By contrast, non-importers account for about 50 percent of employment but only 5 percent of exports.

Table 1: Aggregate statistics for US-based firms in 2007, by firm import and MNE status

		Employment		Sales		Imports		Exports	
Firm Type	Firms	(000s)	Share	($B)	Share	($B)	Share	($B)	Share
Domestic	4,281,000	54,489	0.48	8,004	0.29	0	0.00	45	0.05
Importers	273,000	30,020	0.27	7,528	0.27	439	0.31	221	0.24
Foreign MNEs	7,600	6,964	0.06	3,764	0.13	478	0.33	224	0.24
US MNEs	2,800	21,666	0.19	8,655	0.31	518	0.36	446	0.48
Total	4,564,400	113,139	1.00	27,951	1.00	1,435	1.00	937	1.01

Sources: 2007 Economic censuses, LBD, LFTTD, and BEA inward and outward datasets. Table presents levels of firms, employment, sales, imports, and exports, for US establishments in 2007 by firm type. Sample includes all private, non-farm, employer establishments. 'Domestic' firms are those that are not multinationals and do not import. 'Importers' are firms that import but are not multinationals. 'Foreign MNEs' are firms that are majority owned by a foreign firm. 'US MNEs' are firms that are majority owned by a US firm with majority-owned foreign affiliate activity. Observations rounded per Census disclosure rules.

In this paper, our goal is to understand manufacturing firms' decisions to produce final goods and source inputs across locations. We therefore follow Fort et al. (2018) and focus on the subset of firms with one or more manufacturing establishments in the United States, which ensures that we cover all US manufacturing activity. We provide context on this sample in Table 2 by separating the aggregate totals presented in Table 1 into firms with domestic manufacturing establishments (Panel A) and firms without them (Panel B). Classifying manufacturing multinationals this way requires the comprehensive

[13] We exclude trade in oil in these aggregates by dropping trade in HS2=27.

[14] These figures are smaller than the 90 percent share of trade by MNEs reported in Bernard, Jensen and Schott (2009). Those authors identify MNE trade as all flows for firms with any related-party imports or exports. Their higher share is thus is likely due to the lower ownership thresholds (5 and 10 percent for imports and exports, respectively) in those variables, versus our ownership thresholds of 50 percent. Consistent with that explanation, they calculate that almost a quarter of trading firms are MNEs, whereas column 1 in Table 1 indicates that an upper bound of 3.7 percent of traders are MNEs (we do not separate firms that only export in our statistics, which would increase the denominator of trading firms and thus lower the share of MNEs).

domestic establishment-level data that allow us to identify multinationals with some US manufacturing activity, even if that is not the firm's primary industry. For US MNEs, we further distinguish those that have majority-owned foreign manufacturing affiliates from those that only have majority-owned non-manufacturing affiliates.

Table 2: Aggregate statistics for firms in 2007, by firm manufacturing, import, and MNE type

		Share of Total				
Firm Type	Firms	Emp	Man Emp	Sales	Imports	Exports
Panel A: Manufacturing Firms						
Domestic	182,000	0.02	0.19	0.02	0.00	0.01
Importers	60,000	0.07	0.40	0.08	0.09	0.12
Foreign MNEs	2,200	0.03	0.12	0.10	0.26	0.21
US MNEs						
No foreign manuf affiliates	350	0.04	0.03	0.05	0.03	0.02
With foreign manuf affiliates	1,200	0.06	0.27	0.14	0.29	0.43
Manufacturers' Total	245,750	0.22	1.01	0.39	0.67	0.79
Panel B: Non-Manufacturing Firms						
Domestic	4,099,000	0.46		0.27	0.00	0.04
Importers	213,000	0.19		0.19	0.22	0.11
Foreign MNEs	5,400	0.03		0.04	0.07	0.03
US MNEs						
No foreign manuf affiliates	1,100	0.09		0.11	0.04	0.02
With foreign manuf affiliates	150	0.00		0.01	0.01	0.00
Non-Manuf Total	4,318,650	0.77	0.00	0.62	0.34	0.20

Sources: 2007 Economic censuses, LBD, LFTTD, and BEA inward and outward datasets. Table presents levels of firms and shares of employment, sales, imports, and exports, for all US private, non-farm, employer establishments in 2007. 'Domestic' firms are those that are not multinationals and do not import. 'Importers' are firms that import but are not multinationals. 'Foreign MNEs' are firms that are majority owned by a foreign firm. 'US MNEs' are firms that are majority owned by a US firm with majority-owned foreign affiliate activity, which we split based on whether these include manufacturing affiliates. Top panel presents the number of firms and the shares of total US employment, manufacturing employment, sales, imports, and exports accounted for by firms with manufacturing establishments in the United States in 2007. Total US manufacturing employment for these firms is 13.1 million in 2007. Bottom panel presents comparable statistics for firms without US manufacturing establishments. Observations rounded per Census disclosure rules. Columns sum to 1.00 except due to rounding.

Table 2 shows that a slight majority of US MNEs (1,550 out of 2,800) have domestic manufacturing activity. These MNEs account for 10 percent of total employment and 30 percent of manufacturing employment. US MNEs that manufacture domestically are vastly more important in terms of merchandise trade flows. They mediate about 32 percent of US imports and 45 percent of exports, with the vast majority of these flows driven by US MNEs that also have foreign manufacturing affiliates. By contrast, US MNEs without domestic manufacturing account for only 5 and 2 percent of imports and exports, respectively (Panel B), with almost no trade by those US MNEs without foreign manufacturing affiliates. Foreign MNEs with US manufacturing establishments also trade disproportionately more. They account for 26 percent of imports and 21 percent of exports, compared to only 7 and 3 percent for foreign MNEs that do not manufacture. As a result, manufacturing MNEs in the United States account for a striking 87 percent of manufactures' merchandise imports and 84 percent of their exports.

We summarize the key takeaways from Table 2 as follows:

Fact 1. *Multinational firms comprise only 1.5 percent of all firms engaged in manufacturing in the United States, yet account for 41 percent of US manufacturing employment, 74 percent of manufacturing firms' sales, 87 percent of manufacturing firms' imports, and 84 percent of manufacturing firms' exports.*

In the remainder of the paper, we focus only on firms in Panel A of Table 2 (i.e., firms with at least one US manufacturing establishment), and to be symmetric define a US MNE as a firm with one or more foreign manufacturing affiliates.

2.3 Import and Export Patterns by Firm Type

In this subsection, we use the linked data to show that MNEs are disproportionately involved in trade, even taking into account their significant size premia inherent in Table 2. Focusing on the set of firms with US manufacturing employment, Table 3 documents the relative importance and propensity of MNEs' trade engagement, both for imports and for exports. Column 1 reports the share of total imports over sales, and shows that domestic importers are the least import intensive, with a 6.0 percent value.[15] Imports are almost twice as important for US MNEs, whose imports-to-sales ratio is 11 percent, and foreign MNEs are the most intensive with a ratio of 14 percent. Column 2 reports the share of each firm type that imports. This share is 100 percent for domestic importers (by definition), and equal to 26 percent for all US manufacturer's. The overwhelming majority (more than 90 percent) of multinational firms import.

Columns 3 and 4 of Table 3 depict similar patterns for firm-level exports. Both US and foreign MNEs export significantly higher shares of their sales than domestic firms. Three lessons from the trade data are worth stressing. First, exporting is slightly more common than importing: combining information from Tables 2 and 3, we calculate that there are 4,600 more exporters (about 2 percent of total US manufacturers) than importers. Second, domestic importers are much more likely to export than domestic non-exporters (64 percent versus 14 percent). Third, US MNEs are the most export-intensive of all firm types, with 10 percent of their domestic establishments' sales shipped abroad, which is double the share exported by domestic importers.

[15] We exclude US MNEs without foreign manufacturing affiliates from this comparison since they are few in number and account for a small share of aggregate activity. In the remainder of the paper, US MNEs are defined as firms with majority-owned foreign *manufacturing* affiliates.

Table 3: Trade statistics for manufacturing firms in 2007, by import and MNE status

	$\frac{Imports}{Sales}$	$\frac{Importers}{Firms}$	$\frac{Exports}{Sales}$	$\frac{Exporters}{Firms}$
Domestic	0.00	0.00	0.02	0.14
Importers	0.06	1.00	0.05	0.64
Foreign MNEs	0.14	0.91	0.07	0.91
US MNEs	0.11	0.92	0.10	1.00
Manufacturers' Total	0.09	0.26	0.07	0.28

Sources: 2007 Economic censuses, LBD, LFTTD, and BEA inward and outward datasets. Table presents the ratios of total imports to total sales and total exports to total sales, as well as the share of each firm type that imports and exports. 'Domestic' firms are non-multinationals that do not import. 'Importers' are firms that import but are not multinationals. 'Foreign MNEs' are firms that are majority owned by a foreign firm. 'US MNEs' are firms that are majority owned by a US firm with majority-owned foreign manufacturing affiliates. Sample consists of all firms with US manufacturing establishments (i.e., Panel A from Table 2), except for US MNEs that only have non-manufacturing affiliates which are excluded here.

We also calculate statistics on the relative prevalence of related-party trade by firm type (see Appendix Table B.1). As expected, MNEs are more likely to have related-party trade, and a much higher share of their trade flows occurs within firm boundaries relative to domestic firms.[16] Approximately 60 percent of US MNEs' imports are from related parties, while foreign MNEs import almost 80 percent of goods within the firm. Related-party export shares are substantially lower, with US and foreign MNEs exporting 40 and 42 percent of their goods within the firm, respectively. Capturing MNEs' arm-length transactions is thus crucial for obtaining a full picture of their activities across countries.

We conclude this subsection with new information on the number of countries from which manufacturers import, and the number of countries to which they export. To do so, we focus on the subset of firms that import from, or export to, *at least two* countries. Panel A of Table 4 shows that these multi-country importers comprise just over half of all US importers, and an overwhelming 99 percent of total imports.[17] In Appendix Table B.3 we show that essentially all single-country importers (and exporters) are domestic firms. The second two columns in the table indicate that even among multi-country importers, MNEs source from a much larger set of countries. Domestic manufacturers import from an average of 4 countries, with the median importer sourcing from just 3. Foreign-owned firms import from an average of 12 countries and a median of 8 countries. US MNEs

[16] We find that twenty percent of non-MNE importers have some related-party imports. Recall that the ownership threshold for 'related party' is only 5 percent for imports and 10 percent for exports. We define MNEs as firms with at least 50 percent foreign-ownership thresholds, thus making it possible for our 'domestic' firms to have related-party trade. Measurement error in MNE status or in related-party trade statistics could also explain the positive related-party trade for non-MNE firms.

[17] The data in this table are limited to countries for which gravity variables from the CEPII are available, and from which multiple US firms import and export. This ensures that the samples of firms in this table match the samples used in the regression analysis in the next section.

have the most expansive sourcing strategies, importing from an average of 21 and a median of 17 foreign countries.[18]

Table 4: Import and export statistics in 2007 for US manufacturing firms that import to, or export from, multiple countries, by firm type

	Panel A: Import Statistics				**Panel B: Export Statistics**			
	Share of Aggregate		No. of Countries		Share of Aggregate		No. of Countries	
Firm Type	Importers	Imports	Avg	Median	Exporters	Exports	Avg	Median
Domestic	0.48	0.17	4	3	0.52	0.18	8	4
Foreign MNE	0.03	0.40	12	8	0.03	0.27	19	10
US MNE	0.02	0.43	21	17	0.02	0.54	40	35

Source: 2007 Economic censuses, LBD, LFTTD, and BEA inward and outward datasets. Panel A presents the share of US importers and import value, and the average and median number of countries from which firms import by firm type. Panel B presents comparable statistics for US exports. 'Domestic' firms are non-multinationals. 'Foreign MNEs' are firms that are majority owned by a foreign firm. 'US MNEs' are firms that are majority owned by a US firm with majority-owned foreign manufacturing affiliates. Sample consists of all firms with US manufacturing establishments (i.e., Panel A from Table 2) that import from 2 or more countries (left panel) or export to 2 or more countries (right panel).

Panel B of Table 4 presents comparable statistics for firms' export behavior by MNE status. Multi-country exporters comprise 57 percent of exporters and account for 99 percent of US manufacturers' exports. The extensive margin of exporting is generally larger than the import margin, though also more skewed. Domestic exporters sell to an average of 8 countries, twice their median of 4. Foreign MNEs export to an average of 19 countries and a median of 10. Finally, US MNEs sell to the largest number of countries, with an average of 40 and a median of 35.

We summarize the key take-aways from Tables 3 and 4 in our next fact:

Fact 2. *MNEs are more trade-intensive than domestic firms: they import and export more relative to their sales, and feature richer extensive margins of both imports and exports. Among MNEs, foreign MNEs are the most import-intensive set of firms, while US MNEs are the most export-intensive.*

The data thus indicate that the disproportionate share of trade accounted for by MNEs cannot be explained solely by their size advantage. Instead, MNEs both import and export a greater share of their US establishments' sales.

2.4 Global Production Patterns

We conclude this section by providing new information on MNEs' foreign affiliate activity. We first present US MNEs' total worldwide sales decomposed into sales by these firms' US establishments (domestic and exports), and sales of their majority-owned foreign affiliates. We also include these sales for foreign MNEs, but as explained in Section 2.1, we only observe foreign MNEs' US affiliate sales (classified under 'US Estab Sales'), and the subset of foreign MNEs' affiliate sales conducted by non-US

[18] Census disclosure avoidance rules preclude us from disclosing the true median. We therefore calculate a fuzzy median equal to the average number of countries for firms in the 49th to the 51st percentiles.

affiliates that are majority owned by the US affiliates (Affiliate Sales). The data presented thus provide information on how US establishments serve global markets, including via foreign plants.

Columns 1 to 4 in Table 5 present the levels and shares of MNEs' US and foreign establishment sales and deliver three new messages. First, MNEs with US manufacturing plants account for the vast majority – 80 percent – of all foreign affiliate sales (column 4, bottom row).[19] Second, US MNEs with foreign manufacturing affiliates account for the majority of these sales, while US MNEs without foreign manufacturing affiliates account for only 5 percent, which supports our definition of US MNEs based on these firms in the next section. Finally, US MNEs' size dominance is even more pronounced when we include their affiliate sales. While they account for 14 percent of all firms' US establishment sales (column 2), their share of total firm sales is 20 percent (columns 1 and 3 divided by the implied total for manufacturing and non-manufacturing firms in Table B.4).

Table 5: Sales by US manufacturing MNEs' US and foreign establishments, by firm type

	Total Firm Sales				Sales Ratios	
	US Estabs		Affiliates		$\frac{\text{Affilates}}{\text{US Estabs}}$	$\frac{\text{Manuf Aff}}{\text{Affiliates}}$
	($B)	Share	($B)	Share		
Foreign MNEs	2,702	0.10	839	0.17	0.31	0.43
US MNEs						
No foreign manuf affiliate	1,446	0.05	249	0.05	0.17	-
With foreign manuf affiliate	3,853	0.14	2,857	0.58	0.74	0.60
Total by MNE Manufacturers	8,001	0.29	3,945	0.80	0.49	0.53
Total by All Manufacturers	10,630	0.38	3,945	0.80	0.37	0.53

Source: 2007 Economic censuses, LBD, LFTTD, and BEA inward and outward datasets. Columns 1-4 present levels and corresponding shares of sales by MNEs' US establishments (US Estabs) and their foreign affiliates (Affiliates) by firm type. The last 2 columns present the ratio of MNEs' total sales by their foreign affiliates to total sales by their US establishments ($\frac{\text{Affiliates}}{\text{US Estabs}}$), and the ratio of MNEs' total manufacturing affiliate sales over their total affiliate sales ($\frac{\text{Manuf Aff}}{\text{Affiliates}}$). Only sales by firms' majority-owned foreign affiliates are included. 'Foreign MNEs' are firms that are majority owned by a foreign firm. 'US MNEs' are firms that are majority owned by a US firm with majority-owned foreign manufacturing affiliates. Sample is MNEs with manufacturing establishments in the United States in 2007, but the denominators in the share calculations include domestic and non-manufacturing firms' sales in each column.

We also calculate the ratio of MNEs' foreign affiliate sales to their US establishment sales for each firm type. Column 5 in Table 5 presents the results. Foreign affiliate sales by US MNEs with foreign manufacturing affiliates are equal to a striking 74 percent of their domestic establishment sales. This figure highlights the relevance of these firms' foreign assembly locations. The same statistic is much

[19] In Table B.4 of Appendix B.5, we present analogous figures for non-manufacturing firms, and infer that 99 percent of foreign manufacturing sales are carried out by the manufacturing MNEs in Table 5.

smaller for foreign MNEs, at only 31 percent. However, as noted above, the BEA data only include these firms' foreign affiliates that are majority owned by their US subsidiaries, so we miss all sales by their affiliates directly owned by the headquarter firm. Finally, column 6 presents the share of foreign affiliate sales in manufacturing by each firm type. 60 percent of US MNEs' affiliate sales (i.e., about 1,714 US billion) are sales of manufactured goods. For the remainder of the paper, we use these affiliates and their sales as our measure of US MNEs' foreign assembly locations and operations.

To understand how US MNEs use these affiliates to serve foreign markets, we calculate statistics on their locations. US MNEs have majority-owned foreign manufacturing affiliates in an average of 6.42 countries. Table 6 presents the weighted average of their manufacturing affiliate sales, and shows how they are broken out across destinations. Column 2 shows that the majority of foreign affiliate sales are local, with 54 percent remaining in the host country. Export platform sales are also significant: affiliates ship 35 percent of their sales to 'third' markets (i.e., markets other than the host country or the United States). Only 11 percent of affiliate sales return to the United States, with the vast majority of these (over 80 percent) shipped to affiliated US parties. This is in line with results in Ramondo et al. (2016), who find that sales back to the US are not a dominant feature of affiliates' activity.[20]

Table 6: US MNEs' average foreign manufacturing affiliate sales in 2007, by destination

	Total	Local	Third Markets	US Third Parties	US Intra-Firm
Firm Average	1,458	782.5	506.1	31.06	138
Share	1.00	0.54	0.35	0.02	0.09

Source: 2007 Economic censuses, LBD, LFTTD, BEA inward and outward datasets. Table presents the weighted-average of US MNEs' majority owned foreign manufacturing affiliate sales in millions USD by destination. 'US MNEs' are firms that are majority owned by a US firm with majority-owned foreign manufacturing affiliates. Sample is US MNEs with manufacturing establishments in the United States in 2007 and foreign manufacturing affiliates.

To assess the relative importance of US MNEs' exports versus affiliate sales, we compare their magnitudes using information from Tables 1, 2, 5, and 6. US exports are 43 percent of the 937 US billion figure in Table 1, or 403 US billion. The foreign affiliate sales that do not return to the US are 89 percent of 1,714 US billion, or 1,525 US billion. In sum, manufacturing sales to foreign countries via US MNEs' foreign affiliates are almost four times larger than their corresponding US establishments' merchandise exports. Foreign production is thus by far the most salient method MNEs use to sell US-branded products to foreign consumers.

[20]These statistics include firms with zero reported flows. If some of these zeros include missing flows, our estimates may be biased. We note a significant discrepancy between the average amount of US intra-firm shipments in the BEA data, versus those in the Customs data. The (approximately) 1,200 US MNEs with domestic and foreign manufacturing account for 29 percent (Table 2) of the total 1,435 billion USD US merchandise imports (Table 1). Since 61 percent of these firms' imports are with related parties (Table B.1), these firms' total related-party imports are 1,435 $\times$ 0.29 $\times$ 0.61, or 253.9 billion USD. The Customs data therefore imply an average of 212 million USD of related-party imports per US MNE, which is substantially larger than the 138 million USD reported in Table 6 using BEA data. While some of the differences may be due to the definition of 'intra-firm' in our two data sources and reporting thresholds in the BEA data, the BEA and Census are investigating the potential role of missing trade flows in the BEA data.

We summarize the main insights from Tables 5 and 6 as follows:

Fact 3. *US MNEs' foreign affiliate sales are equal to 74 percent of their US establishments' sales. These foreign affiliates' manufacturing sales abroad are almost four times the size of US MNEs' US establishments' merchandise exports.*

In sum, the newly merged BEA-Census data show that MNEs are substantially larger than domestic firms, account for a vast majority of trade flows, and are relatively more import- and export-intensive than domestic firms, even after taking in account their large size premia. In addition, and despite their export intensity, MNEs rely on foreign affiliates rather than US exports for the vast majority of their foreign sales.

3 MNE Activity and Trade Patterns across Countries

In this section, we use the newly linked data to analyze how US MNEs' foreign affiliate activity and foreign MNEs' headquarter locations relate to their import and export decisions. Since the merged data include the universe of all firms' Customs transactions, we provide one of the first complete portraits of US MNEs' global sourcing and exporting strategies, and directly compare these strategies to those of domestic traders. We also provide new insights into how foreign MNEs' import and export patterns relate to their headquarter country.

3.1 Interdependence between FDI and Importing

We first study whether and how firms' extensive and intensive margins of imports by country relate to their foreign manufacturing affiliate locations, or for foreign MNEs, to their headquarter country. We assess how MNE activity relates to firms' extensive-margin sourcing decisions by estimating the following linear probability model:

$$\begin{aligned} Pr(I_{frc}=1) = \quad & \beta_A Affiliate_{fc} + \beta_{AR} AffiliateRegion_{fr} + \\ & \beta_F ForeignHQ_{fc} + \beta_{FR} ForeignRegionHQ_{fr} + \gamma_f + \gamma_c, \end{aligned} \tag{1}$$

where I_{frc} is an indicator equal to one if firm f imports from country c in region r. The first row of equation (1) includes indicators for US MNEs' foreign manufacturing affiliate locations. $Affiliate_{fc}$ is an indicator for whether the firm has a majority-owned manufacturing affiliate in country c. $AffiliateRegion_{fr}$ is an indicator for whether the firm has a majority-owned manufacturing affiliate in the same region as country c, though not country c itself.[21] The second row in equation (1) includes similar indicators for foreign MNEs. $ForeignHQ_{fc}$ is an indicator for whether the firm is majority owned by a firm headquartered in country c, and $ForeignRegionHQ_{fr}$ is an indicator for whether the

[21] We define the following regions: Africa, Central Asia, East Asia, Europe (excluding the New Member States), Middle East, New Member States of the European Union, North America, OWH, Oceania, South and Central America, South Asia, Southeast Asia, and Western Asia.

firm is owned by a firm with headquarters in the same region as country c, though not in country c itself.

