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To My Parents

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ABSTRACT

Multinational Production and Global Shock Propagation during the Great Recession

Both international trade and multinational production (MP) collapsed during the Great Recession. What fundamentals explained the MP and trade collapse? I answer the question with a model of MP, trade, and sectoral linkages. I highlight the frictions multinational enterprises (MNEs) face when they source from and sell to non-headquarters countries. These parameters govern MNEs' vertical/horizontal-ness and render the rich interactions between MP and trade. I consider two possible sources of the MP collapse: compared to local producers, (1) MNEs respond more adversely to the trade collapse and the decline in durable final demand and (2) MNEs are affected by different shocks (MNE-specific shocks). MNE-specific shocks include those that affect MNEs' productivity relative to local producers and their vertical/horizontal-ness. I find that 71% of cross-country variation in multinational foreign affiliate sales decline and 19% of cross-country variation in trade decline, both relative to GDP, can be explained by MNE-specific shocks. MNE-specific shocks that hit a few important headquarters and host countries propagate worldwide and explain much of the MP collapse. However, sectoral final demand shocks to almost all countries are necessary to explain a significant share of the trade collapse.

The Employment Consequences of Anti-Dumping Tariffs: Lessons from Brazil (with Gustavo De Souza)

Can anti-dumping tariffs increase employment? To answer this question we compile data on all anti-dumping (AD) investigations in Brazil, matched to firm-level administrative employment information. Using difference-in-differences, we estimate the effect of AD tariffs on trade, the national supplier and sectors linked to it. In response to an AD tariff, import decreases and employment increases in the protected sector. Moreover, downstream firms decrease employment by more than the employment gains of the national producers

while upstream ones dramatically increase it. To quantify the aggregate effect of these tariffs, we build a quantitative model with international trade, input-output linkages and labor force participation. The model can reproduce the micro-elasticicities we found and aggregate moments of the Brazilian economy. We show that the Brazilian AD policies increase employment by 0.04%, GDP by 0.04%, but decrease welfare by 0.09%.

The Life-Cycle Dynamics of Exporters and Multinational Firms (with Anna Gumpert, Andreas Moxnes, Natalia Ramondo and Felix Tintelnot)

This paper studies the life-cycle dynamics of exporters and multinational enterprises (MNEs). Using rich firm-level data, we document a comprehensive set of facts on entry, exit, and growth of new exporters and new MNEs. Guided by these facts, we build a model based on the standard proximity-concentration trade-off extended to incorporate time-varying firm productivity and sunk costs of MNE entry. The calibrated version of the model goes far in matching cross-sectional and dynamic moments of the data on exporters and MNEs. Our results point to much higher sunk costs for MNE than for export activities. Finally, we show how including the choice to become an MNE affects the predicted export dynamics after a trade liberalization episode.

CHAPTER 1

MULTINATIONAL PRODUCTION AND GLOBAL SHOCK PROPAGATION DURING THE GREAT RECESSION

1.1 Introduction

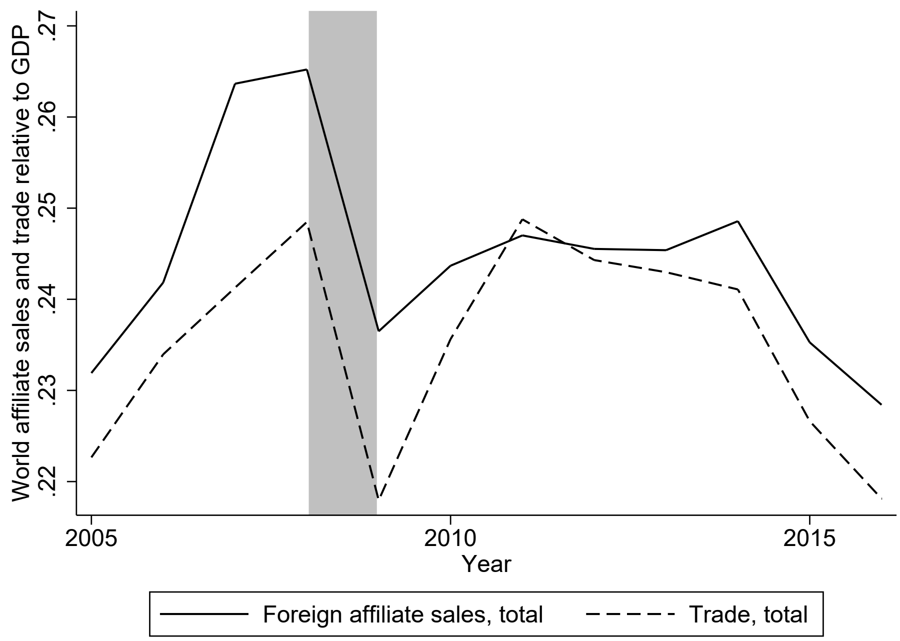
Both international trade and multinational production (MP) collapsed during the Great Recession. Figure 1.1 shows that from 2008 to 2009, world aggregate trade declined by 12% (traditionally known as the "Great Trade Collapse", see Bems et al. 2013, among others) and world aggregate foreign affiliate sales by multinational enterprises (MNEs) declined by 11% (both relative to world GDP). World real GDP dropped by 2%.[1]

What fundamentals explained the MP and trade collapse, and how did they impact countries' differential welfare changes? Understanding the MP collapse is important because MNEs account for a substantial share of global output and an even larger share of international trade,[2] they contribute to the trade collapse, and they provide a new mechanism for international shock propagation (Cravino and Levchenko, 2017). The key challenge, however, lies in the close interactions between trade and MP. Trade by foreign affiliates appears in the national statistics of both declines in total trade and total foreign affiliate sales. Therefore, negative shocks to foreign affiliates may reduce their imports and exports, which, in turn leads to a decline in total trade. Likewise, a collapse in total trade may naturally imply a decline in total foreign affiliate sales. These interdependencies between trade and MP obscure the contributions by individual channels.

1. This paper refers to the Great Recession as the changes from 2008 to 2009. The ratio of world aggregate trade to world GDP fell from 0.25 to 0.22. The ratio of world total foreign affiliate sales to world GDP fell from 0.27 to 0.24. The OECD Analytical Activities of Multinationals Database–the key data source of this paper–is tabulated on the annual level. Using quarterly data on trade and GDP, Eaton et al. (2016) find that global trade fell 20 percent relative to global GDP. They obtain a larger number because they compare the second quarter of 2009, when the Great Recession was most severe, to the third quarter of 2008, which immediately preceded the Great Recession.

2. As of 2008, at least 20% of global gross output was produced by MNE foreign affiliates and at least 40% of world total trade flows had foreign affiliates on at least one side of the transaction (Cadestin et al., 2018).

Figure 1.1: Aggregate MP and Trade Collapse in the Great Recession



OECD Analytical Activities of Multinationals (AAMNE) Database. The figure shows that both world total foreign affiliate sales and world total trade collapsed relative to world GDP during the Great Recession (2008-2009, shadowed years).

In this paper, I unbundle the two margins with a quantitative framework that models shocks that affect sectoral final demand, productivity, and the costs of international trade and MP. Producers (MNEs) use labor and MNE-specific, non-tradable input from all sectors to produce the tradable output. The cross-sector flows of input constitute the input-output linkages, and the cross-border flows of output constitute the trade flows. On top of the usual trade cost, MNEs face additional headquarters-trade partner specific frictions to source and sell the tradable output from and to non-headquarters countries. MNE sourcing and selling frictions govern MNEs' vertical/horizontal-ness and explain the fact that MNE foreign affiliates engage more in both imports and exports than local producers do, and the headquarters countries affect where MNEs source from and sell to.[3] This allows for rich interactions be-

3. Foreign affiliates are located in countries that are different from the headquarters' country. Local producers are located in the same country as their headquarters. Building on Wang (2019), I find that foreign affiliates import and export more than local producers with similar characteristics in the same host country. I also find that, conditional on importing and exporting, foreign affiliates source and sell more from and to their headquarters and the countries closer to their headquarters. I present these empirical evidence in Section 1.2.1.

tween shocks to trade and declines in total foreign affiliate sales, as well as between shocks to MNEs and declines in total trade.

The MNE-specific, non-tradable input consists of the output that the MNE source from all upstream host countries and MNEs along the global value chain. The novelty of my sourcing model is that it features a nesting structure in which the outer nest implies substitution across host countries and the inner nest implies substitution across MNEs within the host country. The key innovations–the MNE sourcing and selling frictions and the nesting structure–allow the model to be exactly matched to the data. In particular, the MNE sourcing and selling frictions match the model-implied MNE sourcing shares (the expenditure shares spent on an origin by a country's local producers or foreign affiliates) and the model-implied MNE output shares (the shares by local producers or foreign affiliates in the host country's outward trade flows) to their data counterparts. With the MNE sourcing and output shares, I conveniently simulate model counterfactuals.

I apply the model to the OECD Analytical Activities of Multinationals Database (henceforth, OECD AAMNE). The database, released in 2019, covers sectoral, international trade and domestic sales by local producers and foreign affiliates. I document the following empirical regularities that suggest potential sources of the MP and trade collapse. Despite aggregate similarity, and unlike the global collapse in trade, the MP collapse was far from a global experience: 9 of the 28 countries studied gained in foreign affiliate sales relative to GDP. Both country-level trade and MP collapse are associated with changes in service sector share in national GDP. A country's MP collapse is positively associated with its exposure other countries' MP collapse, whereas a country's trade collapse is not associated with the its exposure to other countries' trade collapse.[4] These facts suggest that a few important headquarters and host countries may propagate the MP collapse worldwide, whereas sectoral final demand shocks that contribute to the trade collapse should happen in almost all countries.

4. I define the constructed exposure measures in Section 1.2.1.

Counterfactual exercises with shocks to MP and trade require sectoral trade elasticity and MNE elasticity (elasticity of substitution across MNEs within the host country). I develop a new method to estimate them. I regress the sourcing share of a country's local producers from an origin (in log) on bilateral tariff and the origin country's destination-specific producer price index (both in logs), along with other controls. The producer price index can be inverted as a function of the output share of local producers in the origin country's outward trade flows and MNE elasticity. I use the variation in this output share to identify the MNE elasticity, instrumented with the tariffs imposed in the opposite direction, by the origin country on the sales destination. These tariffs shift the costs of origin country's local producers and foreign affiliates differently, leading to variations in their output shares. The trade elasticity is simultaneously estimated using the variation in the destination's importing tariffs. The identifying assumption, as in Head and Mayer (2019), is that tariffs are exogenous to the unobserved factors in bilateral non-tariff trade barriers. The estimated trade and MNE elasticities are higher for the durable manufacturing sector than they are for the non-durable manufacturing and non-manufacturing sectors. The estimated sectoral MNE elasticities are smaller than the trade elasticities.

I use data and model inversion to exactly back out the model shocks. For each sector, I use four sets of moments: (1) MNE gross output of headquarter-host country pairs; (2) foreign affiliates' country-pair-specific sourcing shares; (3) foreign affiliates' country-pair-specific output shares; and (4) country-bilateral total trade.[5] These moments allow me to identify for each sector, changes to the key structural parameters: (1) MNE productivity relative to local producers for headquarter-host country pairs; (2) headquarter-origin-specific MNE sourcing frictions; (3) headquarter-destination-specific MNE selling frictions; (4) country-bilateral non-tariff trade barriers.[6] For each sector, I exactly solve for a country's local

5. OECD AAMNE splits each country-bilateral trade flow only on the grounds of whether the buyer and the seller are local or foreign. The sourcing and output shares of foreign producers and country-bilateral total trade are sufficient to know the shares of local producers. Therefore, local producers' shares do not provide additional information.

6. MNE relative productivity, MNE sourcing and selling frictions, as well as non-tariff trade barriers, are all of dimensionality M^2. I normalize local producers' relative productivity, MNE sourcing and selling

producers' productivity shocks by taking out MNEs' relative productivity shocks to local producers, from the host country's real GDP growth. I back out the sectoral final demand shocks with changes in final expenditure shares. I show that the durable manufacturing sector's final demand declines more relative to other sectors (consistent with Bems et al. 2010, among others), although its local producers' productivity does not. I find that MNE relative productivity shocks decline with the distance between the headquarters and host countries. However, such shocks decrease less if the headquarters had stronger pre-Recession trade and financial investment linkages with the host countries (consistent with Alfaro and Chen 2012).[7]

I consider two possible sources of the MP collapse. First, compared to local producers, MNEs respond more adversely to the trade collapse (because they engage more in trade) and the decline in durable final demand (because they engage more in durable manufacturing sector production). Second, compared to local producers, MNEs are affected by different shocks (which I call MNE-specific shocks). MNE-specific shocks refer to those that affect MNE productivity relative to local producers and MNE sourcing and selling frictions. I calibrate the model to 2008 data and simulate model counterfactuals for 2009 with individual groups of shocks. I have two main sets of findings. The first set of findings concerns the importance of shocks for MP and trade collapse. I find that 71% of cross-country variation in multinational foreign affiliate sales declines relative to GDP and 19% of cross-country variation in trade declines relative to GDP can be explained by MNE-specific shocks. Sectoral final demand shocks and trade shocks contribute to the MP collapse as well, but by a smaller share than the MNE specific shocks. Trade by foreign affiliates is a key channel for the interactions between trade collapse and MP collapse.

The second set of results concerns the cross-border propagation of shocks. Motivated by

frictions with the headquarter, as well as a country's non-tariff trade barriers with itself to 1. Then these parameters are point-identified.

7. The MNE sourcing and selling frictions are found to increase weakly less if the headquarter has stronger pre-Recession trade and financial investment linkages with the countries the MNE sources from or sell to, but to increase weakly more if they are geographically farther away.

the empirical regularities, I find that MNE-specific shocks to a few headquarters and host countries explain a large share of cross-country variation in the MP collapse. For example, MNE-specific shocks that hit the top 5 headquarters of outward MP explain 41%.[8] However, sectoral final demand shocks to almost all countries are necessary to explain the global trade collapse. Those that hit the top 5 exporters just explain 0.3% of cross-country variation in declines of total trade relative to GDP.[9] The differential shock propagation patterns through multinational production and trade linkages relates to the fact that on the country level, inward and outward MP is much more asymmetric than import and export.[10]

Investigating the welfare implications of shocks to trade and MP, I find that MNE-specific shocks contribute 26% of cross-country variation in welfare changes, which is much larger than the contributions by trade shocks and sectoral final demand shocks.[11] MNE-specific shocks to important headquarters propagate broadly to affect other countries' welfare, and contribute significantly to the cross-country variation.[12] A model of trade without MP misses almost all of these variations and considerably misunderstands the sources of welfare changes.[13] These results suggest that policy makers should add to their surveillance list

8. MNE-specific shocks that hit the top 5 host countries of inward MP explain 24%.

9. Sectoral final demand shocks that hit the top 5 importers contribute 1.0%.

10. Intuitively, the countries that do not provide a large amount of outward MP (for example, China, India) may receive a large amount of inward MP from the important global headquarters. Therefore, with regard to total MP, the former group might be substantially impacted by the important headquarters' MNE-specific shocks. On the other hand, a country's import is largely constrained by its ability to export. The countries that do not export a lot also might not import a lot, either. Therefore, they are less prone to sectoral final demand shocks in the large exporters. These results indicate that MNE-specific shocks that hit the MP hubs spread ripples widely in the global economy and lead to the world MP collapse.

11. Trade shocks and sectoral final demand shocks just contribute 1% and 6.9% to cross-country variation in real wage changes. Local productivity shocks contribute 69%–local producers account for a larger global output share than multinationals.

12. However, MNE-specific shocks to important host countries, as well as sectoral final demand shocks to important exporters and importers do not.

13. Specifically, because the trade-only model cannot distinguish between local and foreign producers, it misallocates the welfare contributions made by MNE-specific shocks to local productivity shocks. For example, in the full model, the United States local productivity shocks leads to a 3.5% decline in the country's real wage, as opposed to a 5.5% decline in the the trade-only model. For the United States, the trade only model exaggerates the consequence of local productivity decline and ignores the impact of MNE-specific shocks that accompany the MP collapse. In Turkey, however, the local productivity shocks reduce Turkish real wage by 5.7% and 4.9% in the full model and the trade-only model, respectively. Therefore, the trade-only model underestimates the negative impact of the Great Recession on Turkish domestic firms

the economic shocks that affect important foreign headquarters and host countries as an important type of external shocks. For an average country and during the Great Recession, they contribute more to domestic welfare than many traditional external shocks, for example, shocks to foreign trade.

This paper builds on the strand of literature on MP. It extends Ramondo and Rodríguez-Clare (2013), Tintelnot (2017), Arkolakis et al. (2018) to incorporate sector linkages and MNE sourcing and selling frictions with non-headquarters countries. Head and Mayer (2019) and Wang (2019) consider MNE selling frictions. However, they do not incorporate MNE sourcing frictions as I do, nor do they model individual sectors and input-output linkages. Alviarez (2019) considers sector heterogeneity and linkages but not sourcing nor selling frictions by MNEs. All these papers assume a nesting structure of sourcing problem with substitution across technologies outside and substitution across production locations inside. An analysis that misses any of these frictions will fail to match the MNE sourcing shares or output shares in the data.

This paper contributes to the literature on trade and MP collapse during the Great Recession. Bems et al. (2010), Bems et al. (2013), Eaton et al. (2016), Alessandria et al. (2010a), Alessandria et al. (2010b), among others, find that the decline in final demand for durable manufacturing sector, which is most trade intensive, contributes the most to the global trade collapse. Fewer works study MNEs in the Great Recession. Alfaro and Chen (2012) find that foreign affiliates with strong vertical production and financial linkages with headquarters are hit less. Alviarez et al. (2017) show that the headquarters, size and sector play an important role in explaining foreign affiliates' performance relative to local firms. Biermann and Huber (2019) find that bank lending cuts to German headquarters spillover to affiliates overseas through internal capital markets. I show that a significant fraction of declines in total trade can be explained by MNE-specific shocks and that trade and sectoral final demand shocks contribute to the declines in foreign affiliate sales.

because it classified the foreign affiliates in Turkey that grow relatively faster as local producers.

The paper builds on the literature that studies the propagation of shocks across regions and sectors. Quantitative trade and regional models that draw on the "exact hat algebra" (Rutherford 1995, Dekle et al. 2008, Costinot and Rodríguez-Clare 2014) techniques are applied in this literature. For example, Caliendo and Parro (2015) study the impact of tariff reduction shocks on trade flows and welfare. My model reduces to the model that Caliendo and Parro (2015) present if MP is shut down. Cravino and Levchenko (2017) study the propagation of productivity shocks through multinational production linkages. Alviarez et al. (2020) investigate the cross-country income difference explained by MNE know-hows. Di Giovanni et al. (2018) empirically show that a firm's performance correlates with macroeconomic shocks to the foreign economy to which the firm is linked through trade and MP. My paper contributes a tractable framework that studies shock propagation with trade, MNEs, and input-output linkages.

This paper is organized as follows: Section 1.2 motivates the MNE-specific sourcing and selling frictions, and shows that the MP collapse is more heterogeneous across countries than the trade collapse during the Great Recession. Section 1.3 describes the model. Section 1.4 inverts the model and complements with data to back out all shocks and estimates the trade and MNE elasticities. Section 1.5 investigates the sources of the MP collapse. Section 1.6 concludes.

1.2 Data and Empirical Facts

1.2.1 Cross-sectional Facts about Multinational Production

The main data source, OECD AAMNE (Cadestin et al., 2018),[14] provides information about bilateral gross output and international trade by MNEs, for 59 countries plus a constructed rest of the world. The database consists of two data tables. The first features a complete matrix of MNE gross output by headquarters, production location, and industry (a total of 34 industries). The second extends the coverage by the OECD inter-country input-output database[15] to the full set of countries and sectors, then splits each cell into four according to whether the buyer and seller of each trade flow is a local producer or a foreign affiliate. OECD AAMNE covers the years 2005 to 2016.

The focus of this study is the same set of major countries examined by Caliendo and Parro (2015) (less the tax haven countries Ireland and Netherlands). These 28 countries together account for 83% of the world's GDP in 2008. I pack the other 32 countries into a rest of the world (ROW).[16] Appendix Table A.1 shows the countries in OECD AAMNE and those covered by this paper. To ensure comparability with the trade collapse literature, I use the same classification as Eaton et al. (2016), collapsing the 34 industries in the OECD AAMNE Database into 3 broad sectors: durable manufacturing, non-durable manufacturing, and non-manufacturing. Appendix Table A.2 lists the industries in OECD AAMNE and their

14. OECD AAMNE advances the existing OECD Activities of Multinationals Database. The old database was used in several past works, including Alviarez et al. (2017), Alviarez (2019), etc. While the old database covers many aspects of MNE activities, for example, gross output, value added, total imports and exports, for OECD countries, it does not include important emerging market economies, such as Brazil, China, and India. Consequently, it impedes research on the world level. Additionally, the database provides only the aggregate trade statistics of foreign affiliates (e.g., the total export of foreign affiliates in China); it does not provide a breakdown among their trading partners. For example, the old database is not informative about foreign affiliates' export values in China to Japan. OECD AAMNE made progress on both fronts.

15. OECD ICIO, a database that documents international trade between country-sector pairs. See Ahmad et al. 2006

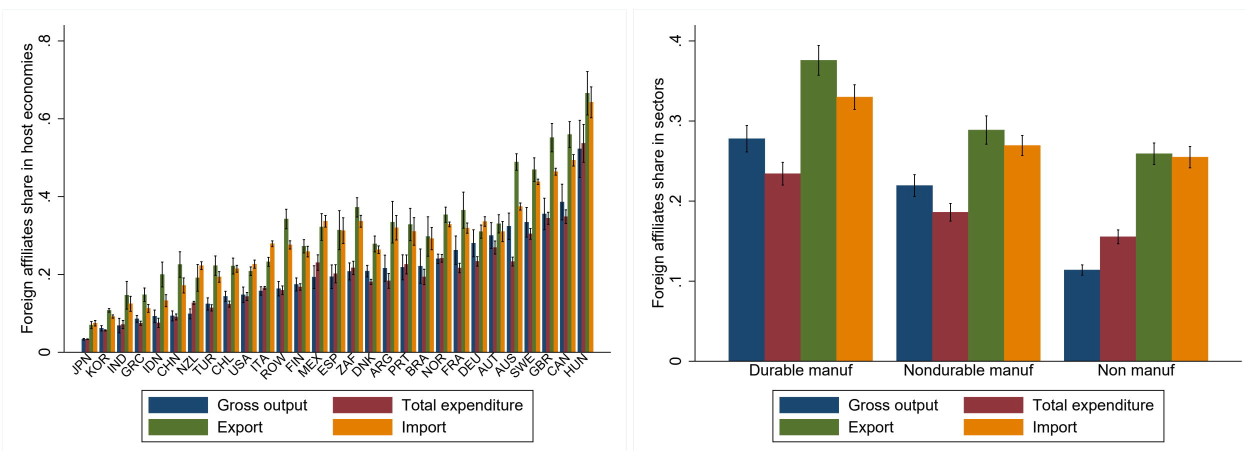
16. To back out MNE-specific shocks in Section 1.4 requires solving a system of nonlinear equations of dimension M^2, where M denotes the number of countries. The computation burden of the problem increases more than linearly with respect to the number of countries. To make the problem feasible I limit the number of countries to 28.

mappings to the broad sectors used in this paper.

The data is complemented with country-sector-level real GDP data from the United Nations National Account Database and the World Input-Output Social Economic Accounts Database (WIOD SEA, see Timmer et al. 2015). To measure the size of the labor forces of countries, I use data from the Penn World Table version 9.1 (Lederman et al., 2017).[17] I further acquire country-bilateral variables, including distance, common language, contiguity, among others, from CEPII data (Head et al. 2010, Head and Mayer 2014), tariffs from TRAINS acquired via World Integrated Trade Solution, and the latest global trade agreements information from Head and Mayer (2019).

Figure 1.2: Foreign Affiliate Shares by Host Country and Sector

(a) Foreign Affiliate Shares by Host Country (b) Foreign Affiliate Shares by Sector



OECD Analytical Activities of Multinationals (AAMNE) Database, 2008-2009. The left panel plots foreign affiliates' shares in country level gross output, intermediate input expenditure, imports and exports, for all countries. For each country, the height of the bar denotes the average value and the spike and caps denote the 95% CI for all sectors and years. The right panel plots foreign affiliates' shares in world total gross output, total intermediate input expenditure, total import and total export, in non-manufacturing, nondurable manufacturing and durable manufacturing sectors. For each sector, the height of the bar denotes the average value and the spike and caps denote the 95% CI for all countries and years.

Referring to OECD AAMNE data, I discuss a few cross-sectional facts for MNEs that motivate important ingredients of the model in Section 1.3.

Fact 1. Foreign affiliates engage more in importing and exporting than local producers.

17. The variable I use is "Number of persons engaged (in millions)".

Figure 1.2a plots by host countries several attributes of foreign affiliates: share in the host country's gross output, intermediate input expenditure, export, and import. A couple of observations follow. First, foreign affiliates' sales shares vary widely, from 5% of gross output in Japan to 55% in Hungary. More importantly, in terms of their shares in the host country, foreign affiliates account for 9.1% higher shares in imports than expenditure on intermediate input and 10.4% higher shares in exports than gross output.[18] This indicates that, on average, foreign affiliates engage in international trade more than the host country's local producers.

Fact 2. Foreign affiliates produce a disproportionately large output share in the durable manufacturing sector.

Figure 1.2b plots the same set of statistics by sector. It shows that MP activities are most intensive in the durable manufacturing sector. For example, foreign affiliates account for, in terms of gross output, about 12% in the non-manufacturing sector, about 23% in the non-durable manufacturing sector, and about 29% in the durable manufacturing sector.[19] Additionally, for all sectors, foreign affiliates also account for larger shares in imports and exports than in gross output and intermediate input expenditure.[20]

Fact 1 and 2 suggest that foreign affiliates engage more in international trade and durable

18. In addition to comparing foreign affiliates' shares in host country import against total intermediate expenditure and their shares in host country export against gross output with Figure 1.2a, I get these numbers by estimating the following regression:

$$S_{csyv} = \beta_1 \mathbf{1}(v = \text{Total expenditure}) + \beta_2 \mathbf{1}(s = \text{Export}) + \beta_3 \mathbf{1}(s = \text{Import}) + \delta_c + \gamma_s + \zeta_y + \epsilon_{csyv}$$

where S_{csyv} denotes foreign affiliates' share in variable v of country c, sector s in year y, and $v \in \{\text{Gross output, Total input expenditure, Export, Import}\}$. I get $\beta_1 = -.011(.005)$, $\beta_2 = .104(.005)$, $\beta_3 = .080(.005)$ with standard errors in parenthesis.

19. In addition to visualization with Figure 1.2b, I also consider the following regressions:

$$S_{csy,v=GO} = \beta_1 \mathbf{1}(s = \text{Durable manuf}) + \beta_2 \mathbf{1}(s = \text{Non-durable manuf}) + \delta_c + \zeta_y + \epsilon_{csy,v=GO}$$

where $S_{csy,v=\text{Gross output}}$ denotes foreign affiliates' share in gross output of country c, sector s in year y. I get $\beta_1 = .163(.004)$, $\beta_2 = .105(.004)$ with standard errors in parenthesis. I also get $\beta_1 = .078(.003)$, $\beta_2 = .030(.003)$ for v = Total intermediate input expenditure, $\beta_1 = .078(.003)$, $\beta_2 = .030(.003)$ for v = Exports, and $\beta_1 = .078(.003)$, $\beta_2 = .030(.003)$ for v = Imports.

20. For each sector, a test that pools all countries and years rejects the null hypothesis that foreign affiliates account for smaller shares in imports and exports at $p = 0.05$.

manufacturing sector output than local firms. Therefore, compared to local firms, foreign affiliates should respond more strongly to negative shocks to foreign trade and domestic durable manufacturing final demand. Compared to domestic sales, the host country's export and import should respond more strongly to negative shocks affecting MNEs. The idea is formally discussed in Proposition 1.This motivates the consideration of international trade by MNEs and sectoral heterogeneity in Section 1.3.

Fact 3. Compared to an average non-headquarters country, foreign affiliates import more from their headquarters and countries closer to their headquarters.

I investigate whether Fact 1 still holds after I control for firm level characteristics. Furthermore, which country a firm sources more from and sells more to may depend not only on whether it is a foreign affiliate but also on the location of the firm's headquarters. To answer these questions, I take advantage of Chinese firm-level databases. They include the Annual Survey of Chinese Manufacturing (ASCM) Database, which covers firm-level business statistics; the Chinese Customs Records (CCR) Database, which covers all importing and exporting transactions by Chinese firms; and the Foreign-Invested Enterprise Survey in China (FIESC), which documents the ownership nationalities of all foreign affiliates in China.[21]

I examine how foreign affiliates differ from local producers in terms of importing. The empirical strategy builds on Wang (2019).[22] That paper finds that, conditional on firm characteristics, foreign affiliates are more likely to export and to export more than local firms. Foreign affiliates also export more back to their headquarters and to destinations closer to their headquarters. Using a similar strategy, and providing more details in Appendix Section A.1.1, I establish two mirror facts for foreign affiliates' importing decisions. Conditional on firm-level characteristics, including employment, capital, intermediate input and TFP,[23] for-

21. Detailed information about these data sets are presented in Section A.1.1.

22. I thank Zi Wang for guiding me through the detailed procedure to clean and merge the three databases.

23. I also control for 2-digit industry fixed effects.

eign affiliates are 36 percentage points more likely to import, and they import 14 percentage points more relative to total sales than local firms (Appendix Table A.3). Conditional on importing and controlling for two-way fixed effects between the host country and the importing origin, foreign affiliates on average are 13 percentage points more likely to source from their headquarters. A one percent increase in the distance between the headquarters and the sourcing origin is associated with 0.3 percentage point decline in the probability of sourcing and 0.2% decline in importing values (Appendix Table A.4). These results, along with the findings of Wang (2019),[24] show that foreign affiliate status and the headquarters country affect firm importing and exporting, conditional on the usual international trade cost as well as firm-level characteristics. These facts show that when MNEs conduct international business, they face additional sourcing and selling frictions that are specific to headquarters and trade partner pairs, which motivates the model counterparts in Section 1.3. The MNE selling frictions may reflect the additional cost of setting up and maintaining the distribution networks in a non-headquarters country, higher marketing cost due to less brand recognition, limited knowledge of consumer preferences, etc. The MNE sourcing frictions may include the incompatibility between a country's technology and input from other countries, different regulatory requirements, little information about where and how to source from other countries, etc.

1.2.2 MP Collapse during the Great Recession

Fact 4. The MP collapse is more heterogeneous across countries than the trade collapse. The MP and trade collapse are positively correlated on the country level.

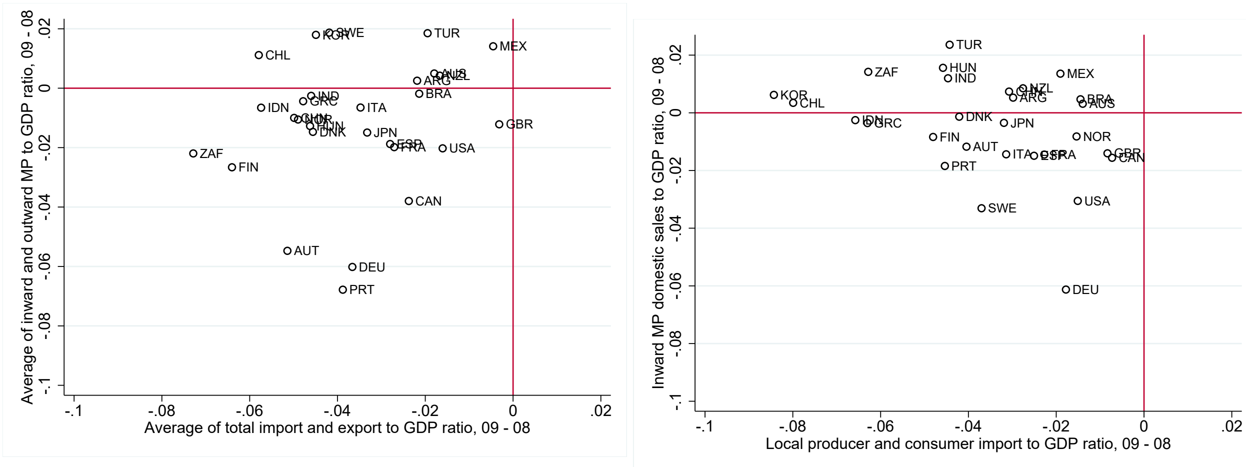
Figure 1.3a plots, by country, the MP collapse–changes in total MP (measured as the average of a country's inward and outward total foreign affiliate sales) relative to GDP, against

24. I replicate findings of Wang (2019) in Section A.1.2. This provides a complete picture of MNE-specific frictions on both the importing and exporting sides of trade. Furthermore, to clean and prepare the databases I have followed the recipes presented in that paper. However, the resulting sample may not necessarily be the same. Thus, I replicate the same set of regressions to show that the results are not sensitive to potential difference in data cleaning.

Figure 1.3: MP and Trade Collapse by Country

(a) Total Trade and Total MP

(b) Affiliate Domestic Sales and Local Producer and Consumer Import



OECD Analytical Activities of Multinationals (AAMNE) Database, 2008-2009. The left panel plots, by country, changes in the average of inward and outward foreign affiliate sales as well as the average of imports and exports, both relative to GDP from 2008 to 2009. The right panel plots, by country, changes in inward foreign affiliate domestic sales as well as local producers and consumers' import, both relative to GDP from 2008 to 2009.

the trade collapse–changes in total trade (measured as the average of the country's imports and exports) relative to GDP, both from 2008 to 2009.[25] The figure shows that, despite both world aggregate MP and trade collapsed, the MP collapse was more heterogeneous across countries than the trade collapse.[26] While trade fell globally, 9 countries experienced a rise in total MP relative to GDP. A country's MP collapse is positively associated with the trade collapse.[27] This suggests that negative shocks to MP may contribute to the declines in total trade. Simultaneously, negative shocks to trade may contribute to the declines in total MP.

25. Following Eaton et al. (2016), I define a country's total trade as the average of a country's imports and exports. Correspondingly, I define a country's total MP as the average of a country's inward and outward foreign affiliate sales. A country's inward foreign affiliate sales refer to the total sales of foreign affiliates headquartered in other countries and operating in this country. A country's outward foreign affiliate sales refer to the total sales of foreign affiliates headquartered in the country and operating in other countries.

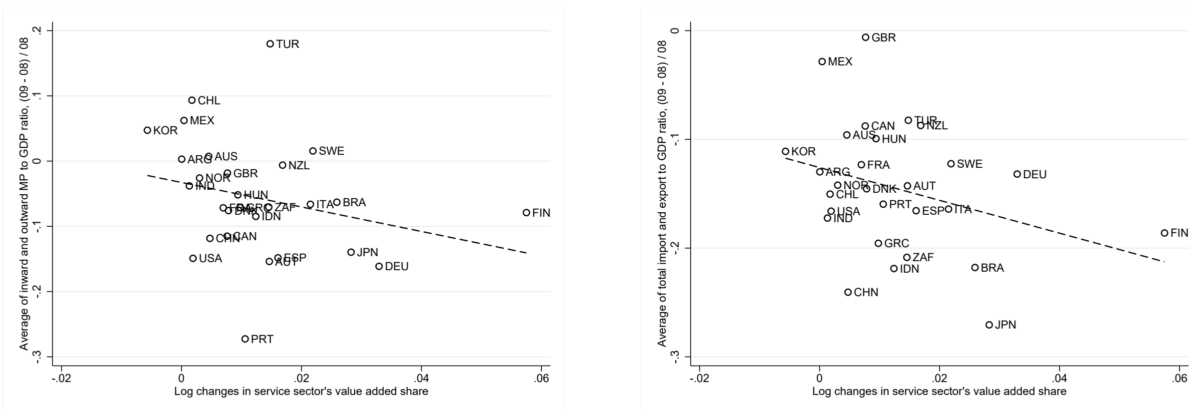
26. The cross-country standard deviation of changes in total MP relative to GDP equals .043 (with a mean of -.013). The cross-country standard deviation of changes in total trade relative to GDP equals .026 (with a mean of -.032). This indicates that the MP collapse is more heterogeneous because it has a larger coefficient of variation. In Appendix Section A.1.3, I further perform a within-between decomposition of world MP and trade collapse. The decomposition shows that the domestic component accounts for the majority of the world trade collapse, whereas the between-country component accounts for the majority of the world MP collapse. This further confirms that the MP collapse is more heterogeneous across countries and is more concentrated in a few countries than the trade collapse.

27. With a correlation coefficient of 0.19.

I quantitatively evaluate the claims in Section 1.5.1.

Figure 1.4: MP and Trade Collapse are Negatively Associated with Changes in Service Sector's Value Added Share

(a) MP Collapse (b) Trade Collapse



The figure plots the MP and trade collapse against log changes in service sector's share in national GDP. The MP collapse is significantly negatively associated with log changes in service sector's share in national GDP (correlation coefficient -0.26). The trade collapse is significantly negatively associated with log changes in service sector's share in national GDP (correlation coefficient -0.32).

Trade by foreign affiliates, as an important covariate for both the collapse in total trade and MP, may drive the positive correlation. To see this, consider the following restricted measures of the MP and trade collapse: measure the MP collapse with changes in the country's inward foreign affiliate domestic sales relative to GDP; and measure the trade collapse with changes in imports by the country's local producers and consumers relative to GDP. Constructed this way, I exclude trade by foreign affiliates from both the MP and trade collapse. Figure 1.3b plots the restricted measures of the MP and trade collapse. The changes in inward foreign affiliate domestic sales relative to GDP are now negatively correlated with the changes in imports by local producers and consumers relative to GDP.[28] Measured this way, the MP collapse shows an even larger heterogeneity across countries. 12 countries increased in their inward foreign affiliate domestic sales relative to GDP. Similar to total trade, in all countries, local producers and consumers experienced a decline in imports relative to GDP.[29]

28. With a correlation coefficient of -0.35.

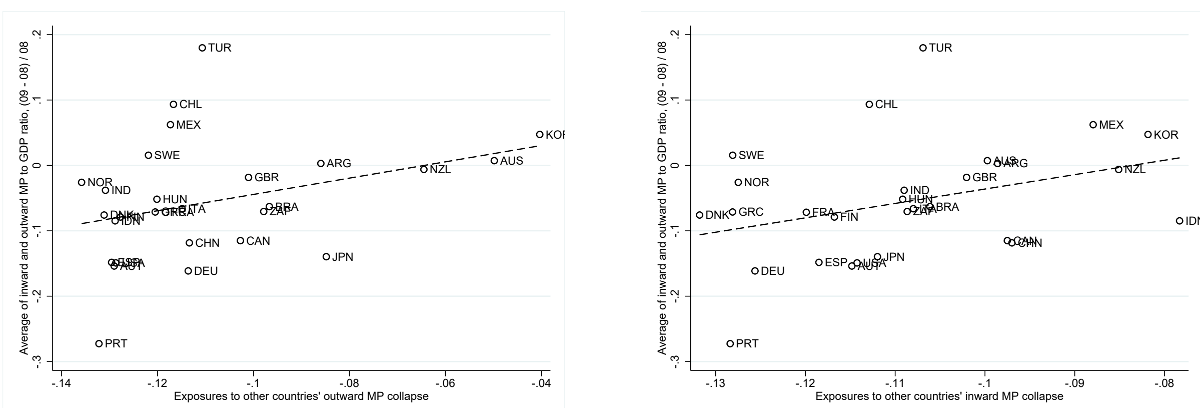
29. The cross-country standard deviation of changes in foreign affiliate domestic sales relative to GDP

Fact 5. Both the MP and trade collapse are negatively associated with changes in service sector's value added share.

Next I explore potential sources of the MP and trade collapse. Figure 1.4 plots, for all countries, MP and trade collapse against changes in service sector's GDP share. Both changes in MP and trade relative to GDP are significantly negatively associated with service sector's share in national GDP.[30] This empirical pattern is supported by **Fact 2** as well as the trade collapse literature that the service sector is least intensive in both multinational production and trade. Therefore a rise in service sector's value added share accompanies declines in both multinational production and trade. Again this suggests that sector composition effect may play an important role in both the MP and trade collapse.

Figure 1.5: A Country's MP Collapse is Significantly Associated with Exposures to Foreign Outward and Inward MP Collapse

(a) Exposures to Foreign Outward MP Collapse (b) Exposures to Foreign Inward MP Collapse



The figure plots a country's MP collapse against exposures to foreign outward and inward MP collapse. A country's MP collapse is significantly positively associated with exposures to foreign outward MP collapse (corr coef 0.34) and is significantly positively associated with exposures to foreign inward MP collapse (corr coef 0.36).

Fact 6. A country's MP collapse is positively associated with its exposures to foreign outward and inward MP collapse. However, a country's trade collapse is not significantly correlated

equals .019 (with a mean of -.002). The cross-country standard deviation of changes in import by local producers and consumers relative to GDP equals .021 (with a mean of -.034). This also indicates the MP collapse is more heterogeneous as it has a larger coefficient of variation.

30. The correlation coefficient is -0.26 for the MP collapse, and the correlation coefficient is -0.32 for the trade collapse.

with its exposures to foreign export and import collapse.

I then investigate how the MP and trade collapse propagate across borders. I construct a Bartik (Bartik, 1991) style measure of the magnitude a country is exposed to the MP and trade collapse in other countries. For example, the exposure to foreign countries' outward MP collapse is constructed as the following:

$$\text{EXPO\_OUTMP}_i = \sum_{i' \neq i} \frac{GO_{ii',2005}}{\sum_{i' \neq i} GO_{ii',2005}} (\log(OUTMP_{-i \leftarrow i',2009}) - \log(OUTMP_{-i \leftarrow i',2008}))$$

$GO_{ii',2005}$ denotes the gross output of MNEs from country i' in i in the benchmark year.[31] The weight that i assigns to i' equals i' share in total inward MNE sales in i. The shocks are leave-one-out shocks, which equal changes in i' outward multinational production in non-i countries. The exposure measure is more negative if i receives larger share of inward MP from countries that have larger collapse in outward MP. Therefore, it captures the importance of foreign headquarters in explaining the multinational production collapse at home. The exposure to foreign inward MP collapse, as well as foreign import and export collapse in a similar way.[32] Figure 1.5 shows that countries' MP collapse is significantly positively associated with the exposures to foreign outward and inward MP collapse.[33] This suggests that a few important headquarters and host countries may play an important role in propagating the MP collapse to the rest of the world. In contrast, Figure 1.6 shows that countries' trade collapse is not significantly associated with exposures to foreign export and import collapse.[34] These findings, along with those in Figure 1.4, suggest that sectoral final demand shocks may play the most important role in the global trade collapse.

