Global Sourcing and Multinational Activity: A Unified Approach*

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Abstract

We develop a multi-country model in which multinational firms choose not only the location of their various assembly plants worldwide, but also the countries from which these plants import inputs. Our framework identifies a natural complementarity between these global sourcing and global assembly decisions. This complementarity delivers novel implications for the role of geography and trade policy in shaping the firms' global production strategies. By merging data on the full range of all US firms' domestic activities and imports from the US Census Bureau with comprehensive information on US multinationals' foreign affiliate activity and on foreign-owned firms' US plants, we provide novel evidence on these interdependencies. Multinationals account for the vast majority of US imports and exports, their export platform sales dwarf US exports, and they are much more likely to import not only from the countries in which they have affiliates, but also from other countries within their affiliate's region.

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1 Introduction

World trade flows are dominated by a small number of large firms – or 'superstar' exporters – that capture large market shares of their sector's exports (see Freund and Pierola, 2015; Gaubert and Itskhoki, 2018). For instance, in 2007, the top one percent exporters accounted for a staggering 79 percent of US exports (Bernard et al., 2018).[1] As significant as their exporting activity is, the global involvement of these superstar firms goes well beyond the mere act of selling domestically produced goods to foreign consumers.

On the one hand, large exporters rely heavily on global sourcing (and thus foreign value added) in the production of their goods (Handley, Kamal and Monarch, 2020), and importing is also highly skewed, with the top one percent of importers accounting for 83.5 percent of US imports (Bernard et al., 2018). In this paper, we calculate that in 2007 almost 95 percent of US goods exports were sold by firms that also import. On the other hand, and despite the fact that large firms dominate international trade flows, surveys conducted by various countries indicate that the very biggest firms often choose to produce their goods in foreign countries, rather than exporting them from their domestic base. This evidence is consistent with the well-known quantitative importance of multinational activity, some of which is explained by firms' incentives to save on transportation and trade costs when selling to foreign consumers. This form of horizontal or export-platform foreign direct investment (FDI) is a prominent feature of the data. We find that in 2007, exports by all US manufacturing firms accounted for just over one fourth of their foreign manufacturing sales.[2]

The incentives of firms, and especially large firms, to import intermediate inputs or to set up assembly plants abroad are well understood, but with very few exceptions that we review below, the literature tends to study each of these activities 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 tends to assume that final goods are either nontradable or are perfectly tradable, with these extreme assumptions rendering export-platform strategies trivial. This pervasive dichotomy in the literature is partly driven by theoretical considerations – the desire to isolate the determinants of either global sourcing or export-platform FDI – and partly by empirical considerations – the fact that available datasets have *not* contained detailed information on *both* the global sourcing strategies of firms as well as on their horizontal and export-platform FDI decisions abroad.

In this paper, we provide a unified framework to study firms' global sourcing and multinational production decisions. We develop a multi-country model in which firms choose not only the locations of their various assembly plants, as in the horizontal FDI and export-platform literatures, but also the countries from which all those plants import inputs, as in the global sourcing literature. Our framework

[1] The analogous figure is 48 percent for Belgium, 44 percent for France, 59 percent for Germany, 77 percent for Hungary, 32 percent for Italy, 53 percent for Norway, and 42 percent for the United Kingdom (see Mayer and Ottaviano, 2007).

[2] Our aggregate matched data include 740 billion USD exports of goods (Tables 1 and 2) and approximately $1,861 billion USD manufacturing sales by the majority-owned foreign affiliates (Tables 5 and 6) of all firms with US manufacturing establishments. The share of US exports in total foreign sales is even lower (about 24 percent) when including multinational enterprises outside manufacturing and when considering sales of services abroad (Antràs and Yeaple, 2014).

identifies a natural complementarity between these two decisions and delivers novel implications for the role of geography and trade policy in shaping the global production strategies of firms. Empirically, we merge US Census domestic and trade data with the US Bureau of Economic Analysis (BEA) comprehensive surveys on multinational activity to document a series of novel facts regarding the global assembly and global sourcing strategies of US-based firms, and how they are interrelated.

We begin in section 2 by describing newly linked, comprehensive data on the domestic and foreign activities of all firms with US operations. We construct this new dataset by merging the Bureau of Economic Analysis (BEA) data on US-based firms' multinational activities to the universe of private, non-farm employer establishments in the United States provided by the US Census Bureau. Throughout the paper, we use the term "US-based MNEs" to describe all multinational firms with positive employment in the United States. We classify firms as multinationals if they are majority owners of affiliates in other countries (US MNEs), or if they are majority owned by a foreign firm (foreign-owned MNEs). We combine these data with detailed Customs trade transactions to construct a unified dataset on the domestic, export, import, and multinational activity of US-based firms. While numerous studies had exploited the BEA and Census data in isolation, ours is one of the first projects to use both.[3]

The newly linked data provide detailed information on the full range of US-based MNEs' imports, exports and global operations. Access to the Customs trade transaction data is critical for characterizing the global sourcing and export strategies of MNEs, since we find that 40 percent of US MNEs' imports are from arms'-length suppliers, and BEA surveys only provide aggregated information on these across-firm trade flows.[4] We use these data to analyze how MNEs' global sourcing decisions differ from those of firms that only sell domestically or that export but do not engage in multinational activity. A crucial novel feature of the data for this project, relative to previous studies using only US Census data, is that they shed light on how US MNEs' global sourcing strategies are related to the geography of their foreign affiliate activity. Furthermore, since our dataset includes information from the BEA surveys on US affiliates of foreign-based multinationals, we can also assess whether and how these firms' US affiliates orient their sourcing decisions towards their parent countries.

We first present a series of novel facts on the aggregate importance of both US and foreign MNEs in the US economy, especially in the manufacturing sector. In line with our emphasis on the dramatic size differences of MNEs, the data indicate that although US MNEs are fewer than 0.06 percent of all US firms, they employ 19 percent of workers, and account for 31 percent of aggregate sales, 36 percent of US imports and 48 percent of US exports. Similarly, foreign-owned MNEs' US affiliates account for only 0.17 percent of all firms, but employ 6 percent of the US labor force, and account for 13 percent of total sales, 33 percent of imports, and 24 percent of exports.

The disproportionate importance of MNEs is even more salient among manufacturers.[5] Firms

[3]As described in section 2, merging the outward and inward MNE BEA datasets is itself challenging because a nontrivial number of firms appears in both datasets. To resolve this duplication issue, we use ownership and voting share information from the BEA data, along with the Census Bureau's Company Organization Survey (COS), to distinguish US MNEs from foreign-owned MNEs.

[4]Conversely, BEA information can be combined to obtain US bilateral related-party imports and exports.

[5]We follow Fort, Pierce and Schott (2018) and classify all firms with one or more manufacturing plants as manufacturers.

engaged in multinational activity (either outward or inward) constitute only 1.5 percent of all US manufacturing firms, yet account for 41 percent of US manufacturing employment, as well as 74 percent of sales, 87 percent of imports, and 84 percent of exports among all manufacturers in the United States. We further show that these MNE manufacturers are not only large in the US, but also have very sizable operations abroad. Total foreign affiliate sales by US MNEs with foreign manufacturing are 74 percent of their total US establishments' sales. Furthermore, manufacturing sales to countries other than the US by these foreign affiliates are about four times larger than their corresponding US establishments' merchandise exports from the US, which highlights that foreign production is by far the most salient method to make US-branded products available to foreign consumers. Taken together, these facts suggest that changes in the global sourcing, exporting, and global assembly strategies of this small set of roughly 3,700 firms have the potential to cause sizable effects on the US manufacturing sector, and the US economy more broadly.[6]

Moving beyond these descriptive statistics on the quantitative importance of multinational companies in the US manufacturing sector, in section 3 we present reduced-form evidence suggesting the existence of significant interdependencies in MNEs' global sourcing and global assembly strategies. The descriptive statistics already hint at the fact that global sourcing is more important for MNEs than for non-MNEs, and that among MNEs, foreign-owned firms import disproportionately more. While domestic importers' ratio of imports to sales is 6.0 percent, US MNEs import 11 percent of their total sales value, and foreign-owned firms import 14 percent. An interpretation of this finding is that global sourcing is more prevalent for firms whose center of gravity, in terms of their global assembly strategies, is further away from the United States.

We explore this hypothesis more formally via regressions that assess how the cross-country variation in the extensive and intensive margins of US global sourcing is related not only to standard gravity variables (such as distance, origin country GDP, common language and contiguity), but also to measures of the global operations (if any) of US importers. To do so, we focus on the subset of manufacturing firms that import from two or more countries. These firms constitute just over half of manufacturing importers, but account for 99 percent of their imports. Even after controlling for firm and country fixed effects, we find that US MNEs are over 50 percentage points more likely to import from countries in which they have a majority-owned manufacturing affiliate, and foreign-owned MNEs are about 70 percentage points more likely to import from their headquarter country. These relationships are economically large: a doubling of GDP is associated only with a 0.02 percentage point increase in the probability of importing from a country. We similarly find an economically large and statistically significant relationship with the amount a firm imports from a country and its MNE activity. US MNEs imports are about 230 log points higher from countries in which they have affiliates, and foreign-owned firms import over 300 log points more from their home country. These strong relationships between firm-country-level imports and MNE activity are suggestive of significant complementarities between a firm's FDI and foreign sourcing decisions.

This ensures that our sample covers all US manufacturing activity.

[6] Relatedly, Setzler and Tintelnot (2021) estimate sizable positive wage effects of foreign multinationals on their workers and sizable positive indirect effects on domestic firms and the workers at those firms.

One interpretation of this novel finding is that performing one type of activity – global assembly or global sourcing – in a country lowers the additional fixed cost associated with the other activity. Alternatively, we hypothesize that activating one of these strategies increases the marginal benefit of activating the other one due to the benefits of locating assembly and suppliers in nearby locations. To provide additional evidence on the existence of this type of spatial correlation between global assembly and global sourcing, we estimate the relationship between a firm's country-level imports and the presence of MNE activity in the country's region, though *not* in the source country itself. We find that the presence of an affiliate in the same region is associated with a 7 percentage point higher probability of importing from a country. We also find that foreign-owned MNEs are 9 percentage points more likely to import from, and have 48 log points higher imports from, countries that are in the same region as their headquarters. By contrast, there is no statistically significant relationship between the amount a firm imports from the country and the presence of a foreign affiliate in the 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.

We conclude our empirical analysis with an analogous study of how the export patterns of US-based manufacturing firms are shaped by their global assembly strategies. We show that the extensive margins of firms' exports are larger from both countries and regions in which US MNEs have foreign affiliates or in which foreign-owned US affiliates have their headquarters. The effects of foreign multinational activity on the intensive margin of exports are more mixed: the intensive margin of exports is positively impacted by the presence of an affiliate in the country or region in which the firm exports, but the existence of a parent company (headquarters) in a given country only enhances the intensive margin of exports to that country but not to other countries in the headquarter's region.

Motivated by these empirical findings, in section 4 we develop a multi-country model in which a firm decides on both its global assembly strategy, namely the set of countries in which to set up assembly plants, as well as its unique global sourcing strategy, that is the set of countries from which all of its plants worldwide source inputs. The model constitutes a marriage of the Tintelnot (2017) model of export-platform of FDI and the global sourcing framework in Antràs, Fort and Tintelnot (2017). We model an economy in which consumers in J countries have nested constant-elasticity-of-substitution (CES) preferences over differentiated varieties produced by various firms in a single manufacturing sector. On the supply side, each firm produces a continuum of differentiated varieties in a sector characterized by monopolistic competition with free entry. Although firms face constant marginal costs, technology features increasing returns to scale due to the presence of several fixed costs of production: each firm pays an initial fixed cost of entry to obtain the blueprint for its bundle of differentiated consumer goods, and then incurs additional overhead costs to market its goods abroad, to set up assembly plants worldwide, and to activate specific countries as sources for its inputs. As in Melitz (2003), firms draw heterogeneous core productivity levels that are revealed upon entry, and which result in heterogeneous levels of participation in the global economy. More specifically, after entry, a firm faces three main decisions regarding the extensive margins of its operations. First, it decides whether to remain domestically oriented (at no further cost), or whether to pay a fixed cost to become a "global exporter," which allows the firm to sell goods in any market (we incorporate *destination-specific* selection into exporting in an extension). Second, it decides on the number and locations of the various assembly plants in which to manufacture goods (these locations serve as export platforms as in Tintelnot, 2017). Third, it chooses the set of countries from which to source inputs (as in Antràs, Fort and Tintelnot, 2017).