A primary goal of this analysis is to document whether and how the geography of firms' MNE activity relates to their foreign sourcing behavior. We therefore include firm fixed effects and use the sample of multi-country imports described in Table 4 to avoid incorrect inference (e.g., see Correia, 2015). The limitation to multi-country importers also makes the comparison to domestic importers more similar. As noted in Section 2.3, this sample covers approximately 99 percent of the value of US imports by manufacturing firms. The firm fixed effects control for all unobservable firm characteristics, so that the patterns we document cannot be explained by the relative size advantage of MNEs. We also include country fixed effects so that we focus exclusively on the firm-by-country variation from the affiliate and foreign headquarter country indicators. In Appendix Section B.5 we provide additional firm-level specifications with region fixed effects to show how these firms' import decisions relate to standard gravity variables. We two-way cluster the standard errors by country and by firm.

We similarly assess how the intensive margin of firms' imports relate to their FDI activity by estimating

$$\begin{aligned} y_{frc} = \quad & \beta_A Affiliate_{fc} + \beta_{AR} AffiliateRegion_{fr} + \\ & \beta_F Foreign_{fc} + \beta_{FR} ForeignRegion_{fr} + \gamma_f + \gamma_c + \varepsilon_{frc}, \end{aligned} \tag{2}$$

where y_{frc} is the log of firm f imports from country c in region r, and the remaining variables are identical to those in equation (1). These intensive-margin regressions are based on the subset of firms with positive import flows in the extensive-margin regressions.

Table 7 presents the results from estimating equations (1) and (2) via ordinary least squares (OLS). Columns 1 and 2 present the extensive-margin estimates, while columns 3 and 4 present the intensive-margin results. The first of each of these regressions includes only the MNE and foreign headquarter indicators for the import country, while the second set of columns also includes the region indicators. Since the coefficients on the country indicators do not change significantly when including the region indicators, we focus on the second column for each margin. Examining the extensive-margin results in column 2, the estimates suggest that US firms are 53.6 percentage points more likely to import from a country in which they have a majority-owned foreign manufacturing affiliate, while foreign MNEs are 74 percentage points more likely to import from their headquarter country.

The most novel results in Table 7 are the positive correlations we estimate between the likelihood a firm will import from a country that is relatively proximate to its foreign manufacturing affiliates, or to its headquarter country. We find that US MNEs are 7.4 percentage points more likely to import from a country if they have an affiliate in the region. This estimate is over three times the size of the average share of countries from which a firm in the sample imports. Foreign MNEs are 9.0 points more likely to import from the same region as their headquarters. These estimates are economically large, since the average multi-country importers sources from only 2.8 percent of the 182 countries in the sample.

Columns 3 and 4 in Table 7 provide results on firms' intensive-margin import decisions. Focusing

Table 7: MNE activity and the extensive and intensive margins of imports

	Extensive Margin		Intensive Margin	
	(1)	(2)	(3)	(4)
Affiliate$_{fc}$	0.501***	0.536***	2.224***	2.331***
	(0.025)	(0.028)	(0.123)	(0.110)
Foreign HQ$_{fc}$	0.669***	0.678***	3.617***	3.765***
	(0.047)	(0.047)	(0.227)	(0.223)
Affiliate in Region$_{fr}$		0.074***		0.181
		(0.015)		(0.113)
Foreign HQ in Region$_{fc}$		0.090***		0.480***
		(0.021)		(0.160)
Adj. R2	0.278	0.28	0.282	0.283
Observations (000s)	6,330	6,330	177	177
Firm & Country FEs	Yes	Yes	Yes	Yes

Source: 2007 Economic censuses, LBD, LFTTD, and BEA inward and outward datasets. Dependent variable for extensive margin regressions is an indicator for whether firm f imports from country c in region r. Dependent variable for intensive-margin regressions is the log of imports by firm f from country c in region r. Sample is all firms with manufacturing establishments in the United States in 2007 that import from multiple countries. Observations in 1000s and rounded per Census disclosure rules. There are 182 countries in this sample. Standard errors two-way clustered by firm and by country. *,**, *** denote p<0.10, p<0.05, and p<0.01, respectively.

on column 4, the estimates suggest that US MNEs import 233 log points more from countries in which they have a foreign affiliate. Foreign MNEs' imports are even more aligned with their headquarter country. The estimates indicate that their imports are 377 log points higher relative to other countries from which they source. Examination of the affiliate and headquarter region indicators reveals two notable differences. First, foreign MNEs also import relatively more from countries in their headquarter region, whereas there is no statistically significant difference between the amount a US MNE imports from countries in its foreign affiliates' regions versus other countries from which it imports.[22] are more likely to import from countries near t Second, and most notably, this lack of a statistically significant relationship on US MNEs' intensive-margin sourcing decision contrasts sharply with the large, positive, and significant relationship we document for their extensive margin sourcing decisions.

In sum, US MNEs are more likely to import from countries in which they have affiliates, and from proximate countries in those affiliates' region. Conditional on importing from a set of countries, however, they do *not* import more from other countries in their affiliates' region.

We summarize these results in the following fact:

[22] Relatedly, Li (2021) finds that foreign-owned firms in China import more from their headquarters and countries close to their headquarters.

Fact 4. *US MNEs are more likely to import from a country in which they have an affiliate, or from other countries in their affiliates' region. By contrast, the amount a US MNE sources from a country in its sourcing set is* not *higher if the MNE has an affiliate in the same region. Foreign MNEs are both more likely to import, and import more, not only from their headquarter country, but also from countries in their headquarter region.*

These findings are consistent with the premise that the set of countries from which US MNEs purchase inputs is related to the geography of their foreign production locations. We incorporate this relationship in our theoretical framework in the next section.

3.2 Interdependence between FDI and Exporting

We also explore the relationship between US MNEs' production locations and their export patterns. A large body of work models FDI and exporting as two, alternative ways by which a firm can serve foreign markets. FDI allows firms to avoid trade costs, but also reduces the benefits of increasing returns to scale from serving multiple markets from a single location. In this setting, exports and FDI to a particular country are substitutes. We use the newly linked data on exports and FDI to assess the empirical support for these predictions. As for our import analysis, we also study whether and how foreign MNEs' export activity is oriented towards their headquarter country.

To assess the extensive margin of exporting, we estimate a variant of equation (1), where the dependent variable is an indicator equal to one if the firm exports to country c. Table 8 presents the results. In contrast to the common assumption that exports and FDI are substitutes, we find that a US MNE is 46 percentage points more likely to export to a country in which it also has an affiliate. Most notably, and similarly to the import results, the estimates also indicate that a US MNE is 8.7 points more likely to import to another country in the same region in which its affiliate is located. Foreign MNEs are also both more likely to export to their headquarter country and to other countries in their headquarter region.

Columns 3 and 4 in Table 8 present results from estimating a variant of equation (2) in which the dependent variable is the log of firm exports to country c. The estimates indicate that US MNEs export relatively more to countries in which their affiliates are located, and similarly, foreign MNEs export relatively more to their headquarter country. In contrast to the import regression estimates, we find that US MNEs also export about 16 percent more to other countries in the same region as their affiliate, whereas foreign MNEs have a negative, though insignificant, relationship between the amount they export to a country and its presence in the same region as its headquarters.

We summarize these results in our final fact:

Fact 5. *US MNEs are more likely to export, and conditional on exporting to a country to export more, both to countries in which they have an affiliate, and to other countries in their affiliates' region. Foreign MNEs are also more likely to export to their headquarter country and to other countries in the same region as their headquarters. While foreign MNEs also export more to their headquarter country,*

Table 8: MNE activity and the extensive and intensive margins of exports

	Extensive Margin		Intensive Margin	
	(1)	(2)	(3)	(4)
Affiliate$_{fc}$	0.423***	0.463***	1.906***	1.993***
	(0.032)	(0.035)	(0.108)	(0.102)
Foreign HQ$_{fc}$	0.518***	0.521***	1.306***	1.286***
	(0.043)	(0.043)	(0.140)	(0.155)
Affiliate in Region$_{fr}$		0.087***		0.163**
		(0.020)		(0.078)
Foreign HQ in Region$_{fc}$		0.035**		-0.112
		(0.014)		(0.122)
Adj. R2	0.266	0.267	0.42	0.42
Observations (000s)	7,230	7,230	350	350
Firm & Country FEs	Yes	Yes	Yes	Yes

Source: 2007 Economic censuses, LBD, LFTTD, and BEA inward and outward datasets. Dependent variable for extensive margin regressions is an indicator for whether firm f exports country c in region r. Dependent variable for intensive-margin regressions is the log of exports by firm f from country c in region r. Sample is all firms with manufacturing establishments in the United States in 2007 that import from multiple countries. Observations in 1000s and rounded per Census disclosure rules. There are 182 countries in this sample. Standard errors two-way clustered by firm and by country. *,**, *** denote p<0.10, p<0.05, and p<0.01, respectively.

conditional on exporting to a country, they do not export more to other countries in their headquarter region.

These results are consistent with US MNEs shipping inputs to their foreign affiliates, and with them exporting final goods produced by their US establishments both to other customers in the country of their affiliates, as well as to other proximate countries in the same region as their affiliates. The results are also consistent with foreign MNEs being more likely to ship inputs and final goods produced in the United States to their headquarter countries, and to other countries in their headquarter region.[23]

The facts in this section provide new insights into how and why MNEs dominate trade flows. We find that, even when controlling for firm size with firm fixed effects, US MNEs are more likely to import and export not only from and to the countries in which their affiliates are located, but also from and to other countries in those affiliates' region. On the import side, these regional patterns are only evident for the extensive margin, suggesting a potential role for firm-country-level fixed costs in explaining the results. On the export side, the estimates for US MNEs suggest that FDI and exporting are complementary activities, rather than substitutes, a result at odds with the underlying

[23]We have tried using product and material trailer files on firms' US establishments inputs and production to distinguish imports of final goods versus inputs. In practice, a large share of US MNEs' imports are classified as both inputs and final goods using this approach.

assumptions in canonical models of FDI. In the next section, we develop a new framework in which firms jointly determine their foreign production, foreign sourcing, and exporting decisions to rationalize these results.

4 Theoretical Framework

Motivated by our empirical results, we develop a new framework to analyze the determinants and consequences of firms' decisions about the countries in which to produce final goods, the countries from which to source inputs, and the countries in which to sell final goods. While each of these decisions has been studied separately, our focus is to explain why firms make these decisions jointly, and to show how these joint decisions lead to interdependencies between FDI and trade that are not predicted by existing models.

In this section, we first present the environment and discuss our main assumptions. We then analyze optimal firm behavior and the industry equilibrium, holding firms' extensive-margin input-sourcing and assembly location decisions fixed. In the next section, we characterize firms' optimal assembly and sourcing strategies, and in Section 6 we relate the theoretical predictions to the evidence in Section 3 on interdependencies between trade and FDI.

4.1 Environment

Consider a world in which individuals in J countries value the consumption of differentiated varieties of manufactured goods as well as the consumption of the output of a non-manufacturing sector. Consumers worldwide spend a constant share η of their income on manufactured goods. Individuals supply one unit of labor inelastically, with L_i denoting the total labor force in country $i \in J$ (with some abuse of notation, J denotes both the number and the set of countries). There are no other factors of production, so labor should be interpreted as being "equipped". The non-manufacturing sector is perfectly competitive and operates under a constant-returns-to scale technology in labor. We assume that the non-manufacturing sector is freely tradable and large enough to pin down wages (denoted by w_i in country i) in the manufacturing sector.

There is an endogenous measure Ω_i of manufacturing firms selling goods in country i. As in Tintelnot (2017), each of these firms produces and sells a continuum of measure one of varieties of manufactured goods. We index firms by φ and varieties within firms by ω. We assume a nested-CES structure in which the degree of substitutability σ across varieties produced by different firms, and the degree of substitutability σ_w across varieties produced by the same firm may differ from each other:

$$U_{Mi} = \left(\int_{\varphi \in \Omega_i} \left(\int_0^1 q_i\left(\varphi, \omega\right)^{(\sigma_w - 1)/\sigma_w} \mathrm{d}\omega \right)^{\frac{\sigma_w}{\sigma_w - 1} \frac{(\sigma-1)}{\sigma}} \mathrm{d}\varphi \right)^{\sigma/(\sigma-1)}, \quad \sigma_w, \sigma > 1. \tag{3}$$

These preferences imply that consumers in country i spend a share

$$s_i(\varphi) = \left(\frac{p_i(\varphi)}{P_i}\right)^{1-\sigma} E_j \tag{4}$$

of their income on firm φ. In this expression, E_i is total spending on manufactured goods in country $i \in J$,

$$p_i(\varphi) = \left(\int_0^1 p_i(\varphi,\omega)^{1-\sigma_w} \mathrm{d}v\right)^{\frac{1}{1-\sigma_w}} \tag{5}$$

is the overall price index for varieties sold by firm φ, and

$$P_i = \left(\int_{\varphi\in\Omega_i} p_i(\varphi)^{1-\sigma} \mathrm{d}\varphi\right)^{\frac{1}{1-\sigma}} \tag{6}$$

is the economy-wide ideal price index in country i.

Demand in country i for each individual variety ω produced by firm φ is given by

$$q_i\left(\varphi,\omega\right) = \left(\frac{p_i(\varphi,\omega)}{p_i(\varphi)}\right)^{1-\sigma_w} s_i(\varphi), \tag{7}$$

where $s_i(\varphi)$ is given in equation (4). Note that we can thus write

$$q_i\left(\varphi,\omega\right) = \left(p_i(\varphi,\omega)\right)^{-(\sigma_w-1)} \left(p_i(\varphi)\right)^{\sigma_w-\sigma} E_j P_i^{\sigma-1},$$

which illustrates that whether demand for individual varieties produced by firm φ increases or decreases with the price of other varieties produced by the same firm depends on the relative size of σ_w and σ. When varieties are more substitutable within firms than across firms ($\sigma_w > \sigma$), the lower the firm-level price index $p_i(\varphi)$, the lower the demand for an individual variety, thus capturing a *demand cannibalization* effect. Conversely, when varieties are more substitutable across firms than within firms ($\sigma_w < \sigma$), a lower firm-level price index $p_i(\varphi)$ disproportionately redirects demand towards all of firm φ's varieties, thus creating a form of *demand complementarity* across a firm's varieties.

4.2 Manufacturing Production

Manufactured varieties are produced under increasing returns to scale, and market structure in this final-good production sector is characterized by monopolistic competition with free entry. As mentioned above, each firm owns blueprints to produce a unit measure of differentiated varieties of goods. Production of final-good varieties requires labor and a bundle of intermediate inputs. We index final-good firms by their 'core productivity', which we denote by φ, and following Melitz (2003), we assume that firms only learn their productivity φ after incurring an entry cost equal to f_h^e units of labor in their country of incorporation h (i.e., in the *h*eadquarter country). This core productivity is drawn from a country-specific distribution $g_h(\varphi)$, with support in $[\underline{\varphi}_h, \infty)$, and with an associated continuous cumulative distribution $G_h(\varphi)$.

The mapping between final-good production and the bundle of intermediate inputs is similar to Antràs, Fort and Tintelnot (2017). The bundle of intermediates contains a continuum of measure one of firm-specific inputs that are imperfectly substitutable with a constant and symmetric elasticity of substitution ρ. Although intermediates are produced worldwide, a final-good producer based in country h only acquires the capability to source inputs from country j after incurring a fixed cost equal to f^s_{hj} units of labor in country h. We denote the set of countries for which a firm headquartered in h with productivity φ has paid the associated fixed costs of sourcing $(w_h f^s_{hj})$ by $\mathcal{J}_h(\varphi) \subseteq J$, and refer to it as the firm's *global sourcing strategy*.

Intermediates are produced by a competitive fringe of suppliers who sell their products at marginal cost.[24] All intermediates are produced with labor under constant-returns-to-scale technologies. We denote by $a_j(v, \varphi)$ the unit-labor requirement associated with the production of firm φ's intermediate $v \in [0, 1]$ in country $j \in J$. Shipping intermediates from country j to country k entails iceberg trade costs τ^s_{jk}. As a result, the cost at which firms producing in k can procure input v from country j is given by $\tau^s_{jk} a_j(v, \varphi) w_j$.

Note that we are using four different subindices to denote countries: h denotes the country in which a firm is headquartered (i.e., the country of entry); k denotes a country in which assembly takes place; j denotes a country from which inputs are sourced; and i denotes the country in which a final good is sold and consumed.

The overall marginal cost for firm φ headquartered in h to produce units of final-good variety ω in country k is given by

$$c_k\left(\{j(v)\}_{v=0}^1, \varphi, \omega\right) = \frac{1}{\varphi}\frac{1}{z_k(\varphi,\omega)}(w_k)^{1-\alpha}\left(\int_0^1\left(\tau^s_{jk(v)} a_{j(v)}(v,\varphi)\, w_{j(v)}\right)^{1-\rho} dv\right)^{\alpha/(1-\rho)}, \tag{8}$$

where $\{j(v)\}_{v=0}^1$ corresponds to the infinitely dimensional vector of locations of intermediate-input production, $\tau_{j(v)k}$ denotes the iceberg trade costs between the input-production location $j(v)$ and the assembly country k, $1-\alpha$ is the value-added (labor) share in final-good production, and $z_k(\varphi, \omega)$ is a firm- and location-specific productivity level associated with assembling product ω in location k.

It is worth stressing that our baseline framework does not feature any *direct* dependence of the cost function in (8) on the country h in which the headquarters are located. Some prior models feature 'headquarter gravity' that arises when a firm's country-specific assembly or input productivities decrease in countries' distance from the firm's headquarters (Tintelnot, 2017; Head and Mayer, 2019; Wang, 2019). We rule out these 'headquarter gravity' terms initially to emphasize the potential for endogenous sourcing strategies to generate interdependencies between firms' global sourcing and global assembly decisions. In section 5.3, however, we develop an extension of our framework that incorporates

[24] As in Antràs, Fort and Tintelnot (2017), we implicitly assume that contracts between final-good producers and suppliers are perfectly enforceable, so that the firm-specificity of inputs is irrelevant for the prices at which inputs are transacted.

these headquarter gravity effects explicitly.

As in Antràs, Fort and Tintelnot (2017), we treat the (infinite-dimensional) vectors of firm-specific intermediate-input efficiencies $1/a_j(v,\varphi)$ as the realization of a Fréchet distribution

$$\Pr(a_j(v,\varphi) \geqslant a) = e^{-T_j^s a^{\theta^s}}, \quad \text{with } T_j^s > 0, \tag{9}$$

which we assume are independent across locations and inputs. As in Eaton and Kortum (2002), T_j^s governs the state of input production technology in country j, while θ^s determines the dispersion of productivity draws across inputs, with a lower θ^s fostering the emergence of comparative advantage *within* the range of intermediates across countries. For technical reasons described below, we impose a lower bound on the dispersion in the input productivity draws, $a_j(v,\varphi)$, to ensure a well-behaved equilibrium:

Technical Assumption 1. $\rho - 1 < \theta^s$.

The main substantive deviations from Antràs, Fort and Tintelnot (2017) are that we analyze firms' foreign production decisions, and relax the assumption that final goods are nontradable by allowing firms to produce and market their goods in *any* country in the world. Selling goods abroad involves additional fixed costs. First, we introduce an initial fixed cost $w_h f_h^g$ required for a firm to become a 'global firm'. Firms must incur this fixed cost to market goods outside their home country h, and to import inputs from countries other than h. Once that fixed cost is paid, a firm can sell goods in any country, but must pay the additional country-specific costs described above to import inputs from a particular country. Second, we assume that setting up an assembly plant in a given country $k \in J$ is associated with fixed overhead costs, so in equilibrium, firms will only find it optimal to set up a limited number of assembly plants (possibly a single one).

Following Tintelnot (2017), we analyze the firm's choice of the optimal set of countries in which to produce final goods and sell to consumers worldwide. We denote this optimal set of countries $k \in J$ for which a firm headquartered in h with productivity φ has paid the associated fixed cost of assembly ($w_h f_{hk}^a$) by $\mathcal{K}_h(\varphi) \subseteq J$, and refer to it as the firm's *global assembly strategy.* Shipping final goods from country k to country i entails variable (iceberg) trade costs τ_{ki}^a, which may differ from the costs to ship intermediate inputs. In this section, we abstract from modeling destination-specific fixed costs of exporting, but note that the fixed cost of going global *does* create selection into exporting in our model (see Proposition 5 below). In section 5.3, we expand the model to include country-specific fixed costs to export, which delivers a richer extensive margin of exports.

Also in line with Tintelnot (2017), we assume that the firm- and location-specific assembly productivity shifters are drawn from the following Fréchet distribution:

$$\Pr(1/z_k(\varphi,\omega) \geqslant a) = e^{-T_k^a a^{\theta^a}}, \quad \text{with } T_k^a > 0. \tag{10}$$

Analogously to (9), T_k^a governs the state of assembly technology in country k, while θ^a determines the dispersion of productivity draws across final-good varieties, with a lower θ^a indicating a higher variance, and thus greater benefits from producing final-good varieties in various locations. Again for technical reasons described below, a well-behaved equilibrium requires that we impose a lower bound on the dispersion in the final-good productivity draws $z_k(\varphi, \omega)$:

Technical Assumption 2. $\sigma_w - 1 < \theta^a$.

As in Tintelnot (2017) and Antràs, Fort and Tintelnot (2017), we assume that firms know the distributions (9) and (10) when they decide on their sourcing and assembly strategies, but not the actual realizations of these random variables.