31. The benchmark year is set to 2005, which is the first year of the OECD AAMNE database.

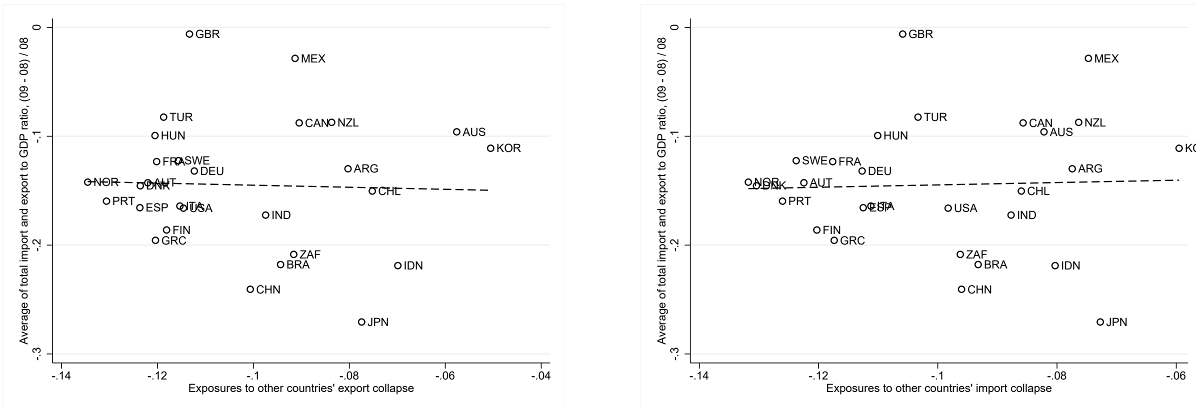
32. See Appendix Section A.1.4.

33. The correlation coefficient equals 0.34 for the exposure to foreign outward MP collapse and equals 0.36 for the exposure to foreign inward MP collapse.

34. The correlation coefficient equals -0.03 for the exposure to foreign export collapse and equals 0.03 for the exposure to foreign import collapse.

Figure 1.6: A Country's Trade Collapse is not Significantly Associated with Exposures to Foreign Export and Import Collapse

(a) Exposures to Foreign Export Collapse (b) Exposures to Foreign Import Collapse



The figure plots a country's trade collapse against exposures to foreign export and import collapse. A country's trade collapse is not correlated with exposures to foreign export collapse (corr coef -0.03) and is not correlated with exposures to foreign import collapse (corr coef 0.03).

1.3 Model

The global economy consists of M countries and S sectors. Each country m, sector s has a technology that is producing in any country n in the world in the same sector. Agents in the economy are workers and producers. If the host country n is different from the headquarters m, the producer is a foreign affiliate. Otherwise, it is a local producer. In this global economy, producers are also called "MNEs" (multinational enterprises) because producers that come out of a headquarters are producing in all countries in the world. An MNE is defined by its headquarters m, platform n, and sector s. Producers use labor and intermediate goods from all sectors as inputs. All markets are competitive.[35]

35. The model environment assumptions follow from Ramondo and Rodríguez-Clare (2013), Caliendo and Parro (2015), Eaton et al. (2016), Caliendo et al. (2017), Cravino and Levchenko (2017), and Alviarez et al. (2017), among others. The paper is intended to study country-sector level aggregate performance. Therefore, it follows the literature to abstract from monopolistic competition and fixed cost, which are features of individual firms' problem.

1.3.1 The Producer's Problem

Country m's MNE in country n, sector s produces quantity y^s_{nm} of tradable output by combining labor with MNE-specific composite input from all sectors:[36]

$$y^s_{nm} = A^s_{nm} \left(\frac{L^s_{nm}}{\gamma^s_n} \right)^{\gamma^s_n} \prod_{s'=1}^{S} \left(\frac{M^{ss'}_{nm}}{\gamma^{ss'}_n} \right)^{\gamma^{ss'}_n} \tag{1.1}$$

A^s_{nm} denotes the TFP of the MNE. The TFP varies with respect to both the headquarters as well as the platform.[37] I call the TFP of local producers, A^s_{nn}, the **local productivity**. I label an MNE's TFP relative to the host country's local productivity, $\frac{A^s_{nm}}{A^s_{nn}}$, the **MNE relative productivity**. L^s_{nm} denotes the quantity of labor hired by the MNE. Assume all MNEs producing in n hire from the same labor market of country n and face the same wage w_n. $M^{ss'}_{nm}$ is the quantity of sector s' non-tradable composite input used to produce s output. The input price is MNE-specific and denoted with P^s_{nm}. Assume all MNEs in platform country n have the same input-output shares γ^s_n and $\gamma^{ss'}_n$.[38] The production function is constant return to scale with $\gamma^s_n + \sum_{s'=1}^{S} \gamma^{ss'}_n = 1$. MNEs that operate in the same host country differ with respect to their TFP as well as MNE-specific input prices.

1.3.2 International Trade by MNEs

A downstream multinational sources its input along the global value chain from imperfectly substitutable upstream countries and upstream multinationals within each host country. Assume the input takes the form of a nested-CES aggregate over global tradable output as

36. I assume technology and trade flow from right to left in the subscripts.

37. The same idea is considered by Cravino and Levchenko (2017), Tintelnot (2017), and others.

38. The same assumption is used by Alviarez (2019).

follows:

$$Q^s_{nm} = \left[\sum_{j=1}^{M} \left(\sum_{i=1}^{M} \left(q^s_{nmji} \right)^{\frac{\zeta^s - 1}{\zeta^s}} \right)^{\frac{\zeta^s}{\zeta^s - 1} \frac{\sigma^s - 1}{\sigma^s}} \right]^{\frac{\sigma^s}{\sigma^s - 1}} \tag{1.2}$$

The tradable output is assumed to differ with respect to where it is produced and where the technology comes from. The composite input is produced with a "love-of-variety" style production function and combines tradable output from all host countries and MNEs in a Dixit-Stiglitz fashion. The outer-nest models trade-offs between platform countries with elasticity of substitution σ^s. Given a platform, the inner nest combines all MNEs that operate in the platform economy with elasticity of substitution ζ^s. We call σ^s the **trade elasticity** and ζ^s the **MNE elasticity**. q^s_{nmji} denotes the quantity of tradable output from an MNE headquartered in country i operating in j, sold to an MNE headquartered in country m that operates in n.

The price paid by an MNE from country m that operates in n, to acquire a unit of output from an MNE from country i that operates in j is assumed to take the following form:

$$\tilde{H}^s_{ni} \tilde{h}^s_{mj} k^s_{nj} t^s_{nj} \frac{\Theta^s_{ji}}{A^s_{ji}} \tag{1.3}$$

Here $\Theta^s_{ji} = (w_j)^{\gamma^s_j} \prod_{s'=1}^{S} \left(P^{s'}_{ji} \right)^{\gamma^{ss'}_j}$ denotes the sourcing capability of the MNE.[39] $\frac{\Theta^s_{ji}}{A^s_{ji}}$ refers to the selling MNE's factory gate price charged for one unit of output. This follows from profit maximization and the perfect competition assumption. Trade flows from country j to country n face iceberg, **non-tariff trade barriers**, denoted with k^s_{nj}. Ad-valorem **tariffs** at rate τ^s_{nj} has to be paid to the buying MNE's country n, and $t^s_{nj} = 1 + \tau^s_{nj}$. Tariff revenues are then transferred to country n's households for consumption. I assume the tariff barriers are

39. Tintelnot et al. (2017) consider a more general form of the sourcing problem in which the sourcing capability equals a CES aggregate of wage and input prices.

multiplicative separable from the non-tariff trade barriers.[40] MNEs face additional iceberg frictions sourcing from and selling to non-headquarter countries. These frictions are assumed to be bilateral, MNE headquarter-trade partner specific. $\tilde{h}^s_{mj}$ denotes the **MNE sourcing friction** for an MNE headquartered in country m to source from country j. $\tilde{H}^s_{ni}$ denotes the **MNE selling friction** for an MNE headquartered in country i to sell to country n. Non-tariff trade barriers within a country, as well as MNEs' selling and sourcing frictions with the headquarter, are normalized to one: $k^s_{nn} = \tilde{H}^s_{ii} = \tilde{h}^s_{mm} = 1$.[41]

The nested-CES aggregate and the price of tradable output imply two sets of key market shares that will guide our analysis through the rest of the paper: the **MNE output shares** and **MNE sourcing shares**. The MNE output shares of the selling MNE (headquartered in i and operating in j) in the total trade flows from host country j to destination n are the inner-nest shares and equal the following:

$$S^s_{n\cdot ji} = \frac{H^s_{ni}\left(\frac{\Theta^s_{ji}}{A^s_{ji}}\right)^{1-\zeta^s}}{\sum_{k=1}^{M} H^s_{nk}\left(\frac{\Theta^s_{jk}}{A^s_{jk}}\right)^{1-\zeta^s}} \tag{1.4}$$

Here I relabel $H^s_{ni} = (\tilde{H}^s_{ni})^{1-\zeta^s}$. H^s_{ni} denotes the **MNE selling efficiency** - efficiency of MNEs headquartered in i to sell to country n. This is the object to be exactly backed out with data and model inversion in Section 1.4.1. I define country j's producer price index for its shipment to n, $P^{s,p}_{nj}$, with the denominator of Equation (1.4): $(P^{s,p}_{nj})^{1-\zeta^s} = \sum_{k=1}^{M} H^s_{nk}\left(\frac{\Theta^s_{jk}}{A^s_{jk}}\right)^{1-\zeta^s}$. Country j's producer price index for destination country n should be lower if the MNEs hosted by country j are more productive, have lower input prices, or are more efficient at selling to n.

The MNE sourcing shares of the buying MNE (headquartered in m and operating in n)

40. The same assumption is used by Caliendo and Parro (2015), among others.

41. A country's tariff barrier with itself always equals 1: $t^s_{nn} = 1$.

from the origin country (country j) are the outer-nest shares and equal the following:

$$\pi^s_{nmj\cdot} = \frac{h^s_{mj}(k^s_{nj}t^s_{nj}P^{s,p}_{nj})^{1-\sigma^s}}{\sum_{l=1}^{M} h^s_{ml}(k^s_{nl}t^s_{nl}P^{s,p}_{nl})^{1-\sigma^s}} \tag{1.5}$$

where I relabel $h^s_{mj} = (\tilde{h}^s_{mj})^{1-\sigma^s}$. h^s_{mj} denotes the **MNE sourcing efficiency** - efficiency of MNEs headquartered in m to source from j. This is the object to be exactly backed out with data and model inversion in Section 1.4.1.[42] The composite input price index of the MNE from m operating in n, P^s_{nm}, then equals the following: $(P^s_{nm})^{1-\sigma^s} = \sum_{l=1}^{M} h^s_{ml}(k^s_{nl}t^s_{nl}P^{s,p}_{nl})^{1-\sigma^s}$. The MNE headquartered in m producing in n will face lower composite input prices if country n benefits from lower trade barriers and lower producer price indices with countries around the globe, or if country m's MNE is more efficient at global sourcing.

In the alternative to the nested-CES setup, in Appendix Section A.2.1, I build on Eaton and Kortum (2002), Ramondo and Rodríguez-Clare (2013), and others, to propose a different foundation for the MNE sourcing problem with CES preference over homogeneous goods on the demand side and multivariate Frechet technology draws on the supply side, which leads to the exact same set of market shares as in Equations (1.4) and (1.5).

The MNE sourcing and selling efficiencies govern the vertical/horizontal-ness of MNEs. Consider the following three knife-edge cases. If $h^s_{mj} = 0$, $\forall j \neq m$, foreign affiliates can only source from their headquarters country m. These MNEs are forward-vertical because the headquarter is the exclusive input supplier to the affiliates abroad. An example of forward-vertical MNEs is the distributors of car manufacturers. Consider TSMC dealers in the United States. They only import computer chips from Taiwan, and they hire a United States sales force to sell the computer chips in the United States and elsewhere. Another knife-edge case is $H^s_{ni} = 0$, $\forall n \neq i$. In this case, foreign affiliates can only sell back to their headquarters. These MNEs are backward-vertical because the headquarter country is the

42. Both the selling and sourcing efficiencies are relative to selling and buying with the MNE headquarters, with the normalization $H^s_{ii} = 1\ \forall i$ and $h^s_{mm} = 1\ \forall m$.

exclusive buyer of the foreign affiliates. Examples include Toyota's tire suppliers in Thailand that only provide tires to Japan. In the third extreme case, $h^s_{mj} = H^s_{ni} = 1$, $\forall m, n, j, i$. With this condition, foreign affiliates will have the same sourcing shares as the host country's local producers and consumers. The share of any destination in foreign affiliates' gross output will be equal to the same destination's share for the host country's local producers. These MNEs are horizontal–they have the same patterns of trade as local producers despite their productivity differences.[43]

Most MNEs in the real world mix features of forward-vertical, backward-vertical and horizontal MNEs.[44] Therefore, the true values of the MNE sourcing and selling efficiencies are unlikely falling into any of the three knife-edge cases. I will back out the sourcing and selling efficiencies exactly by taking the model to the data. Heterogeneous MNE sourcing and selling efficiencies are necessary conditions to explain why foreign affiliates engage more in both international trade than local producers of the same host country and with the headquarters and the trade partners closer to their headquarters - patterns documented in Figure 1.2a and 1.2b and Section A.1.1. The proofs are in Appendix Section A.2.2.

The expenditure share of an MNE from country m that operates in n, on the tradable output from an MNE headquartered in country i that operates in j, is found to be separable in the corresponding sourcing share and output share:

$$\pi^s_{nmji} = \pi^s_{nmj\cdot} S^s_{n\cdot ji} \tag{1.6}$$

43. Compare a foreign affiliate headquartered in m and producing in n, with country n's local producer. With $h^s_{mj} = 1$, $\forall m, j$, the two producers have the same sourcing shares from any origin: $\pi^s_{nmj\cdot} = \pi^s_{nnj\cdot}$, $\forall m, n, j$. Next, compare a foreign affiliate headquartered in i and producing in j, with country j's local producer. With $H^s_{ni} = 1$, $\forall n, i$, MNEs have the same output shares in total trade flows regardless of the destination: $S^s_{n\cdot ji} = S^s_{j\cdot ji}$. Denote total sales from country j to any country n in sector s, T^s_{nj}. The gross output by the foreign affiliate headquartered in i and hosted by j equals $\sum_{n=1}^{M} T^s_{nj} S^s_{n\cdot ji}$. The share of sales by this foreign affiliate to any country n' equals: $\frac{T^s_{n'j} S^s_{n'\cdot ji}}{\sum_{n=1}^{M} T^s_{nj} S^s_{n\cdot ji}}$. This implies that the share of any destination in gross output of foreign affiliates is the same as the local producer in the same host country: $\frac{T^s_{n'j} S^s_{n'\cdot ji}}{\sum_{n=1}^{M} T^s_{nj} S^s_{n\cdot ji}} = \frac{T^s_{nj} S^s_{n\cdot jj}}{\sum_{n=1}^{M} T^s_{nj} S^s_{n\cdot jj}} = \frac{T^s_{nj}}{\sum_{n=1}^{M} T^s_{nj}}$

44. See Yeaple (2003), Antràs and Yeaple (2014), Baldwin and Okubo (2014), Ramondo et al. (2016) for detailed discussions regarding firms having both horizontal and vertical motives to conduct FDI/MP in other countries.

Before moving on to the rest of the model, a discussion is merited of the modeling of international trade by MNEs in my model versus the approach taken in the literature. Seminal papers for MP–for example, Ramondo and Rodríguez-Clare (2013), Arkolakis et al. (2018), Tintelnot (2017), Head and Mayer (2019), etc.–all produce a key formula that characterizes the buyers' expenditure shares on different production platforms and technologies. The formula implies substitutability between production platforms and between technologies. The MNE sourcing and output shares in my model present a similar idea of substitution. The difference is that my outer-nest shares are for platforms and my inner-nest shares are for technologies, whereas in the papers just cited, the order of the nests is flipped. The motivation for my approach is that it helps the model to match exactly with the country-sector level aggregate data in the OECD AAMNE database. The database provides information about the sourcing shares from different countries and the output shares in different trade flows by local producers and foreign affiliates. This allows me to simulate model counterfactuals conveniently with the "exact hat algebra" method.

In the works cited above, however, the outer-nest shares denote the expenditure shares on technologies, and their inner-nest shares refer to the production shares by platforms, conditional on the technology chosen in the outer-nest. This information might be available for brand-level micro data - for example, the car data used by Head and Mayer (2019) and Coşar et al. (2018) documents, say, the expenditure share by American consumers on Toyota, a Japanese car brand, as well as the shares of Toyota cars sold to the US assembled by a plant in China. However, this information might not be available on the aggregate, country-sector level. For example, we may not know the American durable manufacturing sector's expenditure share on Japanese technologies as a whole. We also might not know the shares by all Chinese plants in total sales of Japanese global MNEs in the US. This impedes exactly matching their nesting structure to aggregate data.

1.3.3 The Consumer's Problem

Representative households in country n have Cobb-Douglas utility function over sector consumption goods:

$$U_n = \prod_{s=1}^{S} (\frac{C_n^s}{\alpha_n^s})^{\alpha_n^s}$$

where C_n^s denotes the quantity of sector s composite goods consumed by country n's households. α_n^s denotes the final expenditure share by country n households on sector s goods. Shocks to α_n^s are **sectoral final demand shocks**. I impose the normalization $\sum_{s=1}^{S} \alpha_n^s = 1$, in both baseline and counterfactual equilibrium. Assume a country's households and the country's local producers face the same sourcing frictions from different origin countries.[45] In this case, the sector consumption goods price index faced by the households equals the composite input price of the country's local producers. Equivalently, the composite input of the country's local producers is also consumed. The consumer price index P_n^C is defined as: $P_n^C = \prod_{s=1}^{S}(P_{nn}^s)^{\alpha_n^s}$.

Households have three sources of income: labor income, for which households inelastically supply L_n units of labor at wage rate w_n; the tariff revenue R_n; and a transfer from other countries that compensates for the trade deficit observed in the data, D_n. I use I_n to denote the household income. The household's budget constraint is therefore the following: $\sum_{s=1}^{S} P_{nn}^s C_n^s = I_n = w_n L_n + R_n + D_n$.

45. This is justified by the fact that a country's local producers are owned and managed by the country's households.

1.3.4 Market Clearing

To close the model, the market has to clear for labor and composite input. The labor market clearing condition in j is the following:

$$w_j L_j = \sum_{s=1}^{S} \gamma_j^s \sum_{n=1}^{M} \sum_{m=1}^{M} \frac{X_{nm}^s \pi_{nmj\cdot}^s}{t_{nj}^s} \tag{1.7}$$

On the right-hand side, $\sum_{m=1}^{M} \frac{X_{nm}^s \pi_{nmj\cdot}^s}{t_{nj}^s}$ denotes the pre-tariff total sales from country j to country n in sector s. Aggregated over all destinations n, this leads to country j's gross output in sector s. The total wage bill in country j then aggregtes all sectoral gross output, multiplied by the sector's value-added share in gross output.

The market clearing condition for composite input is the following:

$$X_{ji}^s = \begin{cases} I_j \alpha_j^s + \sum_{s'=1}^{S} \gamma_j^{s's} \sum_{m=1}^{M} \sum_{n=1}^{M} \frac{X_{nm}^{s'}}{t_{nj}^{s'}} \pi_{nmji}^{s'} \,, & \text{if } i = j \\ \sum_{s'=1}^{S} \gamma_j^{s's} \sum_{m=1}^{M} \sum_{n=1}^{M} \frac{X_{nm}^{s'}}{t_{nj}^{s'}} \pi_{nmji}^{s'} \,, & \text{if } i \neq j \end{cases} \tag{1.8}$$

Household consumption of sector s composite good, $I_j \alpha_n^s$, adds to the composite goods used by the country's local producers. The household income $I_j = w_j L_j + R_j + D_j$, with tariff revenue $R_j = \sum_{s=1}^{S} \sum_{l=1}^{M} \sum_{i=1}^{M} X_{ji}^s \pi_{jil\cdot}^s \frac{\tau_{jl}^s}{t_{jl}^s}$. The trade deficit, D_j, is an exogenous transfer from abroad that finances the difference between total import and total export. The demand for headquarter i, host country j's MNE specific, sector s composite input, equals the sum of the MNE's gross output in all downstream sectors s', $\sum_{m=1}^{M} \sum_{n=1}^{M} \frac{X_{nm}^{s'}}{t_{nj}^{s'}} \pi_{nmji}^{s'}$, multiplied by the share of sector s input used in sector s' output, $\gamma_j^{s's}$.

The equilibrium is defined by a set of global prices, including wages $\{w_n\}$, producer price indices $\left\{P_{nj}^{s,p}\right\}$, and composite input prices $\{P_{nm}^s\}$, such that the MNE sourcing and output shares follow Equation (1.4) and (1.5), and labor and composite goods markets clear, following Equations (1.7) and (1.8). To compute the equilibrium, we need to know the values of many economic fundamentals in the model, including the MNE TFP, non-tariff barriers, etc., whose values in levels are unknown and difficult to estimate. To deal with the problem, Section 1.3.5 rewrites the model in changes.

1.3.5 Equilibrium in Changes

To simulate counterfactuals, the paper's methodology takes advantage of the "exact hat algebra" techniques. I rewrite the model variables in terms of changes relative to the baseline equilibrium. I denote the change in an variable x with $\hat{x} = \frac{x'}{x}$, where x is the level of the variable in the baseline equilibrium and x' is the level of the variable in the counterfactual equilibrium. The MNE sourcing and output shares shares, baseline tariffs and household income then contain sufficient information to characterize endogenous variables' response to shocks. This approach reduces the data requirement for counterfactual analysis.[46] The model in "hats" is presented in Section A.2.3.

With the model I study the impact of three groups of shocks. The first group concerns the **MNE-specific shocks**. They include changes in the MNE sourcing efficiency, $\hat{h}^s_{mj}$ (**MNE sourcing shocks**), changes in the MNE selling efficiency, $\hat{H}^s_{ni}$ (**MNE selling shocks**), as well as changes in the MNE relative productivity, $\frac{\hat{A}^s_{ji}}{\hat{A}^s_{jj}}$ (**MNE relative productivity shocks**). The second group, which I call the **trade shocks**, includes changes in non-tariff trade barriers, $\hat{k}^s_{nj}$ (**non-tariff barriers shocks**) and changes in tariffs, $\hat{t}^s_{nj}$ (**tariff shocks**) . The third group, the **domestic shocks**, includes all shocks that take place within a country, including changes in the local productivity, $\hat{A}^s_{jj}$ (**local productivity shocks**) , changes in the final expenditure shares, $\hat{\alpha}_j$ (**sectoral final demand shocks**), the counterfactual trade deficit, TD'_j, as well as changes in the labor endowment, $\hat{L}_j$. Correspondingly, I call MNE-specific shocks and trade shocks the **external shocks**.

How do shocks to foreign trade and domestic sectoral final demand impact MP? How do

46. I no longer need to know the factual levels of economic fundamentals such as the MNE TFP or the non-tariff barriers, which are generally difficult to estimate.

MNE-specific shocks impact trade? These questions lie at the core of interactions between trade and MP. Define MNEs' heterogeneous exposures to trade and domestic shocks as different changes in the composite input prices, $\hat{P}^s_{nm}$, with respect to headquarters m. Define host countries' heterogeneous responses as different changes in the producer price indices, $\hat{P}^{s,p}_{nj}$, with respect to destination of sales, n. I show the following proposition that connects MNEs' sourcing and selling frictions with heterogeneous exposures of MNEs to external shocks and heterogeneous responses of host countries to shocks to MNEs:

Proposition 1. Heterogeneous MNE sourcing frictions are necessary for heterogeneous exposures of MNEs to shocks to foreign trade and domestic sectoral final demand.[47] Heterogeneous MNE selling frictions are necessary for the heterogeneous responses of a host country's export and domestic competitiveness to MNE relative productivity shocks.

Proof. See Appendix A.2.6.

Intuitively, if MNEs did not face heterogeneous sourcing frictions, all MNEs and local producers in the same host country would spend the same sourcing share on an origin. The sourcing shares govern the response in MNEs' composite input prices to unit change in foreign price or trade cost. Homogeneous sourcing shares across headquarters, therefore, imply that the composite input prices of all MNEs in the same host country will change proportionally to global trade and domestic shocks. Proportional changes in the composite input prices then translate into the proportional changes in the MNEs' sourcing capabilities. When MNE-specific shocks are shutdown, changes in sourcing capabilities become the only source of variation in foreign affiliates' output shares. In this case, foreign affiliates' output shares would not change with respect to trade and domestic shocks, limiting the impact of these shocks on MP. On the other hand, if heterogeneous MNE sourcing frictions match the model to the fact that foreign affiliates source larger shares of their input from abroad,

47. This speaks to the complementarity between trade and MP, defined in Ramondo and Rodríguez-Clare (2013). As a special case of the discussion here, without heterogeneous MNE sourcing frictions, shutting down trade will not lead to variations in MNE output shares and the country's openness to MP. In this case, trade is independent from MP.

foreign affiliates will have higher exposures to an increase in trade cost or foreign price. This may lead to a larger increase in the composite input prices of foreign affiliates, which may decrease their output shares. In this case, a trade decline due to higher foreign prices or trade cost is likely to be associated with a decline in MP.

If MNEs did not face heterogeneous selling frictions, an MNEs would account for the same output shares in the host country's sales to all destinations. The output shares in the host country's outward trade flows capture the impact of unit change in the MNE's factory gate price on the host country's producer prices offered to the destinations. Homogeneous output shares imply that the host country's producer prices offered to all destinations will change proportionally in response to the MNE relative productivity shock. The producer price measures how competitive the selling country is in the destination market. Therefore, with homogeneous selling frictions, the MNE relative productivity shocks may not lead to large changes in the host country's export relative to domestic sales, unless this was accompanied by substantial changes in the size of the foreign market relative to the domestic market. On the other hand, if heterogeneous MNE selling frictions match the model to the fact that foreign affiliates account for larger shares in export than domestic sales, a decline in a foreign affiliate's productivity will probably lead to a larger rise in the producer price of export than in domestic sales. This probably generates lower export relative to domestic sales for the host country. In this case, a MP decline due to negative MNE relative productivity shocks is likely to be associated with a decline in total trade. To quantitatively evaluate these predictions, in Appendix Section A.2.4, I present the model where MNEs face homogeneous sourcing and selling frictions such that foreign affiliates only differ from local producers in terms of their productivity. In Section 1.5.1, I compare the impact of trade and and domestic shocks on the MP collapse, as well as the impact of MNE-specific shocks on the trade collapse, in the full model and the model without sourcing and selling frictions.

1.4 Back out Shocks and Estimate Trade and MNE Elasticities

This section discusses the procedure to back out the model shocks and estimate the trade and MNE elasticities. I take advantage of the relationship between MNEs' expenditure on composite input and international trade, and the formula of MNE sourcing shares to exactly back out the MNE sourcing efficiency. I take advantage of the relationship between MNEs' gross output and international trade, and the formula of MNE output shares to exactly back out the MNE selling efficiency. With information on the sourcing and selling efficiencies, I use variations in tariffs and in local producers' output shares in trade flows (instrumented with tariffs in the opposite direction of the trade flows, as discussed further below) to estimate the trade and MNE elasticities. I use foreign affiliates' output relative to local producers, adjusted with the sourcing and selling efficiencies, to back out MNEs' productivity relative to local producers. I then back out the local producers' productivity shocks by taking out the contributions by foreign affiliates. Armed with the MNE-specific shocks, I then back out the rest of the shocks following a similar approach to the trade collapse literature.

1.4.1 Back out MNE Sourcing and Selling Efficiencies

The MNE sourcing efficiency is exactly backed out with the difference between a country's local producer's expenditure share on an sourcing origin, and the country's total expenditure share on the same origin, which is a combination of respective shares of the local producer and MNEs. First, with the MNE gross output data, aided by total income, input-output coefficients, and final expenditure shares, I calculate the total expenditure on MNE-specific, sector composite inputs, X_{ji}^{s}:

$$X_{ji}^{s} = \begin{cases} I_j \alpha_j^s + \sum_{s'=1}^{S} \gamma_j^{s's} GO_{ji}^{s'} , & \text{if } i = j \\ \sum_{s'=1}^{S} \gamma_j^{s's} GO_{ji}^{s'} , & \text{if } i \neq j \end{cases}$$

Consider the trade flow from country j to n in sector s. In the model it equals total expenditure by all MNEs in n on the tradable output from country j:

$$T_{nj}^{s} = \frac{\sum_{m=1}^{N} X_{nm}^{s} \pi_{nmj\cdot}^{s}}{t_{nj}^{s}} = \frac{\sum_{m=1}^{N} X_{nm}^{s} \pi_{nnj\cdot}^{s} \frac{\pi_{nmj\cdot}^{s}}{\pi_{nnj\cdot}^{s}}}{t_{nj}^{s}} \tag{1.9}$$

In the second equality, I divide and multiply by local producers' and consumers' sourcing shares, $\pi_{nnj\cdot}^{s}$, which is known from the data. However, the ratio, $\frac{\pi_{nmj\cdot}^{s}}{\pi_{nnj\cdot}^{s}}$, remains unknown. One may further manipulate the MNE sourcing shares expression, i.e., Equation (1.5), to express the ratio in terms of the known variable $\pi_{nnj\cdot}^{s}$ as well as the sourcing efficiencies h_{mj}^{s}:

$$\frac{\pi_{nmj\cdot}^{s}}{\pi_{nnj\cdot}^{s}} = \frac{\frac{h_{mj}^{s}}{h_{nj}^{s}}}{\sum_{l=1}^{N} \pi_{nnl\cdot}^{s} \frac{h_{ml}^{s}}{h_{nl}^{s}}} \tag{1.10}$$

Combining Equations (1.9) and (1.10), we get the following system of equations for solving h_{mj}^{s}:

$$h_{nj}^{s} = \frac{\pi_{nnj\cdot}^{s}}{T_{nj}^{s} t_{nj}^{s}} \sum_{m=1}^{N} X_{nm}^{s} \frac{h_{mj}^{s}}{\sum_{l=1}^{N} \pi_{nnl\cdot}^{s} \frac{h_{ml}^{s}}{h_{nl}^{s}}} \tag{1.11}$$

With the backed-out MNE sourcing frictions and Equation (1.10), we get the sourcing shares by MNEs with arbitrary headquarters, $\pi_{nmj\cdot}^{s}$.

The MNE selling efficiency, H_{ni}^{s}, is exactly backed out with the difference between a local producer's share in the host country's gross output and its shares in the host country's outward trade flows. Flipping the output shares by local producers I get:

$$\frac{1}{S^s_{n\cdot jj}} = \sum_{k=1}^{N} \frac{\left(\frac{\Theta^s_{jk}}{A^s_{jk}}\right)^{1-\zeta^s}}{\left(\frac{\Theta^s_{jj}}{A^s_{jj}}\right)^{1-\zeta^s}} \frac{H^s_{nk}}{H^s_{nj}} \tag{1.12}$$

To connect the cost ratios, $\frac{\left(\frac{\Theta^s_{jk}}{A^s_{jk}}\right)^{1-\zeta^s}}{\left(\frac{\Theta^s_{jj}}{A^s_{jj}}\right)^{1-\zeta^s}}$, to the known variables, I take advantage of the MNE gross output data by noting that:

$$GO^s_{ji} = \sum_{n=1}^{N} T^s_{nj} S^s_{n\cdot ji} = \sum_{n=1}^{N} T^s_{nj} S^s_{n\cdot jj} \frac{S^s_{n\cdot ji}}{S^s_{n\cdot jj}} = \frac{\left(\frac{\Theta^s_{ji}}{A^s_{ji}}\right)^{1-\zeta^s}}{\left(\frac{\Theta^s_{jj}}{A^s_{jj}}\right)^{1-\zeta^s}} \sum_{n=1}^{N} T^s_{nj} S^s_{n\cdot jj} \frac{H^s_{ni}}{H^s_{nj}}$$

The gross output of an MNE equals the sum of the MNE's sales to all destinations. The MNE's sales to a destination equals the host country's total trade flow to the destination multiplied by the MNE's output share in the trade flow. In the second equality I divide and multiply with the local producer's output share, $S^s_{n\cdot jj}$, which is known in the data. In the third equality I plug in the expression for MNE output shares, i.e., Equation (1.4). With this I get:

$$\frac{\left(\frac{\Theta^s_{ji}}{A^s_{ji}}\right)^{1-\zeta^s}}{\left(\frac{\Theta^s_{jj}}{A^s_{jj}}\right)^{1-\zeta^s}} = \frac{GO^s_{ji}}{\sum_{p=1}^{N} T^s_{pj} S^s_{p\cdot jj} \frac{H^s_{pi}}{H^s_{pj}}} \tag{1.13}$$

Plugging Equation (1.13) into Equation (1.12), we get the following system of equations for solving H^s_{ni}:

$$H^s_{nj} = S^s_{n\cdot jj} \sum_{k=1}^{N} \frac{GO^s_{jk}}{\sum_{p=1}^{N} T^s_{pj} S^s_{p\cdot jj} \frac{H^s_{pk}}{H^s_{pj}}} H^s_{nk} \tag{1.14}$$

With H^s_{ni} backed out, one may calculate the output shares of arbitrary MNEs by noting that:

$$S^s_{n\cdot ji} = S^s_{n\cdot jj} \frac{H^s_{ni}(\frac{\Theta^s_{ji}}{A^s_{ji}})^{1-\zeta^s}}{H^s_{nj}(\frac{\Theta^s_{jj}}{A^s_{jj}})^{1-\zeta^s}}$$

where the ratio of factory gate prices is from Equation (1.13).

For each sector s, Equations (1.11) and (1.14) each have M^2 equations with M^2 unknowns–the MNE sourcing/selling efficiencies. Note in these equations h^s_{mj}'s and H^s_{ni}'s are identified up to a scale.[48] As a result, I normalize the sourcing and selling efficiency with the headquarter economy, h^s_{mm} and H^s_{ii}, to 1, which pins down the rest of the unknown parameters. Further note that calibrating the MNE sourcing and selling efficiencies does not require knowledge of the elasticity of substitution σ^s and ζ^s. I solve Equations (1.11) and (1.14) for all sectors (durable manufacturing, non-durable manufacturing and non-manufacturing) and years (2005-2016).[49] Then I compute the year-on-year changes: $\hat{h}^s_{mj}$ and $\hat{H}^s_{ni}$. These are the shocks to MNE sourcing and selling efficiencies.

Figure A.2 plots the distributions of the calibrated MNE sourcing and selling shocks for all headquarter-location pairs. For all sectors, a majority of these shocks are below one, indicating MNEs' frictions to source from and sell to non-headquarters countries largely became worse during the Great Recession.[50] However, there is heterogeneity in all these distributions, and some headquarter-location pairs have MNE sourcing and selling shocks larger than 1–an improvement in sourcing and selling efficiencies for these pairs.

48. Say $\{h^s_{mj}\}$ and $\{H^s_{ni}\}$ are a set of solutions to Equations (1.11) and (1.14). For any HQ country m or i, if we multiply the HQ's sourcing or selling efficiency with all countries by the same constant, the equations still hold.

49. For each problem, I try different starting values and find they all converge to the same solution.

50. The MNE sourcing shocks have a median of 0.987, 0.987 and 0.965 for durable manufacturing, non-durable manufacturing, and non-manufacturing, respectively. The MNE selling shocks have a median of 0.983, 0.991 and 0.983 for durable manufacturing, nondurable manufacturing and non-manufacturing, respectively.

1.4.2 Estimate Trade and MNE Elasticities

Trade and MNE elasticities are necessary to generate counterfactuals with model shocks, and to associate changes in real wages with the trade and MP collapse. This section presents the method to estimate the two elasticities.[51] The procedure takes advantage of previous knowledge about the MNE sourcing and selling efficiencies. Recall that country n's local producer's sourcing share from country j equals the following:

$$\pi^s_{nnj\cdot} = \frac{h^s_{nj}(P^{s,p}_{nj}k^s_{nj}t^s_{nj})^{1-\sigma^s}}{(P^s_{nn})^{1-\sigma^s}} \tag{1.15}$$

On the right hand side, there is the MNE sourcing efficiency h^s_{nj}, tariff t^s_{nj}, the producer price index $P^{s,p}_{nj}$, and non-tariff barriers k^s_{nj}. The producer price is unknown. However, manipulating Equation (1.4), we may write it as a function of the factory gate price of the local producers in the origin, $\frac{\Theta^s_{jj}}{A^s_{jj}}$, MNE selling efficiency H_{nl}, and the output share of local producers $S^s_{n\cdot jj}$ in bilateral trade from j to n:

$$P^{s,p}_{nj} = \underbrace{\frac{\Theta^s_{jj}}{A^s_{jj}}}_{B^s_j}\left(\underbrace{\frac{S^s_{n\cdot jj}}{H^s_{nj}}}_{C^s_{nj}\text{, adjusted output shares, data+model inversion}}\right)^{\frac{1}{\zeta^s-1}} \tag{1.16}$$

To collect notations I denote $B^s_j = \frac{\Theta^s_{jj}}{A^s_{jj}}$ and $C^s_{nj} = \frac{S^s_{n\cdot jj}}{H^s_{nj}}$. I call C^s_{nj} the adjusted output share. C^s_{nj} is known because $S^s_{n\cdot jj}$ is from data and H_{nj} is learned from model inversion in Section 1.4.1. Plug Equation (1.16) into Equation (1.15) to eliminate the producer price:

$$\underbrace{\frac{\pi^s_{nnj\cdot}}{h^s_{nj}}}_{D^s_{nj}\text{, adjusted sourcing shares, data+calibration}} = \frac{(C^s_{nj})^{-\frac{\sigma^s-1}{\zeta^s-1}}(B^s_j k^s_{nj}t^s_{nj})^{1-\sigma^s}}{(P^s_{nn})^{1-\sigma^s}} \tag{1.17}$$

51. A third elasticity in the model concerns the elasticity of substitution across sector final consumption goods. I follow Caliendo et al. (2017) to set the final demand elasticity $\delta = 4$.

The left-hand side is the sourcing share divided by the sourcing efficiency. To collect notations, I relabel the left-hand side D^s_{nj} and call it the adjusted sourcing shares. D^s_{nj} is known, with π^s_{nnj}. from data and h^s_{nj} from model inversion. Equation (1.17) forms the basis of parameter estimation. The identification strategy for σ^s and ζ^s extends Head and Mayer (2019). First, I assume k^s_{nj} takes the following form:

$$\log(k^s_{nj}) = \beta_1 \log(\text{dist}_{nj}) + \beta_2 \mathbf{1}(\text{contiguity})_{\mathbf{nj}} + \beta_3 \mathbf{1}(\text{common lang})_{\mathbf{nj}} + \beta_4 \mathbf{1}(\text{trade agreement})_{\mathbf{nj}} + FE^s_n + FE^s_j + \phi^s_{nj} \tag{1.18}$$

The log of non-tariff barriers is assumed to be a linear function of log distances between: the importing and exporting countries; a dummy for whether the two countries share a border; a dummy for whether the two countries speak a common official language; and a dummy for whether the two countries sign a trade agreement. Additionally, origin and destination fixed effects are added to allow for Waugh (2010)'s idea that rich and poor countries face asymmetric trade costs. What cannot be controlled by the observables is left in the error term, ϕ^s_{nj}. Taking logs of Equation (1.17), plugging in Equation (1.18), and adding a time subscript gives my key estimation equation:

$$\log\left(D^s_{nj,t}\right) = \frac{1-\sigma^s}{1-\zeta^s} \log\left(C^s_{nj,t}\right) + (1-\sigma^s)\log\left(t^s_{nj,t}\right) + \gamma^s_1 \log(\text{dist})_{nj,t} + \gamma^s_2 \mathbf{1}(\text{contiguity})_{nj,t} + \gamma^s_3 \mathbf{1}(\text{common lang})_{nj,t} + \gamma^s_4 \mathbf{1}(\text{trade agreement})_{nj,t} + FE^s_{n,t} + FE^s_j + \epsilon^s_{nj,t} \tag{1.19}$$

Like Head and Mayer (2019), I assume tariff variation is not correlated with ϵ^s_{nj}, which is the unobserved term in bilateral non-tariff frictions. Variation in tariffs is used to identify the trade elasticity, σ^s. Bilateral variation in adjusted output shares, $C^s_{nj,t}$, are used to identify $\frac{1-\sigma^s}{1-\zeta^s}$, which then gives ζ^s. However, the adjusted output shares may correlate with $\epsilon^s_{nj,t}$. To deal with this problem, I instrument $\log(C^s_{nj,t})$ with the tariffs imposed by the origin country j on the destination n (the reverse direction of the trade flow in the main regression) in its own, upstream and downstream sectors.[52] The instruments' relevance is given by the fact that n's foreign affiliates in j import a larger share from and export a larger share to country n than j's local producers. A rise in the tariffs that j imposes on n raises the cost of n's affiliates in j more than j's local producers. This leads to a decline in n's affiliates' shares in j and a rise in local producers' shares, especially in the sales back to n. This, in turn, causes an increase in $\log(C^s_{nj,t})$.

In my preferred specification, I follow Head and Mayer (2019) to control for the destination-year fixed effect, $FE^s_{n,t}$. I exclude the Great Recession period, 2008 and 2009, from the sample. I also drop the observations of a country that trades with itself, i.e., $n = j$. Following Acemoglu et al. (2016), I use the total input-output shares to construct the upstream and downstream tariffs. (See Appendix A.3.3 for more details.) The estimation results are presented in Table 1.1. In the baseline, I get trade elasticity 12.50 for the durable manufacturing sector, 4.20 for the non-durable manufacturing sector, and 6.46 for the non-manufacturing sector. This indicates that the durable manufacturing sector is more tradable than the other two sectors. In terms of the MNE elasticity, I get 11.27 for the durable manufacturing sector, 2.80 for the non-durable manufacturing sector, and 1.54 for the non-manufacturing sector, indicating that producers are more heterogeneous in the non-manufacturing and non-durable manufacturing sectors than in the durable manufacturing sector. For regressions with individual sectors and that pool them together, the trade elasticity is larger than the MNE elasticity, showing that headquarters are more heterogeneous than production platforms. This aligns with the findings in Head and Mayer (2019), who estimate that for the automobile industry, the elasticity of substitution across production locations is about 9.2, while the elasticity of substitution across brands (the counterparts of the technologies in my model) is about 4.4. They also find that there is more heterogeneity in customers' taste for brands than there is in manufacturers' preference for production locations. Table A.12 shows that the estimates are robust to alternative specifications.[53]

52. The construction of the upstream and downstream tariffs are postponed to Appendix Section A.3.3.

53. The alternative specifications that I consider include having both recession and non-recession years,

‘

Table 1.1: Estimated Trade and MNE Elasticities

Sector name	ISIC classification	$\frac{1-\sigma^s}{1-\zeta^s}$	$1-\sigma^s$	σ^s	ζ^s
Durable manuf	C16,C23-C33	1.12 (0.24)	-11.50 (0.73)	12.50	11.27
Nondurable manuf	C10-C15,C17-C18,C20-C22	1.78 (0.55)	-3.20 (0.47)	4.20	2.80
Non-manuf	Other	10.19 (2.37)	-5.46 (3.49)	6.46	1.54
All	All	1.02 (0.04)	-7.36 (0.26)	8.36	8.21

Estimated coefficients and implied trade and MNE elasticities under the baseline specification, Equation (1.19). Numbers in the parenthesis denote standard errors.