Our theoretical framework shares many features with the model developed by Bernard et al. (2018) to organize their review of the export and import activities of firms producing in the US. A key novel feature of our framework is that a firm's sourcing strategy is a firm-level (rather than plant-level) 'asset', in the sense that all plants worldwide belonging to the same firm have access to the same sources of inputs. More specifically, if a US MNE has an affiliate in Japan that profitably sources inputs from China, the firm's US manufacturing plants will also have access to Chinese inputs at no additional fixed cost. We show that these economies of scale at the firm level in designing global sourcing strategies are crucial for our model to rationalize our empirical findings described above indicating that the global sourcing strategies of US importers are shaped by their global assembly operations.[7]

In order to simplify the characterization of the firm's intensive margin decisions, we follow Tintelnot (2017) and Antràs, Fort and Tintelnot (2017) in applying the probabilistic approach to productivity in Eaton and Kortum (2002). This produces simple gravity-style formulas for both firm-level bilateral shipments of consumer goods from any country where a firm assembles finished goods to all other countries in the world, as well as for firm-level bilateral purchases of intermediate inputs from countries in a firm's sourcing strategy to each country in which that same firm assembles final goods. Furthermore, this probabilistic approach delivers a simple closed-form solution for the profits of the firm as a function of the set of countries 'activated' as sources of inputs and/or as export platforms.

The determination of a firm's extensive margin decisions is much more complex because it is shaped by various forces. Consider a firm that currently produces only in its home country, possibly exporting to other countries. Adding an assembly location entails an additional fixed cost, but also reduces the trade costs the firm will incur when selling not only to consumers in that new assembly location, but also to consumers in nearby locations. Furthermore, this new plant may impact the marginal benefit of setting up additional assembly plants in other countries via demand complementarities or via demand cannibalization effects. The extensive market decisions associated with the global assembly strategy of firms are thus interdependent across countries, but unlike in Tintelnot (2017), we allow for the possibility of the firm's profit function featuring either decreasing *or* increasing differences in pairs of extensive margin assembly decisions.[8]

Next, consider the firm's global sourcing strategy. Adding a new source of inputs again entails a fixed cost, but it also reduces the marginal cost of obtaining inputs for the firm's assembly plant(s), thereby increasing the optimal scale of the firm. Whether extensive margin sourcing decisions are

[7]Our baseline framework is admittedly less general than Bernard et al. (2018) in some dimensions. Notably, we treat all firms as being non-atomistic.

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

complements or substitutes depends on parameter values, much as the condition identified in Antràs, Fort and Tintelnot (2017). Finally, our model features an additional force that, in many (but not all) cases creates a complementarity between both types of extensive margin decisions. Intuitively, a richer sourcing strategy reduces marginal costs, increases optimal firm scale, and thus makes a richer assembly strategy more appealing (or its associated fixed costs easier to amortize). Similarly, richer assembly strategy increases overall firm sales and thus makes a more expansive sourcing strategy more appealing (or its associated fixed costs easier to amortize).

Overall, due to the various sources of substitutability and complementarity in the model, the problem of determining of a firm's extensive margin decisions constitutes a complex combinatorial optimization problem with $2^{J\times 2}$ possible choices, where J denotes the number of possible assembly and source countries. We identify a set of conditions under which the profit function features increasing differences in all extensive margin choices, which facilitates the derivation of sharp comparative statics and simple algorithms to solve the firm-level problem, as in Jia (2008) and Antràs, Fort and Tintelnot (2017). Outside that region of the parameter space, however, our framework does not 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 Arkolakis, Eckert and Shi, 2021).

We conclude the paper with a specific case of our model that isolates the sources of interdependency that are novel to our framework, and we demonstrate that these forces provide a natural explanation for our reduced-form results. Furthermore, we provide two low-dimensional examples to illustrate the implications of the presence of firm-level economies of scale in global sourcing. In particular, we show that changes in tariffs on inputs and on final goods may lead to non-monotonic responses in US manufacturing, in contrast to the results we obtain when global sourcing strategies are at the plant (rather than the firm) level.

Literature Review. Our paper contributes to the literature in two broad ways. First, we provide a unified framework to analyze global sourcing and multinational firm activity, while most previous studies examine each in isolation. Specifically, work on offshoring and global sourcing – such as Helpman (1984), Antràs and Helpman (2004), Grossman and Rossi-Hansberg (2008) and Antràs, Fort and Tintelnot (2017) – typically ignores the fact that firms face a nontrivial choice in their optimal location of assembly in the presence of trade costs in final goods. On the other hand, work on horizontal FDI and export-platform FDI – such Markusen (1984), Brainard (1997), Helpman, Melitz and Yeaple (2004), Arkolakis et al. (2018) or Tintelnot (2017) - typically ignores that the various assembly plants of multinational companies worldwide rely heavily on foreign inputs in their production processes. We are certainly not the first to incorporate intermediate input flows into models of horizontal and export-platform FDI (see, for instance, Helpman, 1985; Ramondo and Rodríguez-Clare, 2013), but previous frameworks did not incorporate an active extensive margin of global sourcing. While Yeaple (2003) and Grossman, Helpman and Szeidl (2006) explicitly discuss the existence of the type of complementarities between global sourcing and global assembly that feature prominently in our framework, they do so in models with at most three countries and two inputs, and do not study the empirical relevance of their findings. In the survey on 'global firms', Bernard et al. (2018) develop a model featuring global assembly and global sourcing strategies, but their framework imposes assumptions that render assembly decisions independent across countries, and also focuses on the case in which global sourcing strategies are at the plant level.[9]

Our second main contribution is to advance the construction and analysis of a newly linked dataset that allows us to observe the global operations of firms based in the United States. We build on extensive work by Kamal, McCloskey and Ouyang (2021) to merge the BEA and Census datasets. Our focus on MNEs' trade behavior adds to a significant literature documenting the export and import decisions of US firms (e.g., as in Bernard and Jensen, 1999; Bernard et al., 2007a, 2018; Antràs et al., 2017) by showing how these decisions are shaped by companies' global operations. Prior work highlights the important role of multinational companies in US trade (see, for instance Bernard et al., 2009a,b), but our linked data allow us to provide the first complete portrait of how these decisions are related to MNEs' global assembly locations (*i.e.*, the countries and regions in which US MNEs locate foreign production), as well as the headquarter country and regions of foreign-owned firms with US operations.

The rest of the paper is structured as follows. In section 2, we introduce our novel, linked dataset and provide descriptive evidence supporting the quantitative relevance of global sourcing, global assembly, and their joint determination. In section 3, we provide reduced-form evidence suggestive of the interdependencies between the various margins of firm participation in global markets. In section 4, we present the assumptions of our model and solve for the equilibrium of the model for fixed global assembly and global sourcing strategies. The choice of these optimal strategies, and the challenges that such a choice entails, are discussed in section 5. In section 6, we seek to isolate the key novel aspects of our theory and relate them to our empirical results in section 3. Section 7 concludes.

2 New Data and Facts on US Multinational Activity

In this section, we describe the newly linked, comprehensive data on US-based firms' domestic and foreign activities. We first describe all the data sources and how we combine them, and define the sample of firms on which we focus in this paper. 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, (ii) their relative propensity to engage in exporting and global sourcing; (iii) the extent to which they rely on foreign production to make their goods available to foreign consumers, and (iv) the extent to which their exporting and global sourcing strategies appear to be interdependent with their global assembly strategy.

[9]The recent literature on global value chains (see Costinot, Vogel and Wang, 2013; Antràs and Chor, 2013; Antràs and De Gortari, 2020) also characterizes the optimal location of input production and assembly. Nevertheless, that work typically assumes environments with either no trade costs or with constant returns to scale, with these assumptions shutting down most of the interesting forces in our framework.

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 US-based firms' multinational activities to the universe of private, non-farm employer establishments in the United States 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 projects to use both. A crucial benefit of the combined data is that they allow us to measure the full extent of US MNEs' import and export patterns, regardless of whether those transactions occur at arm's length or within the boundary of the firm. We are also able to measure the full range of all US-based MNEs' domestic activities, and to compare them to those of domestic-only firms. We focus on 2007 data in this project so that we can employ the most detailed Census data, 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.[10] The LBD contains a firm identifier ($firmid$) that captures all of the establishments that are under common ownership or the control in a given year. We use $firmid$ to identify all establishments under the same firm ownership. This identifier is particularly important for US multinationals, that tend to have multiple establishments across a wide range of industries.[11]

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

We also link the dataset to the 2007 Longitudinal Trade Transaction Database (LFTTD). The trade data are collected by US Customs and Border Protection and based on the universe of import and export transactions by US-based firms. 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.[12] We match these data at the firm level to the LBD and EC data, and follow Antràs, Fort and Tintelnot

[10]In practice, this information is reported 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). New multi-unit firms are identified in the Economic Census data. See Jarmin and Miranda (2002) and Chow et al. (2021) for details on the LBD construction.

[11]The BEA data also contain firm identifiers. In practice, we find that the Census firmid includes more US activity than the BEA firm identifiers. This is likely due to the Census Bureau's access to the COS data that contain annual information on all multi-unit firms' establishments.

[12]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. (2007b) and Kamal and Ouyang (2020) for additional details on the LFTTD. The matched data cover about 80 percent of total exports and imports.

(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 other markets, by affiliate country and industry. These data are collected for US-based firms that have 10 percent or greater ownership shares in foreign affiliates whose sales, assets, or net income are 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.

We use data collected from the BE-12 survey to identify foreign-owned 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 and Census datasets using Employer Identification Numbers (EINs), and by name and address. Additional details on the matching process are in Appendix Section B.1.

It is worth emphasizing how our merged dataset improves upon the independent use of the various underlying data sources. Relative to the BEA foreign direct investment surveys, access to the LFTTD allows us to document US MNEs' imports and exports across source and destination markets regardless of whether those transactions involve foreign affiliates or not. More specifically, BEA's BE-11 survey can be employed to construct related-party trade between US parents and their foreign affiliates, but arm's-length imports by US parents are only reported aggregated across origin countries. For US-based foreign-owned affiliates, BEA's BE-12 survey provides information on their related-party and arm's-length imports and exports, but for neither of these categories can one construct bilateral trade flows, as these entities only report flows aggregated across source and destination countries. Furthermore, we note that the LFFTD dataset contains detailed product information on imports and exports, while BEA only reports these flows at the entity (parent or affiliate) level.[13]

What do BEA surveys add to the information available from the LBD and LFTTD databases? Although some authors (see, for instance, Bernard, Jensen and Schott, 2009a) have inferred US trade by multinational firms by labeling as MNEs those US-based firms trading on a related-party basis according to the LFTTD, the merge with the BEA surveys allow us to gain more precise information on the exact location and nature of the foreign operations of these firms. Another novel contribution of our data construction effort is to distinguish US MNEs from foreign-owned firms. To do so, we use the ownership and voting share information from the BEA data, along with the Census Bureau's Company Organization Survey (COS), to separate US MNEs from foreign-owned MNEs. We provide details of our method in Appendix Section B.2.

It is equally important to stress one important limitation of our merged dataset. Although we believe that we have a close to complete and accurate portrait of the global operations of US MNEs,

[13]Having said this, in this paper we will not exploit the product-level information in imports and exports, except for the exclusion of mineral trade (HS2=27), as mentioned above.

the same is not true of foreign-owned MNEs operating in the US. More specifically, although BEA surveys require US-based firms to report information on their majority-owned foreign affiliates and on the location of their ultimate owner, no such information is available for other foreign affiliates (outside the US) of the foreign parent group (that are not direct affiliates of the US affiliates), and we also lack operational data on the parent company of these foreign-owned affiliates. As such, our merged dataset likely misses a significant share of the foreign parent group global sales, employment and trade flows.