Isomorphism with Armington Model In our model, firms have an incentive to activate assembly and sourcing locations to reduce the costs at which they can serve foreign markets. This cost minimization is due not only to trade-cost reductions (e.g., activating an export-platform close to specific countries), but also to the fact that new assembly plants or sourcing locations allow the firm to access alternative technologies with which to produce final goods or procure inputs. The Fréchet formulation of these technologies coupled with the assumption that the firm produces a continuum of final-good varieties and sources a continuum of inputs leads to a simple expression for the benefits of activating new assembly or sourcing locations (see Section 5 for details).

An entirely isomorphic set of equilibrium conditions arises in an Armington-like setting in which final-good and input varieties are differentiated by country of origin. In that environment, activating a new assembly location entails producing a new differentiated final-good variety, and activating a new country from which to source inputs gives the firm access to a new differentiated input. To derive a set of isomorphic conditions to those of our Fréchet formulation, one needs to set the elasticity of substitution within firms across assembly locations equal to $\sigma_w = 1 + \theta^a$, and the elasticity of substitution across inputs produced in different countries equal to $\rho = 1 + \theta^s$.[25]

This completes the discussion of the assumptions of our model. Before describing its equilibrium, we summarize the precise timing of events in the model for the manufacturing sector.

1. Firms worldwide decide whether to pay a fixed cost $w_h f_h^e$ to set up headquarters in any country $h \in J$.

2. Upon observing their realized core productivity level φ, firms decide whether to exit, pay the fixed costs for domestic sourcing and production and remain purely domestic, or pay a fixed cost $w_h f_h^g$ to become a 'global firm'.

3. Global firms decide on their assembly strategy $\mathcal{K}_h(\varphi)$ and their sourcing strategy $\mathcal{J}_h(\varphi)$, paying the associated fixed costs $w_h f_{hk}^a$ and $w_h f_{hj}^s$. For purely domestic firms, $\mathcal{K}_h(\varphi) = \mathcal{J}_h(\varphi) = \{h\}$.

4. Firms observe the realization of the productivity levels $a_j(v, \varphi)$ and $z_k(\varphi, \omega)$ for all $j \in \mathcal{J}_h(\varphi)$ and all $k \in \mathcal{K}_h(\varphi)$.

[25] Strictly speaking, the isomorphism also requires that the unit labor requirement for producing intermediate inputs in country $j \in J$ be proportional to $(T_j^s)^{-1/\theta^s}$, and the unit labor requirement for producing final goods in country $k \in J$ be proportional to $(T_k^a)^{-1/\theta^a}$.

5. Every assembly plant may: a) source inputs from all countries within the firm's sourcing strategy, with each plant sourcing each input from the cheapest location; and b) sell to all markets, with each final-good produced in the most cost-effective country to satisfy worldwide demand.

6. Production and consumption take place.

4.3 Firm Behavior for Fixed Assembly and Sourcing Strategies

In this section, we describe optimal firm behavior and the industry equilibrium for given assembly and sourcing strategies $\mathcal{K}_h(\varphi)$ and $\mathcal{J}_h(\varphi)$.

Consider a firm headquartered in country h with productivity φ that has incurred all necessary fixed costs for a given assembly strategy $\mathcal{K}_h(\varphi)$ and a given sourcing strategy $\mathcal{J}_h(\varphi)$. From the cost function in (8), it is clear that after learning the vector of unit labor requirements in each country $j \in \mathcal{J}_h(\varphi)$, the firm will source each input v from the country j that solves $\min_{j(v)\in\mathcal{J}_h(\varphi)} \left\{\tau^s_{jk(v)} a_{j(v)}(v,\varphi)\, w_{j(v)}\right\}$ for each of its assembly countries $k \in \mathcal{K}_h(\varphi)$. Notice that this property holds regardless of the particular realization of the firm-by-country specific assembly productivity shifter $z_k(\varphi,\omega)$.

Using the properties of the Fréchet distribution in (9), one can then show that each assembly plant will source a positive measure of intermediates from each country in the firm's sourcing strategy set $\mathcal{J}_h(\varphi)$. Furthermore, the share of intermediate input purchases sourced by an assembly plant in $k \in \mathcal{K}_h(\varphi)$ from any country j is simply given by

$$\chi_{hjk}(\varphi) = \frac{T^s_j \left(\tau^s_{jk} w_j\right)^{-\theta^s}}{\Theta_{hk}(\varphi)} \quad \text{if } j \in \mathcal{J}_h(\varphi) \tag{11}$$

and $\chi_{hjk}(\varphi) = 0$ otherwise, where

$$\Theta_{hk}(\varphi) \equiv \sum_{j'\in\mathcal{J}_h(\varphi)} T^s_{j'} \left(\tau^s_{j'k} w_{j'}\right)^{-\theta^s}. \tag{12}$$

The term $\Theta_{hk}(\varphi)$ summarizes the *sourcing capability* of an assembly plant located in country k producing goods for a firm φ headquartered in country h. Note that, in equation (11), each sourcing country j's market share in country k's assembly plant input purchases corresponds to this sourcing country's contribution to its sourcing capability $\Theta_{hk}(\varphi)$. Countries in the set $\mathcal{J}_h(\varphi)$ with lower wages w_j, or more advanced input technologies T^s_j, will have higher market shares across all of the firm's assembly plants. By contrast, input trade costs τ^s_{jk} vary bilaterally across countries, for example due to proximity between a particular source country and assembly plant. As a result, the share of inputs from country j for an assembly plant in k will be higher relative to the sourcing share for other plants within the same firm when bilateral costs to source inputs from j to k are lower. We refer to the term $T^s_j \left(\tau^s_{jk} w_j\right)^{-\theta^s}$ as the *sourcing potential* of country j from the point of view of assembly plants in k.

After each assembly plant chooses the lowest-cost country for each input, as well as the share of inputs from each country, the marginal cost to assemble in country k, for firm φ, based in h can be expressed as

$$c_{hk}\left(\varphi,\omega\right)=\frac{1}{\varphi}\frac{1}{z_{k}\left(\varphi,\omega\right)}\left(w_{k}\right)^{1-\alpha}\left(\lambda\Theta_{hk}\left(\varphi\right)\right)^{-\alpha/\theta^{s}}, \tag{13}$$

where $\lambda=\left[\Gamma\left(\frac{\theta^{s}+1-\rho}{\theta^{s}}\right)\right]^{\theta^{s}/(1-\rho)}$ and Γ is the gamma function.[26] To ensure a well-defined marginal cost index, we assume that $\theta^{s}>\rho-1$ (Technical Assumption 1). Apart from satisfying this restriction, the value of ρ does not matter for any outcomes of interest.

We now consider the firm's choice of the optimal assembly plant from which to ship each final-good variety to a given destination i. Because the firm has already incurred all requisite fixed costs, this choice amounts to solving: $\min_{k(\omega)\in\mathcal{K}_{h}(\varphi)}\left\{\tau^{a}_{k(\omega)i}c_{hk(\omega)}\left(\varphi,\omega\right)\right\}$ for each variety ω. Using the properties of the Fréchet distribution, firm φ's share of sales in market i originating from assembly plants in country k is given by:

$$\mu_{hki}=\frac{T^{a}_{k}\left(\tau^{a}_{ki}\right)^{-\theta^{a}}\left(w_{k}\right)^{-(1-\alpha)\theta^{a}}\left(\Theta_{hk}\left(\varphi\right)\right)^{\alpha\theta^{a}/\theta^{s}}}{\Psi_{hi}}, \tag{14}$$

with

$$\Psi_{hi}\left(\varphi\right)=\sum_{k'\in\mathcal{K}_{h}(\varphi)}T^{a}_{k'}\left(\tau^{a}_{k'i}\right)^{-\theta^{a}}\left(w_{k'}\right)^{-(1-\alpha)\theta^{a}}\left(\Theta_{hk'}\left(\varphi\right)\right)^{\alpha\theta^{a}/\theta^{s}}. \tag{15}$$

We refer to the term $T^{a}_{k}\left(\tau^{a}_{ki}\right)^{-\theta^{a}}\left(w_{k}\right)^{-(1-\alpha)\theta^{a}}$ as the *assembly potential* of country k when selling to country i, and to the term $\Psi_{hi}\left(\varphi\right)$ in equation (15) as the *global production capability* of a firm φ headquartered in country h when selling in i.

This global production capability is a sufficient statistic for the price index at which firm φ based in h sells its unit measure of varieties in market i, as defined in equation (5). In particular, a cumbersome set of derivations demonstrate that this price index is given by:

$$p_{hi}\left(\varphi\right)=\frac{\sigma_{w}}{\sigma_{w}-1}\frac{1}{\varphi}\left(\zeta\Psi_{hi}\left(\varphi\right)\right)^{-1/\theta^{a}}, \tag{16}$$

where $\zeta=\left[\Gamma\left(\frac{\theta^{a}+1-\sigma}{\theta^{a}}\right)\right]^{\theta^{a}/(1-\sigma_{w})}$ and Γ is again the gamma function. This formula illustrates that the benefits a firm obtains from building a global production capability, either by selecting into global sourcing or assembly from more countries is crucially shaped by the potential productivity gains in assembly from producing in more countries: a lower θ^{a} translates to greater productivity dispersion across countries and reduces the firm-level price index a greater amount. To ensure a well-defined price index, we need to assume that $\sigma_{w}-1<\theta^{a}$ (see Technical Assumption 2).

Finally, we can express the firm's profits conditional on a sourcing strategy $\mathcal{J}_{h}\left(\varphi\right)$ and an assembly strategy $\mathcal{K}_{h}\left(\varphi\right)$ as

$$\pi_{h}\left(\varphi,\mathcal{J}_{h}\left(\varphi\right),\mathcal{K}_{h}\left(\varphi\right)\right)=\kappa\varphi^{\sigma-1}\sum_{i\in J}\left(\Psi_{hi}\left(\varphi\right)\right)^{(\sigma-1)/\theta^{a}}E_{i}P_{i}^{\sigma-1}-w_{h}\sum_{j\in\mathcal{J}_{h}(\varphi)}f^{s}_{hj}-w_{h}\sum_{k\in\mathcal{K}_{h}(\varphi)}f^{a}_{hk}-w_{h}f^{g}_{h}, \tag{17}$$

where κ is a constant, P_{i} is the standard ideal price index associated with (3) and defined in (6), and

[26] These derivations are analogous to those performed by Eaton and Kortum (2002) to solve for the aggregate price index in their model.

E_i is aggregate spending on manufactured goods in country i. As is clear from equation (17), how the global production capability $\Psi_{hi}(\varphi)$ shapes operating profits depends crucially on the exponent $(\sigma-1)/\theta^a$, a key feature on which we elaborate below.

In the derivations above, we assume that the firm has incurred the fixed cost f_h^g of becoming global, so that its global sourcing and assembly strategies are not trivially $\mathcal{K}_h(\varphi) = \mathcal{J}_h(\varphi) = \{h\}$. When the firm decides not to "go global", its profits above reduce to

$$\pi_h(\varphi, \{h\}, \{h\}) = \kappa\varphi^{\sigma-1}\left((T_h^a)^{1/\theta^a}(T_h^s)^{\alpha/\theta^s}(\tau_{hh}^a)^{-1}(\tau_{hh}^s)^{-\alpha}(w_h)^{-(1-\alpha)}\right)^{\sigma-1} E_h P_h^{\sigma-1} - w_h f_{hh}^s - w_h f_{hh}^a.$$

We assume that the fixed costs to produce and source domestically are small relative to the fixed costs of going global, such that $\pi_h(\tilde{\varphi}_h, \{h\}, \{h\}) = 0$ implicitly defines the productivity of the least productive active firm in country h. Firms with productivity $\varphi < \tilde{\varphi}_h$ cannot profitably carry out any strategy and thus exit upon observing their productivity level.

4.4 Intensive Margin Analysis: Complementarities and Cannibalization Effects

We now analyze how firms' bilateral final-good and intermediate-input flows are shaped by key parameters of the model when holding firms' global sourcing and assembly strategies fixed. This analysis is particularly relevant for understanding the potential effects of changes to tariffs and other trade costs in the short- and medium-run, when firms are less likely to adjust their assembly plant and sourcing locations.

We first analyze firms' final-good sales across markets. Given CES preferences in equation (3), it is well understood that final-good sales of firm φ (based in h) to market i are proportional to the operating profits of selling in that market. From equation (17) we therefore have that total final-good sales of firm φ are

$$S_{hi}(\varphi) = \tilde{\kappa}\varphi^{\sigma-1}\sum_{i\in J}(\Psi_{hi}(\varphi))^{(\sigma-1)/\theta^a} E_i P_i^{\sigma-1}, \tag{18}$$

where $\tilde{\kappa}$ is a constant, and recall that $\Psi_{hi}(\varphi)$ is the global production capability of firm φ when selling in i. Since we established above that a share μ_{hki} – defined in equation (14) – of this firm's sales in country i originate in a plant located in k, sales of the firm's plants in k to market i are given by

$$S_{hki}(\varphi) = \tilde{\kappa}\varphi^{\sigma-1}T_k^a(w_k)^{-(1-\alpha)\theta^a}(\Theta_{hk}(\varphi))^{\alpha\theta^a/\theta^s}(\tau_{ki}^a)^{-\theta^a}(\Psi_{hi}(\varphi))^{\frac{(\sigma-1)}{\theta^a}-1} E_i P_i^{\sigma-1}, \tag{19}$$

where remember that $\Theta_{hk}(\varphi)$ is the sourcing capability of that assembly plant.

We can now prove the following result:

Proposition 1. Holding constant the market demand level $E_i P_i^{\sigma-1}$ and a firm's global sourcing $\mathcal{J}_h(\varphi)$ and global assembly $\mathcal{K}_h(\varphi)$ strategies, an increase in plant k's assembly capability, due either to increased assembly potential $T_k^a(\tau_{ki}^a)^{-\theta^a}(w_k)^{-(1-\alpha)\theta^a}$ or decreased bilateral input trade costs τ_{jk}^s (for any j):

i) increases sales $S_{hki}(\varphi)$ of plants based in k to country i;

ii) increases sales $S_{hk'i}(\varphi)$ of plants based in $k' \neq k$ to country i if $(\sigma - 1)/\theta^a > 1$, and reduces them if $(\sigma - 1)/\theta^a < 1$.

Proof: See Appendix A.

Proposition 1 states that the effect of increased profitability of an assembly plant in k (driven by improvements in its assembly potential or reductions in its bilateral sourcing costs) on sales of the firm's assembly plants in other countries depends on the elasticity of demand (σ) and the dispersion of assembly productivities across countries (θ^a). When $\sigma - 1 < \theta^a$, consumers are not as sensitive to price reductions and productivity gains from assembling across countries are relatively small, such that the model delivers cannibalization effects: an increase in productivity for a plant in k increases its sales at the expense of sales by the firm's plants in other countries. Conversely, when $\sigma - 1 > \theta^a$, the productivity gains from assembling across countries is high and consumers respond more to the corresponding reductions in price, such that increased efficiency in one assembly country leads to more sales by the firm's plants in other countries (holding market demand constant).

As an example, consider the recent US-China trade war, and in particular the unilateral increases in US tariffs on Chinese imported inputs (Bown and Zhang, 2019). Proposition 1, part i) implies that these input tariff hikes would decrease sales and exports by firms' US establishments for firms that source inputs from China. Part ii) of Proposition 1 further implies that these unilateral tariff increases would affect foreign affiliate sales by US MNEs importing from China. If demand is inelastic and productivity dispersion across plants is relatively low ($\sigma - 1 < \theta^a$), these MNEs' foreign affiliate sales would increase as they substitute falling US sales towards their affiliates. Alternatively, the tariffs increases would decrease those MNEs' foreign affiliate sales if demand were sufficiently elastic and productivity dispersion were high. Bilateral trade costs between the firm's affiliates and its export markets also play a key role in these intensive-margin responses, with assembly countries that are more proximate to the US plants affected relatively more.

We next study how intermediate-input flows are shaped by trade costs, productivity dispersion, and the elasticity of demand. We first note that given the assumption of Cobb-Douglas production technology in (13), total intermediate-input purchases of a plant are a constant share of the plant's total sales $S_{hk}(\varphi)$ in equation (19). Furthermore, imports from each country j correspond to a share $\chi_{hjk}(\varphi)$ in equation (11) of the firm's input purchases, and are thus given by:

$$M_{hkj}(\varphi) = \widehat{\kappa}\varphi^{\sigma-1} T_k^a (w_k)^{-(1-\alpha)\theta^a} T_j^s \left(\tau_{jk}^s w_j\right)^{-\theta^s} \left(\Theta_{hk}(\varphi)\right)^{\frac{\alpha\theta^a}{\theta^s}-1} \sum_{i\in J} \left(\tau_{ki}^a\right)^{-\theta^a} \left(\Psi_{hi}(\varphi)\right)^{\frac{(\sigma-1)}{\theta^a}-1} E_i P_i^{\sigma-1}. \tag{20}$$

Two results follow from this expression. First, it is an immediate corollary of Proposition 1 that the complementarities or cannibalization effects associated with changes in assembly potential identified in that Proposition carry over to the input purchases of those plants. More formally,

Proposition 2. Holding constant the market demand level $E_i P_i^{\sigma-1}$ and a firm's global sourcing $\mathcal{J}_h(\varphi)$ and global assembly $\mathcal{K}_h(\varphi)$ strategies, an increase in assembly potential $T_k^a \left(\tau_{ki}^a\right)^{-\theta^a} (w_k)^{-(1-\alpha)\theta^a}$ for plants in k:

i) increases input purchases $M_{hkj}(\varphi)$ from all countries in the firm's sourcing strategy $j \in \mathcal{J}_h(\varphi)$ by plants based in k ;

ii) increases input purchases $M_{hk'j}(\varphi)$ from all countries in the firm's sourcing strategy $j \in \mathcal{J}_h(\varphi)$ for plants based in $k' \neq k$ if $(\sigma - 1)/\theta^a > 1$, and reduces them if $(\sigma - 1)/\theta^a < 1$.

Proof: See Appendix A.

Proposition 2 implies that increases in productivity for a firm's assembly plants in a particular country k will necessarily increase the firm's imports in k from all the countries in its global sourcing strategy. Part ii) of the Proposition further implies that these changes will affect imports by the firm's production plants in all other countries in which it is active. In the complementary case in which scale effects dominate ($(\sigma - 1)/\theta^a > 1$), all of the firm's assembly plants in other countries will also increase their imports. By contrast, if substitution effects dominate ($(\sigma - 1)/\theta^a < 1$), the firm's plants in other countries will reduce their imports.

Finally, we characterize the impact of changes in input trade costs on bilateral input purchases. This analysis is more complicated than studying changes in assembly potentials because it is shaped by interdependencies in both final-good sales across assembly plants and in importing across source countries. We are nevertheless able to prove the following result:

Proposition 3. Holding constant the market demand level $E_i P_i^{\sigma-1}$ and a firm's global sourcing $\mathcal{J}_h(\varphi)$ and global assembly $\mathcal{K}_h(\varphi)$ strategies, a decrease in a bilateral input-trade cost τ_{jk}^s:

i) increases input purchases $M_{hkj}(\varphi)$ from country j by plants based in k;

ii) increases input purchases $M_{hkj'}(\varphi)$ from all other countries in the firm's sourcing strategy $j' \in \mathcal{J}_h(\varphi)$ by plants based in k if $\sigma - 1 \geqslant \theta^a > \theta^s/\alpha$, and reduces them if $\sigma - 1 < \theta^a < \theta^s/\alpha$.

Proof: See Appendix A.

This result is related to Proposition 3 in Antràs, Fort and Tintelnot (2017). Intuitively, when demand is sufficiently elastic (i.e., σ is high enough) and the strength of comparative advantage in the intermediate-good sector across countries is sufficiently high (i.e., θ^s is low), the scale effect induced by the reduction in the sourcing cost τ_{jk}^s dominates the direct substitution effect related to market shares shifting towards the sourcing location whose cost of sourcing has been reduced. As a result, the reduction in τ_{jk}^s increases sourcing not only from country j, but also from all other countries in the firm's sourcing strategy. Conversely, when $\sigma - 1 < \theta^a < \theta^s/\alpha$, the reduction in τ_{jk}^s reduces sourcing from other sources. A small departure from the result in Antràs, Fort and Tintelnot (2017) is that whether input sources are complements or substitutes depends not only on the relative sizes of $\sigma - 1$ and θ^s/α, but also on the relative sizes of $\sigma - 1$ and θ^a, because the ratio $(\sigma - 1)/\theta^a$ is a key determinant of the plant-level scale response to a change in marginal costs.

4.5 Industry Equilibrium

We conclude this section with a brief outline of the industry and general equilibrium of the model, again holding firms' global assembly $\mathcal{K}_h(\varphi) \subseteq J$ and global sourcing $\mathcal{J}_h(\varphi) \subseteq J$ strategies fixed. Once the firm problem is solved, the industry equilibrium conditions are straightforward to derive.

As mentioned before, we simplify matters by assuming that consumers spend a constant share (which we denote by η) of their income on manufacturing. The remaining share $1-\eta$ of income is spent on a perfectly competitive, non-manufacturing sector that competes for labor with manufacturing firms. Technology in that sector is linear in labor, and we assume that $1-\eta$ is large enough to guarantee that the wage rate w_h in each country h is pinned down by labor productivity in that sector. For simplicity, we also assume that this 'outside' sector's output is homogeneous, freely tradable across countries, and serves as a numéraire in the model. We thus can treat wages as exogenous in solving for the equilibrium in each country's manufacturing sector.