1.4.3 Back out MNE Relative Productivity

The productivity of foreign affiliates relative to local producers in the same host country is exactly backed out. Note that the relative productivity equals the relative price of input divided by the relative price of output:

$$\frac{A^s_{ji}}{A^s_{jj}} = \frac{\Theta^s_{ji}}{\Theta^s_{jj}} \bigg/ \frac{\frac{\Theta^s_{ji}}{A^s_{jj}}}{\frac{\Theta^s_{jj}}{A^s_{jj}}} \tag{1.20}$$

The denominator of Equation (1.20) is known from Equation (1.13), with knowledge about GO^s_{li}, T^s_{pl} and $S^s_{p\cdot ll}$ obtained from the data, ζ^s estimated in Section 1.4.2, and MNE selling efficiencies H^s_{pi} backed out in Section 1.4.1.:

$$\frac{\frac{\Theta^s_{ji}}{A^s_{ji}}}{\frac{\Theta^s_{jj}}{A^s_{jj}}} = \left(\frac{GO^s_{ji}}{\sum_{p=1}^N T^s_{pj} S^s_{p\cdot jj} \frac{H^s_{pi}}{H^s_{pj}}} \right)^{\frac{1}{1-\zeta^s}} \tag{1.21}$$

The numerator of Equation (1.20) equals the following:

$$\frac{\Theta^s_{ji}}{\Theta^s_{jj}} = \prod_{s'=1}^{S} (\frac{P^{s'}_{ji}}{P^{s'}_{jj}})^{\gamma^{ss'}_l} \tag{1.22}$$

controlling for origin, destination and year fixed effects separately, bringing back the observations where countries trade with themselves and controlling having all country pairs them with a dummy but using a dummy for a country trading with itself, as well as using the direct rather than total input-output shares to construct the instruments.

where the relative price of composite input of foreign affiliates relative to local producers is computed as follows:

$$\frac{P^s_{ji}}{P^s_{jj}} = (\sum_{k=1}^{N} \pi^s_{jjk\cdot} \frac{h^s_{ik}}{h^s_{jk}})^{\frac{1}{1-\sigma^s}} \tag{1.23}$$

where $\pi^s_{jjk\cdot}$ is data and the MNE sourcing efficiency, h^s_{ik}, has been backed out in Section 1.4.1. Combining Equations (1.20), (1.21), (1.22) and (1.23), I get the MNE relative productivity, $\frac{A^s_{ji}}{A^s_{jj}}$, for all sectors and years. Then I compute the year-on-year changes in MNE relative productivity, $\frac{\hat{A}^s_{ji}}{\hat{A}^s_{jj}}$. These are the shocks to MNE relative productivity.

Figure A.3 plots the distributions of the calibrated MNE relative productivity shocks for all headquarters-location pairs. For all sectors, a majority of these shocks are below one, indicating that there is a decline in the productivity of MNEs to local producers.[54] All these distributions have a long left tail. This implies that the productivity of some MNEs' was hit especially hard in the Great Recession.

I study the roles of pre-crisis bilateral financial investment, bilateral trade flow, and distance between the headquarter and the host country for the heterogeneity in MNE relative productivity shocks during the Great Recession. Table A.11, Column 1-4 show that the MNE relative productivity declines less in the Great Recession, if the headquarter has stronger forward and backward financial or trade linkages with the host country in 2007. This is consistent with the findings in Alfaro and Chen (2012) and confirms that the shocks that I back out with macro model and data have similar properties to what these authors find for firm-level, foreign affiliate sales.[55] Furthermore, I find that the MNE relative productivity declines more if the headquarter is more distant from the host country (Column 5). These

54. The MNE relative productivity shocks have a a median of 0.964, 0.966 and .975 for durable manufacturing, nondurable manufacturing and non-manufacturing sectors.

55. The authors find that the growth in foreign affiliate sales is less negatively affected by the Great Recession if the foreign affiliate receives more investment from the headquarter and has more vertical trade linkage with the headquarter before the Great Recession.

results merit further exploration with firm-level data.[56]

1.4.4 Back out Non-tariff Trade Barriers

Next I proceed to the non-tariff barriers. First, with the expression for the producer price index from Equation (1.16), I take the ratio of j's producer price index selling to n, with respect to j's producer price index selling to j:

$$\frac{P_{nj}^{s,p}}{P_{jj}^{s,p}} = \frac{\left(\frac{H_{nj}}{S_{n \cdot jj}^{s}}\right)^{\frac{1}{1-\zeta^s}}}{\left(\frac{H_{jj}}{S_{j \cdot jj}^{s}}\right)^{\frac{1}{1-\zeta^s}}}$$

Local producers' output shares, $S_{n \cdot jj}^{s}$, are known from the data, and the MNE selling efficiency, H_{nj}, has been exactly backed out. The ratio $\frac{P_{nj}^{s,p}}{P_{jj}^{s,p}}$ is then known. If I take the ratio of country n's local producers' and consumers' sourcing share on j, with respect to j's local producers' and consumers' sourcing share on j, I get:

$$\frac{\pi_{nnj\cdot}^{s}}{\pi_{jjj\cdot}^{s}} = \frac{h_{nj}^{s}}{h_{jj}^{s}} \left(\frac{t_{nj}^{s} k_{nj}^{s} P_{nj}^{s,p}}{t_{jj}^{s} k_{jj}^{s} P_{jj}^{s,p}}\right)^{1-\sigma^s} \frac{1}{\sum_{p=1}^{N} \pi_{jjp\cdot}^{s} \frac{h_{np}^{s}}{h_{jp}^{s}} \left(\frac{t_{np}^{s} k_{np}^{s} P_{np}^{s,p}}{t_{jp}^{s} k_{jp}^{s} P_{jp}^{s,p}}\right)^{1-\sigma^s}} \tag{1.24}$$

Note for each sector s, the system of equations (1.24) provides N^2 equations for N^2 unknowns, k_{nl}^{s}, because the other variables in the equations are now known. With the normalization $k_{ll}^{s} = 1, \forall l$, the rest of the unknowns are pinned down. In the same manner that I solves the MNE sourcing and selling efficiencies, one may solve the equations for for k_{nl}^{s} using a nonlinear solver. However, with a close observation of (1.24) and a guess-and-verify

56. Table A.9 and Table A.10 Column 1 - 4 show that MNEs' sourcing and selling shocks are weakly less negative during the financial crisis, if the country that the MNE sources from and sells to has stronger financial or trade linkages with the MNE's headquarter. Furthermore, Column 5 of the two tables shows that the sourcing and selling shocks are weakly more negative if the country that the MNE sources from or sells to is more distant from the headquarter. These results are worth more investigation with more granular, firm-level data on how the Great Recession affects firms' sourcing and selling decisions. I will leave this to future research.

approach, the following is found to be a solution:

$$k^s_{nj} = \left(\frac{\pi^s_{nnj\cdot}}{\pi^s_{jjj\cdot}} \frac{h^s_{jj}}{h^s_{nj}} \right)^{\frac{1}{1-\sigma^s}} \frac{1}{\frac{P^{s,p}_{nj} t^s_{nj}}{P^{s,p}_{jj} t^s_{jj}}} = \left(\frac{\pi^s_{nnj\cdot}}{\pi^s_{jjj\cdot}} \frac{h^s_{jj}}{h^s_{nj}} \right)^{\frac{1}{1-\sigma^s}} \frac{\left(\frac{H_{jj}}{S^s_{j\cdot jj}} \right)^{\frac{1}{1-\zeta^s}} t^s_{jj}}{\left(\frac{H_{nj}}{S^s_{n\cdot jj}} \right)^{\frac{1}{1-\zeta^s}} t^s_{nj}} \tag{1.25}$$

Then shocks to non-tariff barriers, which are the year-on-year changes in k^s_{nj}, equals the following:

$$\hat{k}^s_{nj} = \left(\frac{\hat{\pi}^s_{nnj\cdot}}{\hat{\pi}^s_{jjj\cdot}} \frac{\hat{h}^s_{jj}}{\hat{h}^s_{nj}} \right)^{\frac{1}{1-\sigma^s}} \frac{\left(\frac{\hat{H}_{jj}}{\hat{S}^s_{j\cdot jj}} \right)^{\frac{1}{1-\zeta^s}} \hat{t}^s_{jj}}{\left(\frac{\hat{H}_{nj}}{\hat{S}^s_{n\cdot jj}} \right)^{\frac{1}{1-\zeta^s}} \hat{t}^s_{nj}} \tag{1.26}$$

with $\hat{k}^s_{nl} = 1$. Figure A.4 plots the distributions of the calibrated non-tariff trade barrier shocks for all origin-destination country pairs. For all sectors, a majority of these shocks are larger than one, indicating that non-tariff barriers largely rise.[57] This is consistent with the findings of Eaton et al. (2016).

1.4.5 Local Productivity Shocks

In my model, the TFP is defined as the quantity of output produced with one unit of the input bundle. However, the quantity numbers are not available from the OECD AAMNE database, which only provides the current dollar value information. To separate quantities from prices out of the nominal values, additional information has to be introduced. Dealing with a similar challenge, Eaton et al. (2016) take advantage of changes in country-sector level producer price indices to back out the changes in quantities of output. However, Proposition 1 finds that if MNEs have heterogeneous selling frictions, the producer price index and its changes will likely differ with respect to both the platform country and the destination. Only

57. The MNE relative productivity shocks have a a median of 1.018, 1.010 and 1.006 for durable manufacturing, nondurable manufacturing and non-manufacturing sectors.

using the producer price index information at the host-sector level, as in Eaton et al. (2016), cannot account for the heterogeneity. Instead, I develop a new method that takes advantage of country-sector-level real GDP data as well as the gross output shares of MNEs to back out the local productivity shocks.

Measuring with time t prices, the real GDP of a country j, sector s at time t equals the nominal GDP, which equals the total value of output by all MNEs in the country, subtracting the total input used in the MNEs' production:

$$RGDP^s_{j,t} = \sum_{i=1}^{N} P^{y,s}_{ji,t} y^s_{ji,t} - \sum_{i=1}^{N} \sum_{s'=1}^{S} P^{s'}_{ji,t} M^{ss'}_{ji,t} \tag{1.27}$$

where $P^{y,s}_{ji,t}$ denotes the output price of an MNE from source country i and operating in country j sector s. $y^s_{ji,t}$ is the MNE's output quantity. $M^{ss'}_{ji,t}$ is the quantity of composite input from sector s' used by the MNE. $P^{s'}_{ji,t}$ is the price of the composite input. Real GDP of country j, sector s at time $t+\Delta$ and measured with time t prices replaces all quantities in Equation (1.27) with their real quantities in $t+\Delta$, holding prices fixed at time t:

$$RGDP^s_{j,t+\Delta} = \sum_{i=1}^{N} P^{y,s}_{ji,t} y^s_{ji,t+\Delta} - \sum_{i=1}^{N} \sum_{s'=1}^{S} P^{s'}_{ji,t} M^{ss'}_{ji,t+\Delta}$$

Appendix A.3.2 shows that, in the limit of $\Delta \to 0$, the model implies the real GDP growth equals the following:

$$d\log(RGDP^s_j) = \sum_{i=1}^{N} \frac{GO^s_{ji}}{GDP^s_j} d\log(A^s_{ji}) + d\log(L^s_j) \tag{1.28}$$

Equation (1.28) extends the literature on shock propagation in production networks, as in Hulten (1978), Baqaee and Farhi (2019a), Baqaee and Farhi (2019b), among others. The marginal impact of an MNE's productivity shock on real GDP equals the MNE's Domar weight–the ratio of the MNE's gross output to the nominal GDP of the host country, $\frac{GO^s_{ji}}{GDP^s_j}$.

The marginal impact of a shock to factor endowment on real GDP equals the factor's income relative to nominal GDP. In my model, the host-economy labor is the only production factor and labor income equals value added; thus, the marginal impact of labor endowment equals one.

Log changes in MNE's productivity can be written as the sum of the log changes in local productivity and the log changes in the MNE's relative productivity: $d\log(A^s_{ji}) = d\log(A^s_{jj}) + d\log(\frac{A^s_{ji}}{A^s_{jj}})$. Equation (1.28) is then inverted to compute the changes in local productivity as a function of known variables:

$$d\log(A^s_{jj}) = \frac{GDP^s_j}{GO^s_j}(d\log(RGDP^s_j) - \sum_{i=1}^{N}\frac{GO^s_{ji}}{GDP^s_j}d\log(\frac{A^s_{ji}}{A^s_{jj}}) - d\log(L^s_j)) \tag{1.29}$$

I use the method proposed by Davis et al. (1998) to compute the data counterparts that approximate the log changes.[58] If a variable takes value x at time t and value x' at time $t+1$, then the Davis et al. (1998) measure for percentage (log) changes, $\Delta x\%$, equals the following: $\Delta x\% = \frac{x'-x}{\frac{x'+x}{2}}$. Also following Davis et al. (1998) practice, I use the time-average of the respective variables in t and $t+1$ (define $\overline{x} = \frac{x'+x}{2}$) as the weights to aggregate the productivity shocks. With these, I take Equation (1.29) to the data with the following approximation method:

$$\Delta A^s_{jj}\% \approx \frac{\overline{GDP^s_j}}{\overline{GO^s_j}}(\Delta RGDP^s_j\% - \sum_{i=1}^{N}\frac{\overline{GO^s_{ji}}}{\overline{GDP^s_j}}\Delta(\frac{A^s_{ji}}{A^s_{jj}})\% - \Delta L^s_j\%) \tag{1.30}$$

In the end, I construct local productivity shocks as $\hat{A}^s_{jj} = 1 + \Delta A^s_{jj}\%$. The procedure sheds lights on the fraction of changes in a country's aggregate productivity that can be explained by the MNE relative productivity shocks versus the local productivity shocks. The host-country-sector-level productivity changes aggregate local productivity shocks $d\log(A^s_{jj})$ and MNE relative productivity shocks $d\log(\frac{A^s_{ji}}{A^s_{jj}})$, using MNEs' output

58. The approximation method is also applied by Alviarez et al. (2017) to aggregate firm-level MNE sales growth at the national level.

shares in host-economy sector gross output $\frac{GO^s_{ji}}{GO^s_j}$ as weights:

$$\Delta A^s_j\% = \Delta A^s_{jj}\% + \sum_{i=1}^{N} \frac{\overline{GO^s_{ji}}}{\overline{GO^s_j}} \Delta(\frac{A^s_{ji}}{A^s_{jj}})\% \tag{1.31}$$

$\sum_{i=1}^{N} \frac{\overline{GO^s_{ji}}}{\overline{GO^s_j}} \Delta(\frac{A^s_{ji}}{A^s_{jj}})\%$ refers to the total contribution of MNE relative productivity shocks. Klenow and Rodriguez-Clare (1997), and Alviarez et al. (2020), among others, show that the fraction of variance explained by a variable in its sum with other variables equals the regression coefficient of the individual variable on the sum.[59] With a pooled regression for all sectors and years, I find that local productivity shocks account for 85% of aggregate productivity changes, while MNE relative productivity shocks account for the rest 15%. This aligns with the findings of Alviarez et al. (2020) that country-embedded factors account for the majority of aggregate TFP differences across countries, while the contribution by individual firm know-hows is also non-negligible.

Appendix A.3.5 tests the external validity of my new method to back out local productivity shocks. With the backed out local productivity shocks and the MNE relative productivity shocks, I derive the host country aggregate productivity changes. Figure A.5 shows that my constructed measure of host country aggregate productivity changes are strongly positively correlated with the year-on-year changes in labor productivity and TFP documented in the OECD multi-factor productivity database.[60] Figure A.6a plots the density of the local productivity shocks for each sector. All sectors have a decline in local productivity in most countries. However, the magnitude of the decline does not differ substantially across sectors.

Figure A.6b plots the sectoral final demand shocks, defined as changes in final expenditure

59. Say $y = \sum_{i=1}^{N} x_i$, where y and x_i are random variables. $\sigma^2_y = \text{cov}(y, y) = \sum_{i=1}^{N} \text{cov}(x_i, y)$. The fraction of variation in y explained by x_i equals: $\frac{\text{cov}(x_i,y)}{\sigma^2_y}$, which is the regression coefficient of regressing x_i on y.

60. The model-implied host country aggregate productivity shock has a correlation coefficient of 0.69 (0.67) with country-level year-on-year TFP (labor productivity) growth documented in the OECD multi-factor productivity database.The regression coefficient of OECD TFP (LP) growth on model-implied host country aggregate productivity shocks is 0.997 (1.027).

shares $\hat{\alpha}_n^s = \frac{\alpha^{s\prime}_n}{\alpha_n^s}$. For a majority of countries, the durable manufacturing sector is hit by a negative sectoral final demand shock, whereas the non-durable manufacturing and non-manufacturing sectors receive a positive demand shock. This reinforces the results in the trade collapse literature, as in Bems et al. (2010), among others.

1.5 Sources of the MP Collapse

1.5.1 Importance of Shocks

With the shocks backed out and the elasticities estimated, I can run model counterfactuals. The first question I investigate is which group of shocks is the most important in explaining the cross-country variation in the MP and the trade collapse. I take advantage of the measure used by Klenow and Rodriguez-Clare (1997), Alviarez et al. (2020), among others. I illustrate the MP collapse as an example. Use $\log(\hat{y}_i)$ to denote the log changes in country i's total MP relative to GDP in the data, and $\log(\hat{x}_i)$ to denote the model counterfactual with the shocks of interest. We may write the following accounting identity:

$$\log(\hat{y}_i) = \log(\hat{x}_i) + z_i$$

where z_i denotes the contribution by other shocks. The fraction of cross-country variation in the MP collapse that can be explained by the shocks of interest can be measured with:

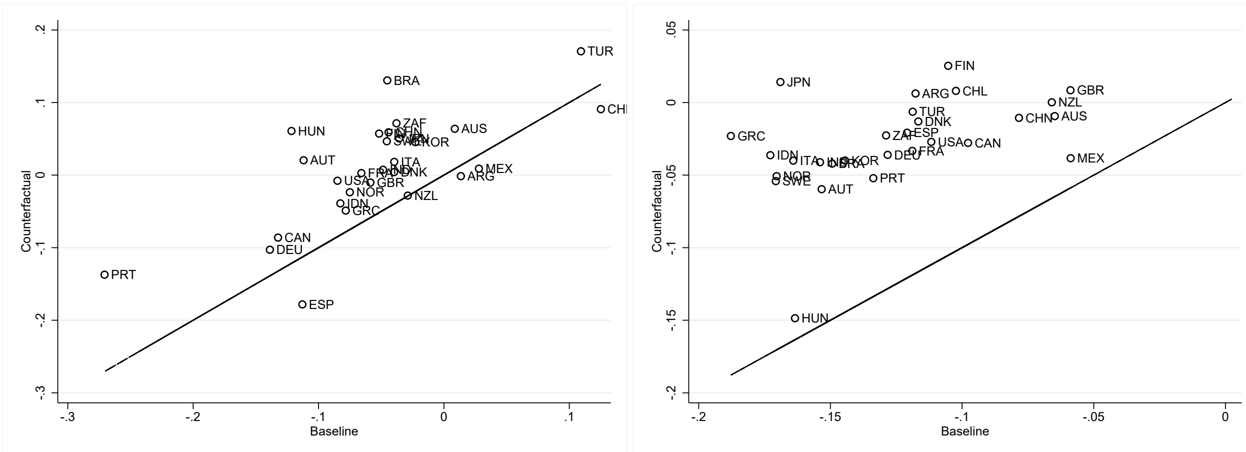
$$\frac{\text{cov}_i(\log(\hat{y}_i), \log(\hat{x}_i))}{\sigma_i^2(\log(\hat{y}_i))}$$

This equals the slope coefficient of regressing the counterfactual on the data. Table A.13 summarizes the explanatory power of many combinations of shocks. Here I would like to highlight a few. Figure 1.7 shows that MNE-specific shocks explain the majority (70.9%) of cross-country variation in total MP declines relative to GDP. On the other hand, domestic

Figure 1.7: Impact of MNE-specific Shocks on MP Collapse and Impact of Domestic Shocks on Trade Collapse

(a) MNE-specific Shocks on MP Collapse

(b) Domestic Shocks on Trade Collapse



The figure plots against the data the counterfactual declines in total MP and total trade both relative to GDP. The counterfactual decline in total MP occurs only with MNE-specific shocks. The counterfactual decline in total trade occurs only with domestic shocks.

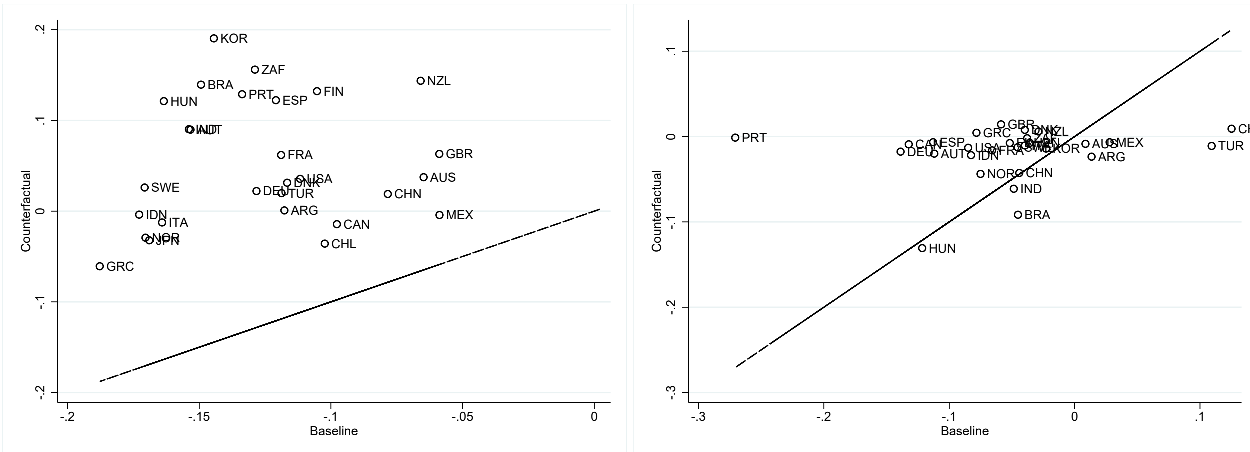
shocks explain a large share (40.3%) of cross-country variation in declines of total trade relative to GDP, which is consistent with the findings in the trade collapse literature. As a side note, Appendix Figure A.7 shows that trade shocks contribute less (29.3%) than the domestic shocks to cross-country variation in trade declines relative to GDP.

Shocks to multinational production affect trade, and shocks to trade affect multinational production. Figure 1.8a shows that MNE-specific shocks contribute to the cross-country variation in the total trade declines relative to GDP, explaining 19.0% of that variation. Figure 1.8b and A.8a show that domestic shocks and trade shocks also contribute to the cross-country variation in total MP declines, explaining 6.8% and 12.3% of those declines, respectively.

Trade by foreign affiliates is the key channel for such interaction. Consider the restricted measures of the trade and MP collapse, where the trade collapse is measured through the decline in import by local producers and consumers, and the MP collapse is measured through the decline in foreign affiliate domestic sales, both relative to GDP. Because trade by foreign affiliates is dropped from both measures, the variation in each margin becomes much less

Figure 1.8: Impact of MNE-specific Shocks on Trade Collapse and Impact of Domestic Shocks on MP collapse

(a) MNE-specific Shocks on Trade Collapse (b) Domestic Shocks on MP collapse



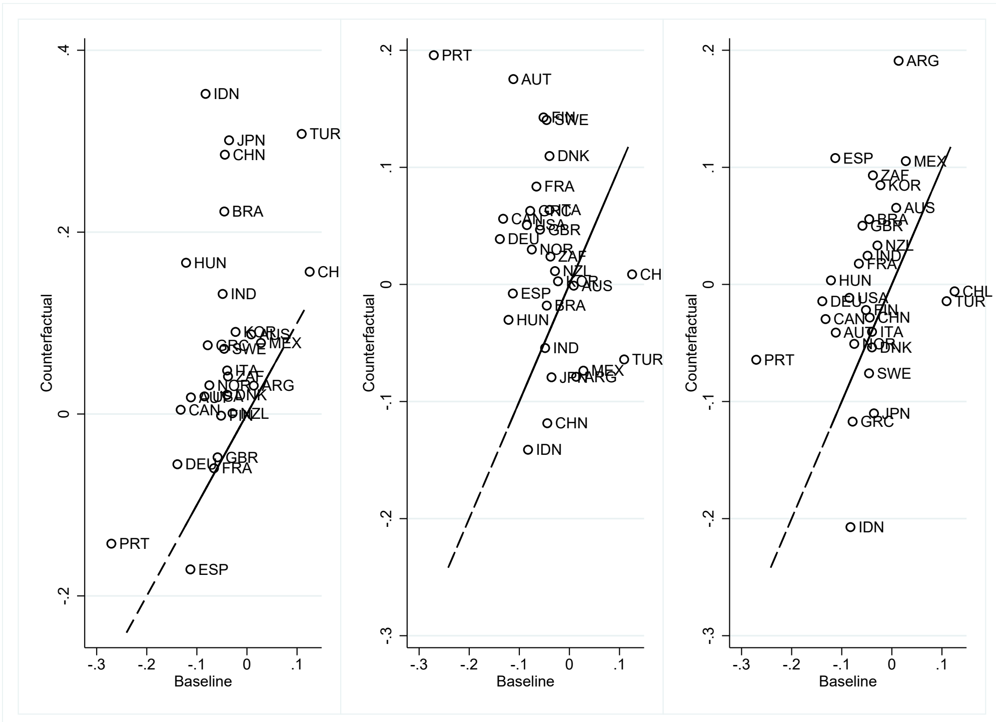
The figure plots against the data the counterfactual declines of total trade in response to MNE-specific shocks (left) and total MP in response to domestic shocks, both relative to GDP.

affected by shocks to the other margin. Figure A.9a shows that MNE-specific shocks do not explain cross-country variation in the restricted measure of the trade collapse (accounting for -6.2%). Figure A.9b and Figure A.8b show that domestic shocks and trade shocks have less explanatory power (4.2% and -1.3%, respectively) for cross-country variation in the restricted measure of the MP collapse. Appendix Figure A.10 further shows that MNE-specific shocks have higher explanatory power for the restricted measure of the MP collapse than for the decline in total MP relative to GDP, explaining as much as 96.0% of cross-country variation. Similarly, domestic shocks have higher explanatory power for the restricted measure of the trade collapse than for the decline in total trade relative to GDP, explaining as much as 67.5% of cross-country variation.

Among the three categories of MNE-specific shocks, which group contributes the most to the MP collapse? Figure 1.9 shows that the MNE relative productivity shocks explain the largest share (84.1%) of the cross-country variation in changes of total MP relative to GDP, whereas the impact of MNE sourcing and selling shocks are smaller (-43.4% and 30.8%).[61]

61. A possible explanation for the negative contribution of MNE sourcing shocks is the following. MNE headquarters, say in the United States, received a negative shock and had a productivity decline. This might lead to declines in the productivity of US-headquartered MNEs relative to local producers in their

Figure 1.9: Impact of MNE Relative Productivity Shocks, Sourcing Shocks, and Selling Shocks on MP Collapse



The figure plots against the data the counterfactual declines of total MP relative to GDP. The left panel only turns on MNE-specific shocks. The middle panel only turns on trade shocks. The right panel only turns on domestic shocks.

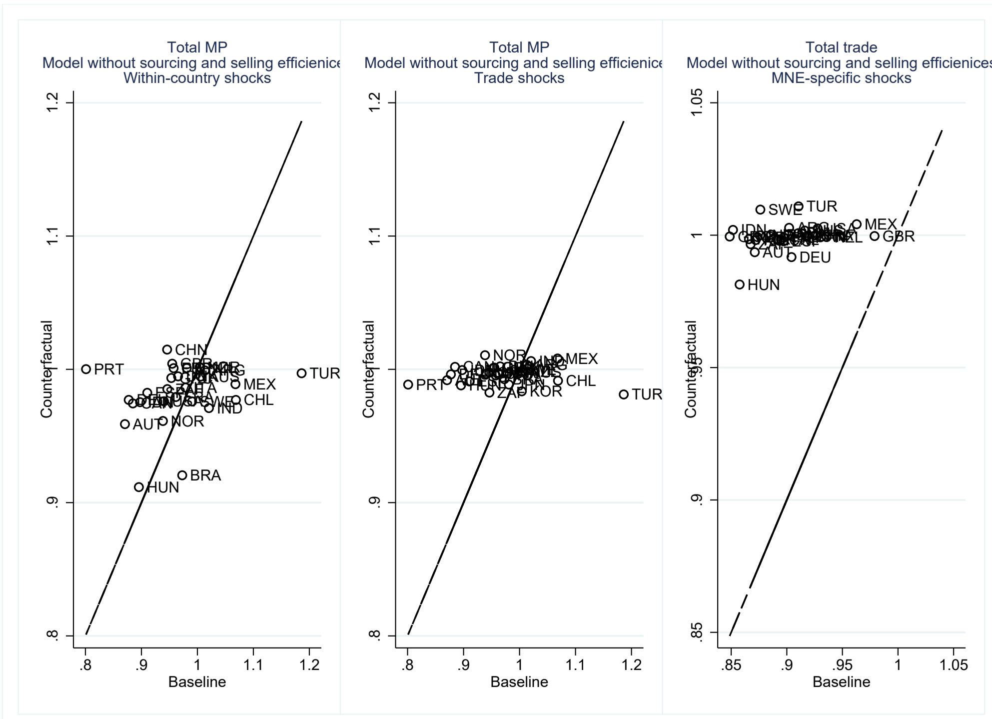
However, as discussed in Proposition 1, the levels (rather than the shocks) of the MNE sourcing and selling frictions are necessary to generate the interactions between trade and MP. They create the heterogeneous exposures of foreign affiliates and local producers to trade shocks, and the heterogeneous responses of international trade and domestic sales to MNE relative productivity shocks.

To see this, I present in Figure 1.10 the results with a model that lacks the MNE sourcing and selling frictions (the model is presented in Appendix Section A.2.4), yet is re-calibrated to the same MNE gross output and country-bilateral total trade data. In stark contrast to Figure 1.8, A.8, and A.9, without the MNE sourcing and selling frictions, MNE-specific

host countries, and their efficiency to sell to other countries. Meanwhile, the US headquarters might become less efficient at supplying to its affiliate abroad. This might lead to an increase in US-MNEs' relative sourcing efficiency from non-headquarters countries. In this case, the MNE sourcing shocks are negatively correlated with the output of US-headquartered MNEs. This paper does not explicitly model the joint distribution of the MNE-specific shock processes, though. I leave this topic to future research.

shocks only account for 4.8% of cross-country variation in the decline of total trade relative to GDP, and domestic shocks and trade shocks only account for 4.3% and -0.4%, respectively, of cross-country variation in the decline of total MP relative to GDP.

Figure 1.10: In a Model without Heterogeneous MNE Sourcing and Selling Frictions, Impact of Domestic and Trade Shocks on Total MP and Impact of MNE-specific Shocks on Total Trade



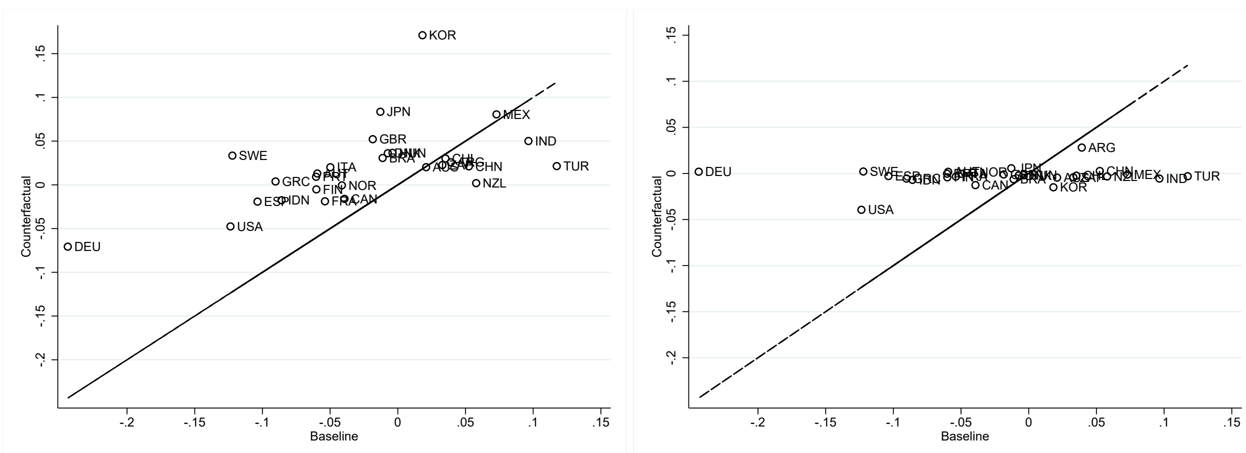
The figure plots the counterfactual changes in total MP and total trade, relative to GDP, in a re-calibrated model without sourcing and selling efficiencies. The left panel studies the impact of domestic shocks on total MP. The middle panel studies the impact of trade shocks on total MP. The right panel studies the impact of MNE-specific shocks on total trade (all relative to GDP).

How do the shocks impact changes in world aggregate trade and MP relative to world GDP? Table A.14 shows the results. MNE-specific shocks lead to 5.69 and 8.97 percentage points, and explain the majority (51.7% and 95.4%) of declines of world aggregate MP and foreign affiliate domestic sales relative to GDP. On the other hand, domestic shocks lead to 6.78 and 6.06 percentage points, and explain the majority (57.4% and 60.0%) of declines of world total trade and import by local producers and consumers relative to world GDP. Domestic shocks and trade shocks explain 47.5% and 35.0% of the decline of world total MP relative to world GDP as well. In contrast, MNE-specific shocks alone lead to 4.18 percentage points increase in world aggregate trade relative to world GDP. The result indicates that MNE-specific shocks have pro-trade effect in the Great Recession. While they might increase trade for the countries where foreign affiliate sales grow and decrease trade for the countries where foreign affiliate sales decline, the MNE-specific shocks change the global productivity distribution. In particular, they might increase the productivity of the countries where foreign affiliate sales grow, which are less developed countries according to Figure 1.3. This might promote trade for almost all global countries.

1.5.2 Propagation of Shocks

Figure 1.11: Impact of Headquarter Shocks and Host Country Shocks to the United States on Cross-country Variation in MP Collapse

(a) Headquarter Shocks to the United States (b) Host Country Shocks to the United States



The figures plot against the data the counterfactual declines of foreign affiliate domestic sales relative to GDP. The left panel shows the impact of the headquarter shocks to the United States. The right panel shows the impact of host country shocks to the United States.

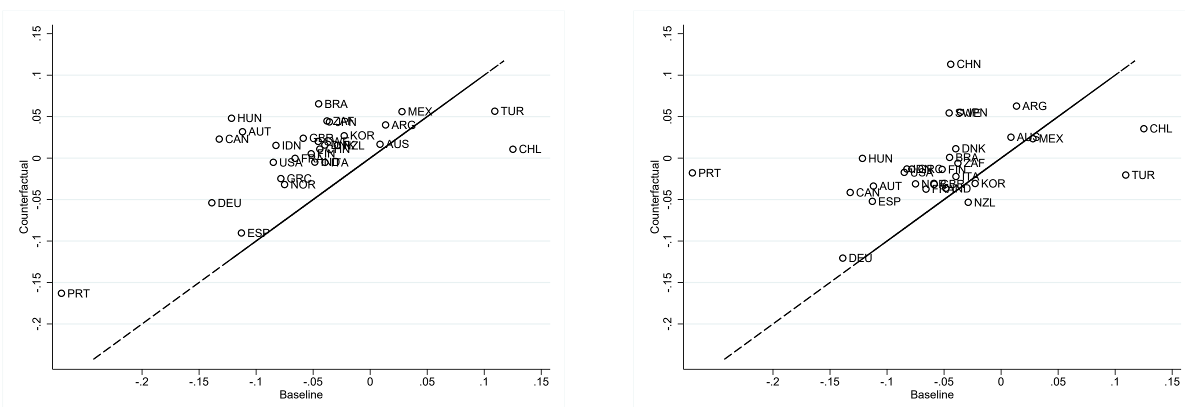
Section 1.2.2 shows that higher exposures to the foreign headquarters and host countries whose MP declines more are associated with greater declines of MP at home. These facts suggest that shocks to a few important headquarters and host countries may play an important role in propagating their MNE-specific shocks to the rest of the world. On the other hand, domestic shocks that hit almost all countries might be required to cause the global trade collapse. I test the hypothesis in this section. Meanwhile, I ask whether MNE-specific shocks to the headquarters or the host countries matter more for the cross-country variation in the decline in MP relative to GDP.

Define MNE headquarter shocks to a set of countries Ω: $\left\{\hat{A}_{ji}, \hat{h}_{mi}, \hat{H}_{ni} | i \in \Omega, \forall j, m, n\right\}$. The headquarter shocks are MNE-specific shocks that pertain to MNEs headquartered in $i \in \Omega$. They capture the changes in relative productivity in i-headquartered MNE to the host country's local producers, and the changes in its efficiencies to source from and sell to non-headquarter countries. Correspondingly, define MNE host country shocks to countries Ω': $\left\{\hat{A}_{ji}, \hat{h}_{mj}, \hat{H}_{jn} | j \in \Omega', \forall i, m, n\right\}$. The host country shocks capture changes in the relative productivity of MNEs hosted by country j to country j's local producers, as well as changes in global MNEs' sourcing and selling efficiencies from and to country j.

Figure 1.12: Impact of Headquarters Shocks to Five Largest MP Headquarters and Host Country Shocks to Five Largest MP Host Economies on MP Collapse

(a) Headquarter shocks to Five Largest MP Headquarters

(b) Host Country Shocks to Five Largest MP Host Economies



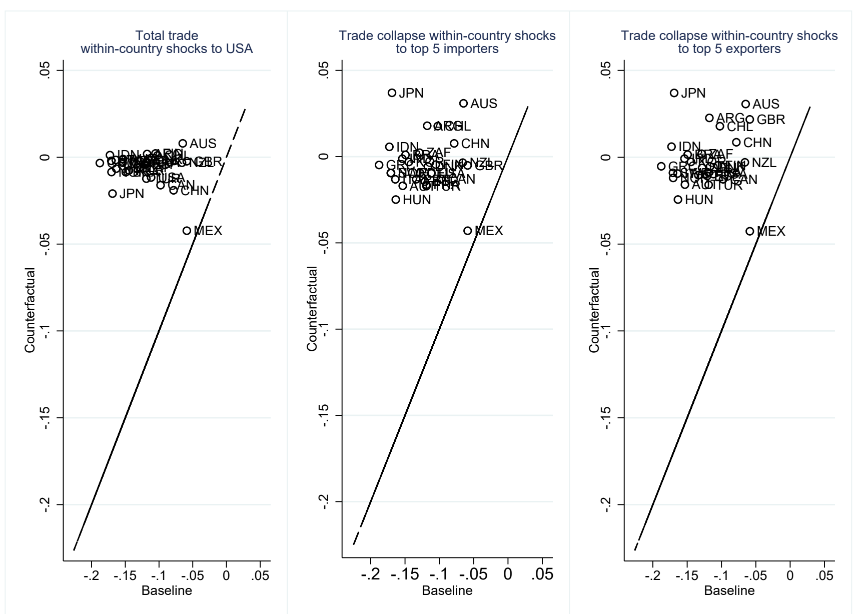
The figures plot the counterfactual declines of total MP relative to GDP. The left panel shows the impact of headquarter shocks to five largest outward MP suppliers as of 2008 (United States, Germany, United Kingdom, Japan and France, which together account for 74% of world outward MP). The right panel shows the impact of host economy shocks to five largest inward MP receivers as of 2008 (United States, Germany, United Kingdom, China and France, which together account for 58% of world inward MP).

First, I look at the United States, the largest importer, exporter, provider and receiver of MP as of 2008.[62] Figure 1.11a shows that the headquarter shocks to US alone can explain, for global economies, 30.6% of cross-country variation in the MP decline relative to GDP. Table A.15 further shows that the contributions to the cross-country variation in the

62. The United States accounts for 24% of world inward foreign affiliate sales, 29% of world outward foreign affiliate sales, 22% of import, and 14% of export in 2008.

MP collapse, by headquarter shocks to individual countries. The United States contributes the most, followed by Germany (15.4%), France (12.6%), Spain (7.8%) and the United Kingdom (5.4%). Figure 1.11b shows that host country shocks to the United States lead to MP collapse in the United States. However, they do not lead to significant changes in MP in other countries and explain only 1.5% of the cross-country difference in MP decline relative to GDP. Table A.16 shows the contributions to the cross-country variation in MP collapse by host country shocks to individual host countries. Germany, the country with the largest decline in total MP relative to GDP, contribute the most (22.6%), followed by Turkey (16.2%), which had the largest increase in inward foreign affiliate domestic sales relative to GDP, India (8.7%), the United States, and New Zealand (5.2%).

Figure 1.13: Impact of Domestic Shocks to the United States and Five Largest Exporters and Importers on the Trade Collapse



The figure plots the counterfactual declines of total trade relative to GDP. The left panel only turns on domestic shocks to the United States. The middle panel only turns on domestic shocks to the top 5 importers as of 2008 (United States, China, Germany, Japan and France, which together account for 54% of world import). The right panel only turns on domestic shocks to the top 5 exporters as of 2008 (United States, China, Germany, Japan and United Kingdom, which together account for 51% of world export).

Second, I focus on the top 5 countries that had the largest outward MP (the five largest MP headquarters) in 2008–the United States, Germany, the United Kingdom, Japan, and France–as well as those that had the largest inward MP–the United States, Germany, the

United Kingdom, France, and China (the five largest MP host economies).[63] Figure 1.12a shows that headquarter shocks that hit the five largest headquarters explain as much as 67.3% of cross-country variation in the decline of total MP relative to GDP. This fraction is substantial if one remembers that all MNE-specific shocks together explain 96.0% of cross-country variation in changes in total MP relative to GDP. This shows that shocks that affect the important headquarters of global MP propagate widely and lead to variations in foreign affiliate sales for many host countries. On the other hand, Figure 1.12b shows that host country shocks hitting the top 5 inward MP receivers explain 35.3% of the MP collapse. They lead to significant adjustments of MP activities in the host countries that are directly hit, but they have limited spillovers to other countries.

Figure 1.13 shows that domestic shocks to important exporters and importers of international trade propagate less widely than the MNE headquarter shocks. Domestic shocks to the United States contribute -3.7% of cross-country variation in the decline of import by local producers and consumers relative to GDP. They lead to declines in trade in the United States, as well as the countries that trade extensively with the United States, such as Canada, Mexico, Germany, and the United Kingdom. However, they spillover less to the countries that trade less with the United States. Similarly, domestic shocks to the top 5 exporters and importers still fail to generate the common decline in trade across countries. They explain 11.8% and 12.6% of cross-country variation in the trade collapse.