2.2 Definition of the Sample and Aggregate Importance of MNEs

We first use the newly linked BEA-Census data to present statistics on the aggregate importance of globally-involved firms. To do so, we focus on four mutually-exclusive firm types: US multinational enterprises (US MNEs), foreign-owned multinationals (foreign-owned MNEs), US importers that are not multinationals (Importers), and all other domestic firms (Domestic). We define foreign-owned MNEs as those that are majority owned by a foreign entity. We define US MNEs as firms that have majority-owned foreign affiliate activity and are not foreign owned. We classify all remaining firms as domestic, and separate these into firms that do or do not import.

Table 1 presents aggregate information on the number of firms, workers, sales, and trade flows 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 workers and account for one third of aggregate sales. US MNEs are even more important in terms of trade, mediating one third of total merchandise imports and almost half of all US merchandise exports.[14] Foreign-owned firms are also disproportionately involved in trade, accounting for 6 percent of aggregate employment, but one third of imports and a quarter of US exports. Finally, (non-MNE) US importers are also important in the aggregate. They account for about a quarter of US employment, sales, imports, and exports. In contrast, non-importers are about 50 percent of employment but account for 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-Owned	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

Notes: Table presents levels of firms, employment, sales, imports, and exports, for US firms in 2007. 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-owned" are firms that are majority-owned by a foreign firm. US MNEs are firms that are majority-owned by a US firm and that have majority-owned foreign affiliate activity. Observations rounded per Census disclosure rules.

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

In this paper, we focus on the subset of firms with one or more manufacturing establishments located in the United States so 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). This distinction for multinationals is new to this paper, since the comprehensive domestic establishment-level data 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 do not. This allows us to analyze the extent and aggregate importance of firms that may have shed (or never had) domestic manufacturing and replaced it with foreign affiliates.[15]

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-Owned	2,200	0.03	0.12	0.10	0.26	0.21
US MNEs						
w/o Manuf Aff	350	0.04	0.03	0.05	0.03	0.02
w/Manuf Aff	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-Owned	5,400	0.03		0.04	0.07	0.03
US MNEs						
w/o Manuf Aff	1,100	0.09		0.11	0.04	0.02
w/Manuf Aff	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

Source: 2007 Economic censuses, LBD, LFTTD, BEA inward, and BEA 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. "Foreign-owned" are firms that are majority-owned by a foreign firm. US MNEs are non-foreign-owned firms with majority-owned foreign affiliates. "Domestic" firms are non-multinationals that do not import. "Importers" are non-multinationals that import. 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 to 6 sum to 1.00 except due to rounding.

[15] The vast majority of foreign-owned US-based firms with US manufacturing activity also report foreign manufacturing activity, so we do not separate these for disclosure avoidance purposes.

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 account for around 32 percent of US imports and 45 percent of exports, whereas US MNEs without domestic manufacturing account for only 5 and 2 percent, respectively (see Panel B). Foreign-owned firms with US manufacturing 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. We can also infer from Table 2 that US-based MNEs account for a striking 87 percent of US manufacturer's imports and 84 percent of US manufacturer's exports.[16] An interesting difference is evident for domestic importers. While non-manufacturing importers account for 22 percent of imports, manufacturing importers mediate just 9 percent of imports. These domestic importers' export shares are comparable, at just over 10 percent each of the aggregate.

We summarize the key takeaways from Table 2 as follows:

Fact 1. *Despite accounting for only 1.5 percent of all firms engaged in manufacturing in the US, US-based multinational firms account for 41 percent of US manufacturing employment, 74 percent of US manufacturing firms' sales, 87 percent of manufacturing firms' imports, and 84 percent of US manufacturing firms' exports.*

2.3 Import and Export Patterns by Firm Type

We can also exploit the newly linked data to provide aggregate statistics on the extensive and intensive margins of manufacturing firms' foreign trade decisions by firm type. Table 3 reveals the relative importance and propensity of firms' 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.[17] Imports are almost twice as important for US MNEs, whose imports-to-sales ratio is 11 percent, and foreign-owned 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 reports comparable statistics for exports. The patterns are quite similar to those for imports. US-based MNEs (US- and foreign-owned) are significantly more engaged

[16] These figures are slighly smaller in magnitude to those obtained by Bernard, Jensen and Schott (2009a). These authors identifed MNE-mediate trade as the trade conducted by firms (manufacturing and non-manufacturing) that report positive values for related-party imports or exports. As is clear from Panel B of Table 2, when taking into account non-manufacturing trade, our methodology would deliver a significantly lower percentage of imports and exports mediated by multinational firms. More specifically, about 70 percent of overall merchandise imports and exports have a US-based MNE on one side of the transaction, which is significantly lower than the 90 percent figure obtained by Bernard, Jensen and Schott (2009a). This divergence is to be expected given that the ownership threshold for a transaction to be recorded as a related-party trade transaction in the LFTTD is much lower than the majority-ownership threshold we have imposed based on the BEA surveys.

[17] We exclude US MNEs without foreign manufacturing affiliates from this comparison since they are few in number and we will classify them as "Domestic Importers" for the remainder of this paper. In other words, we will largely associate US MNE with firm featuring at least one majority-owned foreign manufacturing affiliate activity that is not majority foreign owned.

in exporting than domestic firms. Three lessons from columns 3 and 4 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.

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-Owned	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

Source: 2007 Economic censuses, LBD, LFTTD, BEA inward, and BEA outward datasets. Table presents the ratios of firm imports to sales and exports to 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. "Foreign-owned" are firms that are majority-owned by a foreign firm. "US MNEs" are non-foreign-owned firms with majority-owned foreign affiliates. "Domestic" firms are non-multinationals that do not import. "Importers" are non-multinationals that import.

In Appendix B.5, we also report statistics on the relative prevalence of related-party trade for these different types of firms (see in particular, Table B.1). Quite naturally, we document that US MNEs and foreign-owned MNEs are much more likely to trade within firm boundaries than domestic firms.[18] Still, a large percentage of MNEs imports and exports involve arm's-length trade, which highlights the importance of the Census dataset in providing a more accurate view of the importing and exporting strategies of US-based MNEs. In Table B.2 of Appendix B.5, we also report trade statistics on imports, exports and related-party trade for non-manufacturing firms in 2007.

We next turn to a more detailed description of the extensive margin of imports and exports by firm type. The top panel in Table 4 presents information on the share of imports and importers by firm MNE status, and by single versus multiple country importers.[19] Among domestic firms, it is common for firms to import from a single country, with half of domestic importers sourcing from a

[18]The ownership threshold for related-party trade is only 5 percent, thus making it possible for domestic importers to have related-party transactions imports from related parties.

[19]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.

single location. In contrast, effectively all MNEs import from multiple countries. Despite the large share of firms that imports from a single country, the second column in Table 4 shows that these single-country importers account for only 1.0 percent of manufacturers' imports.

The last two columns in Table 4 report the average and median number of countries from which multi-country importers source. Domestic manufacturers import from an average of 4 countries, while the median number is 3. Foreign-owned firms import from an average of 12 countries and a median of 8 countries. Finally, US MNEs have the most expansive sourcing strategies, importing from an average of 21 and a median of 17 foreign countries.[20]

Table 4: Import and export patterns by MNE status for US manufacturing firms

Panel A: Import Patterns					
Firm Type	No. of Import Countries	Share of Importers	Share of Imports	Number of Import Countries Average	Median
Domestic	1	0.47	0.01	1	1
	2+	0.48	0.17	4	3
Foreign-Owned 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					
Firm Type	No. of Export Countries	Share of Exporters	Share of Exports	Number of Export Countries Average	Median
Domestic	1	0.44	0.01	1	1
	2+	0.52	0.18	8	4
Foreign-Owned 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-owned consists of firms that are majority-owned by a foreign firm. US MNEs consist of firms that have majority-owned foreign affiliate manufacturing activity and are not a foreign-owned. Domestic consists of all other firms.

The bottom panel of Table 4 presents comparable statistics for firms' export behavior by MNE status. Multi-country exporters 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

[20]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.

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.

Tables 3 and 4 offer a wealth of statistics, but we summarize the main lessons we take away from these tables as follows:

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

2.4 Global Production Patterns

We next leverage our merged Census-BEA dataset to calculate the aggregate importance of US-based MNEs' foreign affiliate activity. Table 5 breaks down the total worldwide sales of US-based MNEs into the sum of sales (domestic and exports) by these firms' domestic establishments and the sales of their majority-owned foreign affiliates. Columns 1 to 4 present the levels and shares of each of these flows. We restrict the analysis to US-based firms with US manufacturing establishments, but note from column 4 that these account for 80 percent of all US-based MNEs' foreign sales.[21]

Table 5: US-Based MNEs' foreign affiliate activity, by firm manufacturing and MNE type

	US Estab Sales ($B)	Share	Affiliate Sales ($B)	Share	$\frac{\text{Aff Sales}}{\text{US Estab Sales}}$	$\frac{\text{Manuf Aff Sales}}{\text{Aff Sales}}$
Foreign-Owned	2,702	0.22	839	0.17	0.31	0.43
US MNEs						
w/o Manuf Aff	1,446	0.12	249	0.05	0.17	0.00
w/Manuf Aff	3,853	0.31	2,857	0.58	0.74	0.60
MNE Manufacturers' Total	8,001	0.64	3,945	0.80	0.49	0.53

Source: 2007 Economic censuses, LBD, LFTTD, BEA inward, and BEA outward datasets. Columns 1-4 present levels of firms' sales by US establishments and foreign affiliates, and the share of these aggregates accounted for by each MNE firm type. Column 5 presents $\frac{\text{Aff Sales}}{\text{US Estab Sales}}$, which is the ratio firms' foreign affiliate sales over their US establishments' sales. Column 6 presents $\frac{\text{Manuf Aff Sales}}{\text{Aff Sales}}$, which is the share of firms' total manufacturing affiliate sales over their total affiliate sales. Only sales by the firms' majority-owned foreign affiliates are included in these calculations. "Foreign-owned" are firms that are majority-owned by a foreign firm. US MNEs are non-foreign-owned firms with majority-owned foreign affiliates. All statistics are for firms with manufacturing establishments in the United States in 2007.

Column 5 presents the ratio of MNEs' foreign affiliate sales to US establishment sales, by firm type. Total foreign affiliate sales by US MNEs with foreign manufacturing sales are equal to a striking

[21] In Table B.3 of Appendix B.5, we present analogous figures for non-manufacturing firms, and we infer that 99 percent of foreign manufacturing sales are carried out by the set of manufacturing firms that are the focus on Table 5.

74 percent of their domestic establishment sales. This figure highlights the relevance of these firms' foreign assembly locations. This statistic is much smaller for foreign-owned MNEs, at only 0.31. It is important to reiterate, however, that the BEA data only collects the foreign affiliate sales of these firms' foreign affiliates that are majority-owned by their US operations, and thus we probably miss a significant share of the foreign parent group global sales. Finally, in column 6 we calculate the share of foreign affiliate sales that is 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.

It is revealing to compare these foreign merchandise sales to these same firm's US exports of goods. From Table 2, these firms' US exports are 43 percent of the 937 US billion figure in Table 1, or 403 US billion. This implies that the manufacturing sales of foreign affiliates of US MNEs are more than four times larger than their corresponding US establishments' exports.

We conclude this section with statistics on the foreign affiliate sales in manufacturing by US MNEs with domestic manufacturing establishments. US MNEs have majority-owned foreign manufacturing affiliates in an average of 6.42 countries. In Table 6, we present the weighted average of these firms' total manufacturing affiliate sales, as well as their average sales across destinations. Column 2 shows that the majority of foreign affiliate sales are local, with 54 percent of US MNEs' sales remaining in the host country. Export platform sales are also significant, with 35 percent of US MNEs' affiliate sales shipped to 'third' markets (i.e., markets other than the host country and the US). 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.[22]

Table 6: Foreign affiliate manufacturing sales for US MNEs 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 BEA outward datasets. Table presents the weighted firm-level average of foreign affiliates' manufacturing sales in millions USD by destination for US MNEs with US manufacturing establishments. "US MNEs" are non-foreign-owned firms with majority-owned foreign manufacturing affiliates.