We next turn to describing the equilibrium in the manufacturing sector. Given our assumption that final-good producers only observe their productivity after paying the fixed cost of entry, we can use equation (17) to express the free-entry condition in manufacturing as

$$\int_{\tilde{\varphi}_h}^{\infty} \pi_h\left(\varphi, \mathcal{J}_h(\varphi), \mathcal{K}_h(\varphi)\right) dG_h(\varphi) = w_h f_{eh}. \tag{21}$$

In the lower bound of the integral, $\tilde{\varphi}_h$ denotes the productivity of the least productive active firm in country h. Because expected profits are zero, all income is wage income, so $E_h = \eta w_h L_h$, and equation (21) constitutes a system of J equations from which the manufacturing price indices P_h can be solved. This completes the description of the model for given assembly and sourcing strategies.

5 Optimal Sourcing and Assembly Strategies

In this section, we analyze the optimal sets of countries from which a firm sources inputs (i.e., its global sourcing strategy $\mathcal{J}_h(\varphi) \subseteq J$) and in which it locates final-good assembly plants (i.e., its global assembly strategy $\mathcal{K}_h(\varphi) \subseteq J$). We first show that the relationship between firms' extensive-margin assembly and sourcing decisions systematically depends on whether assembly plants are substitutes or complements. We then characterize extensive-margin decisions under 'pervasive complementarities,' in which both assembly and sourcing strategies are complements. Finally, we extend the model to include country-specific fixed costs to sell in each market, and to allow marginal costs to depend on assembly and sourcing countries' distance from the firm's headquarters.

5.1 The Problem and General Results

Each firm's optimal assembly and sourcing strategies are the solution of a combinatorial optimization problem in which it chooses two sets of locations to maximize profits $\pi_h(\varphi)$ in equation (17).[27] Plugging

[27] More formally, let $\pi_h(\varphi) : \{0,1\}^{2J} \to \mathbb{R}_+$ be a variable profit function defined over the boolean hypercube. Let $\mathcal{I} = (\mathcal{I}^a, \mathcal{I}^s) \in \{0,1\}^{2J}$ with $\mathcal{I}^a \in \{0,1\}^J$ and $\mathcal{I}^s \in \{0,1\}^J$. If the firm builds an assembly plant in location k then

in equations (12) and (15), and defining $\xi^a_{ki} = T^a_k \left(\tau^a_{ki}\right)^{-\theta^a} \left(w_k\right)^{-(1-\alpha)\theta^a}$ and $\xi^s_{jk} = T^s_j \left(\tau^s_{jk} w_j\right)^{-\theta^s}$ we can express this problem as

$$\begin{aligned}\max_{\substack{\mathcal{I}^a_k \in \{0,1\} \\ \mathcal{I}^s_j \in \{0,1\}}} \pi_h\left(\varphi, \mathcal{J}_h\left(\varphi\right), \mathcal{K}_h\left(\varphi\right)\right) &= \kappa \varphi^{\sigma-1} \sum_{i\in J} E_i P_i^{\sigma-1} \left(\sum_{k\in J} \mathcal{I}^a_k \cdot \xi^a_{ki} \left(\sum_{j\in J} \mathcal{I}^s_j \cdot \xi^s_{jk} \right)^{\frac{\alpha\theta^a}{\theta^s}} \right)^{\frac{(\sigma-1)}{\theta^a}} \\ &\quad - \sum_{j\in J} \mathcal{I}^s_j \cdot w_h f^s_{hj} - \sum_{k\in J} \mathcal{I}^a_k \cdot w_h f^a_{hk} - w_h f^g_h, \end{aligned} \tag{22}$$

where the indicator variables $\mathcal{I}^a_k$ (respectively, $\mathcal{I}^s_j$) take a value of 1 when $k \in \mathcal{K}_h\left(\varphi\right)$ (respectively, $j \in \mathcal{J}_h\left(\varphi\right)$), and 0 otherwise. The problem in (22) is an NP-complex combinatorial problem that is infeasible to solve computationally by brute force when the number of countries J is sufficiently large. A similar issue arises when studying the assembly and sourcing strategies separately, as in Antràs, Fort and Tintelnot (2017) and Tintelnot (2017), but the joint determination of these two strategies renders this problem even more formidable. This increased complexity arises because the monotone comparative statics techniques that can be applied in the frameworks of Antràs, Fort and Tintelnot (2017) and Tintelnot (2017) are much less powerful when these strategies are jointly determined.

To elucidate this more complex problem, we begin by identifying three key properties of the profit function in (22).

Lemma 1. The profit function $\pi_h\left(\varphi, \mathcal{J}_h\left(\varphi\right), \mathcal{K}_h\left(\varphi\right)\right)$ in (22) features:

i) increasing differences in $\left(\mathcal{I}^a_k, \mathcal{I}^a_{k'}\right)$ for $k, k' \in \{1, ..., J\}$ and $k \neq k'$ when $\sigma - 1 > \theta^a$, and decreasing differences in $\left(\mathcal{I}^a_k, \mathcal{I}^a_{k'}\right)$ for $k, k' \in \{1, ..., J\}$ and $k \neq k'$ when $\sigma - 1 < \theta^a$;

ii) increasing differences in $\left(\mathcal{I}^s_j, \mathcal{I}^s_{j'}\right)$ for $j, j' \in \{1, ..., J\}$ when $\sigma - 1 \geqslant \theta^a > \theta^s/\alpha$, and decreasing differences in $\left(\mathcal{I}^s_j, \mathcal{I}^s_{j'}\right)$ for $j, j' \in \{1, ..., J\}$ when $\sigma - 1 < \theta^a < \theta^s/\alpha$;

iii) increasing differences in $\left(\mathcal{I}^a_k, \mathcal{I}^s_j\right)$ for $k \in \{1, ..., J\}$ and $j \in \{1, ..., J\}$ when $\sigma - 1 \geqslant \theta^a$.

Proof: See Appendix A.

Part i) of Lemma 1 implies that adding an assembly plant in any given country k may increase or decrease the profitability of adding a plant in any other country k', depending on the relative sizes of $\sigma - 1$ and θ^a. This differs from Tintelnot (2017), who studies export platform FDI in the case without demand cannibalization or complementarity effects (i.e., $\sigma_\omega = \sigma$). Given Technical Assumption 1, his analysis therefore only encompasses cases in which $\sigma - 1 < \theta^a$, and thus assembly extensive margin decisions are necessarily substitutes. In the presence of demand complementarities ($\sigma_w < \sigma$), it is possible for $\sigma - 1 > \theta^a$, in which case assembly extensive-margin decisions are complements.

$\mathcal{I}^a_k = 1$ and $\mathcal{I}^a_k = 0$ otherwise; if the firm builds a sourcing plant in location j then $\mathcal{I}^s_j = 1$ and $\mathcal{I}^s_j = 0$ otherwise. The corresponding assembly and sourcing strategies are defined as $\mathcal{K}_h\left(\varphi\right) = \{k \in J : \mathcal{I}^a_k = 1\}$ and $\mathcal{J}_h\left(\varphi\right) = \left\{j \in J : \mathcal{I}^s_j = 1\right\}$, respectively.

Intuitively, the combination of the scale effect and demand complementarity effects are strong enough to counterbalance the natural substitutability emanating from different plants within a firm competing to serve the same set of consumers worldwide.

Part ii) of Lemma 1 is closely related to one of the main results in Antràs, Fort and Tintelnot (2017): it identifies a key condition under which the extensive margin of global sourcing features substitutability. When demand is relatively inelastic (low σ) or the intermediate input share (α) is low, firm scale is not particularly responsive to reductions in the variable costs of sourcing. Under these circumstances, adding a country to a firm's sourcing strategy necessarily decreases the marginal benefit of activating alternative source countries, particularly when the potential input-productivity gains are low (high θ^s).

A notable departure from the results in Antràs, Fort and Tintelnot (2017) is that the condition $\sigma - 1 > \theta^s/\alpha$ or $\sigma - 1 < \theta^s/\alpha$ is not sufficient to determine whether profits feature increasing or decreasing differences in firms' extensive margin sourcing decisions; it is also necessary for θ^a to fall between these two values. For instance, when final-good sales are substitutes across assembly locations ($\sigma - 1 < \theta^a$), the profit function in equation (22) will not necessarily feature increasing differences in the extensive margin of firm sourcing, even when $\sigma - 1 > \theta^s/\alpha$. Instead, extensive-margin sourcing decisions may feature decreasing differences in profits if there is sufficient heterogeneity in input-trade costs across assembly plants within the same firm, for example due to variation in their distances from input-source countries. In such a case, the addition of a new input-source country disproportionately lowers production costs for plants that use inputs from that country more intensively, leading them to cannibalize sales from the firm's other plants. This potential for cannibalization across assembly locations may in turn reduce the marginal benefit of sourcing from countries that are proximate to the assembly locations for which revenues shrink. As a result, even when the extensive margins of assembly locations are fixed, the addition of one sourcing location has the potential to reduce the marginal benefit of adding another sourcing location.

For similar reasons, even though scale effects and the complementarity between inputs and assembly in technology suggest the existence of complementarities in the global assembly and global sourcing strategies of firms, part iii) of Lemma 1 indicates that for the profit function $\pi_h(\varphi)$ in (22) to feature complementarity between the firm's extensive-margin sourcing and assembly decisions *in all cases* (i.e., increasing differences in $\left(\mathcal{I}_k^a, \mathcal{I}_j^s\right)$ for $k, j \in \{1, ..., J\}$), assembly countries must be complements (i.e., $\sigma - 1 \geqslant \theta^a$). When assembly decisions are substitutes ($\sigma - 1 < \theta^a$), the marginal benefit of activating certain input countries may be diminished by activating certain assembly locations. Furthermore, even when pairs of assembly locations and pairs of sourcing locations are substitutes (i.e., $\sigma - 1 < \theta^a < \theta^s/\alpha$), pairs of assembly and sourcing locations may prove to be complements, due to the scale effects that arise from the marginal-cost reductions from importing inputs.

The fact that the profit function in (22) features various sources of complementarity and substitutability between the extensive margins of sourcing and assembly limits the analytical characterization of these optimal firm strategies. Nevertheless, the fact that the profit function (17) is supermodular in φ and the sum $\sum_{i \in J} \left(\Psi_{hi}(\varphi)\right)^{(\sigma-1)/\theta^a} E_i P_i^{\sigma-1}$ implies that:

Proposition 4. The optimal assembly and sourcing strategies that solve problem (22) imply that the vector of a firm's global production capabilities is such that $\sum_{i\in J}(\Psi_{hi}(\varphi))^{(\sigma-1)/\theta^a} E_i P_i^{\sigma-1}$ is nondecreasing in φ.

Proof: See Appendix A.

Proposition 4 states that firms with higher initial productivity draws will choose global strategies with weakly greater global assembly and sourcing capabilities. These greater capabilities imply that initial firm-productivity differences will be magnified in a world in which global assembly and sourcing are possible. An immediate corollary of this result is that the marginal benefit of paying the fixed cost $w_h f_h^g$ of 'going global' is necessarily higher for more productive firms, which implies that:

Proposition 5. There exists a threshold productivity φ_h^*, such that only firms headquartered in h with $\varphi > \varphi_h^*$ find it optimal to become global firms.

Proof: See Appendix A.

In sum, although characterizing the specific global sourcing and assembly strategies of firms and how they correlate with productivity φ is complicated, our model necessarily features selection into exporting and FDI of the type produced by the canonical frameworks in Melitz (2003), Antràs and Helpman (2004), and Helpman, Melitz and Yeaple (2004). While our empirical evidence in Section 2 suggests that firms with higher core productivity φ both source inputs from, and locate assembly plants in, more countries, our model produces these results only when imposing additional parametric restrictions. In the next section, we illustrate these patterns for a specific region of the parameter space.

We conclude this subsection by noting that beyond complicating the *characterization* of the extensive margins of global sourcing and global assembly, the coexistence of various sources of complementarity and substitutability also complicates the computation of these margins in quantitative analyses. Remember that the problem faced by the firm is a complex combinatorial optimization problem with $2^{J\times 2}$ possible choices, so it is infeasible to solve by brute force when the number of countries J is large. Furthermore, our framework does not generally feature the type of 'single-crossing' properties that typically rationalize the use of iterative algorithms to reduce the dimensionality of the problem of solving for the firm's extensive margin, as in Jia (2008), Antràs, Fort and Tintelnot (2017) or Arkolakis, Eckert and Shi (2021). In the next subsection, we develop a special case in which these algorithms could still be applied.

5.2 The Case with Pervasive Complementarities

In this subsection, we study firms' extensive margin global sourcing and global assembly decisions for the special case in which $\sigma - 1 \geqslant \theta^a > \theta^s/\alpha$, which we refer to as the case with *pervasive complementarities*. From Lemma 1, this case features increasing differences in the profit function for any two extensive-margin decisions, regardless of whether they entail the addition of an input-source country or a final-good production location. As a result, this case differs from the majority of papers in the literature on export-platform FDI, which generally focus on the case in which assembly decisions are substitutes (i.e., $\sigma - 1 < \theta^a$).[28].

In such a case, we can establish the following result:

Proposition 6. Whenever $\sigma - 1 \geqslant \theta^a \geqslant \theta^s/\alpha$, we necessarily have that $\mathcal{J}_h(\varphi_L) \subseteq \mathcal{J}_h(\varphi_H)$ and $\mathcal{K}_h(\varphi_L) \subseteq \mathcal{K}_h(\varphi_H)$ for $\varphi_H \geqslant \varphi_L$, where $\mathcal{J}_h(\varphi) = \left\{ j : \mathcal{I}^s_{hj} = 1 \right\}$ and $\mathcal{K}_h(\varphi) = \left\{ k : \mathcal{I}^a_{hk}(\varphi) = 1 \right\}.$

Proof: See Appendix A.

Proposition 6 states that in the case with pervasive complementarities, our model delivers a strict hierarchical order in the extensive margins of global sourcing and global assembly. More productive firms source from the same countries and possibly from additional ones relative to less productive firms, and they also produce in the same countries as less productive firms, and possibly in additional ones. Obviously, this strict 'pecking order' in firms' extensive margins is violated in the data, but a weaker version of this prediction is that the number of input-source countries and final-good production locations are both increasing in firm productivity.

As in Antràs, Fort and Tintelnot (2017), the presence of (pervasive) complementarities in the extensive margin would also be helpful for computational purposes when estimating the model, as it enables the use of iterative algorithms with the potential to decrease the dimensionality of the firm problem dramatically, even when the fixed costs of sourcing and assembly are heterogeneous across firms. To illustrate the computational implications, consider the following result:

Proposition 7. Define the mappings (i) $V_{h,j}(\varphi, \mathcal{J}, \mathcal{K})$ to take a value of one whenever including country j in the sourcing strategy $\mathcal{J}$ raises firm-level profits $\pi_h(\varphi, \mathcal{J}, \mathcal{K})$, and to take a value of zero otherwise, and (ii) $V_{h,k}(\varphi, \mathcal{J}, \mathcal{K})$ to take a value of one whenever including country k in the assembly strategy $\mathcal{K}$ raises firm-level profits $\pi_h(\varphi, \mathcal{J}, \mathcal{K})$, and to take a value of zero otherwise. Then, whenever $\sigma - 1 \geqslant \theta^a > \theta^s/\alpha$, $V_{h,j}(\varphi, \mathcal{J}', \mathcal{K}) \geqslant V_{h,j}(\varphi, \mathcal{J}, \mathcal{K})$ for $\mathcal{J} \subseteq \mathcal{J}'$ and $V_{h,k}(\varphi, \mathcal{J}, \mathcal{K}') \geqslant V_{h,k}(\varphi, \mathcal{J}, \mathcal{K})$ for $\mathcal{K} \subseteq \mathcal{K}'$.

Proof: See Appendix A.

We demonstrate the usefulness of this result with an example. Suppose that one is trying to assess whether a given country j belongs in the firm's optimal sourcing strategy $\mathcal{J}_h(\varphi)$. Without guidance from the theory, one would need to compute all $2^{J\times 2}$ possible candidate combinations of sourcing and assembly strategies to answer that question. Proposition 7 implies, however, that if for country j, $V_{h,j}(\varphi, j, \varnothing) = 1$ (so the initial sets $\mathcal{J}$ and $\mathcal{K}$ are the null sets and adding j as a input-source country raises profits), then j is necessarily in $\mathcal{J}_h(\varphi)$, while if $V_{i,j}(\varphi, \mathcal{J}) = 0$ when $\mathcal{J}$ includes all countries except for j and $\mathcal{K}$ includes all countries, then j cannot possibly be in $\mathcal{J}_h(\varphi)$. Following Jia (2008), Antràs, Fort and Tintelnot (2017) or Arkolakis, Eckert and Shi (2021), it is then straightforward to

[28] A few recent papers consider environments with either independence or increasing differences in these strategies (Bernard et al., 2018; Arkolakis et al., 2021; Garetto et al., 2019)

implement an iterative application of the V-operator that gradually tightens both the lower bound (i.e., the set of surely activated locations of sourcing and assembly) and the upper bound (i.e., the set of surely discarded locations for sourcing or for assembly) of the firm's sourcing and assembly strategies, thereby reducing the set of combinations that one needs to evaluate by brute force.

5.3 Extensions: The Extensive Margin of Exports and Headquarter Gravity

In our baseline model, we assume that when firms headquartered in country h pay a unique fixed cost $w_h f_h^g$ to 'go global', they can market their goods in *all* countries. In this section, we relax this assumption by introducing destination-specific marketing costs. Firms headquartered in h must now pay a fixed cost $w_h f_{hi}^x$ to to sell their goods in country i. We use the superscript x to capture our assumption that this country-specific fixed cost allows the firm to export to country i from *all* its assembly plants (though note that when $k = i$, the fixed cost allows the firm to sell to local consumers). We denote the optimal set of countries $i \in J$ for which a firm headquartered in h with productivity φ has paid the associated fixed cost of marketing $(w_h f_{hi}^x)$ by $\Upsilon_h(\varphi) \subseteq J$, and refer to it as the firm's *global marketing strategy*. As in our baseline model, we assume that the firm chooses its global assembly, sourcing, and marketing strategies simultaneously (see the timing of events below).

Another simplifying assumption in our baseline model is the lack of any direct dependence of the cost function in (8) on the country h in which the headquarters are located. In practice, the productivity of both suppliers in country j and assemblers in k may be affected by their distance from the headquarter country h, perhaps reflecting the presence of communication or coordination costs. To capture this headquarter gravity (see, Wang, 2019), we now assume that intermediate-input and assembly productivities are drawn from the following Fréchet distributions:

$$\Pr(a_{hj}(v,\varphi) \geqslant a) = e^{-T_j^s\left(a/\gamma_{hj}^s\right)^{\theta^s}}, \quad \text{with } T_j^s > 0,\ \gamma_{jk}^s > 1; \tag{23}$$

$$\Pr(1/z_{hk}(\varphi,\omega) \geqslant a) = e^{-T_k^a\left(a/\gamma_{hk}^a\right)^{\theta^a}}, \quad \text{with } T_k^a > 0,\ \gamma_{hk}^a > 1. \tag{24}$$

The terms γ_{hj}^d and γ_{hk}^a capture iceberg productivity losses from separating the firm's input or final-good production from its headquarters. We normalize $\gamma_{hh}^s = \gamma_{hh}^a = 1$.

The timing of events in this extended version of the model is as follows:

1. Firms worldwide decide whether to pay a fixed cost $w_h f_h^e$ to set up headquarters in any country $h \in J$.

2. Upon observing their realized core productivity level φ, firms decide whether to exit or pay additional fixed costs to procure inputs, produce final-goods, and market them.

3. Global firms decide on their marketing strategy $\Upsilon_h(\varphi)$, their assembly strategy $\mathcal{K}_h(\varphi)$, and their sourcing strategy $\mathcal{J}_h(\varphi)$, paying the associated fixed costs $w_h f_{hi}^x$, $w_h f_{hk}^a$, and $w_h f_{hj}^s$.

4. Firms observe the realization of the productivity levels $1/a_{hj}(v,\varphi)$ and $z_{hk}(\omega,\varphi)$ for all $j \in \mathcal{J}_h(\varphi)$ and all $k \in \mathcal{K}_h(\varphi)$.

5. Every assembly plant may: a) source inputs from all countries within the firm's sourcing strategy, with each plant sourcing each input from the cheapest location; and b) sell to all markets $i \in \Upsilon_h(\varphi)$, with each final-good produced in the most cost-effective country to satisfy worldwide demand.

6. Production and consumption take place.

This extended version of the model can be solved following the same steps in our baseline model. Analogously to equations (20) and (19), bilateral input purchases and final-good sales, when positive, are given by

$$M_{hkj}(\varphi) = \widehat{\kappa}\varphi^{\sigma-1}T_k^a(w_k)^{-(1-\alpha)\theta^a} T_j^s\left(\gamma_{hj}^s\tau_{jk}^s w_j\right)^{-\theta^s}(\Theta_{hk}(\varphi))^{\frac{\alpha\theta^a}{\theta^s}-1}\sum_{i\in J}\left(\gamma_{hk}^a\tau_{ki}^a\right)^{-\theta^a}(\Psi_{hi}(\varphi))^{\frac{(\sigma-1)}{\theta^a}-1}E_iP_i^{\sigma-1} \quad (25)$$

and

$$S_{hki}(\varphi) = \widetilde{\kappa}\varphi^{\sigma-1}T_k^a\left(\gamma_{hk}^a\tau_{ki}^a\right)^{-\theta^a}(w_k)^{-(1-\alpha)\theta^a}(\Theta_{hk}(\varphi))^{\alpha\theta^a/\theta^s}(\Psi_{hi}(\varphi))^{\frac{(\sigma-1)}{\theta^a}-1}E_iP_i^{\sigma-1}, \quad (26)$$

respectively, with $\Theta_{hk}(\varphi)$ and $\Psi_{hi}(\varphi)$ as defined in (12) and (15), but with $\gamma_{hj'}^s\tau_{j'k}^s$ replacing $\tau_{j'k}^s$, and $\gamma_{hk'}^a\tau_{k'i}^a$ replacing $\tau_{k'i}^a$ in those expressions. Naturally, the intensive-margin results in Propositions 1, 2 and 3 continue to hold in the presence of headquarter gravity forces. In Section 6, we highlight the novel implications from introducing γ_{hj}^s and γ_{hk}^a in equations (25) and (26), and discuss how those implications relate to the descriptive evidence in Sections 2 and 3.