These results indicate that MNE-specific shocks to a few important headquarters of outbound MP have wide-spread ripples in the global economy, and they explain a large fraction of cross-country variation in the declines of MP relative to GDP. Intuitively, countries that do not supply a large amount of outward MP, for example, China, India, may receive a large amount of inward MP from the important MP headquarters, for example, the United States. Therefore, these inward MP activities are subject to MNE-specific shocks to the

63. As of 2008, the United States, Germany, United Kingdom, Japan, and France account for 74% of world aggregate outward MP. The United States, Germany, United Kingdom, China and France account for 58% of world aggregate inward MP.

important headquarters. Similarly, countries that do not receive a large amount of inward MP, for example, Japan, may supply a large amount of outward MP to the important MP host countries, for example, China, India. Therefore, these outward MP activities are subject to MNE-specific shocks to the important host countries. On the other hand, due to the trade balance condition, the countries that do not export or import a lot also may not import or export a lot, either. Consequently, they are less prone to the sectoral final demand shocks that occur to the large importers and exporters. Domestic shocks to the countries that trade less are needed to replicate the common decline in trade among countries.

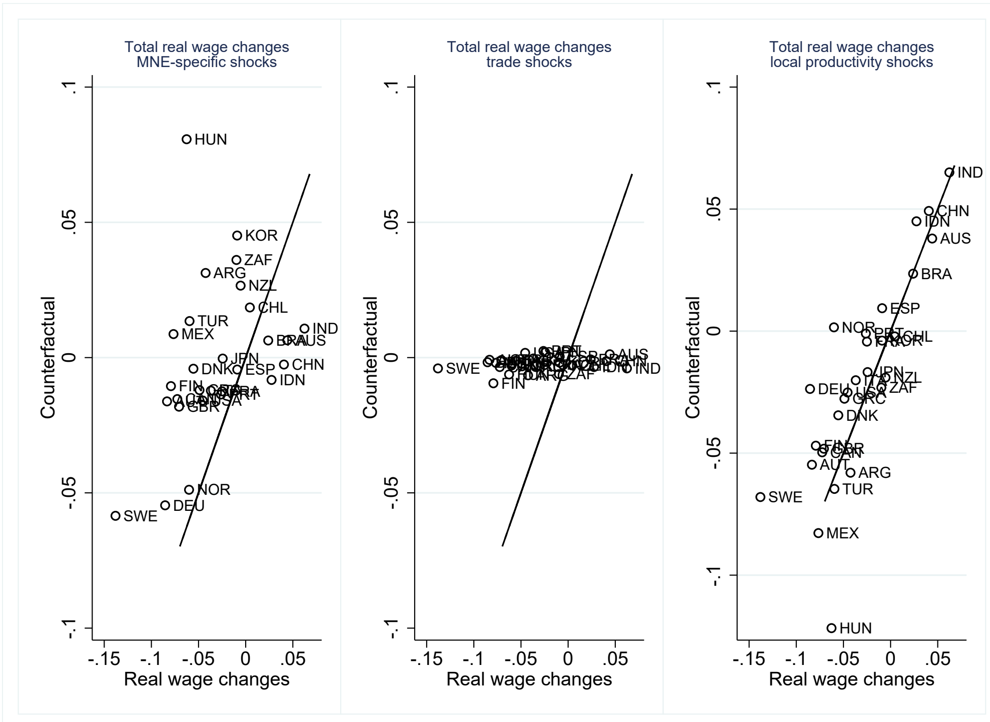
1.5.3 Importance of the MP Collapse for Welfare Changes

I now investigate the impact of model shocks on global welfare changes. Figure 1.14 shows that MNE-specific shocks contribute 26.4% of cross-country variation. Local productivity shocks contribute the most, accounting for 74.7% of such variation. The impact of trade shocks is limited, accounting for 1.1%.

MNE headquarters shocks that hit the important outward MP headquarters propagate widely, affect the welfare of almost all countries, and significantly impact the cross-country variation. Figure 1.15 shows that headquarter shocks to the five largest outward MP headquarters explain 16.8% of cross-country variation in welfare changes. On the other hand, the host country shocks have smaller spillover effect on the welfare of other countries. The host country shocks to the five largest inward MP host countries explain a smaller share–10.7%–of cross-country variation in welfare changes. Furthermore, Appendix Figure A.11 shows that domestic shocks to important exporters and importers affect very little of the cross-country variation in welfare changes. Domestic shocks to the top 5 exporters and to the top 5 importers explain 4.7% and -1.6% of the same, respectively. Similar to the host country shocks, domestic shocks affect the welfare of the countries that are directly hit by the shocks, but very little of that in other countries.

The trade collapse literature has used a model that features only trade and no MP to

Figure 1.14: Impact of MNE-specific Shocks, Trade Shocks and Local Productivity Shocks on Welfare Changes



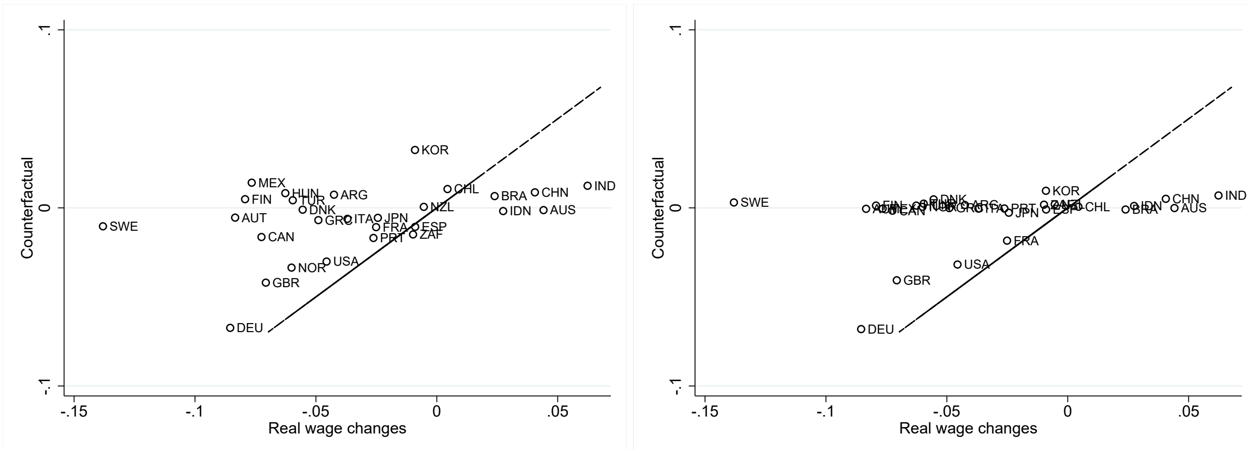
The figure plots the counterfactual welfare changes with MNE-specific shocks, trade shocks, and local productivity shocks, against the baseline.

study the impact of the trade collapse on national well-beings (for example, Eaton et al. 2016). This section further explores whether the no-MP model can account for sources of global welfare changes. As I shut down MP by taking the MNE relative productivity to 0: $\frac{A^s_{ji}}{A^s_{jj}} = 0, \forall i \neq j$, the model is simplified to Caliendo and Parro (2015). Section A.2.5 presents the model in "exact hats".

To what extent does a no-MP model misunderstand the underlying economic fundamentals of a country's welfare change? As countries in the global economy are hit by numerous shocks from different domestic and external sources, it is not feasible to exhaustively examine the impact of every shock or their combinations. Instead, in both the full model and the no-MP model I focus on the impact of a country's local productivity shocks on its welfare. Because the no-MP model cannot distinguish local from foreign producers, it can misallocate the welfare contributions made by MNE-specific shocks to local productivity shocks. This

Figure 1.15: Impact of Headquarters Shocks to Five Largest MP Headquarters and Host Country Shocks to Five Largest MP Host Economies on Welfare Changes

(a) Headquarter Shocks to Five Largest MP Headquarters (b) Host Country Shocks to Five Largest MP Host Economies



The figure plots the impact of headquarter shocks to the top 5 outward MP suppliers as well as the impact of host country shocks to the top 5 inward MP receivers on global welfare changes.

may mislead policies. Table A.18 shows that for many countries, the no-MP model considerably misunderstands the impact of local productivity shocks on that country's welfare. For example, in the full model, the United States local productivity shocks leads to a 3.5% decline in the country's welfare, as opposed to 5.5% decline in the no-MP model. In the case of the United States, the no-MP model probably exaggerates the consequence of the local productivity decline and ignores the impact of MNE-specific shocks that accompany the MP collapse. In Turkey, however, local productivity shocks reduce welfare by 5.7% and 4.9% in the full model and the trade-only model, respectively. Therefore, the trade-only model considers the foreign affiliates in Turkey grew relatively faster during the Great Recession as local producers, and it underestimates the negative impact the Great Recession had on Turkish domestic firms.

1.6 Conclusion

This paper studies the global propagation of economic shocks with MP, trade and input-output linkages, in the context of the Great Recession. It seeks to uncover the sources of the MP and trade collapse and inquires about their welfare implications. To disentangle the contributions by the two channels, I build a model of the global economy that takes into consideration the additional barriers that MNEs face when sourcing from and selling to non-headquarters countries. This innovation, in addition to the nesting structure of the MNE sourcing problem, in which the outer nest implies substitution across host countries and the inner nest implies substitution across technologies, allows the model to match exactly to the OECD AAMNE Database. In particular, the model replicates the empirical facts that foreign affiliates imports and exports more than the host country's local producers of similar characteristics, and that the MNE headquarters affects where the MNE sources from and sells to. This introduces rich interactions (i) between shocks to foreign trade and domestic sectoral final demand, on the one hand, and declines in total MP, on the other hand, and (ii) between shocks to MNEs and declines in total trade.

Although trade collapsed globally, the MP collapse was restricted to about half of the sample economies. Both MP and trade collapse of a country were associated with changes in service sector share in the country's GDP. A country's MP collapse was associated with exposure to other countries' MP collapse. However, a country's trade collapse was not associated with exposure to other countries' trade collapse. This suggests that a few important headquarters and host countries might propagate MP collapse globally, whereas sectoral final demand shocks might play the most important role in the trade collapse.

Counterfactual exercises confirm these hypothesis. I find that MNE-specific shocks explain the majority of cross-country variation in declines in total MP relative to GDP, while domestic shocks explain the largest share of cross-country variation in declines of total trade relative to GDP. That being said, shocks to foreign trade and to domestic sectoral final demand contribute to the MP collapse, and MNE-specific shocks contribute to the trade collapse. Trade by MNEs is the key channel for such interactions. Among the three groups of MNE-specific shocks–MNE relative productivity shocks, and shocks to MNE sourcing and selling frictions–MNE relative productivity shocks contribute the most to cross-country variation in declines of total MP relative to GDP. MNE sourcing shocks and selling shocks contribute less. However, the MNE sourcing and selling frictions match the model to the differential trade patterns by foreign affiliates and local producers, and they are necessary to generate both the response in total trade to MNE-specific shocks and the response in total MP to trade and sectoral final demand shocks. Regarding the cross-border propagation of shocks, MNE-specific shocks to a few important headquarters and host countries of MP contribute substantially to cross-country variation in declines of total MP relative to GDP. However, domestic shocks to the world's important exporters and importers propagate little to the countries that trade less.

Compared to trade and sectoral final demand shocks, I find that during the Great Recession, MNE-specific shocks account for a much larger share of the cross-country variation in welfare changes. A trade-only model misses entirely the contribution of the MP margin and significantly misunderstands the sources of welfare changes. MNE headquarters shocks to a few important headquarters of outward MP propagate globally and account for a substantial share of cross-country variation in welfare changes. In contrast, host country shocks to the important host countries, as well as domestic shocks to important exporters and importers, have limited cross-border propagation effect on welfare and do not explain much of the variation in welfare changes in other countries.

The framework gives us insights about the role that international trade by MNEs plays in propagating shocks across countries and sectors, which has implications for countries' welfare. It provides a useful analytical tool to disentangle the welfare contributions of trade and MP, thus allowing analysts to study how one channel's shocks affect the other. This paper's findings have several policy implications. First, as a country's policy makers monitor external shocks, they should monitor shocks hitting the important foreign headquarters. During the Great Recession, these shocks were more important for domestic welfare than other external shocks. Second, by demonstrating that MNE-specific shocks explain a significant fraction of the cross-country variation in the declines of total trade relative to GDP, the paper highlights FDI/MP-friendly policies as important policy instruments that can promote trade. These policies are useful today, particularly given the intensifying tariffs wars between countries. Third, accounting for welfare changes with a trade-only model leads analysts to miss the contribution of the MP channel and misallocate it to domestic shocks. Because the contribution to the cross-country variation in welfare changes by the MP collapse is much larger than the trade collapse, ignoring the MP margin will lead to a substantial misunderstanding of the sources of welfare changes and, thus, incorrect policies. Besides the Great Recession, the framework has interesting applications to other real-world contexts and policy experiments that feature strong adjustments in both margins of openness. Examples include the trade and technology wars between the US and China, Brexit, the lockdowns of important headquarters and host countries during the COVID crisis, among others.

CHAPTER 2

THE EMPLOYMENT CONSEQUENCES OF ANTI-DUMPING TARIFFS: LESSONS FROM BRAZIL

2.1 Introduction

With the promise of "bringing jobs back", tariffs are usually advocated as a tool to mitigate the negative employment effects of international trade. However, despite its relevance to policy and prominence in the political debate, economists still don't fully understand how tariffs in particular and trade policies in general affect firms, wages, and employment. On the one hand, tariffs shift demand from overseas to the home market. Through this shift in demand, the protected national producers and the upstream sectors that supply input to the protected sectors can increase production and employment. On the other hand, downstream firms, who use the taxed goods as input, face higher costs, which can lead to lower employment. Consequently, the aggregate labor market effect of tariffs should depend on the employment elasticity of winners–the national producers and upstream sectors, and losers–the downstream sectors.

In this paper, we ask: what is the effect of tariffs on aggregate employment, output and welfare? How does the effect propagate through the value chain? We answer these questions with empirical evidence and a quantitative model. We take advantage of a set of unique Brazilian databases. We first collect information on all anti-dumping (AD) investigations initiated by Brazil and document whether each investigation leads to AD tariffs or ends with no tariff changes. We link each investigation to the protected national firm and sector as well as the upstream and downstream sectors. Based on names of the firms that file the complaints which trigger the investigations, the investigations are then merged to a matched employer-employee dataset that contains data on wages and employment.

The causal effect of tariffs is identified with a difference-in-differences strategy. The control group is the products and firms that apply for AD investigations but are rejected a tariff. The treatment group is the products and firms that apply for AD investigations and receive a tariff increase. In this way, we control for the degree of import competition and business environment faced by both groups. The identifying assumption is supported by pre-period parallel trend tests. Furthermore, according to WTO rules and consistent with Brazilian policies, the decision of imposing a tariff and the tariff size is made based on the pre-investigation price of the product in Brazil and the same product in its source country. Both prices are pre-determined variables at the time of treatment and neither is related to firm characteristics. Therefore, conditional on applying for AD investigations, the imposition of AD tariffs is plausibly exogenous. We strengthen the identification strategy by showing that in the pre-period, the treatment and control groups are similar along many other margins. Furthermore, we show that the tariff protection is not significantly associated with other government policy interventions that happen simultaneously when we control for AD investigation applications.

We have three main empirical findings. First, we find that AD tariffs lead to a sizable decrease in imports and an increase in employment in the protected sectors. Five years after implementation, a 100% ad-valorem tariff generates a decrease in imports of 63%. Moreover, different from Flaaen et al. (2019), we don't find evidence for trade diversion–there is no corresponding increase in imports from other locations or substitute products. We also find that AD tariffs increase employment in the protected sectors. A 100% ad-valorem tariff generates a 4% employment increase among firms that are shielded from the international competition. There is no significant effect on wages in the protected sectors. Interestingly, large firms and those filling AD complaints do not increase employment. Second, we find that AD tariffs decrease employment and wages in the downstream sectors. In terms of elasticity, the employment loss of the downstream sectors is greater than the employment gain of the national producers. A 100% ad-valorem tariff generated an average employment decrease of 4.8%. Third, we find that the sectors most responsive to the AD tariff are the upstream sectors of the protected ones. A 100% tariff increases employment by 18.7%.

The empirical results are informative about firm and sector level responses to AD tariffs but are silent about aggregate effects. To make aggregate quantitative predictions, we use the empirically estimated elasticities and Brazilian macroeconomic moments to calibrate a small open economy model with international trade, input-output linkages, and labor force participation. In the model, workers choose to work between different sectors or to stay outside the labor force. To produce, firms use labor and input from all sectors. The sectoral input is supplied by imperfectly substitutable domestic and foreign producers. The Frisch elasticity, the Armington trade elasticity[1] and the elasticity of substitution across product lines are estimated by taking the predictions of the model to the empirical findings.

Quantitative simulations show that the aggregate consequence of all Brazilian AD tariffs increase employment and GDP, and the aggregate effect of a sectoral tariff depends on the position of the taxed product in the value chain. We find that Brazilian AD tariffs increase employment and GDP by 0.04% but decrease Brazilian real income by 0.09%. The input-output structure of the economy has important implications for aggregate predictions. For example, because a model without the input-output linkages ignores the negative employment effect in the downstream sectors, it overestimates the aggregate employment effect. We also find that the effect of a sectoral tariff depends on the position of the product in the value chain. Imposing a tariff on textile or food sector, the two sectors in the downstream of the value chain, increases aggregate employment whereas taxing metal or minerals, which are more upstream sectors, decreases employment. We conclude with that tariffs should be discouraged if consumer welfare constitutes an important goal of policy makers. However, if the goal of tariffs is to increase employment, the tariffs should target sectors at the downstream of the value chain.

This paper contributes to the literature that studies the effect of AD investigations and AD tariffs on international trade.[2] Earlier works like Prusa (1996) and Staiger and Wolak

1. The Armington trade elasticity refers to the elasticity of substitution across countries.

2. Here we present a brief overview of the most related papers. For a complete review of this literature, see Blonigen and Prusa (2016)

(1994) investigate the effect of AD investigations and find that the investigations themselves can disrupt trade. Knetter and Prusa (2003) shows that AD investigations are not random and are more likely to happen in periods of downturn. Bown and Crowley (2007), Baylis (2010), Irwin (2014), Sandkamp (2020), among others, study the effect of AD tariffs. They show that AD tariffs reduce imports of the taxed product-country pair, i.e. trade depression, but could also increase imports of the same product coming from other countries, i.e. trade diversion. Flaaen et al. (2019) studies recent US AD policies on washing machines and also find evidence for both effects.[3] We contribute to this literature by proposing a new empirical strategy that addresses non-random assignment of AD investigations and tariffs, and eliminates the confounding effect of investigations that contaminates the effect of tariffs. We also find that the effect of tariffs on trade diversion is limited in Brazil. Moreover, we investigate the employment and wage consequences of AD tariffs, which is an important question for policy discussion but is still open in the literature.

This paper contributes to the literature that studies the labor market consequences of international trade. Autor et al. (2013) and Autor et al. (2014) find that import competition from China negatively affects employment in the US. Rodríguez-Clare et al. (2020) explores the employment effect of import competition with a New-Keynesian small open economy model. Acemoglu et al. (2016) studies if the "China shock" propagates along the value chain. They find a negative effect on upstream sectors but no effect on downstream sectors. Different from them, we find that the impact of AD tariffs propagates both upstream and downstream. Tariffs play the dual role of a positive demand shock for upstream sectors as well as a negative productivity shock for downstream sectors. A couple of seminal papers explore the topic in Brazil. In the early '90s, Brazil began a period of openness to international trade.[4] Dix-Carneiro and Kovak (2017), among others, exploit the heterogeneous exposure of regions to this event to identify that openness to trade reduces employment and wages in Brazil. Dix-

3. Relatedly, Fajgelbaum and Goldberg (2019) and Amiti (2019) study the impact of US-China trade war.

4. Tariffs fell from an average of 30.5 percent to 12.8 percent. The cuts were heterogeneous across sectors.

Carneiro and Kovak (2019) shows that workers are more likely to be informally hired and to transition into nontradable sectors as a response to higher international trade competition. Dix-Carneiro and Kovak (2015) shows that Brazilian trade liberalization increase the skill premium. Despite their importance, these major trade events, such as China entering the WTO or Brazilian trade liberalization, may not happen again and may generate large general equilibrium effects that are not captured by these estimates that rely on heterogeneous exposures. Rather, we evaluate the impact of a common trade policy instrument imposed on the granular product level, which is potentially more relevant to the interests of policy makers.

The closest papers to ours are Trimarchi (2019) and Bown et al. (2021). Both papers, developed simultaneously with ours, study the impact of AD tariffs on sectoral employment and imports in the United States. Trimarchi (2019) finds that AD tariffs increase employment in the protected sector, whereas Bown et al. (2021) finds that AD tariffs decrease employment in downstream sectors. They construct an instrument for AD tariffs based on a sector's political importance and its experience filling dumping complaints in the pre-period. We employ a different identification strategy. Furthermore, we discover large and positive employment response in upstream sectors. In the end, we use a quantitative model to investigate the aggregate employment consequence, which takes into account positive effects in the protected sector and the upstream, as well as negative effect in the downstream. Additionally, we take advantage of administrative databases that are of higher quality, which allows us to identify heterogeneous firms' response to AD policy. The finding provides insights into how international trade protection affects industry concentration.

The paper also contributes to the literature that studies the propagation of economic shocks, in particular tariffs, with quantitative trade and regional economic models. For example, Ossa (2014) studies the impact of optimal tariffs on countries' welfare when countries set tariffs reciprocally. Caliendo and Parro (2015) studies impact of tariff reductions under NAFTA on trade flows and welfare. However, most of these works focus on the impact of tariffs on welfare. With upward sloping labor supply into production sectors and the option of staying outside the labor force, we simulate aggregate labor market response–a highly important policy question. A rare exception is Caliendo et al. (2019), which investigates the dynamic regional and sectoral employment effects of import competition from China. However, the paper focuses on how the US economy responds to Chinese productivity growth rather than trade policies.

The rest of the paper proceeds as follows. Section 2.2 discusses WTO anti-dumping rules, the practice in Brazil, and the data used in this paper. Section 2.3 discusses the empirical strategy. Section 2.4 presents the main results. Section 2.5 introduces the model. Section 2.6 presents the procedure to estimate the model and the simulation results. Section 2.7 concludes.

2.2 Institutions and Data

2.2.1 Anti-Dumping Investigations

Dumping is defined as the practice of charging a price in the exporting market below the home market value. According to WTO regulations, the destination market harmed by dumping is allowed to set an AD tariff to exactly offset the difference between price that the foreign competitor charges in its own country and in the destination country. The WTO AD regulation, which Brazil follows, defines three steps for the creation of an AD tariff: (1) firms harmed by dumping file a complaint to the Ministry of Economy, (2) the government opens an investigation into whether the foreign competitor engaged in dumping and (3) the government decides on whether to impose the AD tariff and the tariff size, if any.

The process starts with a domestic firm or a group of domestic firms filing a complaint to the Ministry of Economy. The complaint must show that the sector is harmed by foreign dumping practices. Firms must precent evidence that they experience a decrease in profits, sales, or wage, and link this to increased import competition from an international competitor. Moreover, the international competitor must have increasing volume and decreasing price in Brazil. This explains why the sales and price of the investigated and non-investigated products may have different trends. We discuss this further in Appendix Section B.1.2.

The government, upon receiving the complaint, then determines whether it should open an investigation or dismiss the case. This decision is made based on whether there is enough proof that links national supplier's decline in economic performance to increased imports from the international competitor. This paper only considers the cases in which an investigation is opened.

After the government opens an investigation, it identifies the price of the imported product in its home market and in Brazil during the period before the investigation. If the government finds that the foreign competitor involved in unfair trade practices by charging a lower price in Brazil than in its home market, the government will create an anti-dumping tariff to equate the Brazilian post-tariff price to the price in the origin country. Therefore, the AD tariff is set based on pre-determined price differences. The AD tariff, once imposed, lasts for 5 years.

2.2.2 Data

We base our empirical findings on four databases. The first is a unique database provided by the Secretary of International Trade of the Ministry of Economy that contains all the AD investigations initiated in Brazil. It contains the product name and classification investigated, the country of origin, the date the investigations were initiated, the conclusion date and the measures taken. Starting in 2008, we also observe the name of the firm filing the complaint. We manually add to the data set the value of the AD tariffs imposed by each investigation. Appendix Section B.1.1 presents a set of summary statistics of anti-dumping investigations in Brazil.

The second database covers international trade in Brazil. The Secretary of International

Trade of the Ministry of Economy provides on its website monthly Brazilian international trade statistics by granular product classification. This is used to understand the effect of tariffs on trade. The third database, RAIS, covers employment information of Brazilian firms. It is a yearly employer-employee matched data set containing information on wages, hours, occupation, and demographics of workers. It also contains data on the sector and location of the firm. Using a concordance table provided by the Brazilian Secretary of International Trade, we link each AD investigation to its sector. This allows us to study how tariff increases affect employment in domestic sectors. Moreover, we manually match the names of firms that file dumping complaints to RAIS to study the employment behavior on the firm level. In the fourth database, we gather from the Secretary of International Trade the list of firms that import from abroad. We use this data set to study how tariffs propagate along the value chain.

Throughout the paper, we constrain the analysis to firms with more than one worker that are active for more than 10 years. The goal is to prevent changes in the composition of firms from driving the results. We constrain our analysis from 1995 to 2016.

2.3 Empirical Strategy

The key challenge to identify the impact of AD tariffs is that it is confounded by the impact of AD investigations. There are two channels. The first one is that AD investigations are not random. As Appendix B.1.2 shows, investigated products have a lower price and higher importing volume than non-investigated ones. At the time of the investigation, they are also on a decreasing price and increasing importing volume trend. Furthermore, AD complaints are more likely to be filed by expanding firms. The second confounding effect is the trade policy uncertainty created by investigations. As highlighted by Staiger and Wolak (1994), among others, the investigation itself has negative effects on trade and employment.

To address these issues we employ a difference-in-differences strategy. The control group is the set of products and firms that receive AD investigations but experience no tariff changes. The treatment group is the set of products and firms that are both investigated and experience a tariff hike. By doing so, we control for the confounding effects of AD investigations. To increase power, we also exploit variations in the magnitude of the AD tariffs. In Section 2.4, we show that the treatment and control groups have parallel trends in the pre-treatment period. The fact that tariff increases are decided based on pre-investigation price differences makes it reasonable to assume that parallel trends would be preserved in post-treatment.

We further show that the assignment of the treatment status is not associated with political interventions. In principle, whether to impose the AD tariffs should depend only on if the international competitors engage in unfair trade practices and should not be associated with the political connections of domestic firms. However, if in practice, firms protected with higher tariffs are also those that receive more benefits from the government in the post-treatment period, the estimated impact of AD tariffs would also capture the effects of other policies. In Appendix Section B.1.6 we show that treatment and control groups do not differ in the amount of federal protection and revenues from the government. We also perform a placebo test linking investigations to sectors unrelated to the investigated ones. Both results support the hypothesis of parallel trends for the difference-in-differences design.

2.3.1 Imports

First we study the impact of AD tariffs on imports. We use the following estimation equation:

$$y_{p,c,q} = \theta \tau_{p,c} \times \mathbb{I}_{p,c,q}\left\{\text{After AD}\right\} + \beta \mathbb{I}_{p,c,q}\left\{\text{After AD}\right\} + \eta_{p,c} + \eta_{q,c} + \epsilon_{p,c,q} \tag{2.1}$$

Here $y_{p,c,q}$ is the log of total Brazilian imports of product p from country c in quarter q. $\mathbb{I}_{p,c,q}\left\{\text{After AD}\right\}$ is a dummy variable taking 1 up to 5 quarters after the conclusion of the investigation. $\tau_{p,c}$ is the ad-valorem AD tariff imposed.[5] For the control group this variable always takes zero. $\eta_{p,c}$ is a product-country fixed effect removing any level differences between treatment and control. $\eta_{q,c}$ is a quarter-country fixed effect. β is common to treatment and control and captures the effect of being exposed to an AD investigation. The parameter of interest is θ, which captures the effect of tariffs $\tau_{p,c}$. To test for parallel trends in the pre-period we use the following specification:

$$y_{p,c,q} = \sum_{j=-\underline{t}}^{\bar{t}} \theta_j \tau_{p,c} \times \mathbb{I}_{p,c,q} \{j \text{ Qrt. to AD}\} + \sum_{j=-\underline{t}}^{\bar{t}} \beta_j \mathbb{I}_{p,c,q} \{j \text{ Qrt. to AD}\} + \eta_{p,c} + \eta_{q,c} + \epsilon_{p,c,q} \tag{2.2}$$

Compared to Equation 2.1, here we make the coefficients θ and β quarter-specific. Parallel trends in the pre-period imply that $\theta_j = 0$ for all $j < 0$.

2.3.2 National Producer

We employ the same identification strategy to identify the elasticity of employment by the national producer to AD tariffs. The treatment group is the set of firms that receive an AD investigation and a tariff increase. The control group is the set of firms that receive an AD investigation but do not experience a tariff increase. The main specification is the following:

$$y_{i,s,t} = \theta \tau_{s,t} \mathbb{I}_{s,t} \{\text{After AD}\} + \beta \mathbb{I}_{s,t} \{\text{After AD}\} + \eta_i + \eta_t + \epsilon_{i,t} \tag{2.3}$$

$y_{i,s,t}$ is the labor outcome of firm i in sector s in year t. $\tau_{s,t}$ is all ad-valorem AD tariffs imposed on sector s at year t. The firms in the control group have zero tariff while $\tau_{s,t}$ increase from zero after the decision of the first investigation for the treatment group. Coefficient β in front of variable $\mathbb{I}_{s,t} \{\text{After AD}\}$ captures the effect of an AD investigation. One may expect the effect that the firms that expect future possible tariff protection increase hiring

5. See Appendix Section B.1.7 for the calculation of ad-valorem equivalent of AD tariffs on country-product/country-sector level.

or investment. Furthermore, this term captures any other common trend between control and treatment group. Finally, η_i is a firm fixed effect and η_t is a time fixed effect. To test for parallel trends between control and treatment group, we use the following model:

$$y_{i,s,t} = \sum_{j=-\underline{q}}^{\overline{q}} \theta_j \tau_{s,max} \times \mathbb{I}_{s,t}\{j \text{ Yrs. to AD}\} + \sum_{j=-\underline{q}}^{\overline{q}} \beta_j \mathbb{I}_{s,t}\{j \text{ Yrs. to AD}\} + \eta_i + \eta_t + \epsilon_{i,t} \tag{2.4}$$

$\tau_{s,max}$ is the maximum AD tariff imposed on sector s products. $\mathbb{I}_{s,t}\{j \text{ Yrs. to AD}\}$ is a dummy taking 1 j years before the conclusion of the investigation of the maximum AD tariff. Compared to Equation 2.3, here we make the coefficients θ and β year-specific. Parallel trends in the pre-period imply that $\theta_j = 0$ for all $j < 0$.

We are also interested in how the effect of AD tariff varies according to firm characteristics. To understand that we use the following model that allows heterogeneous impact of tariffs according to:

$$\begin{aligned} y_{i,s,t} = &\sum_{q=1}^{4} \theta_q \mathbb{I}_{i,s}\{\text{quartile q}\} \tau_{s,t} \mathbb{I}_{s,t}\{\text{After AD}\} \\ &+ \sum_{q=1}^{4} \beta_q \mathbb{I}_{i,s}\{\text{quartile q}\} \mathbb{I}_{s,t}\{\text{After AD}\} + \eta_i + \eta_t + \epsilon_{i,t} \end{aligned} \tag{2.5}$$

$\mathbb{I}_{i,s}\{\text{quartile q}\}$ is a dummy variable that takes 1 if firm i is in quartile q of firm distribution in sector s in the year prior to the AD inspection. In our analysis we consider the distribution of firm size measured with sales and the distribution of firm average wage. θ_q captures the effect of AD tariff $\tau_{s,t}$ on firms in quartile q.

2.3.3 Downstream and Upstream Firms

Next we investigate the propagation of AD tariffs along the value chain. To properly construct a control group, we study the impact of an AD tariff on the sector that the protected sector sells the largest share of output to–the downstream sector, and the sector that the protected sector buys the largest share of input from–the upstream sector. If we do not observe significant effect on major downstream and upstream sectors, we should not expect significant effects on the sectors that are less important customers and suppliers of the protected sector.[6] We make the linkages using the Brazilian input-output table. For example, the specification for downstream propagation effect is the following:

$$y_{i,d(s),t} = \theta\tau_{s,t} + \beta\mathbb{I}_{s,t}\left\{\text{After AD}\right\} + \eta_i + \eta_t + \kappa_d(s)t + \epsilon_{i,t} \tag{2.6}$$

$y_{i,d(s),t}$ is the labor outcome of firm i in sector d which buys the largest value of output from sector s. $\tau_{s,t}$ is the AD tariff imposed against sector s in year t. The control group is the major downstream sector of the sector that receives an AD investigation but have no corresponding tariff increase. The treatment group is the major downstream sector of the sector that receives an AD investigation and experiences a tariff increase.

The only difference between Equations 2.6 and 2.3 is the inclusion of a sector specific linear trend. The identifying assumption here becomes that there is parallel trends between control and treatment groups after controlling for a linear trend.[7] This assumption can again be tested by the examination of parallel trends in the pre-period and, as discussed in Finkelstein (2007), among others, the trend break after the treatment. We will further show why this linear trend is necessary when considering the full set of upstream and downstream firms. We also estimate the model without a linear trend for the downstream firms constraining the sample to the group more affected by the tariff change: the ones that import inputs. It shows that parallel trend holds and the results are the same as those that use Equation 2.6.

Similarly, we investigate the impact of AD tariffs on upstream sectors by considering the

6. A similar empirical strategy is used by Feng and Li (2021) to study how climate disasters affect upstream and downstream foreign stock market valuation through international trade linkages.

7. In other words, there is parallel trends in the first derivative of $y_{i,d(s),t}$ and not at its level.

following specification:

$$y_{i,u(s),t} = \theta\tau_{s,t} + \beta\mathbb{I}_{s,t}\left\{\text{After AD}\right\} + \eta_i + \eta_t + \kappa_u(s)t + \epsilon_{i,t} \tag{2.7}$$

where $u(s)$ denotes the upstream sector from which sector s buys the largest value of input. $y_{i,u(s),t}$ denotes the variable of interest of firm i in sector $u(s)$ year t.

We also investigate the heterogeneous effects of AD tariffs on upstream and downstream firms in different quartiles of the sector that these upstream and downstream firms belong to. Again we consider both the distribution of firm size measured with sales and the distribution of firm average wage. The specifications for heterogeneous treatment effects are presented in Equations B.3 and B.4.

2.4 Results

2.4.1 Imports

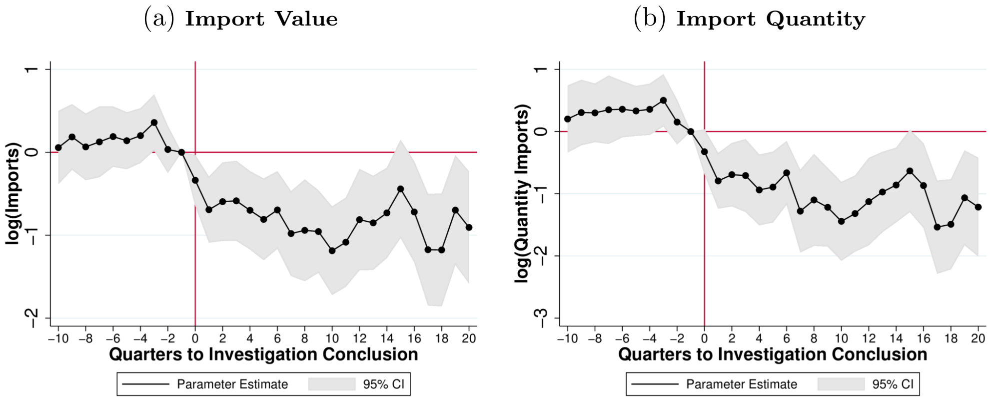
Tariffs are expected to disrupt the imports of taxed product, an effect known as trade depression. Moreover, it could shift the demand of taxed product from the targeted country to other producers or products, an effect known as trade diversion. We estimate the magnitude of the two effects in this section.

Trade Depression

Figure 2.1a displays the estimated parameters of Equation 2.2. In the quarters before the announcement of the tariff increase, control and treatment groups were in the same trend. This abruptly changes with the tariff increase: 2 quarters after its implementation, a 100% increase in tariff leads to an approximate 50% decrease in international trade. As expected, this magnitude increase over time as firms and consumers adjust to the new prices. Figure

2.1b uses quantities of imported goods instead of value in dollars.[8] We find an identical result. Table 2.1 presents the estimates of Equation 2.1. It indicates that a 100% marginal ad-valorem tariff would depress imports from that country-product pair by 64.8%.

Figure 2.1: Impact of AD Tariffs on Imports Value and Quantity



Trade Diversion

Is the demand for the tariffed goods shifted towards other countries? Figure 2.2a answers this question. It presents the estimated parameters of Equation 2.2 on imports of the product that faces an AD investigation from all countries that are not investigated. For example, if China is hit by an AD tariff on imports of steel, this model runs steel imports from other countries such as the US and India on Chinese AD steel tariff. Trade diversion would imply a positive coefficient. However, Figure 2.2a does not show significant effect of trade diversion to other countries. Columns (3) and (4) of Table 2.1 also show that while the impact of AD tariffs on the value of imports in the same product from other countries is marginally significant, the impact on quantity is insignificant. Therefore, we do not find strong evidence for trade diversion to other countries.

Is the demand for the tariffed goods shifted towards other products? To answer this

8. The customs office records product quantity using different measures: unit for countable products (like cars or computers), weight, squared meter or liter. The measure is consistent over time within the same product. As a result, we can compare different measures due to the product fixed effect.

question we first identify the set of substitutable products to a product that faces an AD investigation. We select the products that are in the same 4 digit classification but are not taxed for dumping. For instance, in 2012 table knives from China were taxed for dumping. But other knife types, such as cooking knives, were not. In this case, we run Chinese cooking knives imports on China table knife tariffs. Product trade deflection would imply a positive coefficient. However, Figure 2.2b and Column (5) and (6) of Table 2.1 indicate that there is no significant trade diversion on the substituting products margin, either.

Figure 2.2: Impact on Imports of Same Product from Other Countries and of Other Products

(a) **Imports f/ Other Countries** (b) **Imports of Other Products**

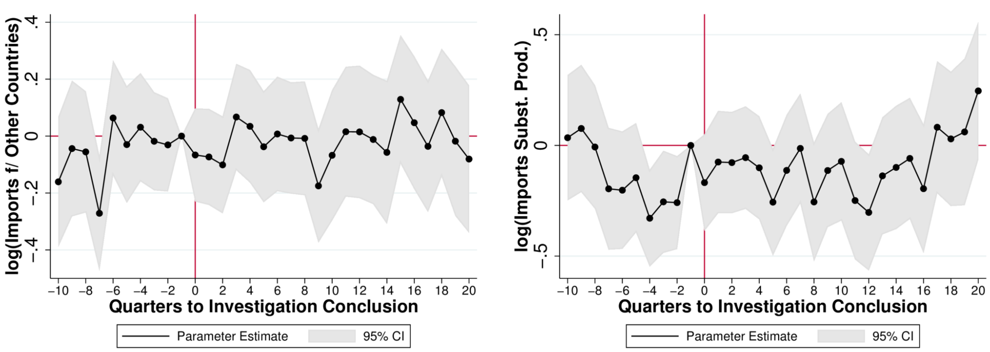


Table 2.1: Anti-Dumping Tariffs and International Trade

Sample:	Product-Country		Same Product, Other Countries		Other Products, Same Country	
	(1)	(2)	(3)	(4)	(5)	(6)
	log(Imports)	log(Quant.)	log(Imports)	log(Quant.)	log(Imports)	log(Quant.)
AD Tariff	-0.791***	-0.960***	0.0948*	0.0841	-0.0109	0.0902
	(0.000)	(0.000)	(0.061)	(0.175)	(0.880)	(0.296)
N	26618	26528	128283	125928	103611	100915
R^2	0.652	0.692	0.669	0.718	0.690	0.723
Mean Dep. Var	12.63	11.524	10.005	7.848	10.973	9.184
Mean Ind. Var	.12	.12	.2	.2	.13	.13
Product X Orig. FE	Yes	Yes	Yes	Yes	Yes	Yes
Time X Country FE	Yes	Yes	Yes	Yes	Yes	Yes

This table presents the estimated parameters of Equation 2.1. log(Imports) is the log of total Brazilian imports by product, country of origin and quarter. log(Quant.) is the number of units of the product imported according to the measure used by the Brazilian port authority. Columns (1) and (2) constrain the sample to the set of product-country that faced an AD investigation. In case there were no AD tariff implemented, AD Tariff takes the value of zero. Columns (3) and (4) constraint the sample to all products which had a AD investigation but exclude the country investigated. Columns (5) and (6) estimates the same model to all other products of investigated countries. The sample goes from 1995 to 2019.

2.4.2 National Producer

Figure 2.3 presents the impact of AD tariffs on protected national producers. They contain the estimated parameters of Equation 2.4 for employment and average wage. It shows that AD tariffs significantly increase both employment and wage bill in the protected firms. The estimated parameters indicate that a 100% ad-valorem tariff would increase employment at the national supplier by about 4.5% and average wage by about 0.5% 5 years after the implementation of the tariff.

Figure 2.3: Employment and Wages at the National Producer

(a) **Number of Workers** (b) **Wage Bill**

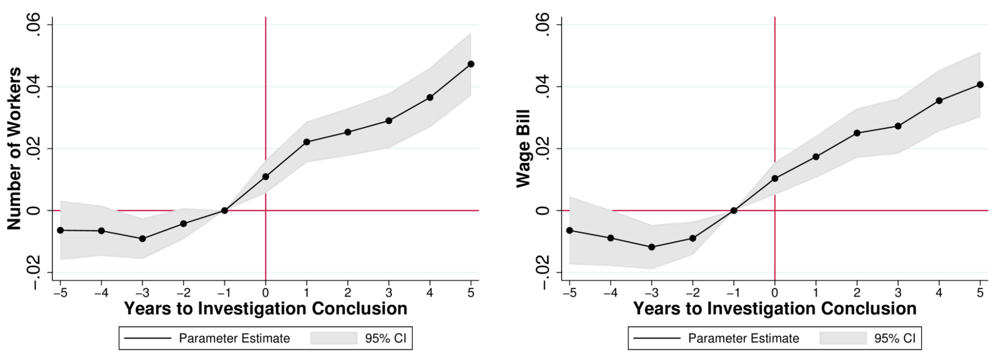


Table 2.2 presents the impact of AD tariffs on various margins of adjustment by domestic firms. Notice that since sample selection assumptions are relaxed and more AD measures are included in the sample, the model gives a better picture of the effect of AD tariff. On average, a 100% ad-valorem tariff increases national suppliers' wage bill and employment by 0.3%. AD tariffs do not significantly affect the monthly earnings or the number of establishments of protected firms. Columns (5) and (6) show that the protected firms are more likely to engage in international trade.