Combining the figures in Tables 5 and 6, we can also assess the extent to which US MNEs sell their goods to foreign consumers via exports or via FDI sales. Remember that US exports of goods by

[22]We note that these statistics include firms with zero reported flows. If some of these zeros include missing flows, our estimates may be biased. For instance, our results in Tables 1, 2, and 3 imply that US MNEs import 253.9 billion USD within their firm boundaries, which corresponds to an average of 211 million USD per firm. This figure clearly exceeds the 138 million USD figure reported in the last column of Table 6. Specifically, the (roughly) 1,200 US MNEs with domestic and foreign manufacturing account for 29 percent of US merchandise imports (see Table 2), and 61 percent of these imports are related-party imports (see Table 3). Thus, their total imports are 1,435 billion US $\times$ 0.29 $\times$ 0.61, or 253.9 billion USD, and each of these 1,200 MNEs imports an average of 211 million USD within their firm boundaries.

these companies are around 403 US billion, while 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 countries other than the US by these foreign affiliates are almost four times larger than their corresponding US establishments' merchandise exports from the US. Clearly, foreign production is by far the most salient method to make US-branded products available to foreign consumers.

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

Fact 3. *The sales of foreign affiliates of US MNEs are close in magnitude (74 percent) to the domestic sales of the MNE's US establishments. These affiliates' manufacturing sales abroad are almost four times larger than US merchandise exports by the MNE's US establishments.*

3 Global Sourcing and MNE Status: Reduced-Form Evidence

In this section, we use the newly linked data to analyze the foreign sourcing and exporting patterns of multinational enterprises (MNEs), and to assess how they differ from those of domestic importers and exporters. More specifically, we study how US MNEs' foreign affiliate activity and foreign-owned firms' headquarter locations, relate to their global sourcing and exporting decisions. Unlike previous studies that analyze the trading patterns of MNEs using their foreign affiliate shipments, we use the Census Bureau's LFTTD, which is based on US Customs transactions. These data provide the first complete portrait of the global sourcing and exporting strategies of US MNEs with majority-owned affiliates.

3.1 Interdependence between FDI and Importing

We begin by studying how firms' foreign ownership and manufacturing affiliate activity relate to their import behavior, beginning with its interdependence with the extensive margin of imports. To do so, we estimate the following linear probability model of a firm's extensive margin import decisions:

$$\begin{aligned} Pr(I_{frc}=1|X) = \quad & \beta_D log(distance_c) + log(GDP_c) + \beta_L Language_c + \beta_C Contiguous_c + \\ & \beta_A Affiliate_{fc} + \beta_{AR} AffiliateRegion_{fr} + \\ & \beta_F Foreign_{fc} + \beta_{FR} ForeignRegion_{fr} + \gamma_f + \gamma_r, \end{aligned} \tag{1}$$

where I_{frc} is an indicator equal to one if firm f imports from country c that belongs to region r. The first row of equation (1) includes the following standard gravity variables: $log(distance_c)$, the distance from the United States to country c, $Language_c$, an indicator for whether country c speaks English, and $Contiguous_c$, an indicator for whether country c is contiguous to the United States (i.e., Mexico or Canada).[23] The variables in the second row capture new information on firms' MNE status inferred from the merge with BEA surveys. $Affiliate_{fc}$ is an indicator for whether the firm has a majority-owned manufacturing affiliate in country c. $AffiliateRegion_{fr}$ is an indicator for whether

[23] We download these gravity variables from the CEPII (Centre d'Etudes Prospectives et d'Informations Internationales) gravity dataset. See Head, Mayer and Ries (2010) for details on the construction of these variables.

the firm has a majority-owned manufacturing affiliate in the same region as country c, though not country c itself.[24] $Foreign_{fc}$ is an indicator for whether the firm is majority owned by a firm in country c, and $ForeignRegion_{fr}$ is an indicator for whether it is owned by a firm in the same region as country c, though not country c itself.

A primary goal of this analysis is to document whether and how the geography of firms' MNE activity influences their foreign sourcing behavior. We therefore include firm fixed effects and limit the regression sample to firms that import from two or more countries to avoid incorrect inference (e.g., see Correia, 2015). The firm fixed effects control for all unobservable firm characteristics that are constant across countries, and the limitation to multi-country importers makes the comparison to domestic importers more similar. As noted above, this sample covers about 99 percent of the value of US-based manufacturers' imports. We also estimate equation (1) either with region fixed effects, or with country fixed effects, in which case we focus exclusively on the firm-by-country variation from the affiliate and foreign-owned indicators. We cluster the standard errors by country and by firm.

Table 7 presents the results from estimating equation (1) via ordinary least squares (OLS) on all firms with US manufacturing establishments that import from multiple countries. Columns 1-4 include firm and region fixed effects, while columns 5 and 6 include firm and country fixed effects. The first two columns present estimates from specifications with standard gravity variables, where we add an indicator for contiguity in column 2.[25] As expected, firms are more likely to import from richer countries and from contiguous ones. In column 3, we add indicators to capture firms' multinational activity in a particular country. The estimates suggest that firms are 55 percentage points more likely to import from a country in which they have a majority-owned foreign manufacturing affiliate, and 73 percentage points more likely to import from their home country. In column 4, we also include regional indicators, which show that firms are 7 percentage points more likely to import from a country if they have an affiliate in the region, and 8.6 points more likely to import from the same region as their home country. 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 5 and 6 show that these relationships persist even when controlling for firm and country fixed effects.

We also examine how the intensive margin of imports relates to firms' MNE activity across countries. To do so, we estimate:

[24] 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.

[25] Our region definitions designate Canada to North America and Mexico to South and Central America. The contiguity dummy with region fixed effects thus identifies Mexico. In additional specifications available upon request, we note that the coefficient on the contiguity dummy is approximately double when we exclude the region dummies. We focus on specifications with the region controls since the intensive margin of imports is strongly increasing in $log(distance_c)$ without them once we control for contiguity.

Table 7: 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.

$$
\begin{aligned}
y_{frc} = \quad & \beta_D log(distance_c) + log(GDP_c) + \beta_L Language_c + \beta_C Contiguous_c + \\
& \beta_A Affiliate_{fc} + \beta_{AR} AffiliateRegion_{fr} + \\
& \beta_F Foreign_{fc} + \beta_{FR} ForeignRegion_{fr} + \gamma_f + \gamma_r + \varepsilon_{frc}, \qquad (2)
\end{aligned}
$$

where y_{frc} is the log of firm f imports from country c belonging to region r.

Table 8 reports the results from estimating equation (2) via OLS on all firms with US manufacturing establishments that import from multiple countries. As before, the specifications reported in columns 1 to 4 include firm and region fixed effects, while columns 5 and 6 include firm and country fixed effects. Columns 1 and 2 report coefficient estimates for standard gravity variables. While the column 1 suggests that firm-level imports decrease in distance, the estimates in column 2 suggest that this is driven by trade with Mexico, since contiguity has a large and statistically significant coefficient, and its inclusion in the specification reduces the size of the distance coefficient dramatically and renders it statistically insignificant. Column 3 shows that firms' imports are 227 log points higher from countries in which they have a foreign affiliate, and 340 log points higher from their home country. The starkest difference between firms' extensive and intensive margin import decisions is evident in column 5: while foreign-owned MNEs import about 48 percent more from countries in the same region as their home country, there is no statistically significant relationship between the amount US MNEs import from a country and the presence of a foreign affiliate in the same region. Columns 5 and 6 present comparable estimates when controlling for firm fixed effects.

Table 8: 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.

The results in Tables 7 and 8 provide new evidence that firms' MNE activity is strongly related to their import behavior. The estimates indicate that although the amount a US MNE sources from a country is not higher if it has an affiliate in the same region, the likelihood that it will import from a country is about 9 percentage points higher if it has an affiliate elsewhere 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. These results are consistent with the premise that a firm's global sourcing strategy – *i.e.*, the set of countries from which it purchases inputs – is influenced by the geography of its foreign production locations.

We can summarize this as follows:

Fact 4. *The importing and global production decisions of US-based MNEs appear to be interdependent. Relative to domestic firms, US-based MNEs are much more likely to import from a country c if they have an affiliate or a foreign parent in that country c or in other countries in the same region r as country c (though not country c itself). The amount a US MNE sources from a country c is however* not *higher if the MNE has an affiliate in the same region r.*

3.2 Interdependence between FDI and Exporting

In order to explore the existence of interdependencies between FDI and exporting, we next estimate a variant of equation (1) where the dependent variable is an indicator of whether or not the firm exports to country c. Table 9 presents these results. Analogously to Table 7, in column 3 we find that firms are 47 percentage points more likely to export to a country in which they have a majority-owned foreign manufacturing affiliate, and 59 percentage points more likely to export to the country of their foreign headquarters. The results in column 6, which control for firm and country fixed effects indicate that firms are 8.7 percentage points more likely to export to a country if they have an affiliate in the region, and 3.5 points more likely to export to a country in the same region as their home country.

We finally estimate a variant of equation (2) where the dependent variable is the log of firm exports to country c. As the results in Table 10 indicate, while foreign-owned MNEs export about 16.3 percentage points more to countries in the same region as their foreign affiliates, we do not see a significant relationship between the amount US MNEs export to a country and the presence of the foreign parent company in the same region. In fact, the latter coefficient is negative, though not statistically significant.

Tables 9 and 10 lead us to conclude that:

Fact 5. *The exporting and global production decisions of US-based MNEs appear to be interdependent. Relative to domestic firms, US-based MNEs are much more likely to export to a country c if they have an affiliate or a foreign parent in that country c or in other countries in the same region r as country c (but though not in country c itself). The amount a US MNE exports to a country c is however* not *higher if the MNE has a parent company in the same region r.*

Table 9: 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.

4 Theoretical Framework

Motivated by our empirical results, in this section we develop a theoretical framework to analyze the determinants and consequences of firms' joint decisions on the countries in which to locate their production establishments, the countries from which to source their inputs, and the countries in which to market their goods.

4.1 Environment

Consider a world in which individuals in J countries value the consumption of differentiated varieties of manufacturing goods as well as the consumption of the output of a non-manufacturing sector.

Table 10: 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.

Consumers worldwide spend a constant share η of their income on manufacturing 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, we denote by J both the number as well as the set of countries). There are no other factors of production, so labor should be interpreted as "equipped" labor. 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, or

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

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 manufacturing goods in country $i \in J$,

$$p_i(\varphi) = \left(\int\limits_0^1 p_i(\varphi, \omega)^{1-\sigma_w} \mathrm{d}v \right)^{\frac{1}{1-\sigma_w}} \tag{5}$$

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

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

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 $p_i(\varphi)$ will disproportionately redirect 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 a blueprint 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 that in Antràs, Fort and Tintelnot (2017). The bundle of intermediates contains a continuum of measure one of firm-specific inputs, assumed to be imperfectly substitutable with each other, with a constant and symmetric elasticity of substitution equal to ρ. Although intermediates are produced worldwide, a final-good producer based in country h only acquires the capability to offshore to j after incurring a fixed cost equal to f_{hj}^s units of labor in country h. We denote by $\mathcal{J}_h(\varphi) \subseteq J$ the set of countries for which a firm headquartered in h with productivity φ has paid the associated fixed cost of offshoring (denoted by $w_h f_{hj}^s$ for $j \in \mathcal{J}_h(\varphi)$). For brevity, we will often refer to $\mathcal{J}_h(\varphi)$ as the *global sourcing strategy* of that firm.

Intermediates are produced by a competitive fringe of suppliers who sell their products at marginal cost.[26] 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_{jk}^s. As a result, the cost at which firms producing in k can procure input v from country j is given by $\tau_{jk}^s a_j(v, \varphi) w_j$.