Moving to the determination of the extensive margin of exports, imports and assembly, the problem in (22) now becomes:

$$\max_{\substack{\mathcal{I}_i^x\in\{0,1\}\\ \mathcal{I}_k^a\in\{0,1\}\\ \mathcal{I}_j^s\in\{0,1\}}} \pi_h(\varphi,\Upsilon_h(\varphi),\mathcal{J}_h(\varphi),\mathcal{K}_h(\varphi)) = \kappa\varphi^{\sigma-1}\sum_{i\in J}\mathcal{I}_i^x\cdot E_iP_i^{\sigma-1}\left(\sum_{k\in J}\mathcal{I}_k^a\cdot\xi_{ki}^a\left(\sum_{j\in J}\mathcal{I}_j^s\cdot\xi_{jk}^s\right)^{\frac{\alpha\theta^a}{\theta^s}}\right)^{\frac{(\sigma-1)}{\theta^a}}$$
$$-\sum_{i\in J}\mathcal{I}_i^x\cdot w_hf_{hi}^x-\sum_{j\in J}\mathcal{I}_j^s\cdot w_hf_{hj}^s-\sum_{k\in J}\mathcal{I}_k^a\cdot w_hf_{hk}^a-w_hf_h^g.$$

Despite the addition of an active extensive margin of exporting, it is straightforward to show that the patterns of complementarity and substitutability summarized in Lemma 1 continue to apply. The main novel implications from this richer setting arises from the fact that:

Lemma 2. The profit function $\pi_h(\varphi,\Upsilon_h(\varphi),\mathcal{J}_h(\varphi),\mathcal{K}_h(\varphi))$ features increasing differences in $(\mathcal{I}_i^x,\mathcal{I}_k^a)$ for any $i,k\in\{1,...,J\}$ and also in $\left(\mathcal{I}_i^x,\mathcal{I}_j^s\right)$ for any $i,j\in\{1,...,J\}$.

Proof: See Appendix A.

Lemma 2 states that, regardless of parameter values, the activation of an assembly location k or a sourcing location j will always increase the marginal benefit of activating any destination of final goods i. Similarly, the activation of a destination market i will always increase the marginal benefit of activating an assembly location k or a sourcing location j. An immediate corollary of this result is that Proposition 4 continues to hold with an active margin of exporting.

While it may seem that Lemma 2 further implies that more productive firms necessarily select into marketing their goods in more markets, this prediction may not hold in the presence of substitutabilities across assembly locations or across sourcing locations. For the special case with *pervasive complementarities* ($\sigma - 1 \geqslant \theta^a > \theta^s/\alpha$), however, we can conclude that:

Proposition 8. Whenever $\sigma - 1 \geqslant \theta^a \geqslant \theta^s/\alpha$, we necessarily have that $\Upsilon_h(\varphi_L) \subseteq \Upsilon_h(\varphi_H)$, $\mathcal{J}_h(\varphi_L) \subseteq \mathcal{J}_h(\varphi_H)$ and $\mathcal{K}_h(\varphi_L) \subseteq \mathcal{K}_h(\varphi_H)$ for $\varphi_H \geqslant \varphi_L$, where $\Upsilon_h(\varphi) = \{i : \mathcal{I}^x_{hi} = 1\}$, $\mathcal{J}_h(\varphi) = \left\{j : \mathcal{I}^s_{hj} = 1\right\}$ and $\mathcal{K}_h(\varphi) = \{k : \mathcal{I}^a_{hk}(\varphi) = 1\}$.

Proof: See Appendix A.

In the case with pervasive complementarities, Proposition 8 states that our extended model delivers a strict hierarchical order in the extensive margin of exporting, global sourcing, and global assembly. This hierarchy implies that even with firm-level heterogeneity in fixed costs, more productive firms will, on average, sell in more markets, assemble final goods in more locations, and source inputs from more countries. Similarly, with pervasive complementarities, a result analogous to Proposition 7 can also be derived, which opens the door for the implementation of iterative algorithms of the type in Jia (2008), Antràs et al. (2017) or Arkolakis et al. (2021) to estimate the model.

6 Implications of Assembly-Sourcing Complementarity

In this section, we highlight the novel interdependencies between firms' FDI and input-sourcing decisions that arise in our framework. While prior work features interdependencies across countries in firms' FDI patterns (Tintelnot, 2017) or import decisions (Antràs et al., 2017), this paper is one of the first to study the interactions between firms' joint decisions to engage in FDI and source inputs in a multi-country setting.

We first discuss how the ensuing interdependence in these choices can rationalize the descriptive evidence in Sections 2 and 3, focusing on those patterns that are not explained by most existing models. We then present two simple cases to highlight how the potential policy implications of tariff changes differ when firms undertake assembly and sourcing decisions jointly.

6.1 Assembly-Sourcing Complementarity in the Extensive Margin

To isolate the new forces in our paper, we study a firm's decision to add an input-source country to its sourcing strategy for the special case in which the firm's extensive margin of assembly is independent across countries, and similarly, its extensive margin of sourcing is also independent across countries. In the model, this corresponds to the case in which $\sigma - 1 = \theta^a = \theta^s/\alpha$. Using equation (22), these parameters lead to *operating* profits for firm φ based in h equal to

$$\pi_h^{op}(\varphi) = \kappa\varphi^{\sigma-1} \sum_{i\in\Upsilon_h(\varphi)} E_i P_i^{\sigma-1} \sum_{k\in\mathcal{K}_h(\varphi)} T_k^a \left(\gamma_{hk}^a \tau_{ki}^a\right)^{-\theta^a} (w_k)^{-(1-\alpha)\theta^a} \sum_{j\in\mathcal{J}_h(\varphi)} T_j^s \left(\gamma_{hj}^s \tau_{jk}^s w_j\right)^{-\theta^s}. \quad (27)$$

Given these operating profits, the firm finds the addition of country j' to its sourcing strategy $\mathcal{J}_h(\varphi)$ profitable whenever

$$\kappa\varphi^{\sigma-1} \sum_{i\in\Upsilon_h(\varphi)} E_i P_i^{\sigma-1} \sum_{k\in\mathcal{K}_h(\varphi)} T_k^a \left(\gamma_{hk}^a \tau_{ki}^a\right)^{-\theta^a} (w_k)^{-(1-\alpha)\theta^a} T_{j'}^s \left(\gamma_{hj'}^s \tau_{j'k}^s w_{j'}\right)^{-\theta^s} > w_h f_{hj'}^s, \quad (28)$$

where the right-hand side is the fixed cost of activating that input-source country j'. Clearly, this decision is shaped by both the sourcing potential $T_{j'}^s \left(\gamma_{hj'}^s \tau_{j'k}^s w_{j'}\right)^{-\theta^s}$ of location j' vis-à-vis all assembly locations $k \in \mathcal{K}_h(\varphi)$, as well as by the assembly potential $T_k^a \left(\gamma_{hk}^a \tau_{ki}^a\right)^{-\theta^a} (w_k)^{-(1-\alpha)\theta^a}$ of the firm's activated assembly locations. The marginal benefit of adding a high sourcing-potential country to its strategy is increasing in the firm's assembly capability. Firms with higher assembly capability, due either to more assembly locations or locations with better assembly potential, enjoy a larger benefit from adding a new sourcing location j'. Moreover, the relative benefits of adding an input-source country are higher when the bilateral trade costs between that country and the firm's existing assembly plants are low. The same logic applies to the firm's decision to add a new assembly location. Firms with greater sourcing capability will experience a larger benefit from adding a new assembly location, with the size of the benefit decreasing in the bilateral trade costs between the firm's current source countries and its new assembly location.

To illustrate the role of geography further – or trade costs more broadly – on this complementarity, we consider the special case in which $T_k^a (w_k)^{-(1-\alpha)\theta^a} = G^a$, $T_j^s (w_j)^{-\theta^s} = G^s$, so that variation in assembly and sourcing potentials is shaped only by trade and communication costs. In this case, inequality (28) reduces to

$$\kappa\varphi^{\sigma-1} G^a G^s \sum_{k\in\mathcal{K}_h(\varphi)} \sum_{i\in\Upsilon_h(\varphi)} E_i P_i^{\sigma-1} \left(\gamma_{hk}^a \tau_{ki}^a\right)^{-\theta^a} \left(\gamma_{hj'}^s \tau_{j'k}^s\right)^{-\theta^s} > w_h f_{hj'}^s. \quad (29)$$

Inequality (29) shows that whether an input source j' is activated depends on a market-access-weighted 'distance' of this source market j' from all the firm's assembly plants, and from the firm's headquarter country h. In this weighted distance, the term $E_i P_i^{\sigma-1} \left(\gamma_{hk}^a \tau_{ki}^a\right)^{-\theta^a}$ constitutes the market-access weights, and 'distance' is captured by the trade costs $\tau_{j'k}^s$ and the coordination costs $\gamma_{hj'}^s$. Put simply, inequality (28) indicates that adding an input-source country is particularly profitable when the firm's various assembly plants can import inputs from that country at relatively low costs.

The model thus predicts that bilateral trade costs between a firm's assembly and input-source countries influence the relative profitability of each location choice. This result rationalizes the positive, economically large, and statistically significant correlation between a firm's extensive-margin import decisions and its foreign-affiliate locations we document in Table 7. Those estimates indicate that US MNEs are more likely to import not only from countries in which they have affiliates, but also from other countries within the same region as their affiliates. In our framework, this correlation arises because the country-specific fixed cost to source inputs is incurred at the *firm* level, thereby granting every assembly plant within the firm the ability to source inputs from that country. Since each plant's benefit of importing inputs from a particular country j is decreasing in that plant's distance (or other trade costs) from j, a firm with an affiliate in a particular region is more likely to source inputs from proximate countries in that region. A US MNE with an affiliate in China is thus more likely to import inputs into the United States not only from China, but also from proximate countries with large sourcing potentials from the perspective of its Chinese assembly plant. This correlation in an MNE's extensive margin sourcing and affiliate locations is a strong feature of the US data, seems to be present in other countries' data (e.g. Conconi et al., 2022), yet is not predicted by canonical models of FDI that also consider input trade (e.g. Keller and Yeaple, 2013; Ramondo and Rodríguez-Clare, 2013).

The simple assumption in our model that the country-specific fixed costs to import inputs are incurred at the firm level, rather than the plant level, is a powerful source of firm-level scale economies magnified by globalization. To illustrate the key role of firm-level sourcing fixed costs in rationalizing the evidence in Section 3, we compare the the optimality condition captured in inequality (28) to one in which each individual assembly plant chooses its own sourcing strategy (e.g., as in Bernard et al., 2018). In that case, a given plant k adds location j' to its unique sourcing strategy $\mathcal{J}_{hk}(\varphi)$ whenever

$$\kappa\varphi^{\sigma-1}T_k^a\left(w_k\right)^{-(1-\alpha)\theta^a}T_{j'}^s\left(\gamma_{hj'}^s\tau_{j'k}^s w_{j'}\right)^{-\theta^s}\sum_{i\in\Upsilon_h(\varphi)}E_iP_i^{\sigma-1}\left(\gamma_{hk}^a\tau_{ki}^a\right)^{-\theta^a}>w_hf_{hj'}^s.$$

This expression still features complementarity between country j's sourcing potential and country k's assembly potential, but the locations of the firm's *other* assembly plants (except the headquarter country h when it has an assembly plant) are now irrelevant. Since the specifications in Table 7 hold the firm's headquarter country h fixed (the United States in our case) and the firm's assembly country k fixed (by including input-source country fixed effects), a model with plant-level fixed costs to source from particular countries predicts no correlation between a firm's extensive margins of domestic sourcing and foreign assembly. A US MNE with a Chinese foreign affiliate that sources from Vietnam is no more likely to have its US manufacturing plants import inputs from Vietnam than from any other country. By contrast, a firm-level fixed cost of sourcing from a particular country provides a strong rationale for the extensive-margin correlations we document in Table 7.[29]

6.2 Assembly-Sourcing-Exporting Complementarity in the Extensive Margin

The extended model with exporting fixed costs also provides new empirical implications that can rationalize the extensive-margin export results in Table 8. We demonstrate these implications by showing how a firm's decision to market its goods in a particular country i depends on its global sourcing and assembly strategies, continuing to focus on the same case of independence in a firm's extensive margin of sourcing and its extensive margin of assembly, as in subsection 6.1. Given equation

[29] A firm-level fixed cost to source from a particular country is also consistent with firm-level supply chain management operations, often undertaken at headquarters.

(27), a firm headquartered in country h with productivity φ finds it profitable to sell goods in country i whenever

$$\kappa\varphi^{\sigma-1}E_iP_i^{\sigma-1}\sum_{k\in\mathcal{K}_h(\varphi)}T_k^a\left(\gamma_{hk}^a\tau_{ki}^a\right)^{-\theta^a}\left(w_k\right)^{-(1-\alpha)\theta^a}\sum_{j\in\mathcal{J}_h(\varphi)}T_j^s\left(\gamma_{hj}^s\tau_{jk}^s w_j\right)^{-\theta^s}>w_hf_{hi}^x.$$

Destinations with larger (residual) market demand $E_iP_i^{\sigma-1}$, and those with lower bilateral trade costs with its assembly locations, are more likely to be in the firm's marketing strategy.

We further isolate the role of geography in a firm's decision to sell to country i by setting $T_k^a\left(w_k\right)^{-(1-\alpha)\theta^a}=G^a$, $T_j^s\left(w_j\right)^{-\theta^s}=G^s$, which reduces the benefit of marketing in country i to

$$\kappa\varphi^{\sigma-1}G^aG^sE_iP_i^{\sigma-1}\sum_{k\in\mathcal{K}_h(\varphi)}\sum_{j\in\mathcal{J}_h(\varphi)}\left(\gamma_{hk}^a\tau_{ki}^a\right)^{-\theta^a}\left(\gamma_{hj}^s\tau_{jk}^s\right)^{-\theta^s}>w_hf_{hi}^x.$$

The firm is more likely to export to destination i if it has more assembly plants, and especially if those assembly plants are close to the destination market i or the firm's headquarter country h.

These empirical predictions on firms' extensive-margin export decisions can account for the patterns we document in the extensive-margin results in Table 8. While canonical models of FDI often posit that exports versus FDI are alternative ways in which a firm can serve a particular market – thus implying they are substitutes – we find that US MNEs are *more* likely to export not only to countries in which they have affiliates, but also to other countries in the same region as their affiliates. Our assumption of a firm-level, fixed marketing cost that allows all plants in the firm to sell in that market implies this correlation. A firm with an affiliate in China is more likely to sell in China, as well as to other proximate countries, since the marginal costs to serve those countries are relatively low for its Chinese affiliate. In our framework, this firm will sell to China and proximate countries not only from its Chinese affiliate, but also from its US plants.

The firm-level fixed cost to market in a country thus provides a new source of firm-level scale economies and rationalizes the positive correlation across countries in firms' extensive-margin export and assembly location decisions. This new feature of our framework is absent from other FDI models where the higher export intensity by MNEs observed in the data is often attributed to differences in firm productivity. Since the evidence in Table 3 shows that MNEs export more as a share of their sales, and the specifications in Table 8 include firm and country fixed effects, MNEs' higher initial productivity draws cannot explain their increased proclivity to export, or the correlation in their extensive margins of exporting and FDI. By contrast, the firm-level fixed cost to sell in a market in our framework predicts precisely this correlation, which arises from the role that geography plays in bilateral trade costs between affiliates and proximate markets.

The complementarities that influence the marginal benefit of adding an input-source country or an export market similarly affect a firm's extensive-margin decision to open an assembly plant. Again assuming no interdependencies within each sourcing and assembly strategy (i.e., $\sigma-1=\theta^a=\theta^s/\alpha$), the addition of plant k' is profitable whenever

$$\kappa\varphi^{\sigma-1}\sum_{j\in\mathcal{J}_h(\varphi)}\sum_{i\in\Upsilon_h(\varphi)}E_iP_i^{\sigma-1}T_{k'}^a\left(w_{k'}\right)^{-(1-\alpha)\theta^a}\left(\gamma_{hk'}^a\tau_{k'i}^a\right)^{-\theta^a}T_j^s\left(\gamma_{hj}^s\tau_{jk'}^s w_j\right)^{-\theta^s}>w_hf_{hk'}^a,$$

which depends not only on the assembly potential of k' vis-à-vis all active export markets $i\in\Upsilon_h(\varphi)$, but also on the firm's overall global sourcing strategy. Focusing on the role of geography (i.e., setting $T_k^a(w_k)^{-(1-\alpha)\theta^a}=G^a$, $T_j^s(w_j)^{-\theta^s}=G^s$), this condition reduces to

$$\kappa\varphi^{\sigma-1}G^aG^s\sum_{j\in\mathcal{J}_h(\varphi)}\sum_{i\in\Upsilon_h(\varphi)}E_iP_i^{\sigma-1}T\left(\gamma_{hk'}^a\tau_{k'i}^a\right)^{-\theta^a}\left(\gamma_{hj}^s\tau_{jk'}^s\right)^{-\theta^s}>w_hf_{hk'}^a,$$

which indicates that a new assembly plant in country k' is more likely to be profitable if the firm has active destination markets i and sourcing locations j that are relatively close to country k'.

6.3 Assembly-Sourcing Complementarity and the Intensive Margin

In this subsection, we discuss the implications of our framework for the intensive margins of exporting and global sourcing, and how these predictions relate to the descriptive evidence in Section 3.

To analyze the intensive-margin of input sourcing, we express the bilateral intermediate-input imports from country j to country k for firm φ, headquartered in h in equation (25), conditional on country j being activated and for any relative sizes of $\sigma-1$, θ^a, and θ^s/α, as

$$\log M_{hkj}(\varphi)=\alpha^s+d_k^s+d_j^s+d_{hk\varphi}^s-\theta^s\log\left(\tau_{jk}^s\right)-\theta^s\log\left(\gamma_{hj}^s\right)\tag{30}$$

where $d_k^s\equiv\log T_k^a(w_k)^{-(1-\alpha)\theta^a}$, $d_j^s\equiv\log T_j^s(w_j)^{-\theta^s}$, and

$$d_{hk\varphi}^s\equiv\left(\frac{\alpha\theta^a}{\theta^s}-1\right)\log\Theta_{hk}(\varphi)+\log\left(\sum_{i\in\Upsilon_h(\varphi)}\left(\gamma_{hk}^a\tau_{ki}^a\right)^{-\theta^a}E_iP_i^{\sigma-1}\right).$$

Equation (30) decomposes bilateral input purchases into a constant α^s, an assembly country k fixed effect d_k^s, an input-source country j fixed effect d_j^s, an importing-firm fixed effect (independent of j) $d_{hk\varphi}^s$, bilateral trade frictions between the input-source country j and the assembly country k, and communication costs between the input-source country j and the headquarter country h.

To map equation (30) to our descriptive evidence in Table 7, first note that the assembly country in our empirical application is fixed at $k=US$. Controlling for firm and source-country fixed effects, equation (30) indicates that the intensive margin of imports should *only* be shaped by bilateral trade frictions between j and k, and by communication costs between country j and the headquarter-country h. In sharp contrast to its extensive-margin implications, our model thus predicts that the amount a US MNE imports from a particular country already in its sourcing set should *not* be affected by its foreign-affiliate locations. For foreign MNEs, however, the model does predict disproportionately high import volumes from countries with lower bilateral communication costs γ_{hj}^s between the firm's headquarter country h and input-source country j.

The intensive-margin estimates in Table 7 are generally consistent with the model's predictions for both types of MNEs. Most notably, the coefficient estimate on the dummy for whether a US MNE has an affiliate in the region is statistically insignificant for the intensive margin of imports, while it is large and significant for the extensive margin. In line with lower costs for domestic and proximate communication, the estimates indicate that foreign MNEs import relatively more from their headquarter country, and from other countries in that region. Although we find that US MNEs also import more from countries in which they have an affiliate, these imports may reflect export-platform sales by their assembly plants back to the US market, which are entirely consistent with the model's predictions, but hard for us to disentangle from input purchases.[30]

We also assess the empirical support for the model's predictions on the intensive margin of exports. Using equation (26), we express bilateral exports from k to i, conditional on country i being an activated destination by

$$S_{hki}(\varphi) = \alpha^x + d_k^x + d_i^x + d_{hk\varphi}^x - \theta^a \log(\tau_{ki}^a) + \left(\frac{\sigma-1}{\theta^a} - 1\right) \log \Psi_{hi}(\varphi), \tag{31}$$

where $d_k^x \equiv \log T_k^a (w_k)^{-(1-\alpha)\theta^a}$, $d_i^x \equiv \log E_i P_i^{\sigma-1}$, and

$$d_{hk\varphi}^x \equiv -\theta^a \ln \gamma_{hk}^a + \frac{\alpha\theta^a}{\theta^s} \ln \Theta_{hk}(\varphi).$$

Equation (31) decomposes bilateral final-good sales into a constant α^x, an exporter country k fixed effect d_k^x, a destination market i fixed effect d_i^x, an exporting-firm fixed effect $d_{hk\varphi}^x$ (independent of i), bilateral trade frictions between the exporter country k and the destination market i, and the firm's *global production capability* $\Psi_{hi}(\varphi)$ when selling in i. Remember that this global production capability is given by

$$\Psi_{hi}(\varphi) = \sum_{k' \in \mathcal{K}_h(\varphi)} T_{k'}^a \left(\gamma_{hk'}^a \tau_{k'i}^a\right)^{-\theta^a} (w_{k'})^{-(1-\alpha)\theta^a} \left(\Theta_{hk'}(\varphi)\right)^{\alpha\theta^a/\theta^s},$$

and is thus disproportionately higher when the firm has assembly plants relatively close to country i, and when these plants can source inputs cheaply. This global production capability is further enhanced by the proximity of the firm's assembly plants to the firm's headquarters in h, as captured by the term $(\gamma_{hk'}^a)^{-\theta^a}$ in $\Psi_{hi}(\varphi)$. Importantly, whether a higher or a lower $\Psi_{hi}(\varphi)$ has a positive impact on exports to country i depends on whether $(\sigma-1)/\theta^a$ is greater or smaller than one. When $(\sigma-1)/\theta^a > 1$, assembly locations are complements, and a higher global production capability $\Psi_{hi}(\varphi)$ enhances sales from k to i. By contrast, when $(\sigma-1)/\theta^a < 1$, cannibalization effects dominate, so a higher $\Psi_{hi}(\varphi)$ reduces the sales by the assembly plant in k. In the knife-edge case with $(\sigma-1)/\theta^a = 1$, the model predicts that, controlling for exporter-firm and destination-market fixed effects, bilateral sales to

[30] As mentioned earlier (see footnote 23), it is hard to distinguish imports of final goods versus inputs in the data, since a large share of the value of MNE imports appear to be both. The regression estimates for the indicator for whether a firm has an affiliate in the same region are less susceptible to this data limitation since, by definition, that indicator excludes countries in which the firm has majority-owned manufacturing affiliates.

country i depend *only* on bilateral frictions between the export-platform country k and destination market i, and are thus independent of the firm's other affiliate locations.