How does the response to AD tariffs vary according to firm size? Table 2.3 answer this question. Column (1) shows that firms of all sizes increase their wage bill in response to the tariff increase. But this is due to different reasons. While small firms increase their employment, large firms only increase the wage of their workers. Table 2.3 also presents the

Table 2.2: Effect of AD Tariffs on the National Producer

	(1) log(Wage Bill)	(2) log(Number Workers)	(3) log(Monthly Earnings)	(4) log(Establishments)	(5) 𝕀{exporter}	(6) 𝕀{importer}
AD Tariff	0.0260***	0.0332***	-0.00719***	0.000293	0.0109***	0.0120***
	(0.00720)	(0.00629)	(0.00223)	(0.00129)	(0.00196)	(0.00202)
N	118027	118027	118027	118027	118027	118027
R^2	0.858	0.833	0.842	0.883	0.582	0.605
# Firms	7057	7057	7057	7057	7057	7057
Mean Dep. Var	9.883	2.472	7.412	.062	.133	.142
Mean Ind. Var	.43	.43	.43	.43	.43	.43
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

This table presents the estimated parameters of Equation 2.3. The sample is composed of firms in sectors producing the product under AD investigation. We constrain the sample to the set of firms observed after and before the AD investigation, that have more than 10 observations and more than one worker. These sample restrictions are made to avoid composition change and special firms. log(Wage Bill) is the log of total labor expenditure of the firm. log(Number Workers) is the log of the total number of workers of the firm. log(Monthly Earnings) is the avg. monthly earnings of workers at that firm. log(Establishments) is the log of number of establishments of the firm. 𝕀{exporter} is a dummy taking one if the exported any product that year and 𝕀{importer} is a dummy for importing. AD tariff is the average anti-dumping tariff imposed against products produced by the sector of each firm. The sample goes from 1995 to 2016.

effect of tariffs according to the firm's position at the pre-period wage distribution. It shows that low wage firms are the ones increasing in size due to the shielding against international trade competition. If we take firm size and firm wage as measures of productivity, these results indicate that tariffs cause misallocation within the national supplier and favors more unproductive firms.

Table 2.3: Heterogeneous Effects of AD Tariff on the National Producer

	(2) log(Wage Bill)	(3) log(N. Workers)	(1) log(Monthly Earnings)	(2) log(Wage Bill)	(3) log(N. Workers)	(1) log(Monthly Earnings)
AD Tariff × T1	0.0154	0.0191*	-0.00368	0.0355***	0.0425***	-0.00697*
	(0.0132)	(0.0115)	(0.00411)	(0.0123)	(0.0108)	(0.00363)
AD Tariff × T2	0.0420***	0.0489***	-0.00692**	0.0214	0.0251**	-0.00372
	(0.0120)	(0.0108)	(0.00342)	(0.0131)	(0.0113)	(0.00393)
AD Tariff × T3	0.0239*	0.0330***	-0.00908**	0.0277**	0.0371***	-0.00936***
	(0.0124)	(0.0105)	(0.00376)	(0.0121)	(0.0108)	(0.00342)
N	118022	118022	118022	118023	118023	118023
R^2	0.860	0.835	0.843	0.859	0.834	0.845
# Firms	7057	7057	7057	7057	7057	7057
Mean Dep. Var	9.883	2.472	7.412	9.883	2.472	7.412
Mean Ind. Var	.43	.43	.43	.43	.43	.43
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Tercile	N. Workers	N. Workers	N. Workers	Monthly Earnings	Monthly Earnings	Monthly Earnings

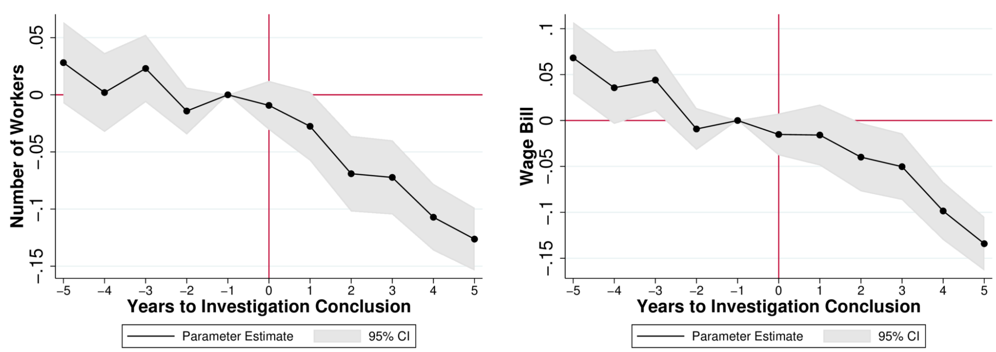
This table presents the estimated parameters of Equation 2.5. Firms are divided according to their position on the distribution of firm sales and average wage within sector one year before the AD investigation. The sample is composed of firms in sectors producing the product under AD investigation. We constrain the sample to the set of firms observed after and before the AD investigation, that have more than 10 observations and more than one worker. These sample restrictions are made to avoid composition change and special firms. log(Wage Bill) is the log of total labor expenditure of the firm. log(Number Workers) is the log of the total number of workers of the firm. log(Monthly Earnings) is the avg. monthly earnings of workers at that firm. log(Establishments) is the log of number of establishments of the firm. 𝕀{exporter} is a dummy taking one if the exported any product that year and 𝕀{importer} is a dummy for importing. AD tariff is the average anti-dumping tariff imposed against products produced by the sector of each firm. The sample goes from 1995 to 2016.

2.4.3 Downstream Firms

Upstream tariffs may increase the cost of input for downstream firms or force them to switch suppliers. In either case, the performance of downstream firms should be negatively affected. In this section, we empirically evaluate the hypothesis. Figure 2.4 displays how tariffs affect employment and average wage in downstream sectors. There is no discernible trend in the periods leading to the tariff. This supports the assumption of parallel trends. We observe a significant trend break at the year of the tariff. After a 100% AD tariff is imposed, employment decreases by 15% after 5 years. This validates the view that AD tariffs substantially affect firms downstream of the protected sector, to the contrary of the view that import competition or the lack of it does not significantly affect downstream employment, which was suggested in the literature (Acemoglu et al., 2016). Downstream wage bill decreases by 15% in 5 years after a 100% AD tariff.

Figure 2.4: Effects of Anti-Dumping Tariffs on Downstream Firms

(a) **Number of Workers** (b) **Wage Bill**



Notice that Figures 2.4a and 2.4b only use variation of the largest tariff imposed in each sector. Table 2.4, on the other hand, presents the estimated average effect of all AD tariffs and all years after the imposition of tariffs. It indicates that a 100% tariff increase on inputs of a given sector decreases employment and wage bill by 5%. This number has an important implication: if the national producer and the downstream firm are of the same size, AD tariffs have negative employment effect. A 100% AD tariff increases employment by 4.4% at the national supplier while decreases it by 5.1% at the downstream sector. Column (4) to (6) of Table 2.4 also shows that this number does not depend on the addition of the sector trend.

Tariffs affect the downstream sector through two channels. There is a direct effect hitting firms that were importing inputs from abroad. They need to decide between paying higher prices of the imported good or buying from the national supplier. Given that employment on the national supplier increases, there are at least some firms going through the second road. Since the national producer has lower competition and higher demand, one could expect prices to also adjust. This would affect all downstream firms in the economy, even those not forced to switch suppliers. Table 2.6 helps us tease apart the magnitude of these two channels. It shows the effect of AD tariffs on firms that imported in the pre-period and those not. It indicates that importers are indeed more affected by the tariff but the negative labor effect is widespread through the whole sector. This teaches us that the price adjustment made by the national supplier is large.

Table 2.7 shows how downstream firm heterogeneity affects their responses to tariffs. Columns (1) to (3) show the response by firms in different quantiles of firm size measured with sales. Columns (4) to (6) show the the response by firms in different quantiles of average monthly earnings. Small and low wage firms are more affected.

Table 2.4: Effect of AD Tariffs on Downstream Firms

	(1) log(Number Workers)	(2) log(Monthly Earnings)	(3) log(Establishments)	(4) log(Number Workers)	(5) log(Monthly Earnings)	(6) log(Establishments)
AD Tariff	-0.0484**	-0.00487	-0.0185***	-0.0294	0.0332***	-0.00624*
	(0.0204)	(0.00658)	(0.00408)	(0.0221)	(0.00751)	(0.00358)
N	759433	759433	759433	759433	759433	759433
R^2	0.789	0.783	0.874	0.791	0.785	0.876
# Firms	38857	38857	38857	38857	38857	38857
Mean Dep. Var	1.587	7.071	.04	1.587	7.071	.04
Mean Ind. Var	.08	.08	.08	.08	.08	.08
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector Trend	No	No	No	Yes	Yes	Yes

This table presents the estimated parameters of Equation 2.6. The sample is composed of firms in the main downstream sectors of the sectors to which the products under AD investigation belong. We constrain the sample to the set of firms observed after and before the AD investigation, that have more than 10 observations and more than one worker. These sample restrictions are made to avoid composition change and special firms. log(Wage Bill) is the log of total labor expenditure of the firm. log(Number Workers) is the log of the total number of workers of the firm. log(Monthly Earnings) is the avg. monthly earnings of workers at that firm. log(Establishments) is the log of number of establishments of the firm. $\mathbb{I}\{exporter\}$ is a dummy taking one if the exported any product that year and $\mathbb{I}\{importer\}$ is a dummy for importing. AD tariff is the average anti-dumping tariff imposed against products produced by the sector of each firm. The sample goes from 1995 to 2016.

Table 2.5: Effect of AD Tariffs on Employment Composition at Downstream Firms

	(1) log(N. MW)	(2) log(N. High Drop.)	(3) log(N. High Complete)	(4) log(N. High More)	(5) Routine Task Content
AD Tariff	-0.333***	-0.0352	-0.103***	0.0358	-0.0433***
	(0.0796)	(0.0244)	(0.0299)	(0.0371)	(0.0112)
N	82414	663922	467180	138014	759433
R^2	0.586	0.752	0.743	0.839	0.560
# Firms	13090	38451	35923	16682	38857
Mean Dep. Var	.608	1.258	1.042	.647	-.096
Mean Ind. Var	.08	.08	.08	.08	.08
Firm FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Sector Trend	Yes	Yes	Yes	Yes	Yes

This table presents the estimated parameters of Equation 2.6. The sample is composed of firms in the main downstream sectors of the sectors to which the products under AD investigation belong. We constrain the sample to the set of firms observed after and before the AD investigation, that have more than 10 observations and more than one worker. These sample restrictions are made to avoid composition change and special firms. log(Wage Bill) is the log of total labor expenditure of the firm. log(Number Workers) is the log of the total number of workers of the firm. log(Monthly Earnings) is the avg. monthly earnings of workers at that firm. log(Establishments) is the log of number of establishments of the firm. $\mathbb{I}\{exporter\}$ is a dummy taking one if the exported any product that year and $\mathbb{I}\{importer\}$ is a dummy for importing. AD tariff is the average anti-dumping tariff imposed against products produced by the sector of each firm. The sample goes from 1995 to 2016.

Table 2.6: Effect of AD Tariffs on Importers at Downstream Firms

	(1) log(N. Workers)	(2) log(Monthly Earnings)	(3) $\mathbb{I}\{Exporter\}$	(4) $\mathbb{I}\{Importer\}$	(5) log(N. Workers)	(6) log(Monthly Earnings)	(7) $\mathbb{I}\{Exporter\}$	(8) $\mathbb{I}\{Importer\}$
AD Tariff × Importer	-0.0771	0.0534*	-0.169***	-0.0880***	-0.714***	-0.119***	-0.0672*	-0.00824
	(0.0644)	(0.0280)	(0.0305)	(0.0330)	(0.0864)	(0.0342)	(0.0374)	(0.0390)
AD Tariff × N. Importer	0.0140	0.0229***	-0.0196***	0.00215	-0.479***	-0.106***	0.0631***	0.0708***
	(0.0177)	(0.00579)	(0.00393)	(0.00257)	(0.0490)	(0.0173)	(0.0155)	(0.0159)
N	786250	786250	786250	786250	786250	786250	786250	786250
R^2	0.792	0.784	0.625	0.665	0.807	0.797	0.628	0.667
# Firms	38857	38857	38857	38857	38857	38857	38857	38857
Mean Dep. Var	1.587	7.071	.127	.007	1.587	7.071	.127	.007
Mean Ind. Var	.07	.07	.07	.07	.07	.07	.07	.07
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control Size	No	No	No	No	No	No	No	No

This table presents the estimated parameters of Equation 2.6. The sample is composed of firms in the main downstream sectors of the sectors to which the products under AD investigation belong. We constrain the sample to the set of firms observed after and before the AD investigation, that have more than 10 observations and more than one worker. These sample restrictions are made to avoid composition change and special firms. log(Wage Bill) is the log of total labor expenditure of the firm. log(Number Workers) is the log of the total number of workers of the firm. log(Monthly Earnings) is the avg. monthly earnings of workers at that firm. log(Establishments) is the log of number of establishments of the firm. $\mathbb{I}\{exporter\}$ is a dummy taking one if the exported any product that year and $\mathbb{I}\{importer\}$ is a dummy for importing. AD tariff is the average anti-dumping tariff imposed against products produced by the sector of each firm. The sample goes from 1995 to 2016.

2.4.4 Upstream Firms

The national producers protected by tariffs expand their production. As a result, they demand more input supplies from upstream firms, which should increase upstream employment. We test this hypothesis in this section.

Figure 2.5 shows the results of the main model that tests for parallel trends. We don't see any trend in the pre-period. Tariffs increase employment and wage bill in upstream firms. On average, an 100% AD tariffs that protect domestic customers increase upstream employment by 15% in 5 years after the tariff. Table 2.8 uses variation from all AD tariffs to estimate the average effect of tariffs on upstream firms. It shows that a 100% tariff increase

Table 2.7: Heterogeneous Effects of AD Tariff on Downstream Firms

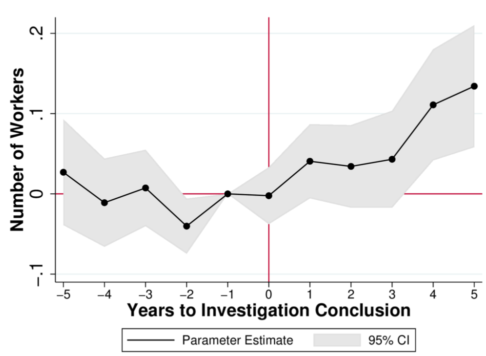
	(1) log(Wage Bill)	(2) log(Number Workers)	(3) log(Monthly Earnings)	(4) log(Wage Bill)	(5) log(Number Workers)	(6) log(Monthly Earnings)
AD tariff × Q1	-0.0534***	-0.0569***	0.00352	-0.0625***	-0.0643***	0.00172
	(0.00563)	(0.00508)	(0.00220)	(0.00681)	(0.00632)	(0.00243)
AD tariff × Q2	-0.0533***	-0.0477***	-0.00565*	-0.0479***	-0.0467***	-0.00124
	(0.00746)	(0.00653)	(0.00335)	(0.00665)	(0.00614)	(0.00235)
AD tariff × Q3	-0.0471***	-0.0458***	-0.00136	-0.0435***	-0.0462***	0.00266
	(0.00673)	(0.00618)	(0.00263)	(0.00657)	(0.00611)	(0.00248)
AD tariff × Q4	-0.0433***	-0.0445***	0.00117	-0.0500***	-0.0439***	-0.00614**
	(0.00834)	(0.00809)	(0.00266)	(0.00782)	(0.00715)	(0.00311)
N	781344	781344	781344	781344	781344	781344
R^2	0.864	0.847	0.949	0.857	0.836	0.949
# Firms	39413	39413	39413	39413	39413	39413
Mean Dep. Var	9.383	2.272	.16	9.383	2.272	.16
Mean Ind. Var	.18	.18	.18	.18	.18	.18
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Quartile	Number Workers	Number Workers	Number Workers	Monthly Earnings	Monthly Earnings	Monthly Earnings

This table presents the estimated parameters of Equation 2.5. Firms are divided according to their position on the distribution of firm sales and average wage within sector one year before the AD investigation. The sample is composed of firms in the main downstream sectors of the sectors to which the products under AD investigation belong. We constrain the sample to the set of firms observed after and before the AD investigation, that have more than 10 observations and more than one worker. These sample restrictions are made to avoid composition change and special firms. log(Wage Bill) is the log of total labor expenditure of the firm. log(Number Workers) is the log of the total number of workers of the firm. log(Monthly Earnings) is the avg. monthly earnings of workers at that firm. log(Establishments) is the log of number of establishments of the firm. $\mathbb{I}\{\text{exporter}\}$ is a dummy taking one if the exported any product that year and $\mathbb{I}\{\text{importer}\}$ is a dummy for importing. AD tariff is the average anti-dumping tariff imposed against products produced by the sector of each firm. The sample goes from 1995 to 2016.

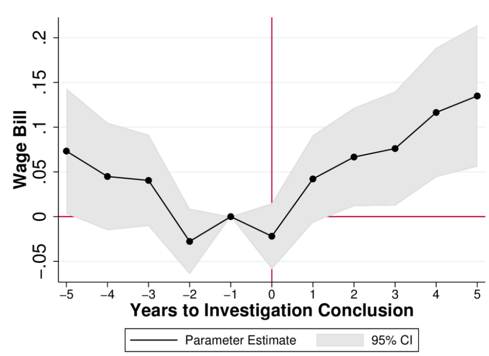
wage bill by 17% and employment by 19% in upstream firms. Interestingly, average wage decreases at the upstream firm. In auxiliaries regressions we find that the employment among minimum-wage and low educated workers increases. This pushes down the average wage. Finally, Table 2.9 evaluate the heterogeneity of this effect according to firm size and wage. Different from the other sections, there is no clear pattern. Firms of middle size more likely to adjust employment.

Figure 2.5: Effects of Anti-Dumping Tariffs on Upstream Firms

(a) **Number of Workers**



(b) **Wage Bill**



What do we learn from these empirical findings about trade policy? The main implication is that tariffs can create employment but not always do, because upstream tariffs negatively affect other downstream sectors. However, an overall employment gain is still possible if the

Table 2.8: Effect of Anti-Dumping Tariffs on Upstream Firms

	(1) log(Wage Bill)	(2) log(Number Workers)	(3) log(Monthly Earnings)	(4) log(Establishments)	(5) $\mathbb{I}$\{exporter\}	(6) $\mathbb{I}$\{importer\}
AD Tariff	0.166***	0.187***	-0.0215*	-0.0124*	0.0537***	0.0407***
	(0.0369)	(0.0335)	(0.0112)	(0.00687)	(0.00833)	(0.0100)
N	91518	91518	91518	91518	91518	91518
R^2	0.839	0.827	0.828	0.953	0.582	0.603
# Firms	4965	4965	4965	4965	4965	4965
Mean Dep. Var	9.705	2.603	7.102	.463	.214	.009
Mean Ind. Var	.23	.23	.23	.23	.23	.23
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

This table presents the estimated parameters of Equation 2.7. The sample is composed of firms in the main upstream sectors of the sectors to which the products under AD investigation belong. We constrain the sample to the set of firms observed after and before the AD investigation, that have more than 10 observations and more than one worker. These sample restrictions are made to avoid composition change and special firms. log(Wage Bill) is the log of total labor expenditure of the firm. log(Number Workers) is the log of the total number of workers of the firm. log(Monthly Earnings) is the avg. monthly earnings of workers at that firm. log(Establishments) is the log of number of establishments of the firm. $\mathbb{I}$\{exporter\} is a dummy taking one if the exported any product that year and $\mathbb{I}$\{importer\} is a dummy for importing. AD tariff is the average anti-dumping tariff imposed against products produced by the sector of each firm. The sample goes from 1995 to 2016.

Table 2.9: Heterogeneous Effects of AD Tariff on the Upstream Sector

	(1) log(Wage Bill)	(2) log(Number Workers)	(3) log(Monthly Earnings)	(4) log(Wage Bill)	(5) log(Number Workers)	(6) log(Monthly Earnings)
AD Tariff × T1	0.157***	0.168***	-0.0115	0.0870	0.104**	-0.0170
	(0.0571)	(0.0512)	(0.0185)	(0.0582)	(0.0520)	(0.0181)
AD Tariff × T2	0.325***	0.323***	0.00177	0.351***	0.340***	0.0110
	(0.0671)	(0.0613)	(0.0202)	(0.0637)	(0.0589)	(0.0195)
AD Tariff × T3	0.0953	0.143**	-0.0475**	0.125*	0.175***	-0.0501**
	(0.0666)	(0.0620)	(0.0191)	(0.0691)	(0.0629)	(0.0202)
N	91518	91518	91518	91518	91518	91518
R^2	0.842	0.830	0.829	0.841	0.829	0.830
# Firms	4965	4965	4965	4965	4965	4965
Mean Dep. Var	9.705	2.603	7.102	9.705	2.603	7.102
Mean Ind. Var	.23	.23	.23	.23	.23	.23
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
tercile	Number Workers	Number Workers	Number Workers	Monthly Earnings	Monthly Earnings	Monthly Earnings

This table presents the estimated parameters of Equation 2.5. Firms are divided according to their position on the distribution of firm sales and average wage within sector one year before the AD investigation. The sample is composed of firms in the main upstream sectors of the sectors to which the products under AD investigation belong. we constrain the sample to the set of firms observed after and before the AD investigation, that have more than 10 observations and more than one worker. These sample restrictions are made to avoid composition change and special firms. log(Wage Bill) is the log of total labor expenditure of the firm. log(Number Workers) is the log of the total number of workers of the firm. log(Monthly Earnings) is the avg. monthly earnings of workers at that firm. log(Establishments) is the log of number of establishments of the firm. $\mathbb{I}$\{exporter\} is a dummy taking one if the exported any product that year and $\mathbb{I}$\{importer\} is a dummy for importing. AD tariff is the average anti-dumping tariff imposed against products produced by the sector of each firm. The sample goes from 1995 to 2016.

tariffed goods are at the bottom of the value chain, because upstream sectors expand their employment as a result of downstream tariffs. If all sectors are of the same size, a 100% AD tariff at a midstream sector connected by a downstream and an upstream one would increase overall employment by 6%.

The second lesson is on the distributive effects of tariffs. First, tariffs shift employment to less productive and declining firms.[9] Moreover, within the protected sector, firms that are smaller and pay lower wages gain more in employment. Third, downstream firms that are

9. To apply for AD tariff, a firm must prove a reduction in revenue and employment.

more internationally connected are more harmed. These findings suggest that while tariffs increase equality across firms and workers, they decrease efficiency because it is the less productive firms that take more advantage of the tariffs.

2.5 Model

The empirical results indicate that the anti-dumping tariffs increase employment in the protected sector and the upstream sectors, but decrease employment in the downstream sectors. Therefore, the reduced form evidence may not conclude on the aggregate employment effect of AD tariffs. To study the aggregate labor market consequences, we build a quantitative model of the Brazilian economy. The model takes advantage of micro elasticities found in the empirical section and replicates macroeconomic facts of the Brazilian labor market. The model also gains insights into the aggregate effects of tariffs on real GDP and real GNI.

2.5.1 Setup

Our country of interest is Brazil. Let $s \in \{1, 2, ..., S\}$ denote sectors. There is a measure L of individuals in the economy. Use L^s to denote the measure of workers working in sector s. L^u denotes the measure of unemployed individuals. They have to satisfy the adding up condition: $\sum_{s=1}^{s} L^s + L^u = L$. Individuals are ex-ante homogeneous and risk neutral. They either work in a sector s or stays unemployed (denoted with status u). An individual's utility index equals her consumption bundle conditional on the chosen sector or unemployment, multiplied by an idiosyncratic shock specific to the individual and sector:

$$U_{si} = C_{si} z_{si}$$

where $s \in \{1, 2, ...S\} + u$. Following Eaton and Kortum (2002), we assume z_i^s follows a Frechet distribution with shape parameter μ: $F(z_i^s) = \exp(-(z_i^s)^{\mu})$.[10] The consumption bundle is Cobb-Douglas in the individual's consumption of sector roundabout goods:[11]

$$C_{si} = \prod_{t=1}^{S} \left(\frac{c_{si}^t}{\alpha^t} \right)^{\alpha^t}$$

where c_{si}^t denotes the consumption of sector t ($t \in \{1, 2, ..., S\}$) goods, for an individual i working in sector s (or staying unemployed). Use P^t to denote the price of sector t goods. Assume all individuals face the same sectoral consumption goods price, regardless of the sector they work in and their unemployment status. The consumer price index therefore equals:

$$P = \prod_{t=1}^{S} \left(P^t \right)^{\alpha^t}$$

If an individual i works in sector s, she earns wage w^s. If she chooses unemployment, she receives unemployment benefit b. We assume the unemployment benefit is financed by government revenues. The government raises revenues by collecting tariff revenues, borrowing from abroad and imposing an income tax with rate δ applied to all sectors and the unemployed. Consequently, the tax does not distort the worker's sector choice and the regarding whether to work or stay unemployed. δ is endogenously set by the government to make sure the government budget holds. δ could be negative. In this case, the sum of transfers from abroad plus collected tariff revenues is larger than total unemployment benefits the government pays out. The budget surplus is then subsidized to all individuals at a constant rate to their income. The government problem is the following:

$$bL^b = \delta(\sum_{s=1}^{S} w^s L^s + bL^u) + TD + TR \tag{2.8}$$

10. The scale parameter does not affect the quantitative results in terms of changes from the baseline equilibrium and is set to 1.

11. The goods are called roundabout because they are used as both consumption goods and intermediate input for sectoral production.

The left hand side denotes government expenditures and the right hand side denotes government incomes. TD is the trade deficit and TR is the tariff revenue to be specified later.

Individuals' budget constraints equal the following:

$$PC_i^s = \begin{cases} (1-\delta)w^s & \text{if working in sector } s \in \{1, 2...S\} \\ (1-\delta)b & \text{if unemployed } (s = u) \end{cases}$$

After observing the idiosyncratic shocks z_i^s and the consumption bundle C_i^s, the individual i chooses the sector to work or unemployment to maximize her utility. As workers are ex-ante homogeneous, the individual's probability choosing each sector should equal the population share working in that sector. This leads to the following sectoral labor supply function:

$$L^s = \begin{cases} \frac{\left(\frac{w^s(1-\delta)}{P}\right)^\mu}{\sum_{s=1}^S \left(\frac{w^s(1-\delta)}{P}\right)^\mu + \left(\frac{b(1-\delta)}{P}\right)^\mu} L = \frac{(w^s)^\mu}{\sum_{s=1}^S (w^s)^\mu + b^\mu} L & \text{if working in sector s } (s \in \{1, 2...S\}) \\ \frac{b^\mu}{\sum_{s=1}^S (w^s)^\mu + b^\mu} L & \text{if unemployed } (s = u) \end{cases} \tag{2.9}$$

Note μ is the labor supply elasticity. Prior to observing the shock, a Brazilian individual's expected real income is:

$$U = \gamma \frac{(1-\delta)(\sum_{s=1}^S (w^s)^\mu + b^\mu)^{\frac{1}{\mu}}}{P}$$

where γ is a constant. We use this as the measure of the Brazilian welfare. Now consider the producer's problem. All markets are competitive. Brazilian sector s producer produces tradable output using labor and roundabout composite input from all sectors following a Cobb-Douglas function:

$$Y^s = A^s \left(\frac{L^s}{\gamma^s}\right)^{\gamma^s} \prod_{s'=1}^S \left(\frac{M^{ss'}}{\gamma^{ss'}}\right)^{\gamma^{ss'}} \tag{2.10}$$

where γ^s is the share of value added in gross output. $\gamma^{ss'}$ is the share of roundabout composite input from sector s' in sector s output. $\sum_{s'=1} \gamma^{ss'} + \gamma^s = 1$. Remember sector s roundabout composite goods price is denoted with P^s. Implied by the perfect competition assumption, the price of Brazilian sector s output equals:

$$P_B^s = \frac{1}{A^s} (w^s)^{\gamma^s} \prod_{s'=1}^{S} \left(P^{s'}\right)^{\gamma^{ss'}}$$

The sectoral tradable output is assumed to differ according to where it is produced. The roundabout composite input then combines the same sector's tradable output from home (Brazil) and all foreign countries with a "love-of-variety" production function. The function is "Dixit-Stiglitz"' style, with the Armington trade elasticity - the elasticity of substitution across country-specific goods, σ^s:

$$Q^s = \left((Y_B^s)^{\frac{\sigma^s - 1}{\sigma^s}} + \sum_{i \in \Xi_F} (Y_i^s)^{\frac{\sigma^s - 1}{\sigma^s}} \right)^{\frac{\sigma^s}{\sigma^s - 1}}$$

where Y_B^s is the quantity of Brazilian output used in Brazil. The rest is exported. Ξ_F is the set of foreign countries that export to Brazil. Y_i^s denotes the quantity of sectoral import from foreign country i in sector s.

Assume Y_i^s takes the form of a CES aggregator over product line level imports from the country, with the elasticity of substitution ζ^s across product lines within the sector. The assumption allows for finite substitutability between product lines for a given foreign country-sector pair, and the product line level elasticity of substitution to differ from country-level substitution:

$$Y_i^s = \left(\sum_{l \in \Omega_i^s} (y_{il}^s)^{\frac{\zeta^s - 1}{\zeta^s}} \right)^{\frac{\zeta^s}{\zeta^s - 1}}$$

where ζ^s could differ from σ^s. Ω_i^s denotes the product lines Brazil imports from country i in sector s and y^s_{il} denotes the quantity of import in the product line. Brazil imposes tariffs on the product lines. Assume Brazil is a small open economy such that its tariffs do not affect prices asked by foreign sellers. Denote the ex-tariff price of output from country i, product line l of sector s with p^s_{li}. The expenditure share on product line l conditional on Brazil imports from country i, s^s_{li}, then equals the following:

$$s^s_{il} = \frac{(p^s_{il}\tau^s_{il})^{1-\zeta^s}}{(P^s_i)^{1-\zeta^s}}$$

where $\tau^s_{il} = 1 + t^s_{il}$ with t^s_{il} denoting tariffs. P^s_i is the sectoral import price index from country i and equals:

$$(P^s_i)^{1-\zeta^s} = \sum_{l\in\Omega^s_i}(p^s_{il}\tau^s_{il})^{1-\zeta^s}$$

Sector s expenditure share on country i ($i \in \Xi_F + B$) is:

$$s^s_i = \frac{(P^s_i)^{1-\zeta^s}}{(P^s)^{1-\zeta^s}}$$

where sector s roundabout composite goods price: $(P^s)^{1-\zeta^s} = \sum_{i\in\Xi_F+B}(P^s_i)^{1-\zeta^s}$.

To close the model, we specify the market clearing conditions for labor and the roundabout composite input. Assume Brazilian exporters face the same sectoral demand elasticity σ^s. Then denote Brazilian sector s export values with $E^s_{FB} = (P^s_B)^{1-\sigma^s}E_F$. Use X^s to denote Brazilian total expenditure on sector s roundabout composite goods. Brazilian value added in sector s equals:

$$w^s L^s = \gamma^s(P^s_B)^{1-\sigma^s}\left(\frac{1}{(P^s)^{1-\sigma^s}}X^s + E_F\right)$$

The market clearing condition for labor equates labor equation with labor supply:

$$\frac{1}{w^s}\gamma^s (P_B^s)^{1-\sigma^s}\left(\frac{1}{(P^s)^{1-\sigma^s}}X^s + E_F\right) = L^s = \frac{(w^s)^\mu}{\sum_{s=1}^S (w^s)^\mu + b^\mu}L$$

Market clearing condition for the roundabout composite good X^s:

$$X^s = P^s C^s + \sum_{s'=1}^{S} \gamma^{s's} \underbrace{(P_B^{s'})^{1-\sigma^{s'}}\left(\frac{1}{(P^{s'})^{1-\sigma^{s'}}}X^{s'} + E_F^{s'}\right)}_{\text{Sector s' output}}$$

where the right hand side refers to the aggregate demand for the roundabout composite good. It is used for final consumption and input to sectoral production. The sectoral output is either used domestically or exported. Total consumption is the following:

$$P^s C^s = \alpha^s (1-\delta)(\sum_{s=1}^{S} w^s L^s + bL^b)$$

With knowledge about product line level trade flows, we derive the tariff revenue and trade deficit, which add to the government revenue in Equation 2.8. The tariff revenue equals the following:

$$TR = \sum_{s=1}^{S} \sum_{i\in\Xi_F} \sum_{l\in\Omega_i^s} X^s s_i^s s_{il}^s \frac{t_{il}^s}{\tau_{il}^s}$$

And trade deficit:

$$TD = \sum_{s=1}^{S} \sum_{i\in\Xi_F} \sum_{l\in\Omega_i^s} X^s s_i^s s_{il}^s \frac{1}{\tau_{il}^s} - \sum_{s=1}^{S} \frac{(P_B^s)^{1-\sigma^s}}{(P_F^s)^{1-\sigma^s}} E_F^s$$

2.5.2 Model in Changes

Now we rewrite the problem in changes to study the counterfactuals. Doing so we eliminate the economic fundamentals that are invariant to tariff shocks, for example, productivity A^s.

These local fundamentals are generally difficult to calibrate or estimate directly. We use V' to denote the post tariff shock value of a variable V, and $\hat{V} = \frac{V'}{V}$ to denote the changes. Changes in labor supply are the following:

$$\hat{L}^s = \begin{cases} \frac{(\hat{w}^s)^\mu}{\sum_{s=1}^S s_L^s(\hat{w}^s)^\mu + s_L^b(\hat{b})^\mu}\hat{L} & \text{if working in sector s } (s \in \{1, 2...S\}) \\ \frac{(\hat{b})^\mu}{\sum_{s=1}^S s_L^s(\hat{w}^s)^\mu + s_L^b(\hat{b})^\mu}\hat{L} & \text{if unemployed } (s = u) \end{cases} \tag{2.11}$$

where s_L^s is the share of population employed in sector s and s_L^u is the share of population that is unemployed.

Changes in expenditure shares on country $i \in B + \Xi_F$:

$$\hat{s}_i^s = \frac{(\hat{P}_i^s)^{1-\sigma^s}}{(\hat{P}^s)^{1-\sigma^s}} \tag{2.12}$$

where

$$(\hat{P}^s)^{1-\sigma^s} = \sum_{i \in B + \Xi_F} s_i^s(\hat{P}_i^s)^{1-\sigma^s} \tag{2.13}$$

Changes in expenditure shares on product line l conditional on buying from country $i \in \Xi_F$:

$$\hat{s}_{il}^s = \frac{(\hat{p}_{il}^s\hat{\tau}_{il}^s)^{1-\zeta^s}}{(\hat{P}_i^s)^{1-\zeta^s}} \tag{2.14}$$

where $(\hat{P}_i^s)^{1-\zeta^s} = \sum_{l \in \Omega_i^s} s_{il}^s(\hat{p}_{il}^s\hat{\tau}_{il}^s)^{1-\zeta^s}$. Changes in the output price equal:

$$\hat{P}_B^s = \frac{1}{\hat{A}^s}(\hat{w}^s)^{\gamma^s}\prod_{s'=1}^S\left(\hat{P}^{s'}\right)^{\gamma^{ss'}} \tag{2.15}$$

Post-tariff change labor market clearing for sector s:

$$\frac{1}{w^{s\prime}}\gamma^s\left(s_B^{s\prime}X_B^{s\prime}+E_{FB}^s(\hat{P}_B^s)^{1-\sigma^s}\right)=L^{s\prime}=\frac{(w^{s\prime})^\mu}{\sum_{s=1}^S(w^{s\prime})^\mu+(b^\prime)^\mu}L^\prime \tag{2.16}$$

Post-tariff change market clearing condition for roundabout composite goods:

$$X^{s\prime}=P^{s\prime}C^{s\prime}+\sum_{s^\prime=1}^{S}\gamma^{s^\prime s}\left(s_B^{s^\prime\prime}X_B^{s^\prime\prime}+E_{FB}^{s^\prime}(\hat{P}_B^{s^\prime})^{1-\sigma^{s^\prime}}\right) \tag{2.17}$$

Consumption after tariff changes is the following:

$$P^{s\prime}C^{s\prime}=\alpha^s(1-\delta^\prime)(\sum_{s=1}^{S}w_s^\prime L^{s\prime}+b^\prime L^{w\prime}) \tag{2.18}$$

Ex-post government budget balance condition:

$$b^\prime L^{w\prime}=\delta^\prime(\sum_{s=1}^{S}w^{s\prime}L^{s\prime}+b^\prime L^{w\prime})+TD^\prime+TR^\prime$$

where tariff revenue after changes equals:

$$TR^\prime=\sum_{s=1}^{S}\sum_{i\in\Xi_F}\sum_{l\in\Omega_i^s}X^{s\prime}s_i^{s\prime}s_{il}^{s\prime}\frac{t_{il}^{s\prime}}{\tau_{il}^{s\prime}} \tag{2.19}$$

And trade deficit after changes equals:

$$TD^\prime=\sum_{s=1}^{S}\sum_{i\in\Xi_F}\sum_{l\in\Omega_i^s}X^{s\prime}s_i^{s\prime}s_{il}^{s\prime}\frac{1}{\tau_{il}^{s\prime}}-\sum_{s=1}^{S}(\hat{P}_B^s)^{1-\sigma^s}E_{FB}^s \tag{2.20}$$

2.5.3 Equilibrium

We first define the equilibrium for model in changes. With knowledge of the following variables:

1. market shares: factual expenditure shares by country: $\left\{s_i^s\right\}_{i\in B+\Xi_F}$, product line expenditure shares conditional on importing from a specific country: $\left\{s_{il}^s\right\}_{i\in\Xi_F,l\in\Omega_{il}^s}$, sector employment and unemployment shares in the population: $\left\{s_L^s\right\}_{s\in\{1,2,...,S\}+u}$, input-output coefficients $\gamma^{ss'}$ and γ^s, final consumption shares α^s

2. fundamentals: Brazilian exports E_{FB}^s, incumbent tariffs t_{il}^s, total population L

3. factual unemployment benefit b

4. foreign shocks: $\hat{p}_{il}^s$, $\hat{t}_{il}^s$, $\hat{\tau}_{il}^s$

5. domestic shocks: change in total population $\hat{L}$, productivity $\hat{A}^s$

6. elasticities: elasticities of substitution across countries σ^s, elasticity of substitution across product lines ζ^s, labor supply elasticity μ

2.6 Quantitative Results

2.6.1 Calibration and Estimation

This section describes the procedure to calibrate and estimate the required variables in Section 2.5.3. The baseline economy is calibrated to Brazil in 1995, the initial year of the database. The market shares and exogenous fundamentals (bullet point 1 and 2 of Section 2.5.3) are directly calibrated to the Brazilian data. We back out the unemployment benefit b with the government budget constraint. We are interested in the impact of tariff shocks. Therefore, we set changes in foreign prices $\hat{p}_{il}^s \equiv 1$. We use $\hat{t}_{il}^s$, $\hat{\tau}_{il}^s$ to represent all AD tariffs from 1995 to 2016. In the data a product line l refers to an HS 6-digit code. We group HS codes into 2-digit sectors using a concordance table. There are 10 of them, spanning from agriculture, resources, to manufacturing (see Table 2.10). We group other non-tradable sectors in the national input-output database into a comprehensive service sector. Let $s = 1$ denote the service sector and $s = 2, ..., 11$ denote other sectors. We set domestic shocks

$\hat{L} = \hat{A} = 1$. The quantitative results should be interpreted as the implications of all AD tariffs while holding other economic fundamentals as fixed.

The elasticities are estimated in the following steps. First, consider the elasticity of substitution across products, ζ^s. It captures how easy the importer could switch across product lines within sectoral import from an origin, and governs the impact of AD tariffs on sector-country level prices. ζ^s is estimated with cross-product differences in AD tariff variations and product-country level imports. Taking log of Equation 2.14:

$$\log(\hat{s}^s_{il}) = (1-\zeta^s)(\log(\hat{p}^s_{il}) + \log(\hat{\tau}^s_{il})) - (1-\zeta^s)\log(\hat{P}^s_i)$$

We estimate ζ^s by running the following regression, sector by sector:

$$\log(\hat{s}^s_{il})_t = \beta^s \log(\hat{\tau}^s_{il})_t + \Phi^s_{it} + \epsilon^s_{ilt}$$

where $\beta^s = 1 - \zeta^s$. The exclusion restriction is changes in ex-AD tariff international prices are not correlated with AD tariff shocks.

Table 2.10 shows the estimates for β^s. The implied elasticity of substitution across product lines is generally low, ranging from 1.552 for chemicals to 6.509 for paper and petroleum. This shows AD tariffs imposed on the product lines will lead to substantial variations in country-sector level prices and move aggregate import.

We estimate the Armington trade elasticity with country level price changes, constructed with $\hat{P}^s_i = (\sum_{l\in\Omega^s_i} s^s_{il}(\hat{\tau}^s_{il})^{1-\zeta^s})^{\frac{1}{1-\zeta^s}}$. σ^s measures how substitutable sectoral goods are from different origins, and governs the impact of foreign price shocks on demand for domestic products. Taking log of Equation 2.12:

$$\log(\hat{s}^s_i) = (1-\sigma^s)(\hat{P}^s_i) - (1-\sigma^s)\log(\hat{P}^s)$$

Table 2.10: Estimated Elasticity of Substitution across Product Lines

Sector name	β^s	Standard Err.	p-value	Implied ζ^s
Agriculture and Mining	- 1.577	.353	9.77e-06	2.577
Food	-.781	.465	.093	1.781
Textile	-1.540	.481	.0014	2.540
Paper and Petroleum	-5.509	.769	2.71e-12	6.509
Chemicals	-.552	.433	.202	1.552
Rubber	-.628	.360	.081	1.628
Non-Metallic Minerals	-1.318	.431	.002	2.318
Metallurgy	- 1.212	.481	.012	2.212
Metal Products	-.707	.703	.315	1.707
Machinery and Equipment	-.709	.272	.009	1.709

σ^s is then estimated with the following regression sector by sector:

$$\log(\hat{s}_i^s)_t = \theta^s \log(\hat{P}_i^s)_t + \Delta_t^s + \epsilon_{it}^s$$

$\sigma^s = 1 - \theta^s$ is identified with cross-country differences in price index changes caused by cross-country heterogeneous exposure to anti-dumping tariffs.[12]

The labor supply elasticity μ governs the impact of demand shocks on sector employment. It is estimated with the inverse labor demand curve. We consider the following regression specification:

$$\log(\hat{w}_t^s) = \frac{1}{\mu} \log(\hat{L}_t^s) + \Psi_t + \epsilon_t^s$$

The regressor, $\log(\hat{L}^s)_t$, is instrumented with own sector, upstream and downstream tariffs. Findings in the empirical section show tariffs have significant impacts on own sector, upstream and downstream employment guarantees the relevance of the instruments. The exclusion restriction requires holding the sector wage as fixed, tariffs are uncorrelated with cross-sector variations in other job characteristics that move the labor supply to individual

12. We are still working to estimate σ^s. For now, we use comparable estimates from Caliendo and Parro (2015). They take advantage of the tariff variations from NAFTA to estimate sectoral Armington trade elasticity.

sectors. We believe this is a reasonable assumption.[13]

2.6.2 *Relating Aggregate Employment, Real GDP and Real GNI to Sectoral Employment Changes*

Changes in aggregate employment equals a weighted average of changes in sectoral employment, with sectoral employment shares as the weights:

$$\hat{L}^e = \sum_{s=1}^{S} \frac{L^s}{\sum_{s=1}^{S} L^s} \hat{L}^s$$

Protectionist policies draw additional labor from the pool of unemployment and from other sectors, such that the protected sectors observe an increase in employment. However, as shown in the empirical section, downstream sectors of the protected sectors lose employment as they face higher input prices. With many sectors buying from and selling to each other, we need to solve the counterfactual equilibrium to sign and quantify the aggregate effects.