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

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

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, for the time being, we do not introduce any *direct* dependence of the cost

[26] 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.

function in (8) on the country h in which the headquarters are located. It might be natural, as in Tintelnot (2017), to let $z_k(\varphi, \omega)$ include a shifter that decreases in the distance between countries h and k, thereby generating "headquarter gravity" (see also Wang, 2019). Similarly, it may seem plausible that input productivity $a_j(v, \varphi)$ could also be shaped by the distance between the headquarters h and suppliers j. We ignore these 'headquarter gravity' terms (see also Wang, 2019) to emphasize the role of endogenous sourcing strategies in generating interdependencies between global sourcing and global assembly. Having said this, in section 5.3 we develop an extension of our framework that incorporates these explicit headquarter gravity terms.

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

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

These draws are assumed to be 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, for our equilibrium to be well-behaved, we need to impose a lower bound on the dispersion in the input productivity draws $a_j(v, \varphi)$:

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

The main substantive deviation from Antràs, Fort and Tintelnot (2017) is that we relax the assumption that final goods are nontradable and allow 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'. More specifically, firms that do not incur this fixed cost cannot market goods in countries other than their home base h and cannot import inputs from countries other than h; once that fixed cost is paid, a firm can market goods in any country, but to import inputs from particular countries, it needs to pay the additional costs described above.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 consider the problem of solving for the optimal set of assembly locations from which to service consumers worldwide. We denote by $\mathcal{K}_h(\varphi) \subseteq J$ the set of countries $k \in J$ for which a firm headquartered in h with productivity φ has paid the associated fixed cost of assembly $w_h f_{hk}^a$. For brevity, we will often refer to $\mathcal{K}_h(\varphi)$ as the *global assembly strategy* of that firm. Shipping final goods from country k to country i entails variable (iceberg) trade costs τ_{ki}^a, which in principle may differ from those associated with shipping intermediate inputs. For the time being, we abstract from modeling destination-specific fixed costs of exporting, but we note that the fixed cost of becoming global *will* create selection into exporting in our model (see Proposition 5 below). In section 5.3, we will expand the model to feature a richer extensive margin of exports.

Following 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 being associated with a higher variance, and thus with a higher benefit 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, at the time at which they decide on their sourcing and assembly strategies, firms know the distributions (9) and (10) but not the actual realizations of these various random variables (across the different goods ω they produce and the various active locations in their sourcing and assembly strategies).

Isomorphism with Armington Model In our model, firms have an incentive to activate assembly locations or sourcing locations to reduce the cost at which they can satisfy the foreign demand for their products. Such cost minimization partly takes the shape of trade-cost reductions (e.g., activating an export-platform close to specific countries), but it is also related to the fact that new assembly plants or sourcing locations allow the firm to learn about 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 (sources) a continuum of final-good (input) varieties leads to a simple expression for the benefits of activating new assembly or sourcing locations (see section 5 for more on this). It should be noted, however, that an entirely isomorphic set of equilibrium conditions arises in an Armington-like world in which final-good and input varieties are differentiated by country of origin. In that world, activating assembly locations would confer the firm the benefit to produce a new differentiated final-good variety, and activating a source of inputs would allow the firm to get 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 $\rho = 1 + \theta^s$.[27]

This completes the discussion of the assumptions of our model. Before describing its equilibrium, it is worth pausing to spell out the precise timing of events in the model (focusing on the manufacturing sector).

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

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, remain inward oriented, 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 inward-oriented 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 $k \in \mathcal{K}_h(\varphi)$.

5. All assembly plants source inputs from their cheapest location within the firm's global sourcing strategy and consumers worldwide purchase manufacturing good varieties from the assembly plants that offer the minimum price for those varieties.

6. Production and consumption take place.

We solve for the equilibrium of the model in three steps. In the remainder of this section, we describe optimal firm behavior, industry equilibrium, and general equilibrium for given assembly and sourcing strategies $\mathcal{K}_h(\varphi)$ and $\mathcal{J}_h(\varphi)$, and we also describe some comparative statics related to how final-good and intermediate-input trade flows respond to changes in the parameters of the model. In the next section, we focus on characterizing the choice of these assembly and sourcing strategies, Finally, in section 6, we relate our results to our empirical evidence on interdependencies in section 3 and numerically evaluate some implications of the model.

4.3 Firm Behavior for Fixed Assembly and Sourcing Strategies

Consider a firm headquartered in country h with productivity φ that has incurred all necessary fixed costs associated with a given assembly strategy $\mathcal{K}_h(\varphi)$ and a given sourcing strategy $\mathcal{J}_h(\varphi)$. In light of the cost function in (8), it is clear that after learning the vector of unit labor requirements for each country $j \in \mathcal{J}_h(\varphi)$ and for each location of assembly $k \in \mathcal{K}_h(\varphi)$, the firm will choose the location of production for each input v that solves $\min_{j(v) \in \mathcal{J}_h(\varphi)} \left\{ \tau_{jk(v)}^s a_{j(v)}(v, \varphi) w_{j(v)} \right\}$. Notice that this is true independently of the particular realization of the productivity of the firm- and location-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 of the firm 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

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

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, more advanced input technologies T^s_j, or lower trade costs when selling to country k will have higher market shares in the intermediate input purchases of firms based in country i. We shall 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 choosing the lowest-cost country for each input v, the overall marginal cost faced by firm φ, based in h, assembling final goods in country k can be expressed as

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

where $\lambda = \left[\Gamma\left(\frac{\theta^s+1-\rho}{\theta^s}\right)\right]^{\theta^s/(1-\rho)}$ and Γ is the gamma function.[28] 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 and will be absorbed into a constant.

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

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

with

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

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

This global production capability turns out to be 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,

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

a cumbersome set of derivations demonstrate that this price index is given by:

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

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 by either selecting into global sourcing or assembly from more and more countries is crucially shaped by the parameter θ^a: the lower is θ^a, the higher is the achieved firm-level price index reduction. To ensure a well-defined price index, we need to assume that $\sigma_w - 1 < \theta^a$ (see Technical Assumption 2). Beyond ensuring that this restriction is satisfied, the parameter σ_w will not play an important role in the results below, so we will absorb into a constant (as we did with ρ above).

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

$$\pi_h(\varphi, \mathcal{J}_h(\varphi), \mathcal{K}_h(\varphi)) = \kappa\varphi^{\sigma-1}\sum_{i\in J}\left(\Psi_{hi}(\varphi)\right)^{(\sigma-1)/\theta^a} E_i P_i^{\sigma-1} - w_h \sum_{j\in\mathcal{J}_h(\varphi)} f_{hj}^s - w_h \sum_{k\in\mathcal{K}_h(\varphi)} f_{hk}^a - w_h f_h^g, \tag{17}$$

where κ is a constant, P_i is the standard ideal price index associated with (3) and defined in (6), and E_i is aggregate spending on manufactured goods in country i. As is clear from equation (17), the manner in which the global production capability $\Psi_{hi}(\varphi)$ shapes operating profits is crucially shaped by the exponent $(\sigma-1)/\theta^a$. As we discussed above, a lower θ^a enhances the scope for the within-firm exploitation of comparative advantage across the firm's assembly plants, thereby leading to a disproportionately lower firm-level price index $p_{hi}(\varphi)$ for firms choosing more complex global production strategies. A higher σ, in turn, leads to a larger impact of a reduction in $p_{hi}(\varphi)$ on firm-level sales (the often-called 'scale effect') and operating profits.

As we shall discuss in sections 4.4 and 5, whether $(\sigma-1)/\theta^a$ is higher or lower than 1 will have important implications for certain comparative statics results as well as for the determination of the optimal global sourcing and global assembly strategies of firms. In Tintelnot (2017), varieties are assumed to be equally substitutable across and within firms, or $\sigma_w = \sigma$ in our notation, so invoking Technical Assumption 2 ($\sigma_w - 1 < \theta_a$), his analysis focuses on the case in which $(\sigma-1)/\theta^a < 1$. Our more general formulation of preferences demonstrates that the same condition would apply in the presence of demand cannibalization effects, which is associated with cases in which $\sigma_w < \sigma$ (see our discussion at the end of section 4.1). Nevertheless, in the presence of demand complementarities (i.e., $\sigma_w > \sigma$), it is perfectly possible for the case $(\sigma-1)/\theta^a \geqslant 1$ to apply.

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

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

If a firm's core productivity is such that $\pi_h(\varphi, \{h\}, \{h\}) < 0$, this firm will exit upon observing its core productivity level.

4.4 Intensive Margin Analysis: Complementarities and Cannibalization Effects

Before discussing the determination of the global sourcing and assembly strategies of firms, we briefly describe how conditional on these strategies, bilateral final-good and intermediate-input flows are shaped by the parameters of the model.

Given CES preferences in equation (3), it is well understood that final-good sales of firm φ (based in h) in market i are proportional to the operating profits of selling in that market, so from equation (17), we have that the total final-good sales of firm φ are

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

where $\widetilde{\kappa}$ is a constant, and where remember that $\Psi_{hi}(\varphi)$ is the global production capability of firm φ when selling in i. We also 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, and thus sales of the firm's plant in k in market i are given by

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

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 potential $T_k^a (\tau_{ki}^a)^{-\theta^a} (w_k)^{-(1-\alpha)\theta^a}$ or a decrease in a bilateral input trade cost τ_{jk}^s (for any j):

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

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

Proof: See Appendix A.

In words, whether increases in the profitability of a given assembly plant k (driven by improvements in assembly potential or reductions in sourcing costs) increase or decrease the sales of other plants selling the firm's goods in market i crucially depends on the relative size of $\sigma - 1$ and θ^a. When $\sigma - 1 < \theta^a$, the dispersion in productivity across plants is relatively low, and our model delivers cannibalization effects. Conversely, when $\sigma - 1 > \theta^a$, complementarities in demand are high and productivity dispersion across plants is high, so increases in the efficiency of particular plants generate a positive effect on the sales of other plants of the same firm (holding constant market demand).

We next turn to study how intermediate-input flows are shaped by the fundamental parameters of our model. We first note that given our functional form assumptions (particularly the Cobb-Douglas technology in (13)), total intermediate input purchases of a given plant (say in country k) are a constant share of this plant's total sales $S_{hk}(\varphi)$ in equation (19). Furthermore, imports from each source j correspond to a share $\chi_{hjk}(\varphi)$ in equation (11) of all 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 plant k's assembly potential $T_k^a \left(\tau_{ki}^a\right)^{-\theta^a} (w_k)^{-(1-\alpha)\theta^a}$:

i) increases input purchases $M_{hkj}(\varphi)$ from any source country $j \in \mathcal{J}_h(\varphi)$ of the plant based in k;

ii) increases input purchases $M_{hk'j}(\varphi)$ from any source country $j \in \mathcal{J}_h(\varphi)$ for plants based in $k' \neq k$ in country i if $(\sigma-1)/\theta^a > 1$, and reduces them if $(\sigma-1)/\theta^a < 1$.

Proof: See Appendix A.

Our second result relates to the impact of changes in input trade costs on bilateral input purchases. Such an analysis is a bit more cumbersome than the one related to changes in assembly potentials because it is shaped by interdependencies in both final-good sales across assembly plants, as well as by interdependencies in importing across sourcing countries j. We are however 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 any country $j' \neq j$ 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 enough), the scale effect induced by the reduction in the sourcing cost τ^s_{jk} 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^s_{jk} leads to an increase in sourcing by the plant in k from country j but also from all others sources of inputs. Conversely, when $\sigma - 1 < \theta^a < \theta^s/\alpha$, the reduction in τ^s_{jk} 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 does not only depend on the relative size of $\sigma - 1$ and θ^s/α, but also on the relative size 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.

In section 6, we will return to equation (20) and will leverage it to attempt to interpret the reduced-form results we obtained in section 3.

4.5 Industry and General Equilibrium

Although a more natural next step would perhaps be to solve for all firms' global assembly $\mathcal{K}_h(\varphi) \subseteq J$ and global sourcing $\mathcal{J}_h(\varphi) \subseteq J$ sets, we first briefly outline the industry and general equilibrium of the model given those sets. Once the problem of the firm is solved, this is straightforward to carry out.

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. Firms with productivity $\varphi < \tilde{\varphi}_h$ cannot profitably carry out any strategy and thus exit upon observing their productivity level. 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 for. This completes the description of the model for given assembly and sourcing strategies.