The intensive-margin results in Table 8 indicate a large, positive relationship between the amount a US MNE exports to a country and the presence of an affiliate in that country, or in other countries in its affiliate's region. This result differs from the intensive-margin import estimates, and suggests two potential explanations. One possibility is that strong demand complementarities lead to a positive impact of the firm's global production capability for serving market i, $\Psi_{hi}(\varphi)$, on its US exports to i. This interpretation, however, is at odds with the negative (statistically insignificant) coefficient on foreign MNEs' headquarter country being in the same region as market i, which suggests cannibalization across plants. A second possibility is that the intensive-margin export estimates also capture variation in the number of customers within a country to which the firm sells each product.[31] The positive and significant estimate on the dummy for an affiliate in the region may thus capture additional extensive-margin variation in the number of customers the firm has within market i, which is higher if it has a proximate affiliate that also sells to those customers. By contrast, cannibalization effects are likely to dominate for the foreign MNEs whose domestic manufacturing plants are in close proximity to export markets.

6.4 The Complementarity in Action: Two Illustrative Firm-Level Examples

We close our analysis with two examples that illustrate how the new source of scale economies in our framework – that arises because firms incur a single, country-specific fixed cost that allows all their assembly plants to import inputs from that country – affects firm responses to changes in input and final-good tariffs. To do so, we compare the effects of these tariff changes on firm sourcing and exports in our framework with firm-level country-specific fixed costs of sourcing to those from a model with plant-level country-specific fixed costs (e.g., as in Bernard et al., 2018).

6.4.1 Non-Monotonic Effects of Tariffs on Inputs

Consider a scaled down version of our model with only three countries: USA (us), China (ch), and Mexico (mex). Without loss of generality we normalize the US assembly and sourcing potentials to 1, so that $\xi^a_{us,us} = \xi^s_{us,us} = 1$. We also set $\kappa\varphi^{\sigma-1} = 1$ and $E_{us}P^{\sigma-1}_{us} = 1$. We focus on the optimal global production strategy of a firm headquartered in the United States. We further simplify the problem by assuming that (see also Figure 1):

1. The firm's goods are only demanded in the US, so $E_{mex}P^{\sigma-1}_{mex} = E_{ch}P^{\sigma-1}_{ch} = 0$.

2. The fixed costs of assembly and sourcing in the US are 0, so $\{US\} \in \mathcal{J}_h(\varphi)$ and $\{US\} \in \mathcal{K}_h(\varphi)$.

3. Mexico only has the capability of producing final goods, so $\xi^a_{mex,us} > 0$, but $\xi^s_{mex,us} = \xi^s_{mex,ch} = \xi^s_{mex,mex} = 0$).

[31] Prior work finds that US firms tend to import each HS6 product from one country, but export an HS6 product to multiple locations (Antràs et al., 2017). The same logic may apply across customers within a country. A firm exports the same product to multiple customers within a country, but imports each input from the lowest-cost supplier.

4. China only has the capability of producing intermediate inputs, so $\xi^s_{ch,us} > 0$ and $\xi^s_{ch,mex} > 0$, but $\xi^a_{ch,us} = 0$.

5. The US does not export intermediate inputs to Mexico, or $\xi^s_{us,mex} = 0$.

6. Pairs of assembly locations and pairs of sourcing locations are independent, or $\sigma - 1 = \theta^a = \theta^s/\alpha$.

The last assumption abstracts from any interdependencies other than those generated by the complementarity between global sourcing and global assembly. A key feature in this example is that the profitability of assembly in Mexico is partly shaped by its access to inputs sourced from China, which is partly shaped by China's sourcing potential vis-à-vis the United States. To see this more formally, let us write the extensive margin problem of the firm as:

$$\max_{(\mathcal{I}^s_{ch}, \mathcal{I}^a_{mex}) \in \{0,1\}^2} \quad 1 + \mathcal{I}^s_{ch} \cdot \xi^s_{ch,us} + \mathcal{I}^a_{mex} \cdot \mathcal{I}^s_{ch} \cdot \xi^a_{mex,us} \cdot \xi^s_{ch,mex} - \mathcal{I}^s_{ch} \cdot f^s_{ch} - \mathcal{I}^a_{mex} \cdot f^a_{mex}.$$

Clearly, the firm only has three possible choices: (i) activate both assembly in Mexico and sourcing from China, (ii) activate only sourcing from China, or (iii) activate neither.[32]

The solution to this problem is the following:

$$\begin{cases} \text{Activate Both if} & \xi^s_{ch,us} + \xi^a_{mex,us} \cdot \xi^s_{ch,mex} \geqslant f^s_{ch} + f^a_{mex} \text{ and } \xi^a_{mex,us} \cdot \xi^s_{ch,mex} \geqslant f^a_{mex} \\ \text{Activate China Sourcing only if} & \xi^s_{ch,us} \geqslant f^s_{ch} \text{ and } \xi^a_{mex,us} \cdot \xi^s_{ch,mex} < f^a_{mex} \\ \text{Activate Neither if} & \xi^s_{ch,us} + \xi^a_{mex,us} \cdot \xi^s_{ch,mex} < f^s_{ch} + f^a_{mex} \text{ and } \xi^s_{ch,us} < f^s_{ch}. \end{cases}$$

The solution is also illustrated in panel (a) of Figure 2a, which shows that the assembly decision in Mexico ($\mathcal{I}^a_{mex}$) depends not only on the Mexican assembly potential ($\xi^a_{mex,us}$) and sourcing potential of Chinese inputs vis-à-vis Mexico ($\xi^s_{ch,mex}$), but also on the sourcing potential of Chinese inputs vis-à-vis the United States ($\xi^s_{ch,us}$). Panel (b) of Figure 2b shows the equilibrium under the alternative assumption of plant-level sourcing strategies. In this case, all assembly plants must pay plant-specific fixed costs ($f^s_{ch,us}$ and $f^s_{ch,mex}$) to activate each sourcing location for each plant. In contrast to the firm-level sourcing case, the decision to activate an assembly plant in Mexico is now independent of the value of inputs to the US plant ($\xi^s_{ch,us}$).[33]

The differences between firm-level and plant-level global sourcing strategies is further illustrated by their differential implications for the response of the firm global production strategy to changes in tariffs. In particular, Figure 3 shows how unilateral tariffs on Chinese inputs set by the United States affect the share of inputs imported from China ($\frac{\xi^s_{ch,us}}{1+\xi^s_{ch,us}}$) and the share of final goods imported from Mexico ($\frac{\xi^a_{mex,us} \cdot \xi^s_{ch,mex}}{1+\xi^s_{ch,usa}+\xi^a_{mex,us} \cdot \xi^s_{ch,mex}}$).

Under both firm- and plant-level global sourcing strategies, the US share of Chinese inputs gradually falls, and at some point drops to zero. The Mexican assembly shares, however, respond quite differently.

[32] Only activating assembly in Mexico is never optimal because without inputs from China, the Mexican plant cannot produce.

[33] More specifically, the firm chooses $(\mathcal{I}^s_{ch,us}, \mathcal{I}^s_{ch,mex}, \mathcal{I}^a_{mex})$ to solve the problem $\max 1 + \mathcal{I}^s_{ch,us} \cdot \xi^s_{ch,us} + \mathcal{I}^a_{mex} \cdot \mathcal{I}^s_{ch,mex} \cdot \xi^a_{mex,us} \cdot \xi^s_{ch,mex} - \mathcal{I}^s_{ch,us} \cdot f^s_{ch} - \mathcal{I}^s_{ch,us} \cdot f^s_{ch} - \mathcal{I}^a_{mex} \cdot f^a_{mex}$.

Figure 1: Trade Structure

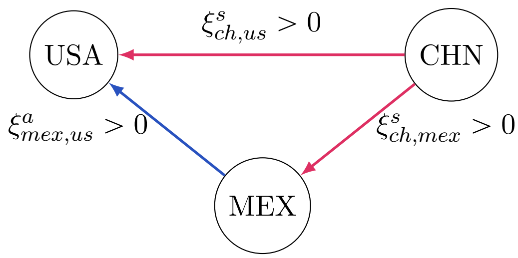
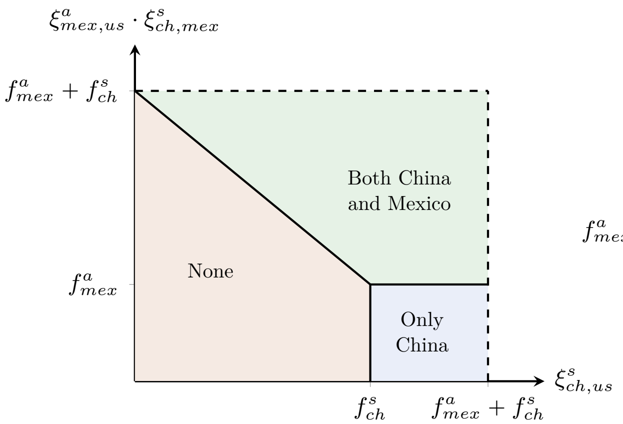
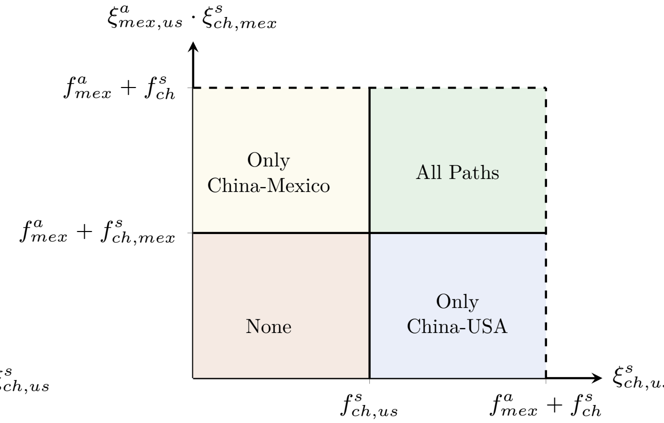


Figure 2: Equilibrium Assembly and Sourcing Decisions



(a) Firm-level Sourcing Strategy



(b) Plant-level Sourcing Strategy

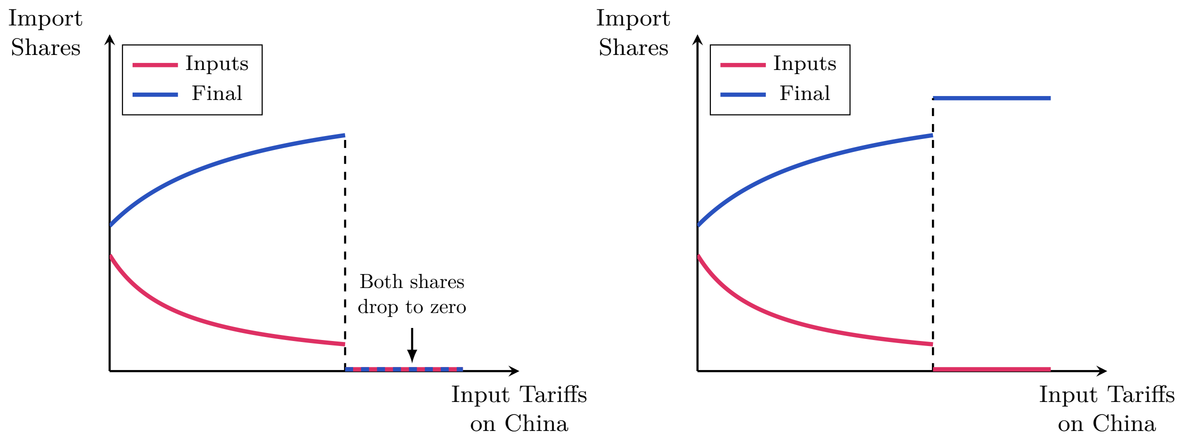
Those shares increase increase initially as the US plant's productivity falls in response to more costly Chinese inputs. As the Chinese input tariffs continue to rise, however, the firm eventually ceases sourcing from China (assuming that the fixed cost f^s_{ch} is not sunk). Under a firm-level global sourcing strategy, the loss of Chinese inputs leads to the closure of the Mexican assembly plant, and thus the Mexican share of final-goods imports drops to zero discontinuously. Under plant-level global sourcing strategies, the Mexican assembly plant continues to source from China (since the cost of those inputs is unaffected by US tariffs), such that the Mexican final-good import share *rises* discontinuously.

The example above illustrates how firm-level economies of scale in sourcing can generate an endogenous complementarity between assembly plants: a deterioration in the productivity of US final-good production leads to the closure of the foreign assembly plant due to a change in the firm's sourcing strategy. Conversely, under plant-level economies of scale there is instead endogenous substitutability between assembly plants, as declining US assembly productivity raises the importance of foreign assembly in US consumption.

6.4.2 Non-Monotonic Effects of Tariffs on Final Goods

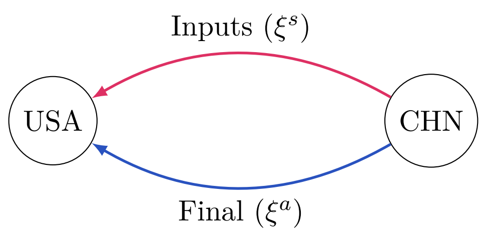
We next consider an even simpler example with just two countries: USA (us) and China (ch). Without loss of generality we again normalize the US assembly and sourcing potentials to 1, so that

Figure 3: The Effect of US Input Tariffs on US Import Shares



(a) Firm-level Sourcing Strategy **(b)** Plant-level Sourcing Strategy

Figure 4: Trade Structure



$\xi^a_{us,us} = \xi^s_{us,us} = 1$, and we also set $\kappa\varphi^{\sigma-1} = 1$ and $E_{us}P^{\sigma-1}_{us} = 1$. We focus on the optimal global production strategy of a firm headquartered in the United States. We further simplify the problem by assuming that (see also Figure 4):

1. The firm's goods are only demanded in the US, so $E_{ch}P^{\sigma-1}_{ch} = 0$.

2. The fixed costs of assembly are zero in both countries, so $\mathcal{K}_h(\varphi) = \{US, Ch\}$.

3. The fixed costs of sourcing in the US are 0, so $\{US\} \in \mathcal{J}_h(\varphi)$.

4. The US does not export intermediate inputs to China, or $\xi^s_{us,ch} = 0$.

5. Pairs of assembly locations are substitutes $\sigma - 1 < \theta^a$, while pairs of sourcing locations are independent $\theta^a = \theta^s/\alpha$.

Under these assumptions, if the firm sets its global sourcing strategy at the firm level, then it solves the simple problem

$$\max_{\mathcal{I}^s_{ch}\in\{0,1\}} \quad \left(1 + \mathcal{I}^s_{ch} \cdot \left[\xi^s_{ch,us} + \xi^a_{ch,us}\xi^s_{ch,ch}\right]\right)^{\frac{\sigma-1}{\theta^a}} - \mathcal{I}^s_{ch} \cdot f^s_{ch},$$

and generates sales in the US assembly plant that are proportional to :

$$\text{Sales of US Assembly Plant} \sim \left(1 + \mathcal{I}^s_{ch} \cdot \xi^s_{ch,us}\right) \cdot \left(1 + \mathcal{I}^s_{ch} \cdot \left[\xi^s_{ch,us} + \xi^a_{ch,us}\xi^s_{ch,ch}\right]\right)^{\frac{\sigma-1}{\theta^a}-1}. \tag{32}$$

The wage bill paid by the firm to US workers is also proportional to (32).

Assume the following initial conditions on parameters

$$\left(1 + \xi^s_{ch,us} + \xi^a_{ch,us}\xi^s_{ch,ch}\right)^{\frac{\sigma-1}{\theta^a}} > 1 + f^s_{ch} > \left(1 + \xi^s_{ch,us}\right)^{\frac{\sigma-1}{\theta^a}}, \tag{33}$$

so that activating China as a source of inputs is initially profitable, but if the assembly potential of China (vis-àvis the United States) deteriorates sufficiently ($\xi^a_{ch,us} \to 0$), activating China as an input source is no longer profitable.

Consider now the implications of a unilateral increase in US final-good tariffs on China. This policy immediately reduces Chinese assembly potential $\xi^a_{ch,us}$ vis-à-vis the United States. Figure 5a shows the response of US final-good sales under firm-level sourcing strategies. Sales initially increase because tariffs make the Chinese assembly plant less competitive, and the US plant gains additional market share due to the substitutability implied by $\sigma - 1 < \theta^a$. However, after increasing tariffs beyond a certain threshold, at the resulting lower value of $\xi^a_{ch,us}$, it is no longer profitable to incur the fixed cost to source inputs from China. Dropping China from its sourcing strategy increases the marginal cost of the US plant, leading to a discontinuous drop in its sales, profitability, and wage bill.[34] The assembly-sourcing complementarity thus results in the unexpected outcome that US final-good sales fall in response to higher final-good tariffs on Chinese imports.

A model with plant-level fixed costs of sourcing predicts the opposite outcome from high final-good tariffs. When each plant chooses its sourcing strategy independently, firm' problem is

$$\max_{(\mathcal{I}^s_{us,ch},\mathcal{I}^s_{ch,ch})\in\{0,1\}^2} \left(1 + \mathcal{I}^s_{us,ch} \cdot \xi^s_{ch,us} + \mathcal{I}^s_{ch,ch} \cdot \xi^a_{ch,us}\xi^s_{ch,ch}\right)^{\frac{\sigma-1}{\theta^a}} - \mathcal{I}^s_{ch,us} \cdot f^s_{ch} - \mathcal{I}^s_{ch,ch} \cdot f^s_{ch}. \tag{34}$$

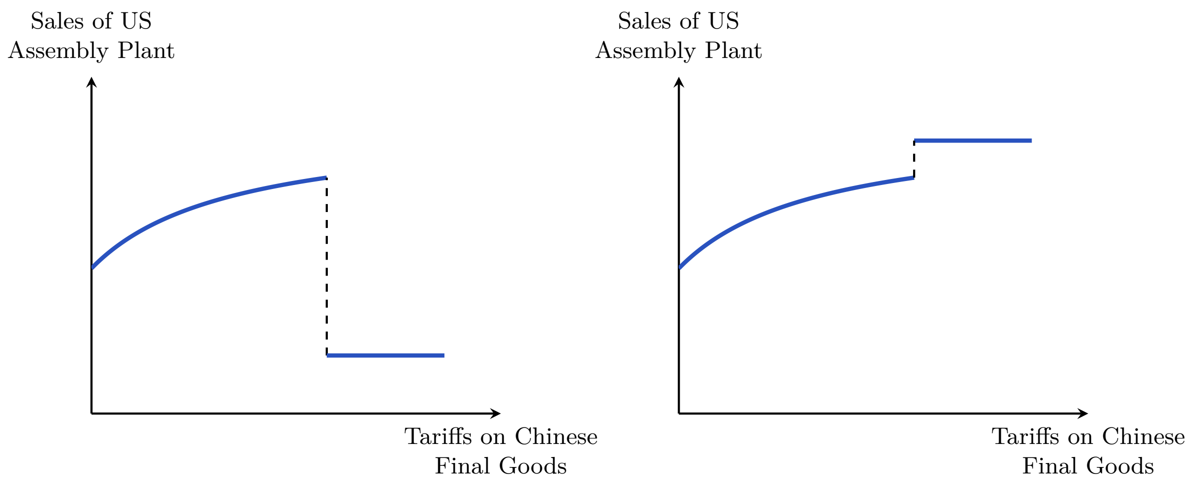
Given the solution of this problem, it is then straightforward to show that an increase in tariffs on Chinese final goods (and the associated fall in $\xi^a_{ch,us}$) will never decrease the sales, operating profits, and wage bill paid by the US assembly plant.

Figure 5b shows how US plant sales respond to increases in final-good tariffs on Chinese imports under plant-level sourcing strategies. The increasingly costly Chinese final-good imports lead US sales to rise initially due to the substitution implied by $\sigma - 1 < \theta^a$. After a certain threshold, however, it is no longer profitable to assemble in China, so that US sales rise discontinuously as the US plant continues importing inputs from China, but no longer faces competition from a Chinese assembly plant.[35]

[34]Figure 5a is generated under condition (33). We model the effect of tariffs on $\xi^a_{ch,us}$ as $\tilde{\xi}^a_{ch,us} = \xi^a_{ch,us}(1+t)^{-\theta^a}$. For a drop to be below the initial (pre-tariffs, $t = 0$) sales of the US assembly plant the following condition should be satisfied $\left(1 + \xi^s_{ch,us} + \xi^a_{ch,us}\xi^s_{ch,ch}\right)^{1-\frac{\sigma-1}{\theta^a}} < 1 + \xi^s_{ch,us}$.