Section B.2.1 shows, changes in real GDP could be written as a function of sectoral employment changes in the following way:

$$\widehat{rGDP} = \sum_{s=1}^{S} \frac{w^s L^s}{\sum_{s=1}^{S} w^s L^s} \hat{L}^s \tag{2.21}$$

Similar to changes in aggregate employment, changes in real GDP with the first order approximation are also a weighted average of changes in sector employment. However, the weights are the sectoral value added shares in nominal GDP.

13. We are still working on this session. As of now we use $\mu = 1.4$ from Eckert et al. (2019).

We measure real GNI with the following:

$$rGNI = \frac{(1-\delta)(\sum_{s=1}^{S} w^s L^s + bL^b)}{P} = \frac{\overbrace{\sum_{s=1}^{S} w^s L^s}^{\text{Value added}} + \overbrace{TD + TR}^{\text{Non-labor income}}}{P}$$

Real GNI equals the ratio of the country's total nominal income, including labor income and non-labor income from foreign transfers and tariff revenues, divided by the consumer price index. This is equivalent to the real income measure, a common proxy for welfare, in the international trade literature. Changes in real GNI is the following:

$$\widehat{rGNI} = \frac{\widehat{\sum_{s=1}^{S} w^s L^s + TD + TR}}{\widehat{P}}$$

Section B.2.2 shows, the first order approximation of change in real GNI equals the following:

$$\widehat{rGNI} = \overbrace{\sum_{s=1}^{S} \frac{w^s L^s}{GNI} \widehat{L}^s}^{\text{Employment effect}} + \overbrace{\frac{1}{GNI} \sum_{s=1}^{S} (E^s_{FB} \widehat{P^{s'}_B} - X^s(1 - s^s_B))}^{\text{Terms of trade effect}} + \overbrace{\frac{1}{GNI} \sum_{s=1}^{S} \sum_{i \in \Xi_F} \sum_{l \in \Omega^s_i} \tau^s_{il} T^s_{il} \widehat{T^s_{il}}}^{\text{Volume of trade effect}}$$

The result extends Caliendo and Parro (2015) by considering sector-specific labor supply as well as unemployment. The employment effect summarizes the aggregate impact of sectoral employment changes. The term is identical to changes in real GDP. The only difference is the denominator for changes in real GNI is nominal GNI, whereas the denominator for changes in real GDP is nominal GDP. The terms of trade effect summarizes the difference between changes in the exporting price and changes in the importing price. The volume of trade effect summarizes the losses in tariff revenues due to less trade. Tariffs contribute positively to the terms of trade effect and negatively to the volume of trade effect. The two extra terms indicate that conditional on sectoral employment changes, tariffs affect real GNI but not real GDP.

2.6.3 Aggregate Implications of Brazilian AD Tariffs

Table 2.11 show the counterfactual results. The total effect of all AD tariffs imposed in Brazil from 1995 to 2016 increased employment by 0.04% and real GDP by 0.04%. The positive own sector and upstream employment effect outweighed the negative downstream effect, leading to gains in aggregate employment and real GDP. On the other hand, AD tariffs reduce real GNI by 0.09%. This indicates the terms of trade and the volume of trade effects together made negative contribution to the real GNI, by a magnitude greater than the labor market effect.

To show the impact of input-output linkages, I compare predictions of the full model with the model abstracting from input-output linkages as well as the model with diagonal input-output linkages, where sectors only use the same sector's composite intermediate input. The differences are substantial. With the negative downstream employment effect, input-output linkages undermined the positive impact of AD tariffs on aggregate employment and real GDP and dampened the negative impact on real GNI, compared to without input-output linkages.[14] Compared to diagonal input-output linkages, actual linkages made the employment and real GDP effect less positive and the real GNI effect less negative.

Table 2.11: Aggregate Implications of All AD Tariffs

	Full model	Diagonal I-O	No I-O
Employment	+0.04%	+0.07%	+0.17%
Real GDP	+0.04%	+0.05%	+0.16%
Real GNI	–0.09%	–0.24%	–0.03%

The empirical findings suggest the aggregate employment effect of sectoral tariffs depends on the sector's position in the value chain. Tariffs on a more upstream sector lead to negative employment effects in more downstream sectors, and positive employment effects in

14. The same finding holds if we compare the model with diagonal input-output linkages to the one with no input-output linkages

fewer upstream sectors. Therefore, the aggregate employment effect of sector tariffs should decline with the upstreamness of the protected sectors. We test the intuition with model simulations. We consider 10% increase in sectoral tariffs, sector by sector, and we plot the aggregate employment effect against the upstreamness of the sectors. The sector upstreamness measures are computed with the method discussed in Antràs et al. (2012) and detailed procedures documented in Section B.2.3.

Figure 2.6 shows the results. The aggregate employment effect of all sectoral tariffs is positive. Indeed, the aggregate employment gains from protecting downstream sectors, e.g. food, agriculture and mining, etc., are higher than protecting the upstream sectors, e.g. metallurgy, chemical, rubber, minerals, etc. The association between aggregate employment effect of sectoral tariffs and the sector upstreamness is negative and significant at 10% confidence interval.

Figure 2.6: Aggregate Employment Effect of 10% Increase in Sectoral Tariffs

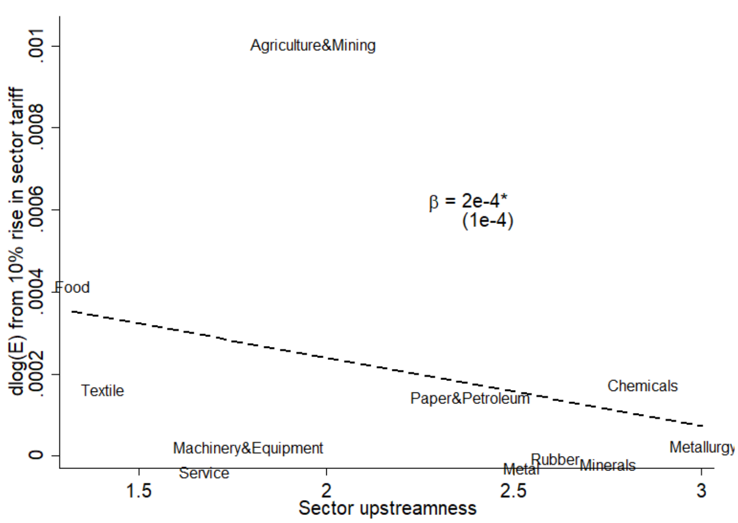


Figure B.6 in Section B.3 shows sectoral tariffs' aggregate implications on real GDP and GNI. Similar to the employment effect, the effect on real GDP is also negatively correlated with the sector upstreamness. However, the aggregate GNI effect is, if anything, weakly positively correlated with the sector upstreamness. The impact of sectoral tariffs on real GNI is negative for all sectors.

2.7 Conclusion

This paper studies the macroeconomic consequences of tariffs, with a focus on the employment effects. We compile data on all anti-dumping investigations in Brazil and match it to firm-level administrative employment data. Using a difference-in-difference strategy, we find that AD tariffs reduce imports. A 100% AD tariff reduces country-product line level import by 79.1%. The protected sectors increase employment significantly, where a 100% AD tariff corresponds to 3.3% employment increase. The employment effect propagates along the production networks. A 100% AD tariff reduces employment in the major downstream sector and increases employment in the major upstream sector of the protected sector by 4.8% and 18.7%.

To quantify the aggregate effects of these tariffs, we build a quantitative small open economy model of Brazil, with international trade, input-output linkages and labor force participation. The model can reproduce the micro-elasticities we found and match the aggregate moments of the Brazilian economy. We show that the total effect of all Brazilian AD tariffs imposed from 1995 to 2016 increased employment by 0.04%, real GDP by 0.04%, but decreased real GNI by 0.09%. Compared to the model that abstracts from input-output linkages, the full model predicts lower effect on aggregate employment, real GDP, and real GNI. The aggregate employment effect of sectoral tariffs depend on the protected sector's position in the value chain and is negatively associated with the sector upstreamness.

To conclude, the aggregate effect of tariffs depends on the macroeconomic variable of policy interest and the position of the tariffs in the value chain. Tariffs should be discouraged if consumer welfare weighs the most to policy makers. However, if the goal of tariffs is to increase employment, the tariffs should target sectors in the downstream of the value chain.

CHAPTER 3

THE LIFE-CYCLE DYNAMICS OF EXPORTERS AND MULTINATIONAL FIRMS

3.1 Introduction

Exporters' life-cycle dynamics are important to understand the long- and short-term effects of economic shocks and trade policy changes. In consequence, they have been extensively studied. However, exporting is only one possible option for firms to serve a foreign market. Firms may also choose to become multinational enterprises (henceforth, MNEs). Despite the overwhelming importance of these firms in the data, we know comparatively little about the life-cycle dynamics of MNEs and their possible interaction with exporter dynamics.[1]

This paper studies the life-cycle dynamics of exporters and MNEs. We exploit data on domestic firms, exporters, and MNEs from France and Norway and complement them with data on MNEs from Germany. Using these rich firm-level data, we first provide a comprehensive set of facts on the life-cycle dynamics of new exporters and new MNEs. First, the exit rates of new exporters in a foreign market are two to three times higher than those of new affiliates of MNEs in the same market. Second, conditional on survival in the market, average sales growth is similar for new exporters and new MNEs. However, the export growth profiles of exporters that switch to serving the market as MNEs are steeper than those of exporters that do not switch to MNE status. Finally, the exit rates of exporters at age one exhibit gravity—they are strongly correlated negatively with foreign market size and positively with distance—whereas those of young MNE affiliates are uncorrelated with

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1. MNE affiliates' global sales are twice as large as global exports, and they account for disproportionally large shares of aggregate output and employment in many countries (Antràs and Yeaple, 2014).

these foreign country characteristics. In contrast, entry rates do not present stark differences in their gravity patterns between the two groups. Our findings are strikingly very similar across the three economies under study, despite their different size and structure.

Guided by the facts, we develop a dynamic model of trade and foreign direct investment (FDI) based on the static model of the proximity-concentration trade-off in Helpman et al. (2004, henceforth, HMY). We introduce dynamics into the model by assuming that firm productivity evolves according to a Markov process and that MNE activities face a sunk entry cost. The model preserves the ranking of the export and MNE choice from the static model: the most productive firms become MNEs; firms with intermediate productivity levels become exporters; and the least productive firms serve only their home market. The sunk costs of MNE activities lead to a band of inaction, a range of productivity levels where existing MNEs do not exit a market, but non-MNEs with the same productivity do not enter. We show that the model is rich enough to *qualitatively* capture the facts we document.

In the calibrated version of the model, we incorporate sunk export costs and assume that fixed and sunk costs for both MNE and export activities are heterogeneous at the firm-destination level. We evaluate the *quantitative* fit of this model where HMY is coupled with dynamics features of Roberts and Tybout (1997). Although we do not target the exit and growth profiles of new exporters and new MNEs, nor the transition probabilities between domestic, exporter, and MNE status, the calibrated model captures the patterns observed in the data fairly well.

Our calibration shows that sunk MNE costs are much higher than sunk export costs: conditional on entry, the average sunk MNE cost across destinations represents 21.4 percent of the median French MNE's affiliate annual sales, while the average sunk export cost across destinations is less than one percent of the median exporter's annual sales to a destination. Similarly for Norway, conditional on entry, the average sunk MNE cost across destinations represents 26.8 percent of the median Norwegian MNE annual affiliate sales, with a very small estimated sunk export cost per destination. Across destinations, the average fixed cost for an affiliate represents about ten percent of the median Norwegian MNE affiliate sales, whereas the annual fixed export cost represents around 15 percent of the median Norwegian annual export sales to a destination. The median affiliate sales, however, are two orders of magnitude larger than the median export sales.

We evaluate the predictions of our calibrated model after a hypothetical trade-liberalization episode. We compare the predictions of our model with both exporters and MNEs to a calibrated version of the model with only exporters. Enriching the canonical dynamic model of trade to include MNEs—a first-order feature of the data—has consequences for the behavior of exporters. The main source of the different responses of exporters between the two models hinges on the right truncation induced by the inclusion of the MNE choice. Without the MNE choice, the most productive firms are exporters, as in the static model in Melitz (2003); with the MNE choice, the most productive firms become MNEs, as in HMY. In a dynamic setup, including the MNE choice not only truncates the exporters' distribution of productivity levels but also induces a higher exit likelihood for the most productive exporters, along with a truncation to the right of the distribution of growth rates. The fastest-growing exporters exit exporting and become MNEs when that option is allowed, whereas the slowest-growing exporters remain exporters. Those exporters with the highest productivity growth do not contribute to the average growth rate of exporters in the model with MNEs—because they change status—but they do so in the model in which the MNE option is not included.[2] While we find significant quantitative differences in the aggregate response of exporters to a trade-liberalization shock, we find only moderate differences in the life-cycle growth profiles of exporters between the models with and without MNEs.

Our paper contributes to several strands of the literature. First, we contribute to the small but growing literature that studies the joint behavior of exporters and MNEs using dynamic models. Ramondo et al. (2013), Fillat and Garetto (2015), Conconi et al. (2016),

2. This mechanism hinges on the assumption that exporters that become MNEs abandon exports to serve a foreign market. We find that exports relative to total sales in a foreign destination decrease sharply after MNE entry, consistent with the evidence documented by Belderbos and Sleuwaegen (1998), Bloningen (2001), and Head and Ries (2001), which use detailed firm- and product-level data.

among others, document and study different implications of the proximity-concentration trade-off in dynamic setups. We present new evidence and study implications related to the joint life-cycle behavior of exporters and MNEs.[3]

Second, we complement the extensive literature that studies exporters' dynamics. Early work by Baldwin (1989), Baldwin and Krugman (1989), and Dixit (1989), followed by Roberts and Tybout (1997), Ghironi and Melitz (2005), Das et al. (2007), Alessandria and Choi (2007), and Impullitti et al. (2013), point to the importance of the hysteresis created by sunk investments for understanding the effects of temporary and permanent shocks on aggregate trade flows and exchange rate movements. Our model combines elements of this rich dynamic literature on exporters with the canonical model of trade and FDI in HMY.

Our paper is closely related to Ruhl and Willis (2017), who document a set of life-cycle dynamics facts for Colombian exporters. We document a similar set of facts for new French and Norwegian exporters but also include facts for new MNEs. We find, as they do, that matching the observed patterns of survival and growth of new exporters requires very low sunk export costs, but this is not the case for MNEs. While they expand the canonical export model to include demand-side frictions, we include MNEs, a first-order feature of the data. We evaluate how far the model with MNEs goes in matching the data and whether the presence of MNEs changes the dynamic behavior of new exporters.[4]

3. Ramondo et al. (2013) include aggregate uncertainty into a two-period model of trade and FDI to analyze how the properties of the international business cycle affect the choice of the entry mode into foreign markets. Fillat and Garetto (2015) include aggregate uncertainty and sunk entry cost to study the consequences for asset pricing. Conconi et al. (2016) include a learning mechanism to explain that most firms enter foreign markets as exporters before opening an affiliate there. Early work by Rob and Vettas (2003) features demand uncertainty together with capacity constraints to study the mechanism behind the choice of firms to simultaneously export to and maintain affiliates in the same market.

4. The literature on the life cycle of domestic firms (summarized by Haltiwanger et al., 2013) and the literature on exporters find that models with a AR(1) firm-level productivity process, as in Hopenhayn (1992), deliver new firms that grow too large too quickly. Both literatures have resorted to demand frictions to slow down firm growth (see Foster et al. (2016) for domestic firms). In relation to exporters' growth driven by demand factors, papers such as Albornoz et al. (2012), Eaton et al. (2014), and Morales et al. (2019) focus on the dynamics of trade associated with learning. Arkolakis (2016) includes the cost of building a customer base in a dynamic model of trade. Fitzgerald et al. (2017) evaluate the importance of demand-learning firm growth versus customer-based firm growth to explain the life-cycle dynamics of firm export quantities and export prices. Araujo et al. (2016) document that in markets with better contracting institutions, new exporters start bigger but grow slower (conditional on survival). They propose a framework in which

The paper proceeds as follows. Section 3.2 describes the data, Section 3.3 documents the facts, Section 3.4 describes the model, Section 3.5 presents the calibration, Section 3.6 presents the counterfactual exercises, and Section 3.7 concludes.

3.2 Data

Our empirical analysis is based on rich firm-level panel datasets from France, Norway, and Germany. The French and Norwegian data contain information on domestic firms, exporters, and MNEs in varying levels of detail. In contrast, the German data contain extremely detailed information on the foreign affiliates of German MNEs but do not provide any information on exporters and domestic firms. Our analysis exploits the strengths of each of the three data sources, all of which cover a period of more than ten years.

France. The data span the years 1999-2011 and combine information from several sources. Information on a firm's domestic sales is from FICUS (1999-2007) and FARE (2008-2011); the export data are from the French customs; information on ownership links between firms in France and between firms in France and abroad are from LiFi; and information on foreign affiliate sales is from OFATS (2007, 2009-2011). We restrict the sample to firms that are subject to the BRN taxation regime and, for some of the analysis, to the subperiod 1999-2007.[5]

The data contain information on each firm's domestic sales and export sales by destination, as well as the location of foreign affiliates of French MNEs. Information on foreign affiliate sales is available only for a subset of large MNEs and for some (non-consecutive)

imperfect contract enforcement, together with imperfect information (and previous export experience in other foreign markets), interact to match the observed pattern of exporter growth and survival.

5. The FICUS/FARE databases provide balance sheet data on virtually all French firms. The principal data source is firms' tax statements. The BRN regime applies to larger firms. We conducted our analysis also including all firms. As small firms rarely export or conduct FDI, results are very similar. The period restriction is made to avoid structural breaks in the time series, as both the industry classification and the definition of the domestic sales variable changed in 2008.

years.[6] While affiliate sales are recorded annually, exports are recorded monthly. Following Kleinert et al. (2015), we consolidate the information on domestic activities, exports, and foreign affiliates to the level of the French group (i.e., if firms A and B belong to firm C, we consolidate all three firms). We keep a consolidated firm in the sample if at least one of its domestic members is active in the manufacturing sector in at least one year.[7] For independent firms, we focus on those that operate in the manufacturing sector in at least one year. Our sample contains only firms headquartered in France and excludes French affiliates of foreign MNEs.

We consider MNE-country pairs and exporter-country pairs with multiple entry and exit over the sample period.[8] We restrict our attention to majority-owned affiliates of French MNEs, which account for around 80 percent of all affiliates of French MNEs. We aggregate both exports and FDI at the parent firm-foreign destination-year level. We end up with a sample of 963,375 firm-year observations. The upper panel of Table C.1 shows that 1.6 percent of firms in our sample are MNEs and 28.7 percent are non-MNE exporters. French MNEs account for almost 60 percent of employment in our sample, while non-MNE exporters account for more than 30 percent. The median (mean) French MNE operates in two (five) markets, with a handful of MNEs serving more than 81 markets, while the median (mean) exporter serves four (ten) markets, with some exporters serving more than 178 markets (top-coded to preserve confidentiality).

Norway. The data, which span the years 1996-2006, include information on each firm's domestic sales, as well as export and foreign affiliate sales by destination country. The data nest balance sheet information on firms in the Norwegian manufacturing sector from Statistics Norway's Capital Database; information on exporters from customs declarations; and

6. OFATS is a survey of French MNEs with affiliates outside of the European Union. The sample is biased toward large MNEs, as a comparison of domestic sales for MNEs in OFATS and the other sources reveals.

7. This consolidation implies that wholesale firms in France may be part of our sample, which is important because large French groups often channel exports through wholesale affiliates.

8. Restricting the sample to MNE-country and exporter-country pairs with a single entry and exit over the sample period yields very similar results.

data on firms' foreign operations from the Directorate of Taxes' Foreign Company Report. The coverage is comprehensive: all foreign affiliates of Norwegian firms in the manufacturing sector, as well as 90 percent of Norwegian manufacturing revenues, are included; firms in the oil sector are excluded.

We consider MNE-country pairs and exporter-country pairs with multiple entry and exit over the sample period. We include both majority- and minority-owned foreign affiliates of Norwegian parents and adjust the affiliate sales by the parent's ownership share.[9] Our sample consists of 89,018 firm-year observations. As the lower panel of Table C.1 shows, only 1.5 percent of Norwegian firms have affiliates abroad, and 36.4 percent are non-MNE exporters. Norwegian MNEs represent more than 13 percent of total manufacturing employment in Norway, while exporters represent 63 percent. The median (mean) Norwegian MNE operates in two (four) markets, with a maximum at 37 markets, while the median (mean) exporter serves three (seven) markets, with a maximum of 122 markets.

Germany. The data, which span the years 1999-2011, contain detailed balance sheet information about foreign affiliates of German MNEs. The main data source is the Micro-database Direct investment (MiDi; see Schild and Walter, 2015). Information about parent firms is limited; for instance, it is not possible to distinguish between domestic and export sales of the parent.

We consolidate the information on direct and indirect ownership shares and restrict our attention to majority-owned affiliates, which represent 95 percent of foreign affiliates of German MNEs and affiliates whose parent operates in the manufacturing sector or whose parent is a holding company belonging to a corporate group in the manufacturing sector in at least one year.[10] We consolidate affiliates at the parent firm-foreign destination-year level

9. A 20 percent ownership threshold, not ten percent, is used to distinguish direct from portfolio investment. The ownership shares considered for Norway are lower than the ones for France (20 versus 50 percent) in order to gain observations.

10. Reporting foreign investments to the German central bank is compulsory, but the reporting requirements change over time. We adjust the sample to unify thresholds: we include only affiliates with either a participation of ten percent and revenues of at least ten million DM (euro equivalent) or with participation of at least 50 percent and revenues of at least three million euro. We consolidate ownership shares and restrict

and end up with a sample of 37,843 parent-year observations. Only 0.21 percent of German firms have affiliates abroad, but they account for 27 percent of total sales in Germany (Buch et al., 2005). The median (mean) German MNE operates in one (three) country(ies), with some parents operating in more than 27 markets (top-coded to preserve confidentiality).

3.3 Facts on the Life-cycle Dynamics of Exporters and MNEs

We document three novel facts about the life-cycle dynamics of MNEs and exporters. First, we show the life-cycle patterns of exit rates. Second, we present evidence on life-cycle growth. Third, we document the relation between exit and entry rates across destination markets and the characteristics of those markets. Taken together, these facts are informative about the features to be included in a dynamic model of exports and FDI, and we explain this connection in more detail below.

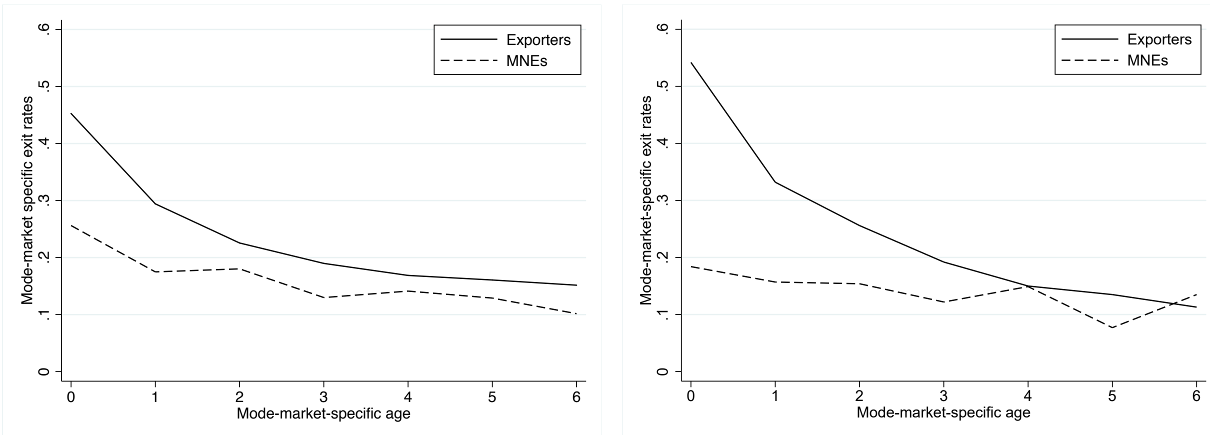
We study the behavior of new firms that start exporting to—or open an affiliate in—a foreign country. We focus on the firm's main mode of international operation and distinguish between non-MNE exporters and MNEs. That is, only firms that are not MNEs are considered exporters to a foreign destination, whereas firms with foreign operations in a market are considered MNEs whether or not they export contemporaneously to the same foreign destination. This distinction is motivated by the observation that FDI is the dominant mode of serving the foreign market after MNE entry. Appendix Figure C.1 shows that the average ratio of exports to total foreign sales decreases from 100 percent to around ten percent in three years after a firm opens its first affiliate in a market and that around ten percent of MNEs with exports to that market before MNE entry completely discontinue exporting in two years after they switch to FDI.

Our facts are based on observations at the firm-destination-year level. For expositional purposes, in the body of the paper, we present figures that show averages across the desti-

the sample to majority-owned affiliates only after unifying the reporting threshold.

Figure 3.1: Exit Rates by Age.

(a) France (b) Norway



Notes: Number of exits from a mode-market relative to the number of firms active in a mode-market, by mode-market-specific age, for exporters and MNEs. Observations are at the firm-destination-year level. We show averages across destinations weighted by each destination's share of export (MNE) firms. Exporters refers to non-MNE exporters.

nations, weighted by each destination's share of export (MNE) firms. Appendix Table C.2 contains the results of ordinary least squares (OLS) regressions that include a battery of fixed effects and additional controls.

3.3.1 Exit Rates

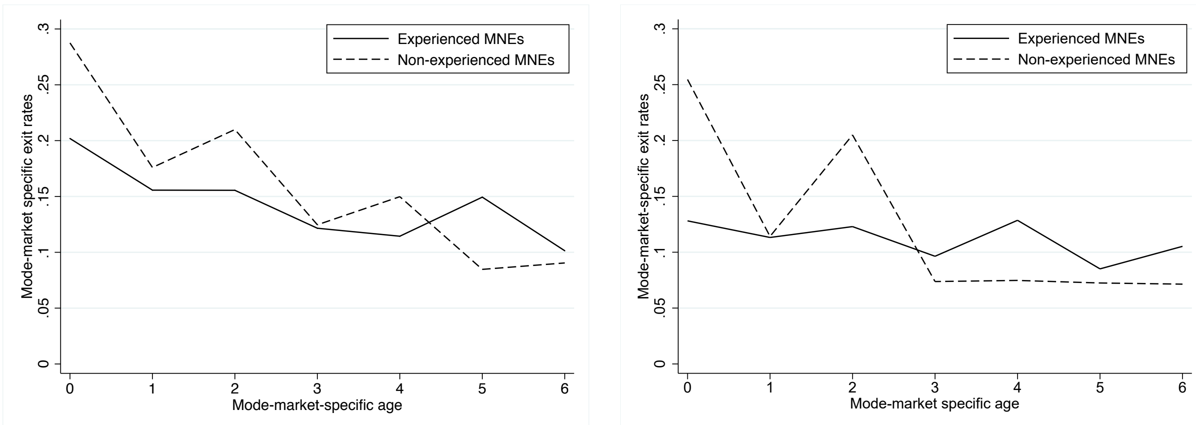
We first study the exit patterns of new exporters and new MNEs. We focus on exit from the current mode of international operation and a foreign country.

Figure 3.1 plots the exit rates of exporters and MNEs at the firm-destination level by age. Exit rates are calculated as the number of MNEs (exporters) that exit a given destination relative to the number of active MNEs (exporters) in that destination at each age. Age refers to the number of years after entry in a given market-mode, with age in the entry year equal to zero. The figure presents averages across all firm-destination pairs.

On average, MNEs in a foreign market have between one-third and one-half of the exit rates of exporters in their first year of life. For both modes of internationalization, exit rates are declining with age, though more drastically for exporters. It is remarkable that results

Figure 3.2: Exit Rates by Age: Experienced versus Non-experienced MNEs.

(a) France (b) Norway



Notes: Number of exits from a mode-market relative to the number of firms active in a mode-market, by mode-market-specific age. Experienced MNEs are new affiliates of MNEs that exported to a foreign market for one or more years before opening an affiliate there. Observations are at the firm-destination-year level. We show averages across destinations weighted by each destination's share of MNE firms.

are qualitatively and quantitatively similar between France and Norway.[11]

A formal test confirms that French exporters are around 15 percentage points more likely to exit than foreign affiliates of French MNEs in the first two years after entry, but the difference disappears later in life. For Norway, the difference in exit rates between exporters and MNEs is 30 percentage points at entry, but, after two years, the difference is not statistically different from zero. This finding is summarized in Appendix Figure C.2.

A reasonable conjecture is that having experienced a destination market as an exporter before entering with an MNE affiliate has an effect on the chances of survival in that market. We explore this evidence in Figure 3.2. We define an "experienced MNE" as an MNE that exported to a given destination market in any year before opening a foreign affiliate there.[12] The exit rate of experienced MNEs is almost 10 percentage points lower, on average, in the first year after entry relative to the exit rate of new affiliates without export experience. However, this advantage disappears later in life (see also Appendix Figure C.3).

11. Eaton et al. (2008) document similar exit rates for new Colombian exporters at the firm-destination level. In unreported evidence, we find that the exit patterns of new MNEs from Germany are also remarkably similar to the patterns found for French and Norwegian MNEs.

12. Experienced MNEs represent almost 60 percent of new MNEs for France (47 percent for Norway).

We conclude that:

Fact 7. New MNEs in a foreign destination have lower exit rates than new exporters in that destination. MNEs with previous export experience in a market have lower exit rates at entry than MNEs without that experience.

The large difference between the exit rates of exporters and MNEs suggests the presence of sunk costs of MNEs that are much higher than the sunk costs of exporting. Additionally, the co-existence of experienced and non-experienced MNEs supports an HMY-type model with time-varying firm productivity.

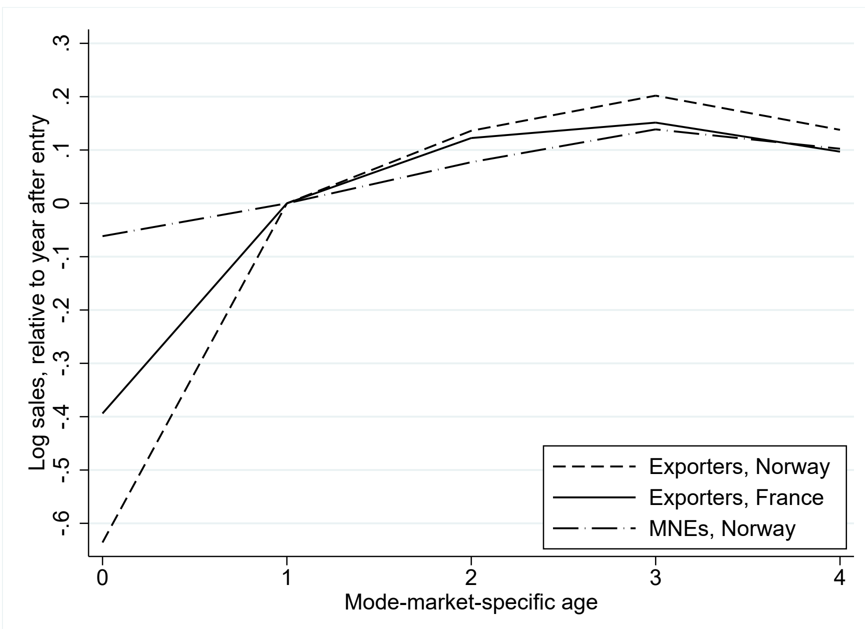
Robustness. One may be concerned that the differences in exit rates documented in Figure 3.1 are not due to differences between the two modes of internationalization, but that they are artifacts of definitions of age and exit. Firms may switch between modes so that exporters become MNEs, and MNEs become exporters, for example. To exclude the possibility that such patterns are driving our results, we present two robustness results using the French data. First, we recompute age as the number of years that the firm is active in a market, regardless of its international mode of operation; that is, we compute market-specific, rather than mode-market-specific, age. Second, we redefine exit as complete exit from the market rather than as exit from either exporting or MNE activities in a market. Baseline results still hold, as columns (3) and (4) in Appendix Table C.2 show. Additionally, one may be concerned that the entry mode of FDI plays a role: if MNEs enter a market through merger and acquisition (M&A), they take over pre-existing domestic firms, whereas Greenfield affiliates are, by definition, brand-new firms. Using the data from Germany, Appendix Figure C.5a shows that there is no difference in exit rates between the two modes of entry of foreign affiliates of German MNEs.[13]

13. In unreported results for France, we find that our baseline results are robust to: splitting the sample into European Single Market (ESM) and non-ESM countries to address concerns about the different reporting thresholds for exports to EU and non-EU members; using the unconsolidated rather than the consolidated data; splitting the sample into the 1999-2005 and 2006-2011 periods; including cohort, rather than year, fixed effects; and correcting for partial-year effects. Additionally, results at the firm level are very similar to results at the firm-destination level.

3.3.2 Sales Growth

Figure 3.3 shows the sales growth of exporters and MNE affiliates by age. We focus on firms that survive for at least four years in a mode-market and demean the firm-destination observations by industry, year, and destination fixed effects. We normalize sales with respect to one year after entry because the entry year may be contaminated, particularly for exporters, by the so-called partial-year effects—artificially high first-year growth rates attributed to firms that start operations in the middle of the calendar year (see Bernard et al., 2017). Columns (5) and (6) in Appendix Table C.2 show the OLS results.

Figure 3.3: Sales Growth by Age.



Notes: Log of firm-destination export (affiliate) sales with respect to firm-destination export (affiliate) sales in the year after entry. Firms have five or more years in the market. Observations are at the firm-destination-year level. We show averages across destinations weighted by each destination's share of export (MNE) firms. Log of sales are first demeaned by industry, year, and destination fixed effects. Exporters refers to non-MNE exporters.

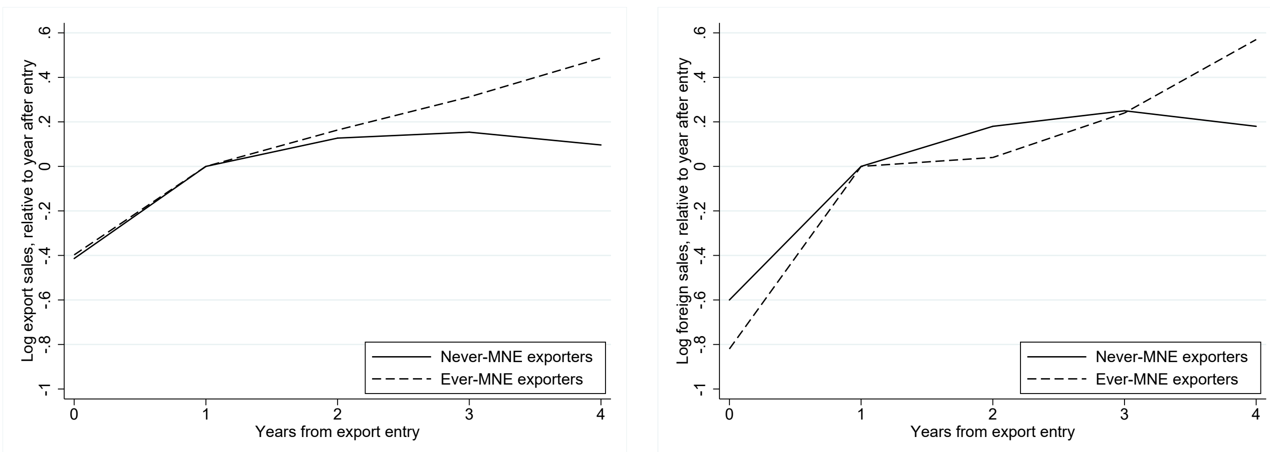
Figure 3.3 shows that foreign sales grow at similar rates for French exporters, Norwegian exporters, and Norwegian MNEs, conditional on surviving for at least four years in the market. Growth rates are markedly different only between age zero and age one, but as outlined, this difference is likely attributable to partial-year effects.[14]

14. Unreported evidence for Germany shows that sales profiles of German MNEs are quite similar to the

Lumping together exporters that eventually become MNEs with the ones that never do may mask substantial heterogeneity. Figure 3.4 shows that, in the French data, the group of exporters that switch to FDI to serve a given market (”ever-MNE” exporters) clearly grow faster, in terms of exports, in the years previous to MNE entry, than the exporters that never become MNE (”never-MNE” exporters). In the Norwegian data, the difference is less marked, but the number of observations also decreases substantially.

Figure 3.4: Exporters’ Sales Growth by Age and Type.

(a) France (b) Norway



Notes: Log of firm-destination export sales with respect to firm-destination export sales in the year after export entry, for firms with five or more years in the market as exporters. Observations are at the firm-destination-year level. We show averages across destinations weighted by each destination’s share of export firms. Log of sales are first demeaned by industry, year, and destination fixed effects. Never-MNE exporters are exporters that, in our sample period, do not change to MNE status. Ever-MNE exporters are exporters that become MNEs after export entry. Exports for ever-MNE exporters are computed for the years before MNE entry, for exporters that enter MNE status after exporting for four years into a given market.

We conclude that:

Fact 8. Average life-cycle sales growth is similar for exporters and MNEs. However, ever-MNE exporters grow, on average, much faster before MNE entry than do never-MNE exporters.

The similarity between export and affiliate sales growth suggests that productivity evolves in a similar way for exporters, parents, and affiliates of MNEs. The higher export sales growth

ones of Norwegian MNEs.

of ever-MNEs relative to never-MNEs supports a strong role for self-selection of firms into the different modes of internationalization, as in HMY.

Robustness. One may be concerned that normalizing sales growth by the year after entry is not sufficient to adequately account for partial-year effects. As the French data contain monthly export sales, we can correct for partial-year effects by calculating 12-month growth rates (as also done by Bernard et al. 2017). A comparison of columns (5) and (7) in Appendix Table C.2 confirms that the entry year does seem contaminated by these effects: growth at age one is much higher for the calendar-year data than for the adjusted data; for subsequent ages, growth rates are quite similar, which supports the age-one normalization in Figure 3.3.

To document the selection induced by non-random survival, Appendix Figure C.4 shows growth profiles by tenure in the market. As expected, firms that survive longer grow faster. The differences are less pronounced for MNEs, but for all tenure lengths, exports from age one onward grow at rates similar to MNE sales.

Finally, one may rightly be concerned that sales growth rates of new MNEs differ between new MNE affiliates that enter the market through M&A versus Greenfield FDI. One may expect that, as brand-new firms, affiliates created through Greenfield FDI grow faster than affiliates created through M&As, which are older.[15] Using the German data, Appendix Figure C.5b shows that, as expected, MNEs that enter through M&A grow less than MNEs that enter a market with a Greenfield project. Nonetheless, the differences are not large if one disregards the entry year, again supporting our normalization choice in Figure 3.3.

3.3.3 Entry, Exit, and Gravity

The previous two facts pool firms across different destination countries. Country characteristics, however, may be an important determinant of a firm's development over its life cycle.

15. Part of the higher growth rate may be due to partial-year effects for MNEs because some affiliates may start operating later in the year rather than January.

To explore this issue, we study the correlation between first-year exit rates and entry rates of exporters and MNEs, and two country characteristics that are prominent in the international trade literature: the size of the destination country, as measured by GDP, and the distance of the destination country from the firm's home country. Our finding is that:

Fact 9. First-year exit rates of exporters exhibit gravity, whereas those of MNEs do not. Entry rates for both exporters and MNEs exhibit gravity.

Figure 3.5 shows scatter plots of first-year exit rates against market size (upper panels) and distance (lower panels) for France. We restrict the sample to countries with at least ten firm-destination observations. We relegate results for Norway, which are extremely similar, to Appendix Figure C.6.

The cross-country patterns of first-year exit between the two modes of international operation are strikingly different: while exporters operating in smaller and more distant markets are more likely to stop operations right after entry, it is not clear that affiliates of MNEs do.[16] An OLS regression shows that the exit probability increases by almost seven percentage points when distance doubles, and it decreases by 3.4 percentage points when GDP doubles, with both coefficients significant at the one percent level. In contrast, the effects of GDP and distance on the exit rates of MNE affiliates are insignificant.

Figure 3.6 shows the same scatter plots for the entry rates. Unlike the exit rates, the entry rates for both exporters and MNEs are correlated with country characteristics. In OLS regressions, we find that the elasticities with respect to market size are quite similar for exporters and MNEs, but the distance elasticities are three times as large for exporters.[17] Appendix Figure C.7 shows that, for Norway, distance elasticities are also higher for exporter entry than for MNE entry, and market size elasticities are similar across the two entry modes.

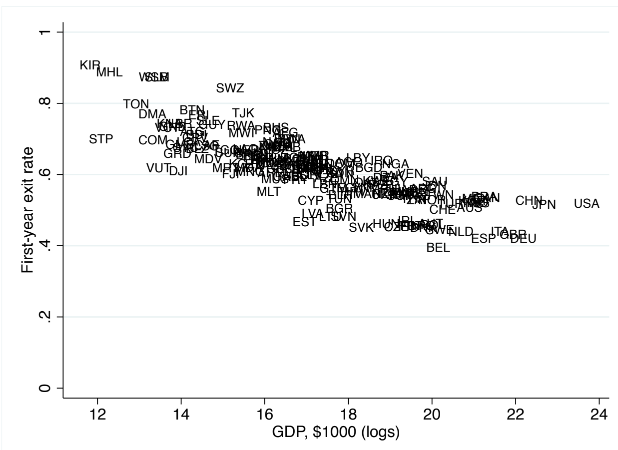
16. Using data from Argentina, Albornoz et al. (2016) document a similar pattern for exporters: survival probabilities decrease with distance. They rationalize this finding with a model in which sunk export costs increase with distance proportionally less than fixed costs.