5 Optimal Sourcing and Assembly Strategies

Having solved for the model's equilibrium conditional on the sets $\mathcal{K}_h(\varphi) \subseteq J$ and $\mathcal{J}_h(\varphi) \subseteq J$, we turn to characterizing these sets.

5.1 The Problem and General Results

Each firm's optimal assembly and sourcing strategy is a combinatorial optimization problem in which two sets of locations are chosen to maximize the firm's profits $\pi_h(\varphi)$ in equation (17).[29] Plugging in equations (12) and (15), and defining $\xi^a_{ki} = T^a_k (\tau^a_{ki})^{-\theta^a} (w_k)^{-(1-\alpha)\theta^a}$ and $\xi^s_{jk} = T^s_j \left(\tau^s_{jk} w_j\right)^{-\theta^s}$ we can express this problem as

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

where the indicator variables $\mathcal{I}^a_k$ (respectively, $\mathcal{I}^s_j$) takes a value of 1 when $k \in \mathcal{K}_h(\varphi)$ (respectively, $j \in \mathcal{J}_h(\varphi)$), 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. The reason for this is that 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 studied jointly.

To elucidate the added complexity of the current setting, we begin by noting some key properties of the profit function in (22).

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

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

[29] 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 $\mathcal{I}^a_k = 1$ 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 $\mathcal{K}_h(\varphi) = \{k \in J : \mathcal{I}^a_k = 1\}$ and $\mathcal{J}_h(\varphi) = \left\{j \in J : \mathcal{I}^s_j = 1\right\}$, respectively.

Proof: See Appendix A.

In words, part i) of Lemma 1 implies that adding an assembly plant in any given country k may increase or decrease the profitability of doing so in any other country k' depending on the relative size of $\sigma - 1$ and θ^a. As mentioned before, Tintelnot (2017) focused on the case with no demand cannibalization or complementarity effects, which naturally led him, given Technical Assumption 1, to focus on the case $\sigma - 1 < \theta^a$, in which assembly extensive margin decisions are substitutes. Nevertheless, in the presence of demand complementarities ($\sigma_w < \sigma$), it is theoretically perfectly possible for $\sigma - 1 > \theta^a$, in which case assembly extensive margin decisions are complements. Intuitively, in such a case, 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 variable cost reductions in sourcing. Under these circumstances, the addition of a country to a firm's sourcing strategy necessarily decreases the marginal benefit of investing in activating alternative sourcing locations, particularly when supplier productivity dispersion is 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 these extensive margin sourcing decision; it is also necessary for θ^a to fall between these two values. For instance, when $\sigma - 1 < \theta^a$, the profit function in equation (22) need not feature increasing differences in the extensive margin of firm sourcing when $\sigma - 1 > \theta^s/\alpha$ due to the substitutability across assembly locations. The reason for this is that if there is enough heterogeneity in input trade costs, the addition of a new input source may lower production costs at plants that use those inputs intensively so much that it reduces the revenues of other assembly locations that do not. 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 margin of assembly locations is 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 would 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 necessarily feature complementarity (or increasing differences) between $\left(\mathcal{I}_k^a, \mathcal{I}_j^s\right)$ for $k, j \in \{1, ..., J\}$, it is necessary that $\sigma - 1 \geqslant \theta^a$. When assembly decisions are substitutes ($\sigma - 1 < \theta^a$), the marginal benefit of activating specific sourcing countries may actually be diminished by the activation of specific 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 actually prove to be complements, due to the scale effects associated with the marginal-cost reducing effects of global sourcing.

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 $\sum_{i \in J} (\Psi_{hi}(\varphi))^{(\sigma-1)/\theta^a} E_i P_i^{\sigma-1}$ 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.

The result implies that more productive firms choose a vector of global production capabilities that translates into differences in world sales across firms that are magnified relative to the differences that would arise in a world without global assembly and global sourcing. 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 correlated 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) and Helpman, Melitz and Yeaple (2004). While our empirical evidence in section 2 suggests that firms with higher core productivity φ 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 this for a specific region of the parameter space.

We conclude 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). A special case where these algorithms continue to be applicable is developed in the next section.

5.2 The Case with Pervasive Complementarities

In this section, we study the determination of the extensive margins of global sourcing and global assembly 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 corresponds to the case in which the profit function features increasing differences in any two extensive margin decisions, regardless of whether they entail the addition of a source of inputs or of a platform of final-good production. Although the literature on export-platform FDI has generally focused on the case in which assembly decisions are substitutes (or $\sigma - 1 < \theta^a$), a few recent papers have considered environments with either independence or increasing differences in these strategies.[30]

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 $\mathcal{K}_h(\varphi) = \{k : \mathcal{I}^a_{hk}(\varphi) = 1\}$.

Proof: See Appendix A.

Proposition 6 states that in the case with pervasive complementarities, our model delivers a strict hierarchical order in the extensive margin of global sourcing and of 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 the extensive margin of firms is violated in the data, but a weaker version of this prediction is that the more productive a firm is, the more countries it will source from and the more foreign affiliates it will set up to produce from.

As in Antràs, Fort and Tintelnot (2017), the presence of (pervasive) complementarities in the extensive margin is also helpful for computational purposes when estimating the model, as it opens the door for the use of iterative algorithms that have the potential to dramatically decrease the dimensionality of the firm problem, even when fixed costs of sourcing and assembly are heterogeneous across firms. To illustrate this, 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.

The usefulness of this result is best demonstrated with an example. Suppose that one is trying to assess whether a given country k belongs in the firm's optimal assembly strategy $\mathcal{J}_h(\varphi)$. Without

[30] See, in particular, Bernard et al. (2018), Arkolakis, Eckert and Shi (2021), and Garetto, Oldenski and Ramondo (2019), with the latter paper offering suggestive evidence of independence in assembly decisions.

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), 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 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 have assumed that firms headquartered in country h pay a unique fixed cost $w_h f_h^g$ to be able to market their goods in all foreign countries. In this section, we relax this assumption and introduce destination-specific marketing costs. More specifically, firms headquartered in h wishing to sell their goods in country i need to pay a fixed cost $w_h f_{hi}^x$ to be able to do so. We use the superscript x to reflect that this allows the firm to export to country i from all its assembly plants (though note that in some cases $k = i$ so the fixed cost is actually associated with the ability to sell to local consumers). As in our baseline model, we assume that this marketing strategy $\Upsilon_h(\varphi)$ – i.e., the set of activated destination markets $i \in \Upsilon_h(\varphi) \subseteq J$ – is chosen simultaneously with the firm's assembly and sourcing strategies (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, it seems realistic to imagine that 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 these headquarter gravity (see, Wang, 2019), we now let intermediate input and assembly productivity be 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 captures iceberg productivity losses when the firm separates 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 input, 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 $w_h f^x_{hi}$, $w_h f^a_{hk}$ and $w_h f^s_{hj}$.

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. All assembly plants source inputs from their cheapest location within the firm's global sourcing strategy and consumers in countries $i \in \Upsilon_h(\varphi)$ purchase manufacturing good varieties from the assembly plants that offer the minimum price for those varieties.

6. Production and consumption take place.

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

$$M_{hkj}(\varphi) = \widehat{\kappa}\varphi^{\sigma-1} T^a_k (w_k)^{-(1-\alpha)\theta^a} T^s_j \left(\gamma^s_{hj}\tau^s_{jk} w_j\right)^{-\theta^s} (\Theta_{hk}(\varphi))^{\frac{\alpha\theta^a}{\theta^s}-1} \sum_{i\in J} \left(\gamma^a_{hk}\tau^a_{ki}\right)^{-\theta^a} (\Psi_{hi}(\varphi))^{\frac{(\sigma-1)}{\theta^a}-1} E_i P_i^{\sigma-1} \tag{25}$$

and

$$S_{hki}(\varphi) = \widetilde{\kappa}\varphi^{\sigma-1} T^a_k \left(\gamma^a_{hk}\tau^a_{ki}\right)^{-\theta^a} (w_k)^{-(1-\alpha)\theta^a} (\Theta_{hk}(\varphi))^{\alpha\theta^a/\theta^s} (\Psi_{hi}(\varphi))^{\frac{(\sigma-1)}{\theta^a}-1} E_i P_i^{\sigma-1}, \tag{26}$$

respectively, with $\Theta_{hk}(\varphi)$ and $\Psi_{hi}(\varphi)$ as defined in (12) and (15) but with $\gamma^s_{hj'}\tau^s_{j'k}$ replacing $\tau^s_{j'k}$, and $\gamma^a_{hk'}\tau^a_{k'i}$ replacing $\tau^a_{k'i}$ 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, when we relate our model to our reduced-form empirical results, we will highlight the novel implications that arise from the introduction of the terms γ^s_{hj} and γ^a_{hk} in equations (25) and (26).

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

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

Despite the addition of an active extension of exporting, it is straightforward to show that the patterns of complementarity and substitutability summarized in Lemma 1 continue to apply in this extended version of our model. The main novel feature 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 $(\mathcal{I}^x_i,\mathcal{I}^a_k)$ for any $i,k\in\{1,...,J\}$ and also in $\left(\mathcal{I}^x_i,\mathcal{I}^s_j\right)$ for any $i,j\in\{1,...,J\}$.

Proof: See Appendix A.

In words, and regardless of parameter values, the activation of an assembly location k or a sourcing location j can only increase the marginal benefit of activating any destination of final goods i, and similarly, the activation of a destination market i can only 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.

It may be tempting to also conclude from Lemma 2 that our model predicts that more productive firms necessarily select into marketing their goods in more markets. Nevertheless, in the presence of substitutabilities across assembly locations or across sourcing locations, this pattern need not hold. For the special case with *pervasive complementarities* ($\sigma - 1 \geqslant \theta^a > \theta^s/\alpha$), we can indeed 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 words, in the case with pervasive complementarities, our extended model delivers a strict hierarchical order in the extensive margin of exporting, global sourcing and global assembly. This implies that even with firm-level heterogeneity in fixed costs, our model predicts that more productive firms will, on average, sell in more markets, assembly 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 structurally estimate the model.

6 Zooming in on the Assembly-Sourcing Complementarity

Our framework features many interdependencies in both the extensive and intensive margins of global sourcing and global assembly. Some of these interdependencies are inherited from the baseline models we build on (i.e., Tintelnot, 2017 and Antràs, Fort and Tintelnot, 2017), but in this section we seek to highlight that some interdependencies are novel to our framework, and we also argue that these forces can be invoked to explain the reduced-form evidence we presented in section 3.

6.1 Isolating the Assembly-Sourcing Complementarity

A natural way to isolate the new forces in our paper is to focus on the case in which the extensive margin of assembly does not feature interdependencies across pairs of assembly locations and in which the extensive margin of sourcing does not feature complementarity or substitutability across pairs of sourcing locations. In terms of the parameters of our model, this corresponds to the case in which $\sigma - 1 = \theta^a = \theta^s/\alpha$, and from equation (22), this results in *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, consider then the impact on overall profits of adding some candidate sourcing location k' to the firm's sourcing strategy $\mathcal{J}_h(\varphi)$. Given equation (27), the firm will find the addition of j' 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 sourcing location j'. Clearly, the 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 these activated assembly locations. Furthermore, the impact of each of these effects is increasing in the size of the other one. In words, the larger are the number of assembly locations and their assembly potential, the larger will be the benefit of activating location j'.

To further isolate the role of geography – or trade costs more broadly – on this complementarity, it is useful to 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 variation in assembly and sourcing potentials is purely shaped by trade and communication costs. In that case, equation (28) reduces

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

It is then clear that whether an input source j' is activated or not depends on a market-access-weighted 'distance' of this source market j' from all the firm's assembly plants and from the firm's headquarters country h. In this weighted distance, the term $E_i P_i^{\sigma-1} \left(\gamma_{hk}^a \tau_{ki}^a\right)^{-\theta^a}$ constitute the market-access weights and 'distance' is captured by the trade costs $\tau_{j'k}^s$ and the coordination costs $\gamma_{hj'}^s$. In more plain words, equation (28) indicates that activating an input source will be particularly profitable when this source can ship to the firm's various assembly plants at a relatively low cost.