[35]The following numerical parameters can generate patterns in Figures 5a and 5b: $\xi^s_{ch,us} = \xi^s_{ch,us} = \xi^a_{ch,us} = 1$, $f^s_{ch} = 0.5$, $f^a_{us} = f^a_{ch} = 0.25$, $\sigma = \theta^a = 2$. Then, the discontinuity in Figure 5a happens at $t = 1$, and in Figure 5b at

Figure 5: The Effect of US Final-Good Tariffs on US Plants' Sales



(a) Firm-level Sourcing Strategy

(b) Plant-level Sourcing Strategy

7 Conclusion

Multinational firms are dominant players in domestic employment, output, and trade. Leveraging newly linked Bureau of Economic Analysis and US Census data, we confirm the quantitative importance of MNEs for the US economy, and document a large, positive, and statistically significant correlation between the countries with which they trade goods and locate their foreign affiliates. Even after controlling for firm and country fixed effects, US MNEs are significantly more likely to import not only from countries in which they have a majority-owned manufacturing affiliate, but also from other countries in their affiliate's region. Foreign MNEs are much more likely to import from their headquarter country, and from other countries in their headquarters region. We find similar extensive-margin patterns for US MNEs' exports.

We develop a multi-country model in which firms jointly decide on the location of their assembly plants (i.e., their assembly strategy) as well as the source of the inputs used in their plants worldwide (i.e., their global sourcing strategy). A key novel feature of our framework is the existence of firm-level economies of scale in firms' global sourcing strategies. A firm incurs a country-specific fixed cost to import inputs, which enables all of its assembly plants to source from that country. This firm-level fixed cost delivers rich complementarities between the global sourcing and global assembly choices of firms, and constitutes a plausible mechanism to explain the strong correlations between import and FDI locations we observe in the data. Our framework also delivers novel predictions on the effects of trade cost changes, for example due to tariff increases, on MNEs' imports and foreign affiliate sales. We show that firm-level fixed costs produce non-monotonic responses to bilateral trade cost changes in firms' imported input shares and affiliate sales. These non-monotonicities arise due to the interdependence in firms' extensive margin sourcing and assembly decisions, and differ from the predictions of a model

$t \approx 0.14$.

with plant-level fixed costs.

The distinct responses in our firm-level fixed cost framework highlight the importance of incorporating this new source of firm-level scale economies when studying the effects of trade cost changes in a globalized world with complex supply chains. We hope our framework will prove useful for analyzing how tariff changes may ripple through economies as they influence the distribution and scale of firms' global operations.

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A Theory Appendix

Proof of Proposition 1

Total sales from plants based in k in country i can be written as

$$S_{hki}(\varphi) = \tilde{\kappa}\varphi^{\sigma-1} \cdot \mu_{hki} \cdot (\Psi_{hi})^{\frac{\sigma-1}{\theta^a}} \cdot E_i P_i^{\sigma-1}$$

where μ_{hki} and Ψ_{hi} are given in equations (14) and (15). Both μ_{hki} and Ψ_{hi} are increasing in $T_k^a \left(\tau_{ki}^a\right)^{-\theta^a} (w_k)^{-(1-\alpha)\theta^a}$ and decreasing in τ_{jk}^s. This proves part (i) of the proposition.

For part (ii), we rewrite $S_{hk'i}(\varphi)$ as

$$\tilde{\kappa}\varphi^{\sigma-1} \cdot T_{k'}^a \left(\tau_{k'i}^a\right)^{-\theta^a} (w_{k'})^{-(1-\alpha)\theta^a} \left(\Theta_{hk'}(\varphi)\right)^{\alpha\theta^a/\theta^s} \cdot (\Psi_{hi})^{\frac{\sigma-1}{\theta^a}-1} \cdot E_i P_i^{\sigma-1}$$

where the term $(\Psi_{hi})^{\frac{\sigma-1}{\theta^a}-1}$ is increasing (decreasing) in $T_k^a \left(\tau_{ki}^a\right)^{-\theta^a} (w_k)^{-(1-\alpha)\theta^a}$ and decreasing (increasing) in τ_{jk}^s if $\sigma - 1 > \theta^a$ ($\sigma - 1 < \theta^a$).

Proof of Proposition 2

Input purchases from source country j of the plant based in k, $M_{hkj}(\varphi)$, can be written as

$$M_{hkj}(\varphi) = \left(1 - \frac{1}{\sigma_w}\right) \alpha \cdot \chi_{hjk} \sum_i S_{hki}(\varphi) \tag{A.1}$$

where term χ_{hjk} is given in (11), and it does not depend on $T_k^a \left(\tau_{ki}^a\right)^{-\theta^a} (w_k)^{-(1-\alpha)\theta^a}$. Proposition 2 follows from Proposition 1.

Proof of Proposition 3

Part (i) follows from (A.1) and Proposition 1: both χ_{hjk} and $\sum_i S_{hki}(\varphi)$ are decreasing in τ_{jk}^s. For part (ii), input purchases from source country $j' \neq j$ of the plant based in k, $M_{hkj'}(\varphi)$, can be written as

$$M_{hkj'}(\varphi) = \tilde{\tilde{\kappa}} \cdot \left(\Theta_{hk}(\varphi)\right)^{\frac{\alpha\theta^a}{\theta^s}-1} \sum_{i \in J} \left(\tau_{ki}^a\right)^{-\theta^a} \left(\Psi_{hi}(\varphi)\right)^{\frac{(\sigma-1)}{\theta^a}-1} E_i P_i^{\sigma-1}$$

where $\tilde{\tilde{\kappa}}$ includes variables which do not depend on τ_{jk}^s. Both $\left(\Theta_{hk}(\varphi)\right)^{\frac{\alpha\theta^a}{\theta^s}-1}$ and $\left(\Psi_{hi}(\varphi)\right)^{\frac{(\sigma-1)}{\theta^a}-1}$ are decreasing (increasing) in τ_{jk}^s if $\sigma - 1 \geqslant \theta^a > \theta^s/\alpha$ ($\sigma - 1 < \theta^a < \theta^s/\alpha$).

Proof of Lemma 1

Denote by

$$\lambda_{ki} = \xi_{ki}^a \left(\sum_j \mathcal{I}_j^s \cdot \xi_{jk}^s\right)^{\frac{\alpha\theta^a}{\theta^s}}$$

For part (i), it is sufficient to prove that for all $i \in J$

$$\left(\sum_{m\neq k,k'} \mathcal{I}_m^a \lambda_{mi} + \mathcal{I}_k^a \lambda_{ki} + \lambda_{k'i}\right)^{\frac{\sigma-1}{\theta^a}} - \left(\sum_{m\neq k,k'} \mathcal{I}_m^a \lambda_{mi} + \mathcal{I}_k^a \lambda_{ki} + 0\right)^{\frac{\sigma-1}{\theta^a}} \tag{A.2}$$

is increasing (decreasing) in $\mathcal{I}_k^a$ if $\sigma - 1 > \theta^a$ ($\sigma - 1 < \theta^a$). Notice that

$$\sum_{m\neq k,k'} \mathcal{I}_m^a \lambda_{mi} + \mathcal{I}_k^a \lambda_{ki} + \lambda_{k'i} > \sum_{m\neq k,k'} \mathcal{I}_m^a \lambda_{mi} + \mathcal{I}_k^a \lambda_{ki} + 0$$

so the derivative of (A.2) with respect to $\mathcal{I}_k^a$ is positive if $\sigma - 1 > \theta^a$ and negative if $\sigma - 1 < \theta^a$.

For part (ii), it is sufficient to prove that for all $i \in J$

$$\left(\sum_{k\in J} \mathcal{I}_k^a \cdot \xi_{ki}^a \left(\sum_{m\neq j,j'} \xi_{mk}^s + \mathcal{I}_j^s \xi_{jk}^s + \xi_{j'k}^s\right)^{\frac{\alpha\theta^a}{\theta^s}}\right)^{\frac{\sigma-1}{\theta^a}} - \left(\sum_{k\in J} \mathcal{I}_k^a \cdot \xi_{ki}^a \left(\sum_{m\neq j,j'} \xi_{mk}^s + \mathcal{I}_j^s \xi_{jk}^s + 0\right)^{\frac{\alpha\theta^a}{\theta^s}}\right)^{\frac{\sigma-1}{\theta^a}} \tag{A.3}$$

is increasing in $\mathcal{I}_j^s$ if $\sigma - 1 \geqslant \theta^a$ and $\alpha\theta^a/\theta^s > 1$ and decreasing in $\mathcal{I}_j^s$ if $\sigma - 1 < \theta^a$ and $\alpha\theta^a/\theta^s < 1$. Notice that

$$\sum_{k\in J} \mathcal{I}_k^a \cdot \xi_{ki}^a \left(\sum_{m\neq j,j'} \xi_{mk}^s + \mathcal{I}_j^s \xi_{jk}^s + \xi_{j'k}^s\right)^{\frac{\alpha\theta^a}{\theta^s}} > \sum_{k\in J} \mathcal{I}_k^a \cdot \xi_{ki}^a \left(\sum_{m\neq j,j'} \xi_{mk}^s + \mathcal{I}_j^s \xi_{jk}^s + 0\right)^{\frac{\alpha\theta^a}{\theta^s}}$$
$$\sum_{m\neq j,j'} \xi_{mk}^s + \mathcal{I}_j^s \xi_{jk}^s + \xi_{j'k}^s > \sum_{m\neq j,j'} \xi_{mk}^s + \mathcal{I}_j^s \xi_{jk}^s + 0$$

so the derivative of (A.3) with respect to $\mathcal{I}_j^s$ is positive if $\sigma - 1 \geqslant \theta^a$ and $\alpha\theta^a/\theta^s > 1$ and negative if $\sigma - 1 < \theta^a$ and $\alpha\theta^a/\theta^s < 1$.

For part (iii), it is sufficient to prove that for all $i \in J$

$$\left(\sum_{k\in J} \mathcal{I}_k^a \xi_{jk}^a \left(\sum_{j'\neq j} \mathcal{I}_{j'}^s \xi_{j'k}^s + \xi_{jk}^s\right)^{\frac{\alpha\theta^a}{\theta^s}}\right)^{\frac{\sigma-1}{\theta^a}} - \left(\sum_{k\in J} \mathcal{I}_k^a \xi_{jk}^a \left(\sum_{j'\neq j} \mathcal{I}_{j'}^s \xi_{j'k}^s + 0\right)^{\frac{\alpha\theta^a}{\theta^s}}\right)^{\frac{\sigma-1}{\theta^a}} \tag{A.4}$$

is increasing in $\mathcal{I}_k^a$ if $\sigma - 1 \geqslant \theta^a$. Notice that

$$\sum_{k\in J} \mathcal{I}_k^a \xi_{jk}^a \left(\sum_{j'\neq j} \mathcal{I}_{j'}^s \xi_{j'k}^s + \xi_{jk}^s\right)^{\frac{\alpha\theta^a}{\theta^s}} > \sum_{k\in J} \mathcal{I}_k^a \xi_{jk}^a \left(\sum_{j'\neq j} \mathcal{I}_{j'}^s \xi_{j'k}^s + 0\right)^{\frac{\alpha\theta^a}{\theta^s}}$$
$$\sum_{j'\neq j} \mathcal{I}_{j'}^s \xi_{j'k}^s + \xi_{jk}^s > \sum_{j'\neq j} \mathcal{I}_{j'}^s \xi_{j'k}^s + 0$$

so the derivative of (A.4) is positive if $\sigma - 1 \geqslant \theta^a$.

Proof of Proposition 4

We introduce the following notation

$$
\begin{aligned}
\Lambda(\mathcal{I}) &= \kappa \cdot \sum_{i \in J} E_i P_i^{\sigma-1} \left(\xi_{hi}^a \left(\xi_{hh}^s + \mathcal{I}^g \cdot \sum_{j \neq h} \mathcal{I}_j^s \cdot \xi_{jk}^s \right)^{\frac{\alpha\theta^a}{\theta^s}} + \mathcal{I}^g \cdot \sum_{k \neq h} \mathcal{I}_k^a \cdot \xi_{ki}^a \left(\xi_{hk}^s + \sum_{j \neq h} \mathcal{I}_j^s \cdot \xi_{jk}^s \right)^{\frac{\alpha\theta^a}{\theta^s}} \right)^{\frac{(\sigma-1)}{\theta^a}} \\
&\equiv \kappa \cdot \sum_{i \in J} \left(\Psi_{hi}(\varphi)\right)^{(\sigma-1)/\theta^a} E_i P_i^{\sigma-1} \\
F(\mathcal{I}) &= \sum_{j \in J} \mathcal{I}_j^s \cdot w_h f_{hj}^s + \sum_{k \in J} \mathcal{I}_k^a \cdot w_h f_{hk}^a + \mathcal{I}^g \cdot w_h f_h^g
\end{aligned}
$$

where $\mathcal{I} = (\mathcal{I}^a, \mathcal{I}^s, \mathcal{I}^g)$.

The problem at the firm level is

$$
\varphi^{\sigma-1} \cdot \Lambda(\mathcal{I}) - F(\mathcal{I}) \to \max_{\mathcal{I}} \tag{A.5}
$$

Denote by $\mathcal{I}(\varphi)$ the optimal sourcing and assembly vector of locations. Consider two firms with $\varphi_H > \varphi_L$, then it should be

$$
\begin{aligned}
\varphi_H^{\sigma-1} \cdot \Lambda(\mathcal{I}(\varphi_H)) - F(\mathcal{I}(\varphi_H)) \geqslant \varphi_H^{\sigma-1} \cdot \Lambda(\mathcal{I}(\varphi_L)) - F(\mathcal{I}(\varphi_L)) \\
\varphi_L^{\sigma-1} \cdot \Lambda(\mathcal{I}(\varphi_L)) - F(\mathcal{I}(\varphi_L)) \geqslant \varphi_L^{\sigma-1} \cdot \Lambda(\mathcal{I}(\varphi_H)) - F(\mathcal{I}(\varphi_H))
\end{aligned}
$$

From these inequalities it follows that

$$
\left[\varphi_H^{\sigma-1} - \varphi_L^{\sigma-1}\right] \cdot \left[\Lambda(\varphi_H) - \Lambda(\varphi_L)\right] \geqslant 0
$$

which implies that $\Lambda(\varphi_H) \geqslant \Lambda(\varphi_L)$.

Proof of Proposition 5

If $\varphi \to \infty$, then the firm will activate all locations, and if $\varphi \to 0$, then the firm will not become global. From Proposition 4 it follows that $\sum_{i \in J} \left(\Psi_{hi}(\varphi)\right)^{(\sigma-1)/\theta^a} E_i P_i^{\sigma-1}$ is increasing in φ, so there exists a threshold φ_h^* such that firms headquartered in h with $\varphi > \varphi_h^*$ find it optimal to become global firms.

Proof of Proposition 6

Lemma 1 shows that under $\sigma - 1 \geqslant \theta^a \geqslant \theta^s/\alpha$, the profit function in (A.5) features increasing differences in different elements of vector $\mathcal{I} = (\mathcal{I}^s, \mathcal{I}^a, \mathcal{I}^g)$. Furthermore, it features increasing differences in $\left(\mathcal{I}_{ij}^r, \varphi\right)$ where $i, j = 1, 2, \ldots J$, $r \in \{a, s, g\}$. Invoking Topkis's monotonicity theorem, we can then conclude that for $\varphi_H \geqslant \varphi_L$ we have $\mathcal{I}(\varphi_H) \geqslant \mathcal{I}(\varphi_L)$. Therefore, $\mathcal{J}_h(\varphi_L) \subseteq \mathcal{J}_h(\varphi_H)$ and $\mathcal{K}_h(\varphi_L) \subseteq \mathcal{K}_h(\varphi_H)$.

Proof of Proposition 7

Consider the firms with headquarters in country h. Denote by $\tilde{\Lambda}(\mathcal{J},\mathcal{K}) \equiv \Lambda(\mathcal{I})$ where $\mathcal{I}_j^s = 1$ if $j \in \mathcal{J}$, $\mathcal{I}_j^s = 0$ if $j \notin \mathcal{J}$, and $\mathcal{I}_k^a = 1$ if $k \in \mathcal{K}$, $\mathcal{I}_k^a = 0$ if $k \notin \mathcal{K}$. Consider $j \notin \mathcal{J}$, $j \notin \mathcal{J}'$ and $\mathcal{J} \subseteq \mathcal{J}'$, $\mathcal{K} \subseteq \mathcal{K}'$. By definition in the proposition, $V_{h,j}^s(\varphi,\mathcal{J},\mathcal{K}) = 1$ if

$$\varphi^{\sigma-1}\left[\tilde{\Lambda}\left(\mathcal{J}\cup j,\mathcal{K}\right)-\tilde{\Lambda}\left(\mathcal{J},\mathcal{K}\right)\right] > f_{hj}^s$$

Under $\sigma - 1 \geqslant \theta^a \geqslant \theta^s/\alpha$, $\Lambda(\cdot)$ satisfies the increasing differences condition, so

$$\varphi^{\sigma-1}\left[\tilde{\Lambda}\left(\mathcal{J}'\cup j,\mathcal{K}'\right)-\tilde{\Lambda}\left(\mathcal{J}',\mathcal{K}'\right)\right] \geqslant \varphi^{\sigma-1}\left[\tilde{\Lambda}\left(\mathcal{J}\cup j,\mathcal{K}\right)-\tilde{\Lambda}\left(\mathcal{J},\mathcal{K}\right)\right] > f_{hj}^s$$

Therefore, $V_{h,j}^s(\varphi,\mathcal{J}',\mathcal{K}') = 1$. The proof for $V_{h,k}^a(\varphi,\mathcal{J},\mathcal{K})$ is analogous.

Proof of Lemma 2

Remember that with an active margin of exporting, the firm solves

$$\begin{aligned}\max_{\substack{\mathcal{I}_i^x\in\{0,1\}\\ \mathcal{I}_k^a\in\{0,1\}\\ \mathcal{I}_j^s\in\{0,1\}}} \pi_h\left(\varphi,\Upsilon_h(\varphi),\mathcal{J}_h(\varphi),\mathcal{K}_h(\varphi)\right) &= \kappa\varphi^{\sigma-1}\sum_{i\in J}\mathcal{I}_i^x\cdot E_iP_i^{\sigma-1}\left(\sum_{k\in J}\mathcal{I}_k^a\cdot\xi_{ki}^a\left(\sum_{j\in J}\mathcal{I}_j^s\cdot\xi_{jk}^s\right)^{\frac{\alpha\theta^a}{\theta^s}}\right)^{\frac{(\sigma-1)}{\theta^a}} \\ &\quad -\sum_{i\in J}\mathcal{I}_i^x\cdot w_hf_{hi}^x-\sum_{j\in J}\mathcal{I}_j^s\cdot w_hf_{hj}^s-\sum_{k\in J}\mathcal{I}_k^a\cdot w_hf_{hk}^a-w_hf_h^g.\end{aligned}$$

Notice then that the increase in operating profits associated with activating destination market i is given by

$$\kappa\varphi^{\sigma-1}E_iP_i^{\sigma-1}\left(\sum_{k\in J}\mathcal{I}_k^a\cdot\xi_{ki}^a\left(\sum_{j\in J}\mathcal{I}_j^s\cdot\xi_{jk}^s\right)^{\frac{\alpha\theta^a}{\theta^s}}\right)^{\frac{(\sigma-1)}{\theta^a}},$$

and is clearly increasing in $\mathcal{I}_k^a$ and $\mathcal{I}_j^s$.

Proof of Proposition 8

Under $\sigma - 1 \geqslant \theta^a \geqslant \theta^s/\alpha$ the profit function $\pi_h(\varphi,\Upsilon_h(\varphi),\mathcal{J}_h(\varphi),\mathcal{K}_h(\varphi))$ is supermodular in the different elements of the vector $\mathcal{I} = (\mathcal{I}^s,\mathcal{I}^a,\mathcal{I}^x)$. Furthermore, it features increasing differences in $(\mathcal{I}_i^r,\varphi)$ where $i = 1,2,\ldots J$, $r \in \{a,s,x\}$. Invoking Topkis's monotonicity theorem, we can then conclude that for $\varphi_H \geqslant \varphi_L$ we have $\mathcal{I}(\varphi_H) \geqslant \mathcal{I}(\varphi_L)$. Therefore, $\mathcal{J}_h(\varphi_L) \subseteq \mathcal{J}_h(\varphi_H)$, $\mathcal{K}_h(\varphi_L) \subseteq \mathcal{K}_h(\varphi_H)$, and $\Upsilon_h(\varphi_L) \subseteq \Upsilon_h(\varphi_H)$.

B Data Appendix

B.1 Matching the Census and BEA data

We build on the matching method developed by Brad Jensen and Fariha Kamal to merge the BEA and Census data. The BEA data contain several employer identification numbers (EINs) per firm, as well as name and address information. We merge these data to the Census Bureau's Business Register (BR) data, which includes EIN, name, and address information by establishment.

The matching method proceeds as follows. First we perform three merges of the BEA data to the BR separately on EIN, name and address. Not all three match successfully; we almost never find a match using the address merge. If all three methods match to a unique record in the BR, then we have found a match and we stop. However, if we find many possible matches in the BR then we follow a series of rules to choose the best match. To implement these rules we also use information on state, two-digit NAICS and employment which we have in both the BEA and BR data. We also prioritize BR records that are multi-unit and in the County Business Pattern (CBP) data. The rules proceed as follows:

1. the record that matches on EIN, name, state, and NAICS and is contained in CBP;
2. the record that matches on EIN, state, and NAICS and is contained in CBP;
3. the record that matches on the max number of EIN, name, state, and NAICS and is contained in CBP;
4. the record that matches on the max number of EIN, name, state, and NAICS, has closest ratio of BR employment to BEA employment, is contained in CBP and is multi-unit;
5. the record that matches on the max number of EIN, name, state, and NAICS, has closest ratio of BR employment to BEA employment, and is contained in CBP;
6. the match that is contained in the CBP, is multi-unit and has the closest employment ratio;
7. the match that is multi-unit;
8. the pair where the match was by EIN;
9. random.