17. The elasticities with respect to market size are 0.52 (s.e. 0.027) and 0.41 (s.e. 0.033) for exporters and MNEs, respectively; distance elasticities are -1.15 (s.e. 0.105) vs -0.36 (s.e. 0.094).

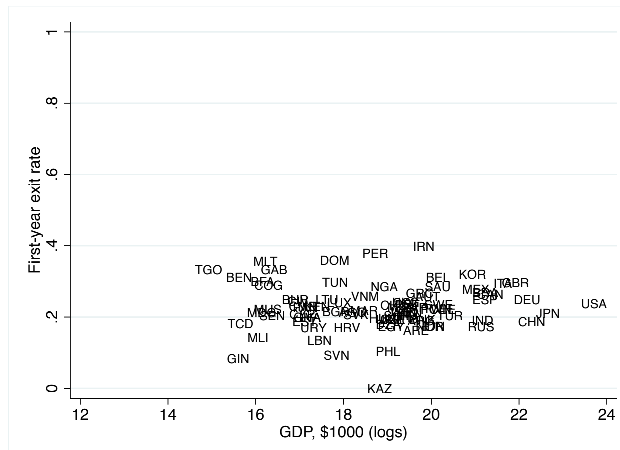
Figure 3.5: First-year Exit Rates and Market Characteristics, France.

Market Size

(a) Exporters

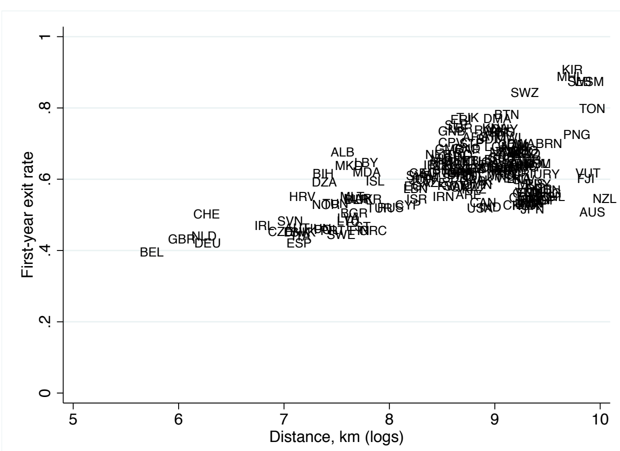


(b) MNEs

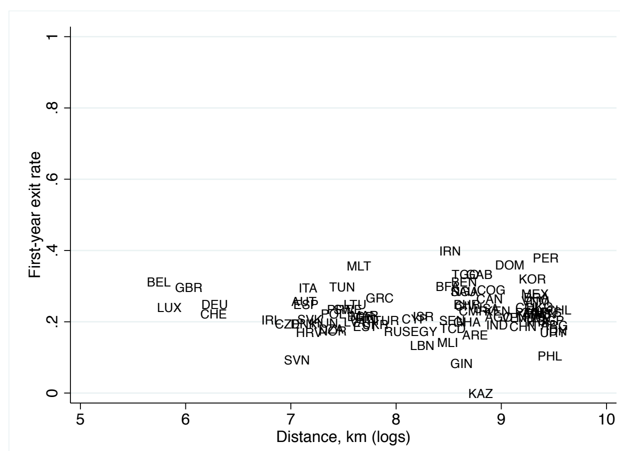


Distance

(c) Exporters



(d) MNEs

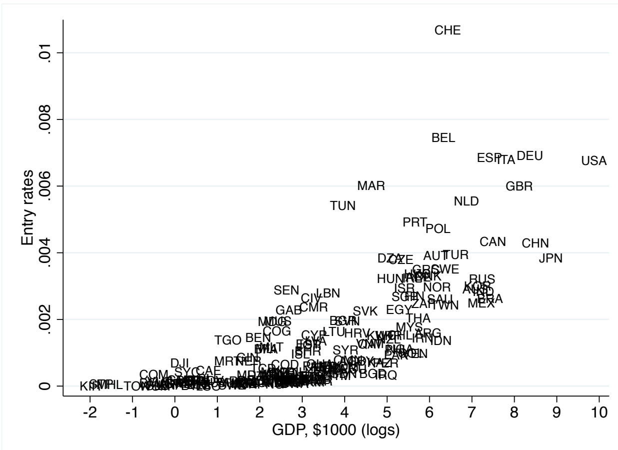


Notes: Number of exits from a mode-market relative to the number of firms active in a mode-market, for exporters and MNEs, in the first year upon mode-market entry (i.e., age zero). Destinations with ten or more firm-year observations and with available GDP data. Exporters refers to non-MNE exporters. GDP data from *International Financial Statistics* (IMF). Distance data from *CEPII* (Mayer and Zignago, 2011).

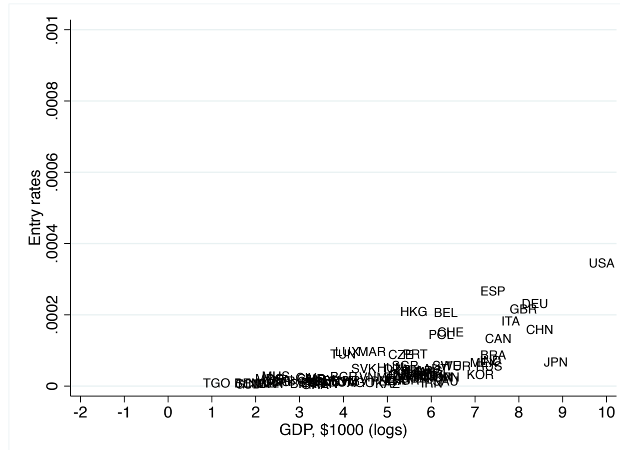
Figure 3.6: Entry Rates and Market Characteristics, France.

Market Size

(a) Exporters

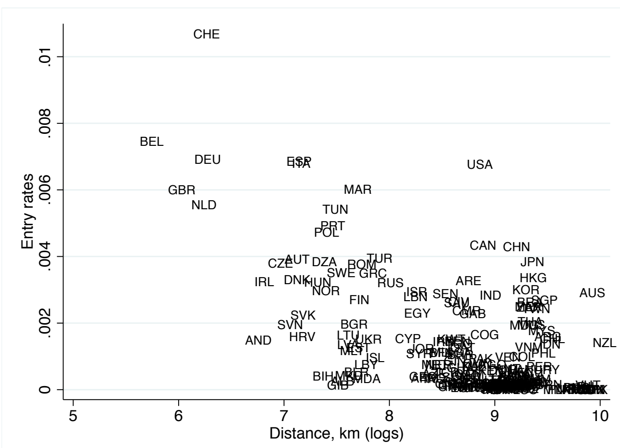


(b) MNEs

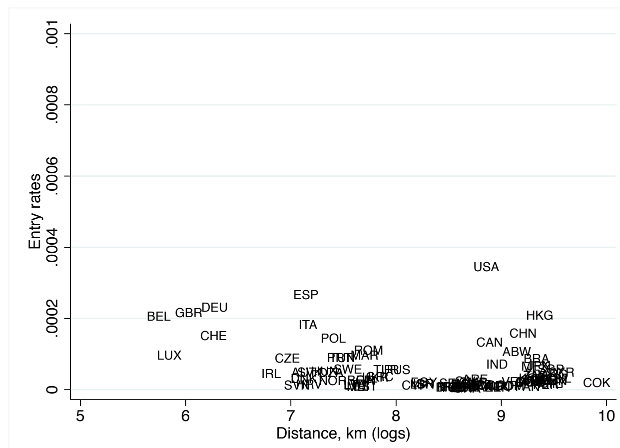


Distance

(c) Exporters



(d) MNEs



Notes: Number of entries to a mode-market relative to the number of domestic firms active in the home market. Destinations with ten or more firm-year observations and with available GDP data. Exporters refers to non-MNE exporters. GDP data from *International Financial Statistics* (IMF). Distance data from *CEPII* (Mayer and Zignago, 2011).

The difference in first-year exit rates between exporters and MNEs suggests that the sunk costs of entry are higher for MNEs than for exporters. This fact is thus key in informing dynamic models of exporters and MNEs. The patterns observed for entry rates suggest that exporters face distance-dependent trade costs, whereas MNEs do not, consistent with the proximity-concentration trade-off in HMY. A static model thus suffices to capture this fact.

Robustness. Exporters and MNEs are active in different countries: firms penetrate many more countries as exporters than as MNEs. To exclude the possibility that the difference in country coverage is driving the results, we replicate our analysis for only those countries with both exporting and multinational activity for France. The patterns of both first-year exit and entry rates for exporters are less pronounced than in the full sample but are still clearly correlated with country characteristics.[18] For MNEs, the results are unchanged.

3.4 A Dynamic Model of Exporters and MNEs

Guided by the facts documented in the previous section, we build a dynamic model of export and MNE activities that is based on the model of the proximity-concentration trade-off with heterogeneous firms in HMY, extended to include an autoregressive process for firm productivity and sunk costs for MNE activities. We construct a model of "horizontal" FDI (i.e., affiliate sales are destined to the host market only). For simplicity, export platforms (i.e., locating production in market l and serving a third market n through exports from l) and intrafirm trade are excluded.[19] We focus on horizontal FDI instead of vertical FDI as the prior literature has found horizontal FDI to be the main form of FDI activity (see Ramondo et al., 2016). We use this simple model to establish a few propositions related to exit and sales growth of exporters and MNEs, with the goal of explaining the facts presented in Section 3.3. We later extend the simple model by further incorporating sunk export costs and assuming that all sunk and fixed costs are firm-destination specific. The full model is then calibrated to the data and aids in simulating counterfactuals.

18. Export exit elasticities with respect to GDP and distance are -0.023 (s.e. 0.003) and 0.046 (s.e. 0.005), whereas entry elasticities with respect to the same variables are 0.23 (s.e. 0.026) and -0.53 (s.e. 0.112).

19. See Ramondo and Rodríguez-Clare (2013) and Tintelnot (2017) for recent models of export-platform FDI.

3.4.1 Setup

We build a partial equilibrium model with two countries, Home and Foreign. Time is discrete. Labor is the only factor of production and is supplied in fixed quantity. The wage in each country is pinned down by a constant returns to scale freely tradable homogeneous good sector and is normalized to one, $w = 1$.

Goods that are exported to the foreign country are subject to an iceberg-type trade cost, $\tau \geq 1$, while production in foreign affiliates is subject to an efficiency loss given by $\gamma \geq 1$, with $\tau > \gamma$, consistent with the empirical evidence (Antràs and Yeaple, 2014). A firm that exports incurs a per-period fixed cost, f^x, and a firm that operates an affiliate in the foreign country incurs a per-period fixed cost, f^m, with $f^m/f^x > (\gamma/\tau)^{\sigma-1}$, as in HMY. Firms that decide to open an affiliate have to pay a sunk cost, $F^m > 0$, at the time of MNE entry. Fixed and sunk costs are paid in units of labor.

A firm is characterized by a core efficiency level, $\phi \equiv \exp(z)$, that evolves over time following a first-order autoregressive AR(1) process,

$$z' = \rho z + \sigma_\epsilon \epsilon',$$

where $0 \leq \rho < 1$ and $\epsilon' \sim N(0, 1)$. If a firm from the home country opens an affiliate in the foreign country, that affiliate inherits its parent's productivity process.

There exists a continuum of firms that compete monopolistically. The mass of home firms, M, is fixed and normalized to one. We assume constant elasticity of substitution (CES) preferences, with the elasticity of substitution denoted by σ. Firms optimally charge a constant markup, $\kappa \equiv \sigma/(\sigma - 1)$, over marginal costs, so that sales follow the standard CES formula. Let $E \equiv \kappa^{1-\sigma} X/P^{1-\sigma}$ be foreign demand. We assume that the firms from the home country account for only a small fraction of the overall sales in the foreign country, so that the price index in the foreign country is taken as fixed. We normalize $E_{home} = 1$ so that E is the size of Foreign relative to Home.

Static profit maximization implies that domestic sales are given by $X^d(\phi) = \phi^{\sigma-1}$, while exports from Home are $X^x(\phi) = E\phi^{\sigma-1}\tau^{1-\sigma}$, and affiliate sales in Foreign are $X^m(\phi) = E\phi^{\sigma-1}\gamma^{1-\sigma}$.

Firms have two possible states: producing in the home market for domestic consumers only and, potentially, for foreign consumers (D); or producing in the home market for domestic consumers and in the foreign market for foreign consumers (M). The value of being a multinational firm with core productivity ϕ is given by

$$V(\phi, M) = \frac{X^d(\phi)}{\sigma} + \max\left\{\frac{X^m(\phi)}{\sigma} - f^m + \beta EV(\phi', M \mid \phi)\,, \right. \\ \left. \max(0, \frac{X^x(\phi)}{\sigma} - f^x) + \beta EV(\phi', D \mid \phi)\right\}; \tag{3.1}$$

and the value of being a domestic firm with core productivity ϕ is given by

$$V(\phi, D) = \frac{X^d(\phi)}{\sigma} + \max\left\{\frac{X^m(\phi)}{\sigma} - f^m - F_e^m + \beta EV(\phi', M \mid \phi)\,, \right. \\ \left. \max(0, \frac{X^x(\phi)}{\sigma} - f^x) + \beta EV(\phi', D \mid \phi)\right\}. \tag{3.2}$$

The optimal policy for an MNE is to discontinue the foreign investment if being domestic (state D) entails larger discounted expected profits than being an MNE (state M). This policy is characterized by a cutoff value of productivity, $\bar{\phi}^m$. If productivity falls below $\bar{\phi}^m$, a current MNE exits the foreign market and produces only in the domestic market. If productivity exceeds $\bar{\phi}^m$, the firm remains an MNE (state M). Similarly, the optimal policy for a domestic firm is characterized by a productivity cutoff level, $\bar{\phi}_e^m$. Once the productivity level of the domestic firm exceeds $\bar{\phi}_e^m$, it becomes an MNE. It is possible to rank the two productivity cutoffs: since the second terms in the outer maximization problem in (3.1) and (3.2), respectively, are identical, and X^m and V are increasing in ϕ, as the expectation operator preserves monotonicity, it follows that $\bar{\phi}^m < \bar{\phi}_e^m$. This implies that the model delivers an "inaction" zone that exists by virtue of the sunk cost of doing FDI (Baldwin, 1989). Domestic firms with productivity $\phi \in [\bar{\phi}^m, \bar{\phi}_e^m]$ remain domestic, whereas MNEs with productivity $\phi \in [\bar{\phi}^m, \bar{\phi}_e^m]$ remain MNEs. The inaction zone thus creates persistence in the MNE status.

Without sunk MNE costs, it suffices to have $f^m/f^x > (\gamma/\tau)^{1-\sigma}$ for MNEs to have a higher exit cutoff than exporters, $\bar{\phi}^m > \bar{\phi}^x$. With sunk MNE costs, that assumption is not enough. We proceed by assuming that the MNE exit cutoff is higher than the exporter exit cutoff.[20]

3.4.2 Model Predictions

We now explain how the model captures the facts documented in Section 3.3.

The model can capture Fact 1 under some conditions. The "inaction" zone created by the presence of sunk and fixed costs makes MNEs less likely to exit than in a setup with no sunk costs. That exit rates for MNEs are lower than for exporters—and by how much—depends on the values of the model's parameters. Proposition 2 states the result.

Proposition 2. Let the entry cutoff for MNEs $\ln(\bar{\phi}_e^m) = \bar{z}_e^m$ and the entry and exit cutoff for exports $\ln(\bar{\phi}^x) = \bar{z}^x$ relate as $\bar{z}_e^m = \bar{z}^x + \varphi$, with $\varphi > 0$. There exists φ^* such that for $0 \leq \varphi < \varphi^*$, the exit probability upon entry is higher for an exporter than for an MNE with identical productivity before exit.

Proof. See Appendix C.2.1.

The effect of export experience on the exit probability of an MNE is driven by selection on productivity, as Proposition 3 shows.

Proposition 3. The probability that a new MNE exits upon entry is lower if the firm switched from export to MNE activity than from domestic to MNE activity.

20. The assumption that $\bar{\phi}^m > \bar{\phi}^x$ is implicit in the way we wrote the value functions: it rules out that, for the marginal MNE, the value of producing at home for the domestic market only is higher than the value of producing at home for the domestic and foreign market. In our calibrations and simulations below, this ranking of cutoffs is never violated.

Proof. See Appendix C.2.2.

All new MNEs have received a sufficiently good productivity shock that induces them to enter a market as MNEs. As exporters are more productive than domestic firms, firms with export experience enter MNE status with a productivity level that is higher than that of a firm with no export experience. Given that productivity follows a Markov process with log-normal distributed shocks, and the exit cutoffs are the same for MNEs with and without export experience, more productive firms at the time of entry are less likely to have a productivity draw that falls below the exit cutoff in the subsequent period. Proposition 3 is for the case of positive sunk costs of MNE entry, but the result also holds in the case of no sunk MNE costs.

Both exporters and MNEs follow the same productivity process in the model. However, this does not automatically lead to the similar sales growth rates of exporters and MNEs documented in Fact 8. The selection patterns that arise from the inclusion of fixed and sunk costs have subtle effects on the growth rates. Ultimately, how well the model can capture the similarity of exporter and MNE growth rates remains a quantitative question, which we address in Section 3.5. Self-selection of firms also drives the higher sales growth of ever-MNE exporters relative to never-MNE exporters.

Finally, the inclusion of sunk MNE costs allows the model to capture Fact 9: first-year exit rates of new exporters are correlated with country characteristics, whereas for MNEs, they are not. The following proposition shows the result.

Proposition 4. Let $\bar{z}$ be the productivity exit cutoff from a mode of international operation. The increase in the first-year exit probability when $\bar{z}$ increases is larger when sunk costs of entry into the mode are zero than when sunk costs are positive.

Proof. See Appendix C.2.3.

Because of MNE sunk costs, the productivity level required for MNE entry exceeds the productivity level for MNE exit, $\bar{\phi}_e^m > \bar{\phi}^m$. The higher the sunk costs, F^m, the higher the option value of being an MNE and, hence, the larger the zone of inaction and the less sensitive the exit behavior to differences in variable profits.[21]

An important implication of the model is that new exporters in an environment without the option to become an MNE have different life-cycle properties than in an environment where they can self-select into MNE activities. Intuitively, including the MNE choice not only truncates the exporters' distribution of productivity levels but also induces a truncation to the right of the distribution of productivity growth rates. Only firms with productivity above the export threshold but below the MNE threshold in two consecutive periods contribute to export productivity (and sales) growth. For each $z \in [\bar{\phi}^x, \bar{\phi}^m]$, there is a maximum possible increase in productivity such that an exporter remains an exporter. Exporters that receive a higher productivity shock turn into MNEs when the MNE choice is allowed. Those exporters with the highest productivity shocks, and thus the highest sales growth, do not contribute to the average growth rate of exporters in the model with MNEs (because they change status), but they do contribute in the model without MNEs. In turn, because the maximum possible growth in productivity decreases with productivity levels, smaller exporters are the ones contributing to average productivity in the model without MNEs, but not in the model with MNEs (because they switch status). As a consequence, exporters in the model for which the MNE option is present have higher average productivity early in life and, hence, lower exit rates.

Proposition 5 derives this result formally for the marginal exporter.[22]

Proposition 5. Assume that firm productivity follows a first-order autoregressive process, $z_t = \rho z_{t-1} + \sigma_\epsilon \epsilon_t$, with $\epsilon_t \sim N(0,1)$, and $0 \leq \rho < 1$, and assume that sunk costs of MNE entry are zero, $F^m = 0$. Consider the firm with $z_{t-1} = \underline{z}$ and $z_t > \underline{z}$, where $\underline{z}$ denotes

21. In an export-only model, Albornoz et al. (2016) show that the probability of export survival in a market increases with the ratio of sunk to fixed costs. While their result is about how export survival rates change with sunk costs, our Proposition 4 states a difference-in-difference result: how the survival—or, equivalently, exit—probability changes in response to a change in market characteristics, for different levels of sunk costs.

22. In Appendix C.1.1, we show that the growth rate for the average exporter can be lower in the model with MNEs for certain parameters' values.

the productivity threshold above which firms become exporters. Expected productivity growth in a model with only left truncation in the productivity distribution is defined as $G^L \equiv \mathbb{E}\left(z_t - z_{t-1} \mid z_t > \underline{z}, z_{t-1} = \underline{z}\right)$, whereas in a model with left and right truncation, expected productivity growth is defined as $G^{LR} \equiv \mathbb{E}\left(z_t - z_{t-1} \mid \underline{z} < z_t < \bar{z}, z_{t-1} = \underline{z}\right)$, with $\bar{z}$ denoting the right truncation point above which the firm changes from export to MNE status. Then, there exists a value $\bar{z}^* \in (\underline{z}, \infty)$ such that for $\underline{z} < \bar{z} < \bar{z}^*$, $G^L > G^{LR}$, with equality for $\bar{z} = \bar{z}^*$.

Proof. See Appendix C.2.4.

We quantitatively explore the effect of including the option to become an MNE by comparing calibrated versions of the model with MNEs and with only exporters in Section 3.6.

3.5 Calibration

We calibrate the model and analyze how well the calibrated model quantitatively captures the patterns observed in the data. To such end, we use a quantitative version of the model in Section 3.4, which includes sunk export costs and firm-destination specific sunk and fixed costs. Assuming firm-destination specific sunk and fixed costs gives the model additional flexibility to match the data by making productivity cutoffs firm-level specific. In particular, this extension allows us to capture the fact that we observe some large firms that are neither exporters nor MNEs and, conversely, that we observe some small firms that are either exporters or MNEs. Additionally, it is through this extension that we incorporate *firm-destination* level heterogeneity into the quantitative model.[23] Appendix C.3 presents the main equations of the full model.

Our goal is to parameterize the quantitative version of the model by targeting cross-sectional features of the data, as well as the dynamics of domestic sales, and then to assess

23. This extension is also the one with the most potential to deliver conservative results regarding the role of MNEs in new exporter dynamics.

how well our calibrated model accounts for new MNE and exporter dynamics as reflected in the facts in Section 3.3. We perform two model calibrations using moments from France and Norway. We present the calibration not only for France but also for Norway because the information on MNE sales in the French data is very limited. For both France and Norway, we use the top 15 destination markets for exports and MNEs, plus a sixteenth country constructed as a weighted average of the rest of the world (RoW). The top 15 destinations represent more than 75 percent of export and MNE sales.[24] We calibrate the model market by market. Consistent with the model presented in the previous section, we abstract away from export-platform sales, so that entry into each destination country can be solved independently. As in the model, we restrict the analysis to a partial equilibrium setting in which wages and price indices are exogenous.

3.5.1 Calibration Procedure

We can divide the set of parameters in the model into three groups: a first group that is set externally; a second group that can be calibrated to moments in the data without having to solve for the firm's dynamic problem; and a third set that requires the computation of the firm's dynamic problem and is jointly calibrated using a moment-matching procedure. We describe each group next. Table 3.1 summarizes the procedure.

First, we set the discount factor for firms $\beta = 0.95$, which is consistent with an interest rate of five percent. The elasticity of substitution σ is set to 4, which implies a markup over unit cost of 33 percent and is a common value estimated for the trade elasticity.

The second set of parameters, which are calibrated without having to solve for the firm's dynamic problem, includes a size-adjusted measure of trade and MNE iceberg costs and the parameters related to the firm-level productivity process. Given σ, we use the ratio of export to domestic sales, for firms serving market n, to directly pin down size-adjusted trade costs

24. In the French data, it is not possible to distinguish exports to Belgium from exports to Luxembourg. Therefore, we aggregate Belgium-Luxembourg and the Netherlands into one country (Benelux). Because of its increasing importance, we add China to the list of foreign destination markets for France.

Table 3.1: Calibrated Parameters and Targeted Moments.

	Parameter	Value	Targeted moments
I	Discount factor β	0.95	Annual interest rate of five percent
	Elasticity of substitution σ	4	Simonovska and Waugh (2014)
II	Size-adjusted trade costs $E_n\tau_n^{1-\sigma}$	Appendix Table C.3	Export-to-domestic sales ratio in n
	Size-adjusted MNE costs $E_n\gamma_n^{1-\sigma}$	Appendix Table C.3	MNE-to-domestic sales ratio in n
	AR(1) productivity process		OLS estimates, AR(1) for domestic sales
	autoregressive coefficient ρ	0.960 (FRA), 0.957 (NOR)	autoregressive coefficient $\hat{\rho}_{sales}^{ols}$
	standard error σ_ϵ	0.197 (FRA), 0.133 (NOR)	standard error $\hat{\sigma}_{sales}^{ols}$
III	Export fixed cost, mean μ_{fn}^x		Fraction of exporters into n
	MNE fixed cost, mean μ_{fn}^m		Fraction of MNEs into n
	Export fixed cost, s.d. σ_{fn}^x		Average exporter exit rate from n
	MNE fixed cost, s.d. σ_{fn}^m	Appendix Table C.5	Average MNE exit rate from n
	Export sunk cost, mean μ_{en}^x		First-year exporter exit rate from n
	MNE sunk cost, mean μ_{en}^m		First-year MNE exit rate from n
	Export sunk cost, s.d. σ_{en}^x		$\lvert\sigma_{en}^x/\mu_{en}^x\rvert = \lvert\sigma_{fn}^x/\mu_{fn}^x\rvert$
	MNE sunk cost, s.d. σ_{en}^m		$\lvert\sigma_{en}^m/\mu_{en}^m\rvert = \lvert\sigma_{fn}^m/\mu_{fn}^m\rvert$

Notes: Panel I: group of externally set parameters. Panel II: group of parameters calibrated without having to solve the firm's dynamic problem. Panel III: group of parameters jointly calibrated. Appendix Table C.4 shows data targets by destination for parameters in Panel III.

for market n, $r_n^x(\phi) \equiv X_n^x(\phi)/X^d(\phi) = E_n\tau_n^{1-\sigma}$. Analogously, we use the ratio of MNE to domestic sales, for MNE affiliates operating in market n, to get an estimate of size-adjusted MNE costs for market n, $r_n^m(\phi) \equiv X_n^m(\phi)/X^d(\phi) = E_n\gamma_n^{1-\sigma}$.[25] We aggregate these ratios across firms serving market n, in each mode, using weights given by the firm's domestic sales. For exports, we restrict attention to firms that served market n at least three years in a row. For MNEs, we do not limit the number of years in a market, given the lower number of observations. Appendix Table C.3 shows the values for these ratios for each destination market.

The parameters characterizing the firm-level productivity process, ρ and σ_ϵ, are pinned down from estimating by OLS a first-order autoregressive process on domestic sales, using all French and Norwegian firms. The regression includes year and industry fixed effects, with standard errors clustered at the industry level. With these estimates, using the equations of the model and $\sigma = 4$, we directly set ρ equal to the estimated sales autocorrelation

25. To gain observations, for some destinations of French MNEs, we impute missing MNE sales using as covariates (log) domestic sales, (log) domestic employment, an interaction of the two previous variables, and year and sector fixed effects, for firms surviving at least five years in a foreign destination.

coefficient, $\hat{\rho}_{sales}$, and σ_ϵ equal to $\hat{\sigma}_{sales}/(\sigma-1)$. For France, $\rho = 0.960$ and $\sigma_\epsilon = 0.197$, whereas for Norway, our estimates imply that $\rho = 0.957$ and $\sigma_\epsilon = 0.133$.[26]

The remaining parameters of the model, related to the sunk and fixed costs of export and MNE activities in each market, are jointly calibrated using a moment-matching procedure. We assume that sunk (fixed) costs are drawn from a log-normal distribution (see Eaton et al., 2011; Tintelnot, 2017; Antrás et al., 2017; Head and Mayer, 2019), are constant for each firm over time, and are independent from firm productivity. The relevant market-specific sunk and fixed cost parameters are: the mean and standard deviation of sunk export costs, μ^x_{en} and σ^x_{en}; the mean and variance of sunk MNE costs, μ^m_{en} and σ^m_{en}; the mean and variance of per-period export costs, μ^x_{fn} and σ^x_{fn}; and the mean and variance of per-period MNE costs, μ^m_{fn} and σ^m_{fn}. This would leave us with 8×16 parameters to jointly calibrate, for each of our data sources, France and Norway. To reduce the dimensionality of the computational problem, we assume that the coefficient of variation for sunk and fixed costs (in logs) is the same for each mode, $|\sigma^s_{en}/\mu^s_{en}| = |\sigma^s_{fn}/\mu^s_{fn}|$ $(s \in x, m)$. We are then left with 6×16 parameters to calibrate for which we target six moments, for each market: the number of non-MNE French (Norwegian) exporters serving market n relative to all French (Norwegian) firms; the number of French (Norwegian) MNEs serving market n relative to all French (Norwegian) firms; the number of French (Norwegian) MNEs that exit at age zero (i.e., entry year) market n relative to all MNEs at age zero in market n; the number of French (Norwegian) exporters that exit at age zero (i.e., entry year) market n relative to all exporter at age zero in market n; the average share of French (Norwegian) MNEs that exit market n; and the average share of French (Norwegian) exporters that exit market n.

Table 3.2 reports the targeted moments in the model and the data, an average across destinations.[27] Among the targeted moments, given the parsimony of parameters and the non-negativity constraint for sunk and fixed costs, the model under-predicts the first-year

26. Results are very similar if we estimate a Tobit model rather than a linear model.

27. See Appendix C.4 for the numerical implementation of the algorithm to compute the model-based moments.

Table 3.2: Targeted Moments, Model and Data, Average.

	Data, avg		Model, avg	
	France	Norway	France	Norway
Share of MNEs	0.003	0.003	0.003	0.003
Share of exporters	0.090	0.087	0.083	0.081
First-year exit rate, MNEs	0.256	0.184	0.252	0.170
First-year exit rate, exporters	0.453	0.542	0.378	0.377
Average exit rate, MNEs	0.182	0.149	0.179	0.147
Average exit rate, exporters	0.316	0.313	0.212	0.210

Notes: Observations are at the firm-destination-year level. For each variable, we show averages across destinations included in the calibration, weighted by each destination's share of export (MNE) firms. Weights are data-based (model-based) for data (model) variables. The number of exporters (MNEs) that serve market n are calculated relative to all firms. The number of exporters (MNEs) that exit a market are calculated relative to all exporters (MNEs) in that market. Exporters in the data refers to non-MNE exporters.

and average exit of new exporters. The model is able to accurately reproduce the remaining moments with the parameters at hand. Appendix Table C.4 shows the data and model moments for each destination.

3.5.2 Calibration Results

We evaluate the size of the calibrated per-period fixed costs and sunk entry costs, for exports and MNE activities, in terms of one year of firm sales and in monetary values. Table 3.3 presents the results, averaged across destinations. Appendix Table C.6 presents results by destination market.

MNE sunk costs are much higher than sunk export costs. Sunk MNE costs represent about six percent of annual sales for large MNEs, 21 percent for median MNEs, and 34 percent for small MNEs, according to our calibration for France. The sunk costs for Norwegian MNEs are comparable to those faced by French MNEs. In Norway, sunk MNE costs account for about 11 percent of annual sales for large MNEs, 27 percent for median MNEs, and 38 percent for small MNEs. In monetary terms, for Norwegian MNEs, sunk costs range from 783,000 to 10 million U.S. dollars. Our estimates for France yield monetary values of these costs in a similar range. In contrast, the calibrated sunk export costs are extremely small,

Table 3.3: The Size of Calibrated Costs.

	Norway				France			
	f_n^x	f_n^m	F_n^x	F_n^m	f_n^x	f_n^m	F_n^x	F_n^m
Values as % of sales								
25th sales pc	20.4	13.4	5e-04	37.7	15.0	7.8	8e-04	33.6
50th sales pc	15.3	9.5	4e-04	26.8	9.7	5.0	5e-04	21.4
75th sales pc	9.9	6.2	3e-04	17.4	5.0	2.6	3e-04	11.4
90th sales pc	6.0	4.0	2e-04	11.3	2.3	1.4	1e-04	5.9
Values in U.S. dollars								
25th sales pc	1,100	278,000	0.03	783,000	1,900	360,000*	0.10	1,555,000*
50th sales pc	5,200	692,000	0.13	1,944,000	6,900	756,000*	0.35	3,262,000*
75th sales pc	23,000	1,628,000	0.58	4,575,000	19,000	1,181,000*	0.99	5,096,000*
90th sales pc	69,000	3,608,000	1.77	10,138,000	42,000	1,954,000*	2.14	8,432,000*

Notes: f_n^x are per-period fixed export costs; f_n^m are per-period fixed MNE costs; F_n^x are sunk export costs; and F_n^m are sunk MNE costs. Values are averages across firms' draws, conditional on a positive measure of exporters (MNEs), in each destination. Averages across destinations included in the calibration, weighted by each destination's share of export (MNE) firms. Weights are data-based (model-based), for data (model) variables. Sales percentiles are with respect to the export (MNE) sales distribution in a destination. The values in U.S. dollars for different percentiles are calculated using the values of sales in the data, transformed to U.S. dollars using an average of the annual exchange rate observed over our sample period, from Penn World Tables 9.0 (Feenstra et al., 2015). (*) estimated values assuming that the xth pc of the MNE sales distribution is proportional to the xth pc of the export sales distribution, with the proportionality factor calculated using the ratio of export to MNE sales for each percentile, for Norway.

ranging from 0.01 percent of annual export sales for large French exporters to 0.08 percent for small exporters. For Norwegian exporters, these costs range from 0.02 percent for large Norwegian exporters to 0.05 percent for small exporters

While fixed per-period costs are relatively much larger than sunk costs for exporters, in terms of sales, for MNEs, both costs are in a similar range. Fixed costs represent six percent of export sales for large Norwegian exporters and reach 20 percent for small exporters; per-period fixed MNEs costs range from more than four percent of sales for large affiliates to 13 percent for small affiliates. French firms face smaller per-period costs in terms of sales relative to the costs faced by Norwegian firms. In monetary terms, given the difference in size between MNEs and exporters, per-period fixed costs for exporters are 278,000 U.S. dollars for the 90th percentile of Norwegian exporters, but reach 3.6 million U.S. dollars for the largest Norwegian MNEs.

3.5.3 Fit of Calibrated Model

We now evaluate how well our calibrated model captures the facts in Section 3.3. We start by comparing the exit rates of new exporters and MNEs in the data and the model. Our calibration procedure targets exit rates of MNEs and exporters at entry and on average, but not at each age. Figure 3.7 shows that the calibrated model does fairly well in capturing the pattern of exit for new MNEs and new exporters. Even though the first-year exit rate for exporters is a targeted moment, the model underestimates how much export exit is observed upon entry into a market—sunk and fixed costs are constrained to be non-negative. The quantitative model, however, captures fairly well the decline in exit rates with age, slightly over-predicting exit at older ages only for Norway. It is important to note that targeting the first-year exit rate is crucial to obtain a sharp decline in exit rates with age for exporters; if this moment were not included in the calibration, exit rates would increase, rather than decrease, at early ages, because of the dramatic difference, for exporters, between first-year and average exit rates, shown in Table 3.2. If only the (lower) average exit rate were targeted, sunk costs would be large(r), creating a large band of inaction for exporters; as a consequence, exit rates would start low, increase, and then decrease with age.[28] Such dramatic difference between first-year and average exit rates is not observed for MNEs, so that the calibrated sunk costs are much higher than for exporters, creating a broader band of inaction for this internationalization mode.[29]

Figure 3.8 shows the ability of the model to capture the growth profiles of MNE and export sales. We compute the geometric average across destination markets and normalize sales with respect to age one (i.e., one year after entry). The model matches the flat sales profile for MNEs remarkably well: with high(er) sunk costs, firms enter already large into the

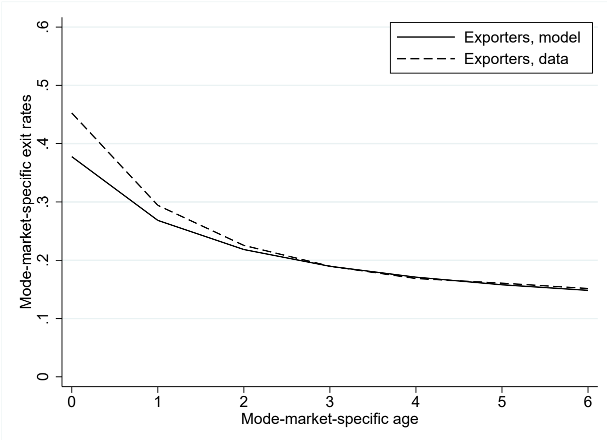
28. This is also the case in Ruhl and Willis (2017) (see their Figures 2b and 3b) for Colombian exporters: when they target first-year exit rates for exporters, they obtain exit rates that decline with age; when they only target the average exit rate, exit rates increase with age. As in our data, first-year and average exit rates for Colombian exporters are dramatically different (0.37 vs 0.11).

29. The model predicted that MNE exit rates for Norway slightly increase in year one, confirming the role of large sunk costs in generating rising exit rates in the first few years upon entry.

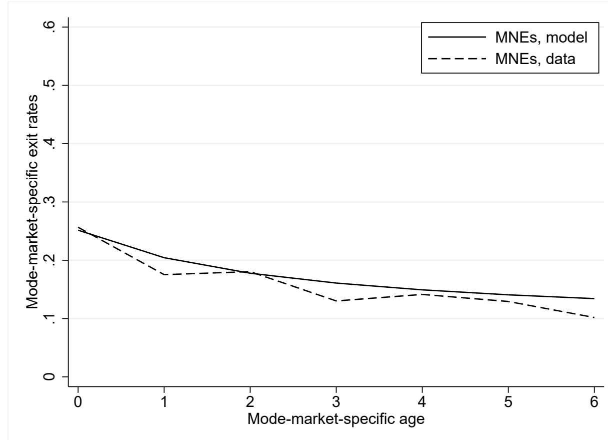
Figure 3.7: Exit Rates by Age, Model and Data.

France

(a) Exporters

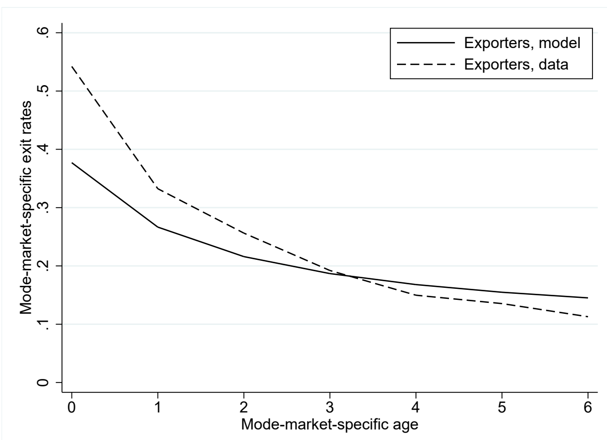


(b) MNEs

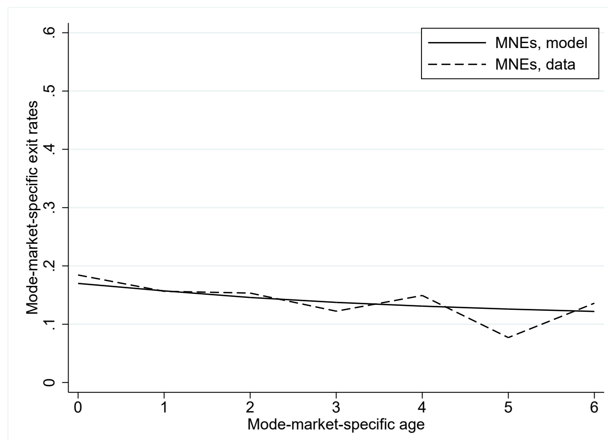


Norway

(c) Exporters



(d) MNEs



Notes: Number of exits from a mode-market relative to the number of firms active in a mode-market, by mode-market-specific age, for exporters and MNEs. Observations are at the firm-destination-year level. We show averages across destinations included in the calibration, weighted by each destination's share of export (MNE) firms. Weights are data-based and model-based, for data and model variables, respectively. Exporters in the data refers to non-MNE exporters.

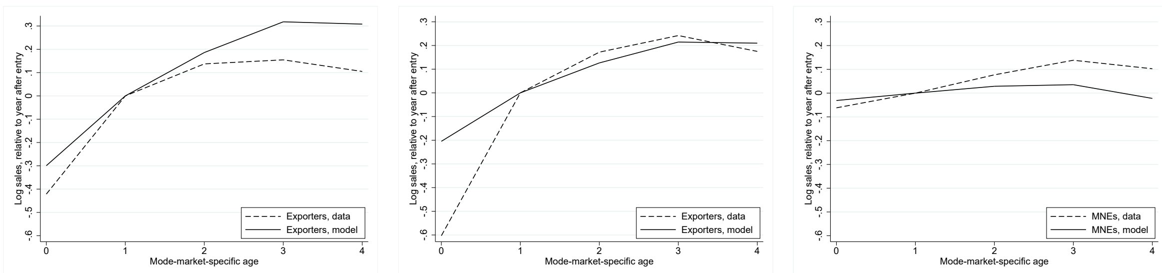
MNE status so that they grow little. The calibrated model captures fairly well the growth profile for Norwegian export sales, but the model calibrated to France delivers exporters that, after age one, grow faster than in the data. This is a feature observed in calibrated models in which firm-level productivity follows an AR(1) process and sunk costs are very low (see Syverson, 2011; Foster et al., 2016): Firms enter small and grow too large too fast.[30]

30. Indeed, other mechanisms, such as the demand-side frictions considered, for example, by Arkolakis

It is worth noting, however, that the differences with the data are exclusively a result of exporters that never become MNEs; for exporters that eventually become MNE, the model matches the data extremely well, as Appendix Figure C.8 shows.

Figure 3.8: Sales Growth by Age, Model and Data.

(a) Exporters, France (b) Exporters, Norway (c) MNEs, Norway



Notes: Log of firm-destination export (affiliate) sales with respect to firm-destination export (affiliate) sales in the year after entry, for firms with five or more years in the market, in each mode. Observations are at the firm-destination-year level. We show averages across destinations included in the calibration, weighted by each destination's share of export (MNE) firms. Weights are data-based and model-based, for data and model variables, respectively. In the data, log of sales are first demeaned by industry, year, and destination fixed effects. Exporters in the data refers to non-MNE exporters.

To evaluate the model's ability to quantitatively capture Fact 9 in Section 3.3, we estimate by OLS the elasticity of exit rates at age zero and entry rates, for exporters and MNEs, on geography-adjusted country size, $r_n^x \equiv E_n \tau_n^{1-\sigma}$ ($r_n^m \equiv E_n \gamma_n^{1-\sigma}$), across the destinations included in our calibration for Norway and France. We use the observed and simulated data. Results are presented in the first two panels of Table 3.4. One has to keep in mind that these regressions have only 16 observations. Still, the model delivers sharper results for exporters' exit rates relative to those for MNEs, as the theory predicts and our third fact shows: new exporters' exit rates decrease with size-adjusted iceberg costs, whereas new MNEs' exit rates do not have a clear pattern. The elasticities of the model's implied entry rates are larger for MNEs than for exporters, as observed in the data, but the model difference between the two is smaller.