This prediction of the model is in line with our empirical findings in section 3, and more specifically with our reduced-form regression results in Table 7, which show that firms with manufacturing operations in the US are more likely to import from countries and regions in which the firm has offshore operations (i.e., foreign affiliates of US-based MNEs or headquarters of foreign MNEs).

To further illustrate the source of this complementarity between sourcing and assembly, we consider the case in which the global sourcing strategy of firms is instead at the plant level, rather than at the firm level, as in the work of Bernard et al. (2018). More precisely, assume that assembly plants of the same company design their own independent sourcing strategies, which we denote by $\mathcal{J}_{hk}(\varphi)$. In that case, a given plant k will choose to add location j' to their plant-specific sourcing strategy 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 j's sourcing potential and k's assembly potential, but notice that the location of the other assembly plants of firm φ (other than the headquarter country when h features an assembly plant) become irrelevant. In regressions, such as those in Table 7 that fix the assembly country k (i.e., the US in our case) and that feature source country fixed effects, this variant of the model would thus predict a null effect of the presence of foreign production plants on the sourcing patterns of assembly plants in k. In other words, the patterns in Table 7 are strongly suggestive of the existence of firm-level (rather than plant-level) global sourcing strategies, which is a key novel feature of our framework.

We next discuss the implications of our framework for the extensive margin of exporting, with the goal of interpreting our empirical results in Table 9. Given equation (27), a firm headquartered in country h with productivity φ will find it profitable to sell goods in country i whenever

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

Destination with larger (residual) market demand $E_iP_i^{\sigma-1}$ and that can be serviced at relatively lower prices will be particularly likely to be activated. Further isolating the role of geography by setting $T_k^a\left(w_k\right)^{-(1-\alpha)\theta^a}=G^a$, $T_j^s\left(w_j\right)^{-\theta^s}=G^s$, this condition reduces to

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

It is then clear that the firm is more likely to export to destination i if the firm has more assembly plants and particularly so if these assembly plants are close to the destination market i or to the firm's headquarters country h. This lines up well with our reduced-form results in Table 9 where remember that we focus on the exports of firms producing in the US (i.e., $k=US$). Controlling for destination market fixed effects (which control for $E_iP_i^{\sigma-1}$), we indeed documented that firms with manufacturing operations in the US are more likely to export to countries and regions in which the firm has additional operations (i.e., foreign affiliates of US-based MNEs or headquarters of foreign MNEs).

In this section, we have focused on the impact of the geography of assembly for the extensive margin of imports and exports because these provided an interpretation of our empirical findings in Tables 7 and 9. We can similarly study how a firm's global marketing and sourcing strategies shape their global assembly strategy. More specifically, when $\sigma-1=\theta^a=\theta^s/\alpha$, 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 activated destination markets $i \in \Upsilon_h(\varphi)$, but also on the overall global sourcing strategy of the firm. 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 the addition of plant in country k' is more likely to be profitable if the firm has activated destination markets i and sourcing locations j that are relative close to country k'.

6.2 Interpreting the Intensive-Margin Reduced-Form Evidence

So far, we have focused on the extensive margin of global sourcing and of exporting, but it is also worth discussing the implications of our framework for the intensive margin of exporting and global sourcing, and how these predictions relate to the findings in Tables 8 and 10.

For that purpose, we first note that, for any relative size of $\sigma - 1$, θ^a, and θ^s/α, we can write bilateral intermediate-input imports in equation (25) conditional on country j being activated 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 importer country k fixed effect d_k^s, an exporter country j fixed effect d_j^s, an importing-firm fixed effect (independent of j), bilateral trade frictions between the exporter country j and the importer country k, and communication costs between the exporter country j and the headquarters country h.

To map equation (30) to our reduced-form results in Table 8, first note that the importer country in our empirical application is fixed at $k = US$. This implies that controlling for firm fixed effects and source country fixed effects, equation (30) indicates that our model predicts 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 headquarters country h. In other words, in contrast to the case of the extensive margin of imports discussed above, the intensive margin of imports should *not* be affected by the presence of an affiliate in the region where country j is located (excluding country j itself).[31] The only exception is when the US importer is owned by a foreign company, in which case, our model predicts disproportionately high import volumes from regions close to that foreign MNE headquarters' country h (on account of the low value of γ_{hj}^s in that case). Interestingly, these predictions are exactly

[31] Although in Table 8 we document that firms import more from countries in which they have affiliates this is perhaps less surprising and driven by factors that are outside our model (such as lower fixed costs when multiple functions are performed in a given country).

in line with the results we obtained in Table 8: our estimates in that table indeed indicate that imports by US-based firms from a given country j are unaffected by the presence of an affiliate in country j's region, but are higher for US affiliates of foreign-owned MNEs with headquarters in the same region as country j.

Let us next turn to a discussion of the intensive margin of exports. Starting from equation (26), we can write bilateral exports from k to i conditional on country i being an activated destination

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

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 *global production capability* $\Psi_{hi}(\varphi)$ of the firm when when selling in i. Remember that this global production capability is given by

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

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 from the firm's headquarters 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 a positive impact on exports to country i depends on whether $(\sigma-1)/\theta^a$ is higher or lower 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, while when $(\sigma-1)/\theta^a < 1$, cannibalization effects are dominant, and a higher $\Psi_{hi}(\varphi)$ reduces the sales of the assembling 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 country i should *only* depend on bilateral frictions between the exporting country k and country i, and should thus be independent of the global operations of the firm.

How do these prediction line up with our empirical results in Table 10? Those results indicate that firms manufacturing in the US tend to export disproportionately more to regions in which the firm has a foreign affiliate, suggestive of the presence of assembly complementarities and thus of a positive impact of $\Psi_{hi}(\varphi)$ on exports to country i. Nevertheless, under that same interpretation it is not straightforward to rationalize the negative (though statistically insignificant) of having a foreign parent company in the same region as country i on US exports to that destination.[32]

[32] One (admittedly convenient) rationalization is that most firms with headquarters in country i's region might also have affiliates in that region, so the bulk of the positive impact of the global production capability is already captured by

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

We close our analysis with two examples to illustrate the implications of the key novel feature of our framework, namely the presence of firm-level economies of scale in global sourcing, in the sense that the global sourcing strategy is a firm-level one. This is in contrast to the approach in Bernard et al. (2018), in which each assembly plant is assumed to have to build its own set of plant-specific sourcing locations. As we have demonstrated in the previous section, this assumption is key for generating a complementarity between sourcing and assembly decisions. The goal of this section is to illustrate some consequences of this novel force. To do so, we will analyze how changes in tariffs on inputs and on final goods affect the optimal strategies of a specific firm, and will contrast the results we obtain under a firm-level global sourcing strategy versus a collection of plant-level global sourcing strategies.

6.3.1 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 $E_{us}P_{us}^{\sigma-1} = 1$. We focus on the optimal global production strategy of a firm headquartered in the US. We further dramatically simplify matters by assuming that (see also Figure 1):

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

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 $\xi^s_{mex,us} = \xi^s_{mex,ch} = \xi^s_{mex,mex} = 0$).

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 $\xi^s_{us,mex} = 0$.

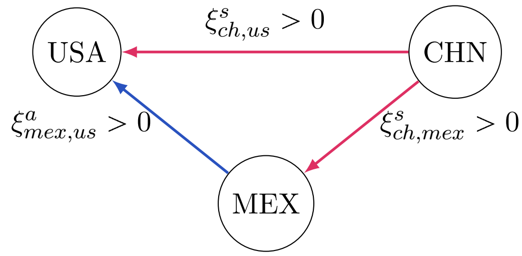
6. Pairs of assembly locations and pairs of sourcing locations are independent, or $\sigma - 1 = \theta^a = \theta^s/\alpha$.

The last assumption serves to abstract from any interdependencies other than those generated by the complementarity between global sourcing and global assembly. In terms of this specific example, a key feature will be that the profitability of assembly in Mexico will be partly shaped by its access to inputs sourced from China, which is partly shaped by the sourcing potential of China vis à vis the US. To see this more formally, let us write the extensive margin problem of the firm as:

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

the affiliate in the region dummy variable.

Figure 1: Trade Structure



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.[33]

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 US ($\xi^s_{ch,us}$). In contrast, panel (b) of Figure 2b shows the equilibrium under the alternative assumption of plant-level sourcing strategies. Specifically, suppose all assembly plants have to pay plant-specific fixed costs ($f^s_{ch,us}$ and $f^s_{ch,mex}$) to activate those sourcing locations for each plant. In this case, the decision to activate an assembly plant in Mexico is independent of the value of inputs to the American plant ($\xi^s_{ch,us}$).[34]

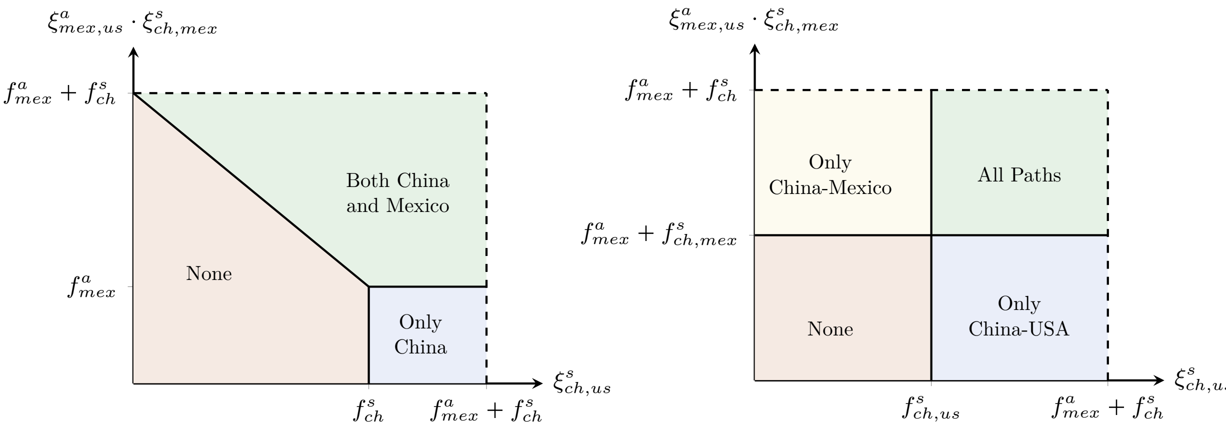
The differences between firm-level and plant-level global sourcing strategies can be further illustrated in terms of their differential implications for the response of the firm global production strategy to changes in tariffs. In particular, Figure 3 shows how unilateral tariffs on Chinese inputs set by the US affect the import share for inputs from China ($\frac{\xi^s_{ch,us}}{1+\xi^s_{ch,us}}$) and the import share for final goods 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 share of Chinese inputs in the US gradually falls, and then after some point it drops to zero. However, for the Mexican assembly shares the response is quite different. The shares increase at first because the American plant becomes less productive as a result of the higher cost of Chinese inputs. Nevertheless, when tariffs on Chinese input are furthered raised, the firm may decide to shut down the Chinese sourcing plant (of course, the example assumes that the fixed cost f^s_{ch} is not sunk). Under firm-level global sourcing strategy, the loss of access to Chinese inputs leads to the closure of the Mexican assembly plant, and thus the