For a subset of the largest MNEs, we use a clerical match provided by Fariha Kamal. In the event of conflicts with the original algorithm, we use the clerical matches which were done by hand. Finally, we use links between BEA firmids and Census firmids from the Business R&D and Innovation Survey.

B.2 Distinguishing US and Foreign-Owned Firms

The BEA data collected via survey BE-11 identifies the foreign affiliate activity by country and industry of firms operating in the United States (this is the outward data). The BEA data collected via survey BE-15 identifies firms operating in the United States that are owned by foreign parents, and provides information on the headquarter country of those parents (this is the inward data). In some cases, firms may exist in both of the BEA datasets. Consider a hypothetical example of foreign-owned firm that bases its North American headquarters in the United States. If those headquarters legally own affiliates in Canada or Mexico, they will report both outward and inward FDI activity. It is important to note that the BEA outward data therefore includes some activity by foreign-owned firms.

In principle, the BE10 file (the parent file), contains a variable BE15_id, which can be used to determine a firm's ultimate ownership country. In practice however, this approach does not seem to work using the Census firm definitions because it appears to overstate the extent of foreign ownership in the US relative to public data posted by the BEA. This overstatement is likely due to the fact that, for a small set of very large firms, the Census firm definition tends to encompass a larger number of EINs than the BEA definition. As a result, if we designate these larger Census firms as foreign-owned whenever they contain some portion of activity that the BEA classifies as foreign-owned, they are much larger than the BEA assignment and firm definition imply. Examination of the data suggests that in some cases, these larger Census firms are foreign-owned, while in other cases they seem to be US-owned.

To address these issues and distinguish between US and foreign MNEs as systematically as possible, we supplement the BEA data using the Census Bureau's Company Organization Survey (COS), which asks firms whether they are majority owned by a foreign firm and whether they own foreign affiliates. Before relying on the COS data, we analyze the accuracy of these previously unused variables by comparing the related party trade status and shares of firms that the COS identifies as foreign-owned or owning foreign affiliates. This analysis is available as technical documentation inside our project and provides reassuring evidence that the COS data do indeed contain relevant information for identifying MNEs.

For the subset of firms that appear in both the outward and inward BEA data and which the BEA classifies as majority foreign-owned, we use the COS and BR data to distinguish whether they are most likely US MNEs or foreign-owned firms when using the broader Census firm definition. First, we use the COS data and identify firms as "Foreign-owned" whenever those firms report that they are majority owned by a foreign firm in the COS. (Note that in this case, the BEA and Census COS data agree so this seems conservative.) Second, for firms that are missing the COS data, we aggregate the BEA data to the BEA-EIN level and calculate the share of the firm's employment at establishments that belong to EINs that the BEA flags as foreign-owned. We then identify firms as "foreign-owned" if their share of US "foreign-owned" employment is greater than 49 percent according to the Census firm definition. Finally, we classify the remaining firms as "US MNEs."

To summarize:

1. All firms that appear only in the BEA inward data are classified as "foreign-owned" firms,

2. All firms that appear only in the BEA outward data are classified as "US MNEs",
3. All firms that appear in both the BEA outward and inward data, and for which the firm reports the United States as the ultimate owner country to BEA are classified as "US MNEs",
4. For firms that appear in both the BEA inward and outward data, and for which the firm reports majority-ownership with the ultimate owner country not as the United States to BEA:
   - Classify as "foreign-owned" firms if they report being majority foreign-owned in the COS data,
   - Classify as "Foreign-owned" if are missing from the COS data but have greater than 49 percent of their US employment per the Census firm definition in establishments with EINs that are present in the BEA inward data,
   - Classify remaining firms as "US MNEs"

This approach results in approximately 7,600 foreign-owned MNEs and 2,800 US MNEs. These firms' share of employment, sales, and trade are reported in Table 1.

B.3 BEA Country Classifications

When matching the Census data to the BEA data, we find several countries that are aggregated in the BEA data (e.g., the French Islands, Kiribati, etc.). We aggregate the import data to match the level of aggregation in the BEA data. Generally gravity are only available for the main country in those cases. If there are multiple countries with gravity data, we use the data for the one with the largest population (e.g., in the case of Australia, Cocos Island, Norfolk Islands, Heard and McDonald Islands, etc., we use the gravity data on Australia).

B.4 Sample Description

The sample of firms in the paper is all firms with one or more manufacturing establishments in 2007, and/or with foreign affiliate manufacturing activity. We define foreign manufacturing activity as observations in the BEA outward data for which there is positive employment or sales activity in manufacturing. Table 5 shows the aggregate amount of all majority-owned affiliate activity, as well as the subset in manufacturing. The difference in these two amounts is likely related to retail, distribution, or other sectors.

We drop firms that have zero employment or sales in the United States. We do not drop the Census of Manufactures administrative records. Although these observations tend to have imputed information for values like inputs, they are surprisingly important for matching the LBD/EC data to the Customs Transactions database. Since our goal is to capture those foreign activities as completely as possible, we choose to retain these records.

We use the LFTTD data which is matched from the LBD to the trade transactions data by the Center for Economic Studies. Import data match rates are generally quite high, with the exception of nine countries like Djibouti, Tonga, etc. Since the focus of the paper is on manufacturing, we drop mineral imports and exports (HS2=27) from our analyses.

As in Antràs, Fort and Tintelnot (2017), we define a firm's total manufacturing inputs as: inputs mat merch and prod worker wages (assuming ww is prod worker wages).

B.5 Additional Tables

Table B.1 reports statistics on related-party imports and exports for US-based manufacturing firms in 2007. Column 2 indicates that 29 percent of domestic firms' imports are with related parties, while US MNEs and foreign-owned MNEs source 61 and 79 percent of their imports from related parties, respectively. As noted in the main text, the ownership threshold for related-party trade is only 5 percent, thus making it possible for domestic importers to feature positive values of related-party trade. Combining information from Tables 2 and 3, we note however that non-MNE manufacturing firms account for only 6.2 percent of the total manufacturers' related-party imports and 7.0 percent of total related-party exports. It is also worth noting that related-party trade shares are considerably lower for exports than for imports: both US and foreign-owned MNEs sell about 40 of their exports to related parties. These shares are approximately 34 percent less than their related-party import shares for US MNEs and 47 percent less for foreign-owned MNEs.

In Table B.2, we present summary statistics on imports and exports analogous to those in Tables 3 and B.1 but for the set of non-manufacturing firms.

In Table B.4, we present results on the relative importance of domestic and foreign production for US-based MNEs analogous to those in Table 5, but focused on the sample of firms that do not manufacture in the US. Note that, relative to the figures in Table 5, manufacturing sales of these affiliates are very small, from which we can infer that 99 percent of foreign manufacturing sales are carried out by the set of manufacturing firms that are the focus on Table 5.

In Table B.5, we aggregate the data used in Section 3 to estimate the firm-level gravity regressions to show that the standard relationships that have become well-known in the trade literature are also present in our data at that aggregated level.

Table B.1: Related-party trade statistics for manufacturing firms in 2007, by firm type

	$\frac{RP\,Importers}{Importers}$	$\frac{RP\,Imports}{Imports}$	$\frac{RP\,Exporters}{Exporters}$	$\frac{RP\,Exports}{Exports}$
Domestic	0.00	0.00	0.06	0.10
Importers	0.20	0.29	0.22	0.16
Foreign-Owned	0.85	0.79	0.70	0.42
US MNEs				
No foreign manuf affiliates	0.86	0.17	0.86	0.24
With foreign manuf affiliates	0.91	0.61	0.92	0.40
Manufacturers' Total	0.24	0.62	0.19	0.36

Sources: 2007 Economic censuses, LBD, LFTTD, BEA inward, and BEA outward datasets. Table presents the share of related-party importers and exporters, and the share of related-party imports and exports. "Domestic" firms are non-multinationals that do not import. "Importers" are non-multinationals that import. "Foreign MNEs" are firms that are majority owned by a foreign firm. "US MNEs" are firms that are majority owned by a US firm with majority-owned foreign affiliate activity, which we split based on whether the MNE owns foreign manufacturing affiliates. Sample consists of firms with one or more US manufacturing establishments in 2007.

Table B.2: Trade statistics in 2007 for firms without US manufacturing establishments, by firm type

Panel A: Imports	$\frac{Imports}{Sales}$	$\frac{Importers}{Firms}$	$\frac{RP\,Importers}{Importers}$	$\frac{RP\,Imports}{Imports}$
Importers	0.06	1.00	0.14	0.23
Foreign MNEs	0.09	0.52	0.68	0.70
US MNEs				
No foreign manuf affiliates	0.02	0.73	0.63	0.07
With foreign manuf affiliates	0.07	0.67	0.90	0.52
Non-Manuf Total	0.03	0.05	0.15	0.32
Panel B: Exports	$\frac{Exports}{Sales}$	$\frac{Exporters}{Firms}$	$\frac{RP\,Exporters}{Exporters}$	$\frac{RP\,Exports}{Exports}$
Domestic	0.01	0.02	0.06	0.10
Importers	0.02	0.34	0.14	0.11
Foreign MNEs	0.02	0.44	0.46	0.26
US MNEs				
No foreign manuf affiliates	0.01	0.73	0.56	0.18
With foreign manuf affiliates	0.02	1.00	0.53	0.22
Non-Manuf Total	0.01	0.04	0.10	0.14

Source: 2007 Economic censuses, LBD, LFTTD, BEA inward, and BEA outward datasets. Table presents the ratios of total imports to total sales and total exports to total sales, the share of each firm type that imports and exports, the share of related-party importers and exporters, and the share of related-party imports and exports. "Domestic" firms are non-multinationals that do not import. "Importers" are non-multinationals that import. "Foreign MNEs" are firms that are majority owned by a foreign firm. "US MNEs" are firms that are majority owned by a US firm with majority-owned foreign affiliate activity, which we split based on whether the MNE owns foreign manufacturing affiliates.

Table B.3: Import and export patterns by MNE status for US manufacturing firms

Panel A: Import Patterns					
	No. of Import	Share of	Share of	Number of Import Countries	
Firm Type	Countries	Importers	Imports	Average	Median
Domestic	1	0.47	0.01	1	1
	2+	0.48	0.17	4	3
Foreign MNEs	1	0.00	0.00	1	1
	2+	0.03	0.40	12	8
US MNEs	1	0.00	0.00	1	1
	2+	0.02	0.43	21	17

Panel B: Export Patterns					
	No. of Export	Share of	Share of	Number of Export Countries	
Firm Type	Countries	Exporters	Exports	Average	Median
Domestic	1	0.44	0.01	1	1
	2+	0.52	0.18	8	4
Foreign MNEs	1	0.00	0.00	1	1
	2+	0.03	0.27	19	10
US MNEs	1	0.00	0.00	1	1
	2+	0.02	0.54	40	35

Source: 2007 Economic censuses, LBD, LFTTD, and BEA inward and outward datasets. Top panel presents the share of US importers and import value, and the average and median number of import countries for all firms with manufacturing establishments in the United States in 2007 by firm MNE status. Bottom panel presents comparable statistics for US exports. "Foreign MNEs" are firms that are majority owned by a foreign firm. "US MNEs" are firms that are majority owned by a US firm with majority-owned foreign affiliate activity. Domestic consists of all other firms.

Table B.4: Sales by non-manufacturing MNEs' US and foreign establishments, by firm type

	Total Firm Sales				Sales Ratios	
	US Estabs		Affiliates		$\frac{\text{Affilates}}{\text{US Estabs}}$	$\frac{\text{Manuf Aff}}{\text{Affiliates}}$
	($B)	Share	($B)	Share		
Foreign MNEs	1,062	0.04	24	0.00	0.02	0.04
US MNEs						
No foreign manuf affiliate	3,183	0.11	809	0.16	0.25	
With foreign manuf affiliate	173	0.01	172	0.03	0.99	0.14
Total by MNE Manufacturers	4,418	0.16	1,005	0.20	0.23	0.02
Total by All Manufacturers	17,321	0.62	1,005	0.20	0.06	0.02

Source: 2007 Economic censuses, LBD, LFTTD, and BEA inward and outward datasets. Columns 1-4 present levels and corresponding shares of sales by MNEs' US establishments (US Estabs) and their foreign affiliates (Affiliates) by firm type. The last 2 columns present the ratio of MNE sales by foreign affiliates to sales by their US establishments ($\frac{\text{Affiliates}}{\text{US Estabs}}$), and the ratio of MNEs' total manufacturing affiliate sales over their total affiliate sales ($\frac{\text{Manuf Aff}}{\text{Affiliates}}$). Only sales by firms' majority-owned foreign affiliates are included. 'Foreign MNEs' are firms that are majority owned by a foreign firm. 'US MNEs' are firms that are majority owned by a US firm with majority-owned foreign manufacturing affiliates. Sample is MNEs with no manufacturing establishments in the United States in 2007, but the denominators in the share calculations include domestic and manufacturing firms' sales in each column.

Table B.5: Aggregate gravity regressions

	$log(imports_c)$		$log(exports_c)$	
	(1)	(2)	(3)	(4)
Common Language$_c$	1.129***	1.127***	0.936***	0.935***
	(0.274)	(0.275)	(0.165)	(0.166)
$log(distance_c)$	-0.991***	-0.984***	-1.107***	-1.106***
	(0.296)	(0.310)	(0.177)	(0.185)
$log(GDP_c)$	1.346***	1.345***	1.126***	1.126***
	(0.055)	(0.056)	(0.033)	(0.033)
Contiguous$_c$		0.11		0.016
		(1.310)		(0.800)
Adj. R2	0.78	0.78	0.87	0.87
Countries	182	182	188	188

Source: 2007 Economic censuses, LBD, LFTTD, BEA inward, BEA outward, and CEPII gravity datasets. The sample is all firms with manufacturing establishments in the United States in 2007 that import from multiple countries. The samples here are identical those used in the firm-level gravity regressions in Section 3. *,**, *** denote p<0.10, p<0.05, and p<0.01, respectively.

Table B.6: Extensive margin import regressions

Dependent variable is $importer_{frc} = 1$ if firm imports from country c

	(1)	(2)	(3)	(4)	(5)	(6)
Common Language$_c$	0.002	0.001	0.001	0.001		
	(0.008)	(0.008)	(0.008)	(0.008)		
$log(distance_c)$	-0.017	-0.006	-0.006	-0.006		
	(0.013)	(0.009)	(0.009)	(0.009)		
$log(GDP_c)$	0.015***	0.014***	0.014***	0.014***		
	(0.003)	(0.003)	(0.002)	(0.002)		
Contiguous$_c$		0.133***	0.128***	0.129***		
		(0.013)	(0.013)	(0.013)		
Affiliate$_{fc}$			0.550***	0.582***	0.501***	0.536***
			(0.028)	(0.031)	(0.025)	(0.028)
Foreign-Owned$_{fc}$			0.726***	0.735***	0.669***	0.678***
			(0.046)	(0.047)	(0.047)	(0.047)
Affiliate in Region$_{fr}$				0.069***		0.074***
				(0.015)		(0.015)
Foreign in Region$_{fr}$				0.086***		0.090***
				(0.020)		(0.021)
Firm FEs	Yes	Yes	Yes	Yes	Yes	Yes
Region FEs	Yes	Yes	Yes	Yes	No	No
Country FEs	No	No	No	No	Yes	Yes
Adj. R2	0.194	0.197	0.215	0.216	0.278	0.28
Observations (000s)	6,330	6,330	6,330	6,330	6,330	6,330

Source: 2007 Economic censuses, LBD, LFTTD, BEA inward and outward datasets, and CEPII. Dependent variable is an indicator for whether firm f imports from country c in region r. Sample is all firms with manufacturing establishments in the United States in 2007 that import from multiple countries. Observations in 1000s and rounded per Census disclosure rules. The mean and standard deviation of the dependent variable are 0.028 and 0.165, respectively. There are 182 countries in this sample. Standard errors two-way clustered by firm and by country. *,**, *** denote p<0.10, p<0.05, and p<0.01, respectively.

Table B.7: Intensive margin import regressions

Dependent variable is $log(imports_{frc})$

	(1)	(2)	(3)	(4)	(5)	(6)
Common Language$_c$	-0.264***	-0.252**	-0.272**	-0.269**		
	(0.101)	(0.110)	(0.113)	(0.113)		
$log(distance_c)$	-0.719***	-0.157	-0.105	-0.107		
	(0.191)	(0.347)	(0.386)	(0.385)		
$log(GDP_c)$	0.392***	0.377***	0.326***	0.331***		
	(0.050)	(0.054)	(0.058)	(0.058)		
Contiguous$_c$		0.874**	0.898**	0.885**		
		(0.378)	(0.411)	(0.411)		
Affiliate$_{fc}$			2.265***	2.363***	2.224***	2.331***
			(0.127)	(0.112)	(0.123)	(0.110)
Foreign-Owned$_{fc}$			3.399***	3.545***	3.617***	3.765***
			(0.165)	(0.177)	(0.227)	(0.223)
Affiliate in Region$_{fr}$				0.162		0.181
				(0.115)		(0.113)
Foreign in Region$_{fr}$				0.468***		0.480***
				(0.156)		(0.160)
Firm FEs	Yes	Yes	Yes	Yes	Yes	Yes
Region FEs	Yes	Yes	Yes	Yes	No	No
Country FEs	No	No	No	No	Yes	Yes
Adj. R2	0.233	0.234	0.268	0.269	0.282	0.283
Observations (000s)	177	177	177	177	177	177

Source: 2007 Economic censuses, LBD, LFTTD, BEA inward and outward datasets, and CEPII. Dependent variable is the log of imports by firm f, from country c, in region r. Sample is all firms with manufacturing establishments in the United States in 2007 that import from multiple countries. Observations in 1000s and rounded per Census disclosure rules. Standard errors two-way clustered by firm and by country. The mean and standard deviation of the dependent variable are 4.198 and 2.606, respectively. There are 182 countries in this sample. *,**, *** denote p<0.10, p<0.05, and p<0.01, respectively.

Table B.8: Extensive margin export regressions

Dependent variable is $exporter_{frc} = 1$ if firm exports to country c

	(1)	(2)	(3)	(4)	(5)	(6)
Common Language$_c$	0.021**	0.021**	0.021**	0.021**		
	(0.009)	(0.009)	(0.009)	(0.009)		
$log(distance_c)$	-0.023	-0.003	-0.003	-0.003		
	(0.020)	(0.012)	(0.011)	(0.011)		
$log(GDP_c)$	0.023***	0.022***	0.022***	0.022***		
	(0.002)	(0.002)	(0.002)	(0.002)		
Contiguous$_c$		0.229***	0.226***	0.226***		
		(0.013)	(0.013)	(0.013)		
Affiliate$_{fc}$			0.474***	0.512***	0.423***	0.463***
			(0.036)	(0.038)	(0.032)	(0.035)
Foreign-Owned$_{fc}$			0.590***	0.593***	0.518***	0.521***
			(0.040)	(0.040)	(0.043)	(0.043)
Affiliate in Region$_{fr}$				0.081***		0.087***
				(0.020)		(0.020)
Foreign in Region$_{fr}$				0.031**		0.035**
				(0.014)		(0.014)
Firm FEs	Yes	Yes	Yes	Yes	Yes	Yes
Region FEs	Yes	Yes	Yes	Yes	No	No
Country FEs	No	No	No	No	Yes	Yes
Adj. R2	0.222	0.227	0.233	0.234	0.266	0.267
Observations (000s)	7,230	7,230	7,230	7,230	7,230	7,230

Source: 2007 Economic censuses, LBD, LFTTD, BEA inward, and BEA outward datasets. Dependent variable is an indicator for whether firm f imports from country c in region r. Sample is all firms with manufacturing establishments in the United States in 2007 that export multiple countries. Observations in 1000s and rounded per Census disclosure rules. The mean and standard deviation of the dependent variable are 0.048 and 0.215, respectively. There are 188 countries in this sample. Standard errors two-way clustered by firm and by country. *,**, *** denote p<0.10, p<0.05, and p<0.01, respectively.

Table B.9: Intensive margin export regressions

Dependent variable is $log(exports_{frc})$

	(1)	(2)	(3)	(4)	(5)	(6)
Common Language$_c$	0.265***	0.267***	0.254***	0.254***		
	(0.080)	(0.078)	(0.073)	(0.073)		
$log(distance_c)$	-0.408***	-0.207*	-0.205*	-0.203*		
	(0.110)	(0.113)	(0.108)	(0.109)		
$log(GDP_c)$	0.407***	0.391***	0.363***	0.364***		
	(0.019)	(0.020)	(0.019)	(0.019)		
Contiguous$_c$		0.402***	0.394***	0.400***		
		(0.118)	(0.112)	(0.113)		
Affiliate$_{fc}$			1.973***	2.049***	1.906***	1.993***
			(0.107)	(0.103)	(0.108)	(0.102)
Foreign-Owned$_{fc}$			1.301***	1.280***	1.306***	1.286***
			(0.147)	(0.162)	(0.140)	(0.155)
Affiliate in Region$_{fr}$				0.142*		0.163**
				(0.079)		(0.078)
Foreign in Region$_{fr}$				-0.115		-0.112
				(0.121)		(0.122)
Firm FEs	Yes	Yes	Yes	Yes	Yes	Yes
Region FEs	Yes	Yes	Yes	Yes	No	No
Country FEs	No	No	No	No	Yes	Yes
Adj. R2	0.396	0.397	0.412	0.412	0.42	0.42
Observations (000s)	350	350	350	350	350	350

Source: 2007 Economic censuses, LBD, LFTTD, BEA inward, and BEA outward datasets. Dependent variable is the log of imports by firm f, from country c, in region r. Sample is all firms with manufacturing establishments in the United States in 2007 that export to multiple countries. Observations rounded per Census disclosure rules. Standard errors two-way clustered by firm and by country. The mean and standard deviation of the dependent variable are 4.098 and 2.153, respectively. There are 188 countries in this sample. *,**, *** denote p<0.10, p<0.05, and p<0.01, respectively.