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

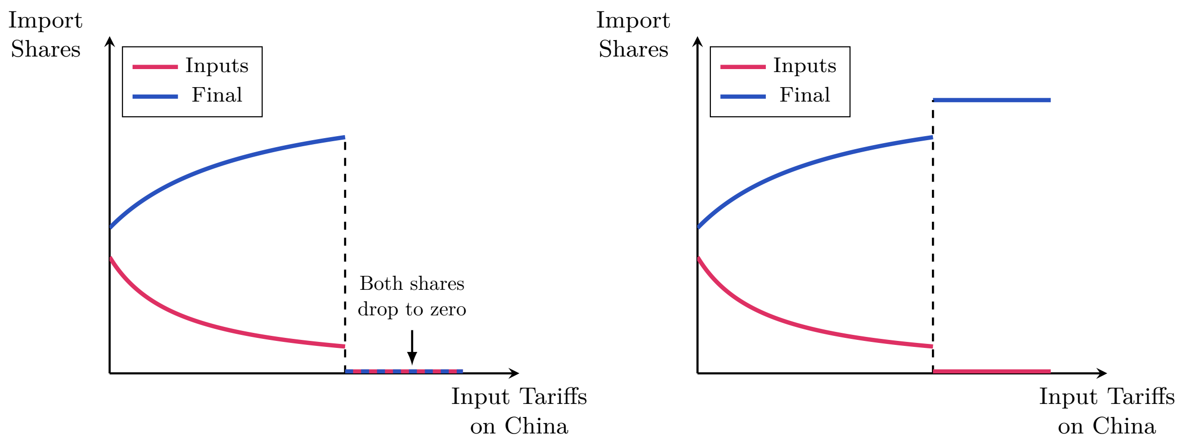
[34]More specifically, the firm chooses $(\mathcal{I}^s_{ch,us}, \mathcal{I}^s_{ch,mex}, \mathcal{I}^a_{mex})$ to solve the problem $\max 1 + \mathcal{I}^s_{ch,us} \cdot \xi^s_{ch,us} + \mathcal{I}^a_{mex} \cdot \mathcal{I}^s_{ch,mex} \cdot \xi^a_{mex,us} \cdot \xi^s_{ch,mex} - \mathcal{I}^s_{ch,us}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

Figure 2: Equilibrium Assembly and Sourcing Decisions



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

Figure 3: The Effect of Tariffs

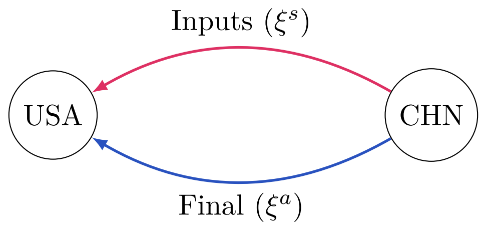


(a) Firm-level Sourcing Strategy **(b)** Plant-level Sourcing Strategy

import share of final goods drops to zero discontinuously. Under plant-level global sourcing strategies, the Mexican assembly plant continues to choose to source from China (since the cost of those inputs is unaffected by US tariffs), so in that case the Mexican import share goes *up* discontinuously.

In sum, the above example illustrates that firm-level economies of scale in sourcing might well generate an endogenous complementarity between assembly plants, in the sense that a deterioration in the productivity of US final-good production leads to the closure of the foreign assembly plant. Conversely, under plant-level economies of scale we instead obtain an endogenous substitutability between assembly plants, in the sense that a deterioration in the productivity of US assembly translates into an increasing role of foreign assembly in US consumption.

Figure 4: Trade Structure



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

1. The firm's goods are only demanded in the US, so $E_{ch}P_{ch}^{\sigma-1} = 0$.
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 very 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 it generate a volume of sales in the US assembly plant that is proportional to :

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

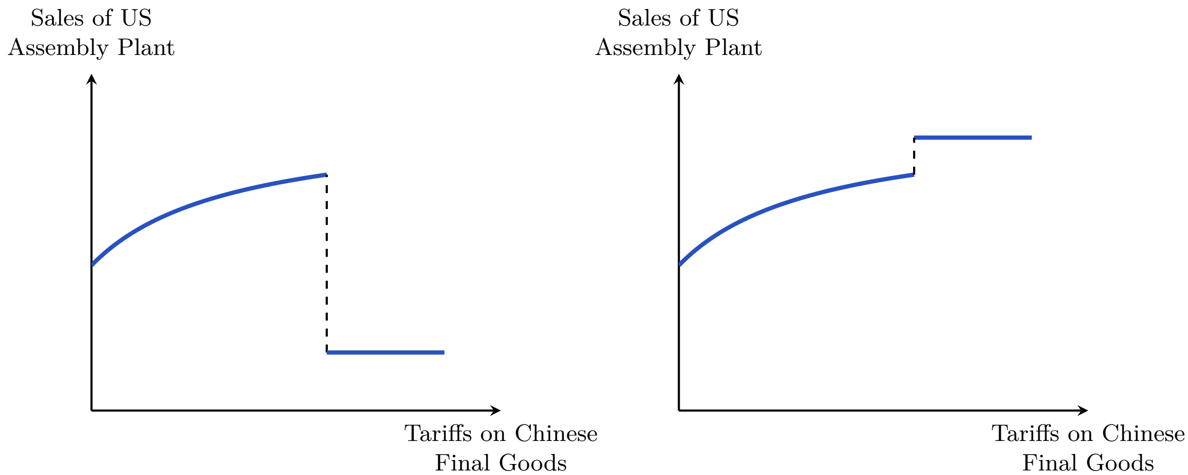
The wage bill paid by the firm to US workers is also proportional to (32).

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 à vis the US) is sufficiently deteriorated ($\xi^a_{ch,us} \to 0$), then activating China as a source of inputs is no longer profitable.

Figure 5: The Effect of Tariffs



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

Consider now the implications of a unilateral increase in tariffs applied by the US on imports of final goods from China. The immediate effect of this policy is to reduce the assembly potential $\xi^a_{ch,us}$ of China vis à vis the US. Figure 5a shows the response of US final-good sales (as well as the wage bill paid by the firm to US workers). 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 $\xi^a_{ch,us}$, the firm does not find it valuable to continue to activate China as a sourcing location. The discontinuation of that plant increases the marginal cost of the US plant on impact, leading to a discontinuous drop in its sales, profitability, and wage bill.[35]

We can compare the above results to the case with plant-level global sourcing strategies. In that case, the firm can activate a sourcing plant in China specifically designed to sell inputs to the US plant, and another one designed to sell inputs to the Chinese assembly plant. The problem of the firm is then

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

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

Figure 5b depicts the response of the size of the assembly plant in the US (and wage bill paid by the firm to US workers) to increases in final-good tariffs. Initially, sales goes up due to the tariffs faced by the Chinese plant and the substitution implied by $\sigma - 1 < \theta^a$. After a certain threshold, the

[35]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 $\left(1 + \xi^s_{ch,us} + \xi^a_{ch,us}\xi^s_{ch,ch}\right)^{1-\frac{\sigma-1}{\theta^a}} < 1 + \xi^s_{ch,us}$.

firm does not find it valuable to assemble in China, and US sales discontinuously jump up (since they continue to source from China but now face lower within-firm competition).[36]

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 have confirmed the quantitative importance of MNEs for the US economy, and have also unveiled the existence of a strong relationship between the importing and export decisions of firms operating in the US and their overall worldwide operations. More specifically, global sourcing is more prevalent for firms whose center of gravity, in terms of their global assembly strategies, is further away from the United States. Furthermore, even after controlling for firm and country fixed effects, US MNEs are significantly more likely to import from countries in which they have a majority-owned manufacturing affiliate (and also from other countries in the same region), and foreign-owned MNEs are much more likely to import from their headquarter country (or other countries in the headquarters' region). Similar patterns are observed when studying the exporting strategies of US-based firms and how they relate to the global operations of these firms.

We have then developed a multi-country model in which firms 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 the global sourcing strategies of firms. This delivers rich complementarities between the global sourcing and global assembly choices of firms, and constitutes a plausible mechanism to explain the observed complementarity between these two strategies we have documented in our reduced-form evidence. In addition to providing a useful lens through which to interpret the data, our framework delivers a rich set of comparative statics, and we have demonstrated via simple numerical analyses that it can produce surprising non-monotonic responses to changes in tariffs on final goods and on inputs.

[36]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 $t \approx 0.14$.

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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

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

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

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

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

where the term $(\Psi_{hi})^{\frac{\sigma-1}{\theta^a}-1}$ is increasing (decreasing) in $T_k^a (\tau_{ki}^a)^{-\theta^a} (w_k)^{-(1-\alpha)\theta^a}$ 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 $T_k^a (\tau_{ki}^a)^{-\theta^a} (w_k)^{-(1-\alpha)\theta^a}$. 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

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

where $\tilde{\tilde{\kappa}}$ includes variables which do not depend on τ_{jk}^s. Both $(\Theta_{hk}(\varphi))^{\frac{\alpha\theta^a}{\theta^s}-1}$ and $(\Psi_{hi}(\varphi))^{\frac{(\sigma-1)}{\theta^a}-1}$ 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

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

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

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

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

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

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

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

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.3, 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.4, 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 import and MNE status

	$\frac{RPImports}{Sales}$	$\frac{RPImporters}{Firms}$	$\frac{RPExports}{Sales}$	$\frac{RPExporters}{Firms}$
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	0.91	0.61	0.92	0.40
Manufacturers' Total	0.24	0.62	0.19	0.36

Source: 2007 Economic censuses, LBD, LFTTD, BEA inward, and BEA outward datasets. Table presents the ratios of firm imports to sales and exports to 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. "Foreign-owned" are firms that are majority-owned by a foreign firm. "US MNEs" are non-foreign-owned firms with majority-owned foreign affiliates. "Domestic" firms are non-multinationals that do not import. "Importers" are non-multinationals that import.

Table B.2: Trade statistics for non-manufacturing firms in 2007, by import and MNE status

Panel A: Imports	$\frac{Imports}{Sales}$	$\frac{Importers}{Firms}$	$\frac{RPImporters}{Importers}$	$\frac{RPImports}{Imports}$
Panel A: Imports				
Importers	0.06	1.00	0.14	0.23
Foreign-Owned	0.09	0.52	0.68	0.70
US MNEs				
w/o Manuf Aff	0.02	0.73	0.63	0.07
w/Manuf Aff	0.07	0.67	0.90	0.52
Non-Manuf Total	0.03	0.05	0.15	0.32
Panel B: Exports	$\frac{Exports}{Sales}$	$\frac{Exporters}{Firms}$	$\frac{RPExporters}{Exporters}$	$\frac{RPExports}{Exports}$
Domestic	0.01	0.02	0.06	0.10
Importers	0.02	0.34	0.14	0.11
Foreign-Owned	0.02	0.44	0.46	0.26
US MNEs				
w/o Manuf Aff	0.01	0.73	0.56	0.18
w/Manuf Aff	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 firm imports to sales and exports to 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. "Foreign-owned" are firms that are majority-owned by a foreign firm. "US MNEs" are non-foreign-owned firms with majority-owned foreign affiliates. "Domestic" firms are non-multinationals that do not import. "Importers" are non-multinationals that import.

Table B.3: US-Based MNEs' foreign affiliate activity for non-manufacturing firms, by firm and MNE type

	US Estab Sales ($B)	US Estab Sales Share	Affiliate Sales ($B)	Affiliate Sales Share	$\frac{\text{Aff Sales}}{\text{US Estab Sales}}$	$\frac{\text{Manuf Aff Sales}}{\text{Aff Sales}}$
Foreign-Owned	1,062	0.09	24	0.00	0.02	0.04
US MNEs						
w/o Manuf Aff	3,183	0.26	809	0.16	0.25	0.00
w/Manuf Aff	173	0.01	172	0.03	0.99	0.14
MNE Non-Manufacturers' Total	4,418	0.36	1,005	0.20	0.23	0.02

Source: 2007 Economic censuses, LBD, LFTTD, BEA inward, and BEA outward datasets. Columns 1-4 present levels of firms' total worldwide sales (sales by US establishments and foreign affiliates) and affiliate sales, and the share of these aggregates accounted for by each MNE firm type. Column 5 presents $\frac{\text{Aff Sales}}{\text{US Estab Sales}}$, which is the ratio firms' foreign affiliate sales over their US establishments' sales. Column 6 presents $\frac{\text{Manuf Aff Sales}}{\text{Aff Sales}}$, which is the share of firms' total manufacturing affiliate sales over their total affiliate sales. Only sales by the firms' majority-owned foreign affiliates are included in these calculations. "Foreign-owned" are firms that are majority-owned by a foreign firm. US MNEs are non-foreign-owned firms with majority-owned foreign affiliates. Top panel statistics for firms with manufacturing establishments in the United States in 2007. Bottom panel presents comparable statistics for firms without US manufacturing establishments.

Table B.4: 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.