Table 3.4 includes comparisons for other non-targeted moments. The third panel shows that the calibrated model correctly captures not only that new experienced MNEs have lower exit rates than non-experienced MNEs, as expected from Proposition 3, but also the

(2016) and Ruhl and Willis (2017), would be needed to better match the data on export sales growth.

magnitudes of such exit rates. Yet, the calibrated model delivers between 23 and 33 percent more new MNEs that were previously exporters than observed in the data, mainly because of the productivity process being a rather persistent AR(1) process.

Additionally, starter rates in the model are close to the ones observed in the data, for both exporters and MNEs, especially for the calibration using the French data.

Despite not being targeted, the model captures rather accurately the transitions from exporter to domestic, from domestic to exporter, and from MNE to domestic. The model, however, over-predicts the transition from exporter to MNE and from MNE to exporter and under-predicts the transition from domestic to MNE. Again, this is a feature that may arise from the AR(1) process for productivity: too many exporters become MNEs, and too many MNEs transition into export status.[31]

3.6 Counterfactual Exercise: the Effects of Trade Liberalization

Armed with the calibrated model, we analyze the effects of a hypothetical trade-liberalization shock on the aggregate dynamics and life-cycle dynamics of MNEs and exporters. We simulate a 20 percent change in the iceberg trade cost, τ_n, for all destinations n and analyze the dynamic aggregate and life-cycle response of exporters and MNEs.

For exporters, we further compare the predictions of the calibrated model with MNEs to the predictions of a calibrated model with only exporters. The calibration of the exporter-only model targets the same moments related to exporters as our calibration of the model with MNEs.[32] Appendix Figures C.9a and C.9b compare exit rates and sales profiles for exporters, averaged across destination markets, in the data and in the calibrated model

31. The domestic size of MNEs relative to exporters, in terms of revenues, is slightly smaller in the model than in the data: in the French (Norwegian) data, the ratio is 2.5 (2.2), and the model implies a size premium of 1.5 (1.4).

32. The calibrated model with only exporters matches the export-related targeted and non-targeted moments equally well as the model with MNEs (not shown). Appendix Table C.5 shows the calibrated values of per-period and sunk export costs for the model without MNEs.

Table 3.4: Additional Non-targeted Moments, Data and Model.

	Data		Model	
	France	**Norway**	**France**	**Norway**
Elasticity of first-year exit rates to size-adjusted iceberg costs, OLS				
exporters	-0.057**	-0.016	-0.023***	-0.073***
MNEs	0.035	0.062	0.073	0.085
Elasticity of entry rates to size-adjusted iceberg costs, OLS				
exporters	0.143***	0.226	0.237***	0.771***
MNEs	0.554***	0.238**	0.518***	0.139
Share of experienced MNEs	0.60	0.47	0.83	0.80
Exit rates at age zero, experienced MNEs	0.21	0.16	0.23	0.16
Exit rates at age zero, non-experienced MNEs	0.29	0.21	0.29	0.20
Starter rate				
exporters	0.020	0.035	0.019	0.019
MNEs	5.4e-04	5.0e-04	5.9e-04	4.1e-04
Probability of:				
exporter to MNE	0.003	0.002	0.006	0.004
exporter to domestic	0.188	0.275	0.206	0.206
domestic to MNE	1.8e-04	9.4e-05	9.9e-05	7.9e-05
domestic to exporter	0.019	0.038	0.018	0.018
MNE to exporter	0.059	0.069	0.138	0.097
MNE to domestic	0.043	0.057	0.042	0.050

Notes: The elasticity of first-year exit rates (entry rates) to size-adjusted iceberg costs (r_n^x and r_n^m, for exporters and MNEs, respectively) is the OLS coefficient of a bivariate regression (with a constant), using the 16 countries included in the calibration, for France and Norway. The fraction of experienced MNEs is calculated as the number of new MNEs of age zero with previous export experience in a market, relative to all new MNEs of age zero entering that market. Starter rates for exporters are calculated as the number of firms that export to j in t, but not in $t-1$, relative to the number of home firms at $t-1$. Starter rates for MNEs are calculated as the number of MNEs that have an affiliate j in t, but not in $t-1$, relative to the number of home firms at $t-1$. The transition probabilities are calculated as a weighted average across destinations: exporter to MNE (domestic) is relative to the number of non-MNE exporters; domestic to MNE (exporter) is relative to the number of domestic firms; and MNE to exporter (domestic) is relative to the number of MNEs. Observations are at the firm-destination-year level. Averages across destinations included in the calibration are weighted by each destination's share of export (MNE) firms, except for starter rates, and transitions from domestic status, which are weighted by (the inverse of) the number of destinations. Weights are data-based (model-based) for data (model) variables. Exporters in the data refers to non-MNE exporters. Levels of significance are denoted by *** p<0.01, ** p<0.05, and * p<0.1. Standard errors are in parentheses.

with and without MNEs for France. While both models deliver very similar sales profiles, the model without MNEs under-predicts the exit rates of old exporters, as it ignores the possibility that high-productivity exporters become MNEs.[33] Notice that even though the calibrated model with and without MNEs fits the data on exporters very similarly, the two models could deliver different *quantitative* predictions regarding counterfactual exercises; we have already showed in Section 3.4 that this is indeed the case theoretically.

3.6.1 Aggregate Dynamics

Figure 3.9 shows the evolution of average sales and participation rates for MNEs and exporters, from the old to the new steady state. The average MNE sales increase by around 20 percent when trade costs decrease, whereas participation rates for MNEs decrease by about ten percent. These effects are not surprising in the context of the proximity-concentration trade-off: as in the static HMY model, lower trade costs create substitution away from MNE activities toward exports; the opposite is true for increases in trade costs (the so-called tariff-jumping effect).[34] Moreover, small MNEs switch to serving the market as an exporter so that the average sales of firm that stay in the market as MNEs increase.

The transition from the old to the new steady state for MNEs is rather fast, with most of the adjustment taking place within three periods. Given that sunk export costs are very low, most of the transition to the new steady state for exporters occurs in one period: for the case of decreasing trade costs, average export sales are about 30 percent higher and participation rates are about 60 percent higher than in the initial steady state. The model without MNEs predicts smaller quantitative effects for exporters than the model with MNEs: average sales and participation rates increase by about ten (five) percent less than in the full model when

33. In contrast with the results in Ruhl and Willis (2017), both our calibrated models yield a monotonic decrease in exit rates with age, which, as explained above, is driven by targeting first-year, rather than average, exit rates. Additionally, Appendix Figure C.8 shows that while both models match equally well the sales profiles of exporters that eventually become MNEs, the model with MNEs matches a bit better the sales profiles of exporters that never become MNEs.

34. See Footnote 2 in the introduction for references on empirical support for the proximity-concentration trade-off, including our own Appendix Figure C.1.

trade costs decrease by 20 percent. At the heart of these differences is the self-selection of exporters into MNE activities when that option is included in the model. In the model with MNEs, a decrease in trade costs creates entry into the exporter status of domestic firms (left truncation), which are small relative to the incumbent exporter, *and* of MNE firms (right truncation), which are large relative to the incumbent exporter. In the model with only exporters, the second margin does not exist.

It is worth noting that increases and decreases in trade costs from the calibrated values do not produce symmetric changes in the aggregate variables under consideration. For instance, average sales for exporters drop by about 20 percent when trade costs increase but increase by as much as about 30 percent when trade costs decrease by the same percentage. This asymmetric effects are related to the density in the distribution of firm productivity; hence, they are directly linked to the calibration of the productivity process.

3.6.2 Life-cycle Dynamics

In Figure 3.10 we show the steady-state exit rates and sales profiles, by age, for MNEs and for exporters for the baseline economy, an economy with 20 percent higher trade costs, and an economy with 20 percent lower trade costs.[35]

While life-cycle exit patterns of MNEs do not change much with trade costs changes, life-cycle growth becomes slower in an environment with lower trade costs: by age four, new MNE sales (relative to entry) are five-percentage points lower than in our calibrated baseline.

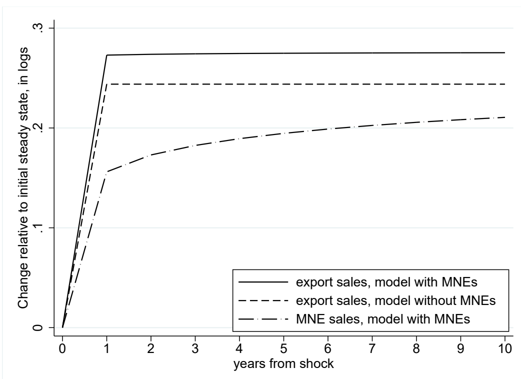
For exporters, including MNEs matters for the effects of moving from an environment with high trade costs to one with low trade costs. The model with MNEs predicts that new exporters decrease their life-cycle exit rates by six percentage points by age nine and experience higher sales growth (seven percentage points by age four). The model without MNEs, however, predicts that new exporters have very similar exit and growth patterns before and

35. Because we only use data from the calibrated model, in Figure 3.10, we normalize sales relative to sales at age 0 rather than age 1.

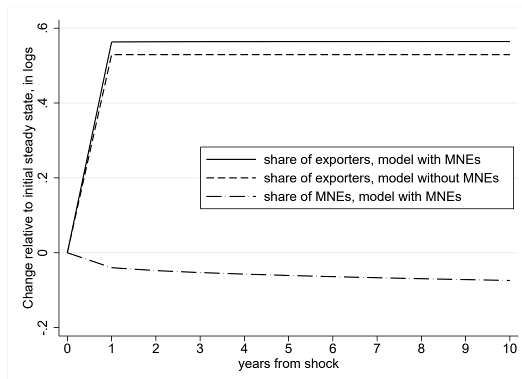
Figure 3.9: Aggregate Effects of a 20 Percent Change in Trade Costs.

Decrease in Trade Costs

(a) Average Sales

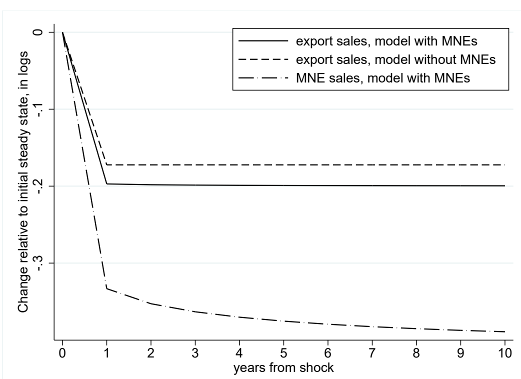


(b) Participation Rates

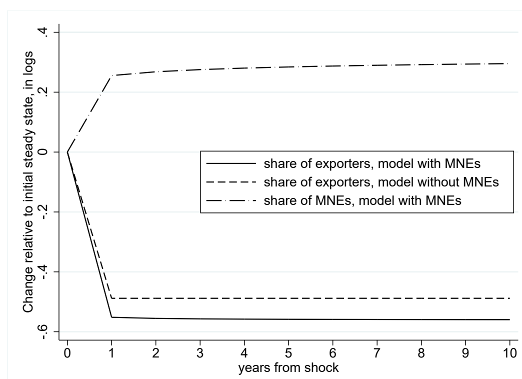


Increase in Trade Costs

(c) Average Sales



(d) Participation Rates



Notes: Models calibrated to French data. The y-axis is log change with respect to the initial steady state. Observations are at the firm-destination-year level. We show averages across destinations included in the calibration, weighted by each destination's share of export (MNE) firms.

after the change. These differences between the two models translate into differences in the dynamic behavior of aggregate exports after a shock shown in Figure 3.9.

A lower τ decreases the likelihood of becoming an MNE but increases the one of becoming (or staying) an exporter; in the limit, for $\tau = 1$, MNEs disappear and the model collapses to one without MNEs. This result implies that exporters' life-cycle profiles are, on average, less similar between the model with and without MNEs as τ increases. At the same time, a change in trade costs produces a larger change in the life-cycle patterns of exit and growth rates of the average exporter in the model with MNEs relative to the model without MNEs. This is because the model with MNEs has two (left and right) margins changing at the same time, which results in a larger change in the number of fast-growing exporters.

Finally, Figure 3.10 naturally relates to the effects of liberalizing MNE activities on new exporters' dynamics. Since the differences in new exporters' dynamics between the model with and without MNEs are larger in an environment with high iceberg trade costs, moving from a scenario without MNEs to one with MNEs leads to small changes in new exporters' dynamics if trade costs are already low but large changes if trade costs are high.

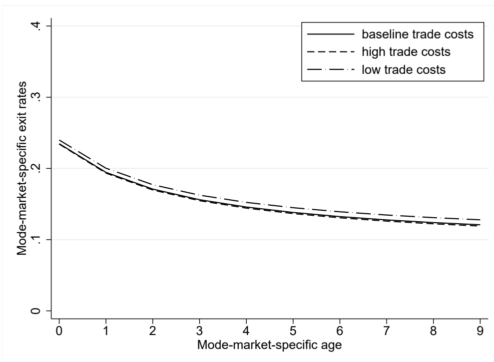
3.7 Conclusions

This paper studies the life-cycle dynamics of exporters and MNEs. We provide a comprehensive set of facts on the life-cycle dynamics of new exporters and new MNEs, which are informative about the features to be included in dynamic models of exporters' and MNEs' behavior. We show that a dynamic model of the proximity-concentration trade-off in HMY is qualitatively consistent with the documented facts. Our calibrated version of the model also includes heterogeneous sunk and fixed costs at the firm-destination level, similar to Roberts and Tybout (1997). We show that, quantitatively, the standard model of exporters' dynamics augmented to include MNEs goes far in matching cross-sectional and dynamic moments of the data on both exporters and MNEs. Our results point to much higher sunk

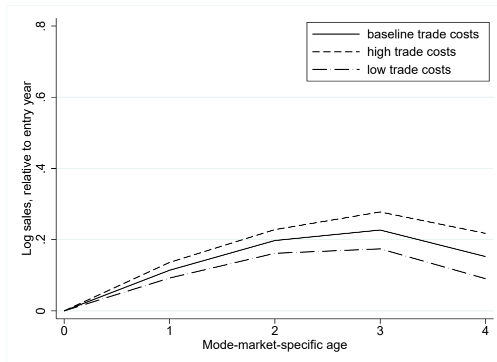
Figure 3.10: Life-cycle Effects of a 20 Percent Change in Trade Costs.

New MNEs' Dynamics

(a) Exit Rates

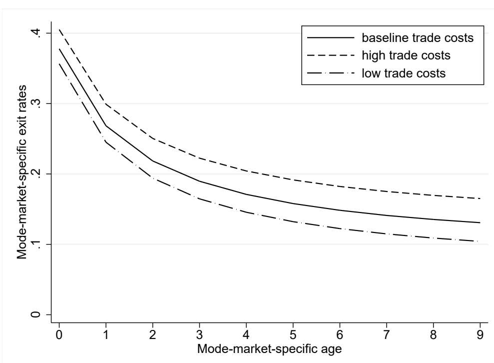


(b) Sales Growth

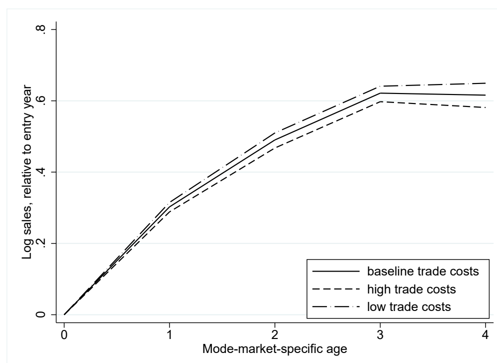


New Exporters' Dynamics, Model with MNEs

(c) Exit Rates

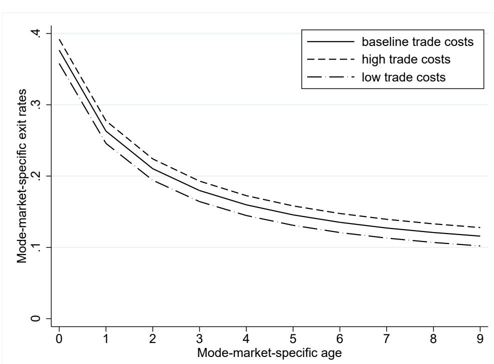


(d) Sales Growth

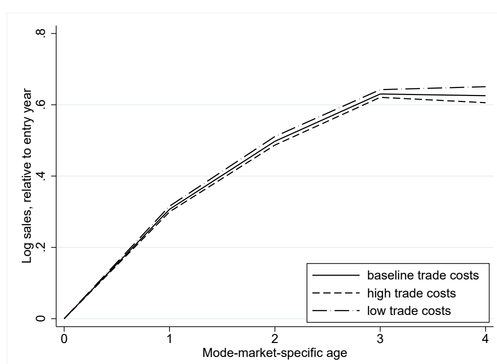


New Exporters' Dynamics, Model without MNEs

(e) Exit Rates



(f) Sales Growth



Notes: Models calibrated to French data. High, low, and baseline trade costs refer, respectively, to iceberg trade costs, τ_n, which are 20 percent higher, lower, and equal to the baseline values, for each destination n. Number of exits from a mode-market relative to the number of firms active in a mode-market, by mode-market-specific age. Log of firm-destination export (affiliate) sales with respect to firm-destination export (affiliate) sales in the year after entry, for firms with five or more years in the market. Observations are at the firm-destination-year level. We show averages across destinations included in the calibration, weighted by each destination's share of export (MNE) firms.

costs for MNE activities relative to export activities.

Comparing the predictions of our calibrated model with both exporters and MNEs and a dynamic model with only exporters, we find that enriching the canonical dynamic model of trade to include MNEs—a first-order feature of the data—may have consequences for the life-cycle and aggregate dynamic behavior of exporters after a trade-liberalization episode. The different response of the exporters between the two models hinges on the right truncation of fast-growing exporters induced by the inclusion of the MNE choice. While we find significant quantitative differences in the aggregate response of exporters to a trade-liberalization shock, we find only moderate differences in the life-cycle growth profiles of exporters between the models with and without MNEs.

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APPENDIX A

APPENDIX TO MULTINATIONAL PRODUCTION AND GLOBAL SHOCK PROPAGATION DURING THE GREAT RECESSION

A.1 Data Appendix

Table A.1: Countries in OECD AAMNE and in the Sample

AAMNE countries	Country code	AAMNE countries	Country code
Argentina	ARG	Israel	ROW
Australia	AUS	Italy	ITA
Austria	AUT	Japan	JPN
Belgium	ROW	Korea	KOR
Bulgaria	ROW	Lithuania	ROW
Brazil	BRA	Luxembourg	ROW
Canada	CAN	Latvia	ROW
Switzerland	ROW	Morocco	ROW
Chile	CHL	Mexico	MEX
China	CHN	Malta	ROW
Colombia	ROW	Malaysia	ROW
Costa Rica	ROW	Netherlands	ROW
Cyprus	ROW	Norway	NOR
Czech Republic	ROW	New Zealand	NZL
Germany	DEU	Philippines	ROW
Denmark	DNK	Poland	ROW
Spain	ESP	Portugal	PRT
Estonia	ROW	Romania	ROW
Finland	FIN	ROW	ROW
France	FRA	Russian Federation	ROW
U.K.	GBR	Saudi Arabia	ROW
Greece	GRC	Singapore	ROW
Hong Kong, China	ROW	Slovak Republic	ROW
Croatia	ROW	Slovenia	ROW
Hungary	HUN	Sweden	SWE
Indonesia	IDN	Thailand	ROW
India	IND	Turkey	TUR
Ireland	ROW	Taiwan	ROW
Iceland	ROW	U.S.	USA
Israel	ROW	Vietnam	ROW
Italy	ITA	South Africa	ZAF

Countries in the OECD AAMNE Database. This paper studies the same 28 major countries (together accounting for 83% of world GDP in 2008) as in Caliendo and Parro (2015) (less the tax haven countries Ireland and Netherlands), and collapses the other countries into s hypothetical country: the Rest of the World (ROW).

Table A.2: Industries in OECD AAMNE

AAMNE industries	Industry name	Durable?
A	Agriculture	3
B	Mining	3
C10T12	Food	2
C13T15	Textile	2
C16	Wood	1
C17T18	Paper	2
C19	Petroleum	3
C20T21	Chemicals	2
C22	Plastic	2
C23	Minerals	1
C24	Basic metals	1
C25	Metal products	1
C26	Electronic & Optical	1
C27	Electrical equipment	1
C28	Machinery n.e.c	1
C29	Auto	1
C30	Other Transport & Other mfg	1
C31T33	Manufacturing n.e.c and recycling	2
DTE	Electricity	3
F	Construction	3
G	Retail	3
H	Transport	3
I	Hotels	3
J58T60	Publishing & media	3
J61	Telecommunications	3
J62T63	Computer service	3
K	Finance	3
L	Real Estate	3
MTN	Other Business	3
O	Public	3
P	Education	3
Q	Health	3
RTS	Other services	3
T	Private	3

Industries in the OECD AAMNE Database (based on ISIC Rev.4 classification) and their mappings to the three broad sectors used in this study. In the last column, 1 means durable manufacturing, 2 means non-durable manufacturing, and 3 means non-manufacturing.

A.1.1 Foreign Affiliates Differ from Local Producers in Importing

This section studies how foreign affiliates differ from local producers with regard to importing. Similar to Wang (2019), I take advantage of the Annual Survey of Chinese Manufacturing (ASCM) Database, which covers firm-level business statistics, e.g. sales, capital, etc., for all Chinese manufacturing firms whose annual sales top 5 million RMB (roughly 0.6 million dollars). I link it with the Chinese Customs Records (CCR) Database, which covers all international transactions by Chinese firms, including imports and exports values, 8-digit HS code, firm registration information, among others. A third database is the Foreign-Invested Enterprise Survey in China (FIESC), which documents the ownership nationalities of all foreign affiliates in China. ASCM and FIESC could be exactly matched with a unique numeric firm identifier, whereas CCR and ASCM are matched according to the registration information, e.g. name, address, etc. Similar to Wang (2019), I take a cross-section of the databases in 2001. More information about the database and the matching algorithm could be found in Wang (2019).

The first fact I establish is conditional on observed firm-level characteristics, foreign affiliates are more likely to import and import more than local firms. I regress a dummy variable regarding whether a firm imports, the firm's share of imported intermediate input in total sales as well as the logged share, on the firm's foreign affiliate status. I control for the firm's employment, capital, intermediate input, TFP, as well as the 2-digit industry fixed effect. The results are presented in Table A.3. Being a foreign affiliate is strongly positively associated with both the firm's importing decision and the share of imported intermediate input in total sales. On average, foreign affiliates are 36% more likely to import (Column 1), 14 percentage points (and 187% for those having positive imports) higher for the share of imports in total sales (Column 2 and 3). Therefore, foreign affiliates engage more in importing than local producers with similar firm-level characteristics.

Next I show that conditional on importing, foreign affiliates also source more from their headquarters and the origin countries closer to their headquarters. Therefore, the sample drops Chinese domestic firms and the firms do not import. For dependent variables, I consider whether a foreign affiliate headquartered in country m and operating in China imports from an origin country j, as well as the associated importing values. I regress them on whether $j = m$, i.e. if the importing origin is the headquarter and the distance between

Table A.3: Conditional on Firm-level Characteristics, Foreign Affiliates Import More

	(1) Imp dummy	(2) Import/Sales	(3) log(Import/Sales)
$\mathbf{1}(m \neq n)$	0.360***	0.140***	1.870***
	(0.00840)	(0.0174)	(0.103)
Employment (log)	0.0102***	0.0139**	-0.100
	(0.00342)	(0.00647)	(0.107)
Capital (log)	0.0213***	0.00841***	0.302***
	(0.00232)	(0.00179)	(0.0432)
Intermediate input (log)	0.0201***	-0.0144**	-0.269**
	(0.00160)	(0.00669)	(0.114)
TFP (log)	0.0118***	0.000381	-0.244**
	(0.00297)	(0.00391)	(0.104)
Fixed effects	2-digit industry	2-digit industry	2-digit industry
Observations	139613	139613	16518

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The table shows the association between importing and foreign affiliate status. The dependent variables are: a dummy variable for firm importing in Column (1), the firm's share of imported intermediate input in firm total sales in Column (2), and the firm's log share of imported intermediate input in firm total sales in Column (3). The independent variables are: a dummy variable for whether the firm is a foreign affiliate, log firm employment, log capital, log total intermediate input, and log TFP (estimated with Olley and Pakes (1996) method). 2-digit CIC industry fixed effects are also controlled. Following Wang (2019), I exclude the state-owned firms, processing traders and firms in the exporting zones.

m and j. I add whether m and j share a common language, common border and common legal origin as controls. I use the origin fixed effect to control for the bilateral trade cost from the sourcing origin to China. I use the firm fixed effect to control for the potentially confounding firm characteristics. Therefore, the variation is within firm, between the foreign affiliate's headquarter and the sourcing origin.

Table A.4 shows the results. Conditional on importing, foreign affiliates on average are 13 percentage points more likely to source from their headquarters (Column 1) and source 246% more from headquarters than non-headquarters (Column 3). Column 2 and 4 show, one percent increase in the distance between the headquarter and the sourcing origin is associated with 0.3 percentage points decline in the probability of sourcing and 0.2% decline in importing values.

Table A.4: Conditional on Importing, Foreign Affiliates Import More from the Headquarter and Origin Countries Closer to the Headquarter

	(1)	(2)	(3)	(4)
	Full sample	$m \neq j$	Full sample	$m \neq j$
	$\mathbf{1}(x_{\text{CN}mj\cdot} > 0)$	$\mathbf{1}(x_{\text{CN}mj\cdot} > 0)$	$\log(x_{\text{CN}mj\cdot})$	$\log(x_{\text{CN}mj\cdot})$
$\mathbf{1}$(m = j)	0.130***		2.456***	
	(0.0244)		(0.214)	
$\log(\text{dist})_{mj}$		-0.00278***		-0.192***
		(0.000579)		(0.0361)
Cmmn lang_{mj}		0.000317		0.0861
		(0.000610)		(0.136)
Contig_{mj}		0.0127***		0.162
		(0.00317)		(0.152)
Cmmn legl ori_{mj}		0.000428		-0.0610
		(0.000915)		(0.0851)
Fixed effects	Firm,origin	Firm,origin	Firm,origin	Firm,origin
Cluster	HQ-origin	HQ-origin	HQ-origin	HQ-origin
Observations	3889704	3868332	25428	21140

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The table shows conditional on importing, the association between a foreign affiliate's import from a sourcing origin, with whether or not the origin is the foreign affiliate's headquarter, and if not, the distance between the importing origin and the headquarter. Column (1) and (3) compare sourcing from headquarter with non-headquarters. Column (2) and (4) study the sample of sourcing from non-headquarters. Dependent variables are dummy variables for Column (1) and (2) and importing values (log) for Column (3) and (4), denoting a foreign affiliate headquartered in m operating in China, importing from origin j. The independent variables include whether the sourcing origin is the headquarter, and if not, the distance between the sourcing origin and the headquarter (log). Whether the headquarter share a common language, common border, and legal origin with the sourcing origin are added as controls. The firm and origin fixed effects are also controlled. Standard errors are clustered on the headquarter-origin level. Following Wang (2019), I exclude the state-owned firms, processing traders and firms in the exporting zones. I exclude firms headquartered in Hong Kong, Macao, Taiwan and China (mainland).

These results, along with the findings in Wang (2019),[1] show foreign affiliate status and the headquarter country affect both importing and exporting of the firm conditioning on the usual international trade cost. Specifically, foreign affiliates are more likely to import and export, and import and export a larger share than local producers. Conditional on importing

1. I replicate the empirical findings in Wang (2019) in Section A.1.2. This provides a complete picture of MNE-specific frictions on both sides of trade: importing and exporting. Furthermore, to clean and prepare the databases I followed the recipes presented in that paper. However, the resulting sample may not necessarily be the same. I thus replicate the same set of regressions to show the results are not sensitive to potential differences in data cleaning.

and exporting, foreign affiliates import and export a great share with their headquarters and the countries closer to their headquarters. These findings are robust to firm-level characteristics, as well as the bilateral trade frictions between the host economy and the importing origin or the exporting destination. These facts show MNEs face headquarter-specific sourcing and selling frictions of international trade with trade partners, motivating respective parts of the model in Section 2.5. The MNE selling frictions may include the additional cost of setting up and maintaining the distribution networks in a non-headquarter country (Head and Mayer, 2019), higher marketing cost, lack of brand recognition, limited knowledge about consumer preference (Wang, 2019), etc. The MNE sourcing frictions may include, for example, incompatibility between a country's technology and other countries' input, different regulatory requirements, bounded information about where and how to source from other countries, etc.

A.1.2 Foreign Affiliates Differ from Local Producers in Exporting

This section replicates the findings in Wang (2019). I show that conditional on observed firm characteristics, foreign affiliates are more likely to export and export more than local firms. Furthermore, conditional on exporting, foreign affiliates are also more likely to export and export more back to their headquarters and the countries closer to their headquarters.

A.1.3 Within-between Country Decomposition of World MP and Trade Collapse

Here I perform a within-between country decomposition for the world aggregate MP and trade collapse relative to world GDP. I use the MP collapse as an example. I use MP_t^i to denote country i's inward foreign affiliate sales at country i in year t and GDP_t^i to denote country i's GDP in year t. I may decompose world MP and trade collapse relative to GDP, into a domestic component, a size component and a GDP component according to the

Table A.5: Conditional on Firm-level Characteristics, Foreign Affiliates Export More

	(1) Exp dummy	(2) Export/Sales	(3) log(Export/Sales)
$\mathbf{1}(i \neq j)$	0.338***	0.254***	0.962***
	(0.0122)	(0.0313)	(0.0705)
Employment (log)	0.0314***	0.0407***	0.259***
	(0.00293)	(0.00903)	(0.0459)
Capital (log)	0.00953***	-0.00346	-0.170***
	(0.00270)	(0.00269)	(0.0331)
Intermediate input (log)	0.0194***	-0.0213**	-0.323***
	(0.00234)	(0.00813)	(0.0436)
TFP (log)	0.00185	-0.00307	-0.336***
	(0.00234)	(0.00292)	(0.0469)
Fixed effects	2-digit industry	2-digit industry	2-digit industry
Observations	139613	139613	19569

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The table shows the association between exporting and foreign affiliate status. The dependent variables are: a dummy variable for firm exporting in Column (1), the firm's export share in total sales in Column (2), and the firm's log export share in total sales in Column (3). The independent variables are: a dummy variable for whether the firm is a foreign affiliate, log firm employment, log capital, log total intermediate input, and log TFP (estimated with Olley and Pakes (1996) method). 2-digit CIC industry fixed effects are also controlled. Following Wang (2019), I exclude the state-owned firms, processing traders and firms in the exporting zones.

following formula:

$$\frac{\sum_{i=1}^{N} MP_{09}^i}{\sum_{i=1}^{N} GDP_{09}^i} - \frac{\sum_{i=1}^{N} MP_{08}^i}{\sum_{i=1}^{N} GDP_{08}^i} = \underbrace{\frac{1}{N}\sum_{i=1}^{N}\left(\frac{MP_{09}^i}{GDP_{09}^i} - \frac{MP_{08}^i}{GDP_{08}^i}\right)}_{\text{Domestic component}} +$$

$$\underbrace{\underbrace{N\,\text{cov}_i\left(\frac{MP_{09}^i}{GDP_{09}^i} - \frac{MP_{08}^i}{GDP_{08}^i}, \frac{\frac{GDP_{09}^i}{\sum_i GDP_{09}^i} + \frac{GDP_{08}^i}{\sum_i GDP_{08}^i}}{2}\right)}_{\text{Size component}} + \underbrace{N\,\text{cov}_i\left(\frac{GDP_{09}^i}{\sum_i GDP_{09}^i} - \frac{GDP_{08}^i}{\sum_i GDP_{08}^i}, \frac{\frac{MP_{09}^i}{GDP_{09}^i} + \frac{MP_{08}^i}{GDP_{08}^i}}{2}\right)}_{\text{GDP component}}}_{\text{Between-country component}}$$

The domestic component equals the simple average of the country-level MP collapse across all countries. The size component equals the cross-country covariance between country-level MP collapse and countries' GDP shares in the world. It summarizes whether MP declines more relative to GDP in countries that account for a greater share of world GDP. The

Table A.6: Conditional on Exporting, Foreign Affiliates Export More to the Headquarter and the Destination Countries Closer to the Headquarter

	(1) Full sample $\mathbf{1}(x_{n\cdot\text{CN}i} > 0)$	(2) $n \neq i$ $\mathbf{1}(x_{n\cdot\text{CN}i} > 0)$	(3) Full sample $\log(x_{n\cdot\text{CN}i})$	(4) $n \neq i$ $\log(x_{n\cdot\text{CN}i})$
$\mathbf{1}$(n = i)	0.124***		1.613***	
	(0.0244)		(0.157)	
$\log(\text{dist})_{ni}$		-0.00128**		-0.0538***
		(0.000509)		(0.00535)
Cmmn lang_{ni}		-0.000465		0.125
		(0.000593)		(0.0857)
Contig_{ni}		0.00540**		-0.0331
		(0.00234)		(0.0935)
Cmmn legl ori_{ni}		0.00130		0.0718
		(0.000850)		(0.0548)
Fixed effects	Firm,destination	Firm,destination	Firm,destination	Firm,destination
Cluster	HQ-destination	HQ-destination	HQ-destination	HQ-destination
Observations	3889704	3868332	25428	21140

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The table shows conditional on exporting, the association between a foreign affiliate's export to a specific destination, with whether or not the destination is the foreign affiliate's headquarter, and if not, the distance between the exporting destination and the headquarter. Column (1) and (3) compare exporting to headquarter with non-headquarters. Column (2) and (4) study the sample of exporting to non-headquarters. Dependent variables are dummy variables for Column (1) and (2) and exporting values (log) for Column (3) and (4), denoting a foreign affiliate headquartered in i operating in China, exporting to destination n. The independent variables include whether the exporting destination is the headquarter, and if not, the distance between the exporting destination and the headquarter (log). Whether the headquarter share a common language, common border, and legal origin with the exporting destination are added as controls. The firm and destination fixed effects are also controlled. Standard errors are clustered on the headquarter-destination level. Following Wang (2019), I exclude the state-owned firms, processing traders and firms in the exporting zones. I exclude firms headquartered in Hong Kong, Macao, Taiwan and China (mainland).

GDP component equals the cross-country covariance between changes in countries' GDP shares in the world and the countries' MP to GDP ratios. It summarizes whether GDP declines more in the countries that have high MP relative to GDP.

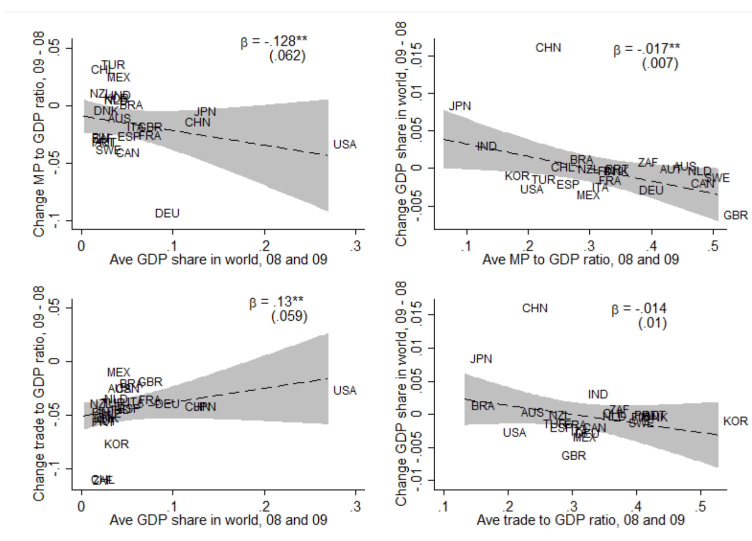
Table A.7 presents the decomposition for changes of inward MP and import relative to GDP. Here Figure A.1 visualizes the size and GDP components for the MP and trade collapse. Changes in countries' MP relative to GDP are significantly negatively associated with countries' GDP shares in the world. Changes in countries GDP shares in the world are significantly negatively associated with countries' MP to GDP ratios. However, these relations do not hold for the trade collapse. To show robustness, Table A.8 presents the decomposition for changes of outward MP and export relative to GDP. Both tables show that the trade collapse is entirely within countries, whereas a greater share of the MP collapse could be explained by between country components.

Table A.7: Decomposition of Declines in Inward MP and Import Relative to GDP

	Within component	Size component	GDP component	Total
MP collapse	-.003 (15.4%)	-.011 (61.1%)	-.004 (23.5%)	-.018 (100%)
Trade collapse	-.027 (124.7%)	.006 (-29.0%)	-.001 (4.3%)	-.038 (100%)

Decomposing the declines in inward MP and import relative to GDP into a domestic component, a size component and a GDP component. The domestic summarizes the domestic declines of all countries. The size component summarizes whether MP declines more in countries that have greater GDP. The GDP component that summarizes whether the countries that have high MP shares experience a greater decline in GDP. Numbers outside the parenthesis denote the size of each component. The numbers inside the parenthesis denote the fraction of the MP and trade collapse explained by the components. The decomposition for world total outward MP and export decline relative to world GDP, which leads to a similar conclusion, is delayed to Table A.8.

Figure A.1: Size and GDP Components of MP and Trade Collapse



OECD Analytical Activities of Multinationals (AAMNE) Database, 2008-2009. The left two panels plot the association between changes in countries' MP and trade relative to GDP with countries' GDP shares in the world. They reflect the size components of the MP and trade collapse. The right two panels plot the association between changes in countries' GDP shares in the world with countries' MP to GDP ratios. They reflect the GDP components of the MP and trade collapse.

Table A.8: Decomposition of Declines in Outward MP and Export Relative to GDP

	Within component	Size component	GDP component	Total
MP collapse	-.012 (51.6%)	-.005 (20.5%)	-.006 (27.9%)	-.023 (100%)
Trade collapse	-.036 (118.3%)	.008 (-25.3%)	-.002 (7.0%)	-.038 (100%)

Decomposing the declines in outward MP and export relative to GDP into a domestic component, a size component and a GDP component. The domestic component summarizes the domestic declines. The size component summarizes whether countries' MP declines more relative to GDP, in countries with greater GDP. The GDP component summarizes whether the countries with high MP shares have declines in GDP. Numbers outside the parenthesis denote the size of each component. The numbers inside the parenthesis denote the fraction of the MP and trade collapse explained by the components.

A.1.4 Exposures to Other Countries' MP and Trade Collapse

Similarly to the exposure to foreign countries' outward MP collapse, I define the measure of exposure to foreign countries' inward MP collapse:

$$EXPO\_INMP_i = \sum_{i' \neq i} \underbrace{\frac{GO_{i'i,2005}}{\sum_{i' \neq i} GO_{i'i,2005}}}_{\text{country } i' \text{ share in outward MP from } i} (\log(INMP_{i' \leftarrow -i,2009}) - \log(\underbrace{INMP_{i' \leftarrow -i,2008}}_{\text{country } i'\text{'s inward MP from outside } i}))$$

The measure of exposure to foreign countries' export collapse:

$$EXPO\_EX_i = \sum_{i' \neq i} \underbrace{\frac{T_{ii',2005}}{\sum_{i' \neq i} T_{ii',2005}}}_{\text{country } i' \text{ share in } i \text{ import}} (\log(EX_{-i \leftarrow i',2009}) - \log(\underbrace{EX_{-i \leftarrow i',2008}}_{\text{country } i'\text{'s export to non-}i \text{ countries}}))$$

The measure of exposure to foreign countries' import collapse:

$$EXPO\_IM_i = \sum_{i' \neq i} \underbrace{\frac{T_{i'i,2005}}{\sum_{i' \neq i} T_{i'i,2005}}}_{\text{country } i' \text{ share in } i \text{ export}} (\log(IM_{i' \leftarrow -i,2009}) - \log(\underbrace{IM_{i' \leftarrow -i,2008}}_{\text{country } i'\text{'s import from non-}i \text{ countries}}))$$

A.2 Theory Appendix

A.2.1 A Micro-foundation for the Sourcing and Output Shares

In this section I derive a micro-foundation for the solution to the sourcing problem in Section 1.3.2. It builds on Eaton and Kortum (2002) and Ramondo and Rodríguez-Clare (2013). Assume an MNE produces composite intermediate input by combining a continuum of measure 1 of homogeneous product lines:

$$Q^s_{nm} = (\int_0^1 (Q^s_{nm}(\omega))^{\frac{\lambda-1}{\lambda}} d\omega)^{\frac{\lambda}{\lambda-1}}$$

For each product line, it draws a random productivity shifter, z^s_{nmji}, for all upstream host economies and technologies. Assume the sourcing MNEs make the sourcing decision independently. Assume z^s_{nmji} is distributed multivariate Frechet, with joint distribution:

$$F(\vec{z}^s_{nm}) = \exp(-(\sum_{j=1}^N (\sum_{i=1}^N (z^s_{nmji})^{-\frac{\theta}{1-\rho^s}})^{\frac{1-\rho^s}{1-\delta^s}})^{1-\delta^s})$$

ρ^s governs the correlation between technologies, and δ^s governs the correlation between production locations. We allow the correlations to differ with respect to sectors. Consider the following special cases. Fix a source technology I. The probability of drawing technology shifter z_{nmjI} for I equals, by taking $z_{nmji} \to \infty, \forall i \neq I$:

$$\tilde{F}(\{z_{nmjI}\}_{j=1}^N) = \exp(-(\sum_{j=1}^N z_{nmjI}^{-\frac{\theta}{1-\delta^s}})^{1-\delta^s})$$

Therefore, the productivity shifter draws for all production locations given a technology is still multivariate Frechet distribution with correlation δ^s across production locations. Now fix a source production location J. The probability of drawing technology shifter z_{nmJi} for J is, taking $z_{nmji} \to \infty, \forall j \neq J$:

$$\tilde{F}(\{z_{nmJi}\}_{i=1}^{N}) = \exp(-(\sum_{i=1}^{N} z_{nmJi}^{-\frac{\theta}{1-\rho^s}})^{1-\rho^s})$$

the productivity shifter draws for all technologies given a production location is still multivariate Frechet distribution with correlation ρ^s across production locations.

Denote the price for nm to get a unit of intermediate input from ji:

$$\frac{\tilde{H}_{ni}^s \tilde{h}_{mj}^s k_{nj}^s t_{nj}^s \Theta_{ji}^s}{A_{ji}^s z_{nmji}^s}$$

First, consider the probability that MNE nm's composite intermediate input price, P_{nm}^s, is no larger than p:

$$\begin{aligned} G_{nm}^s(p) &= 1 - F(\left\{ z_{nmji}^s = \frac{H_{ni}^s h_{mj}^s k_{nj}^s t_{nj}^s \Theta_{ji}^s}{A_{ji}^s p} \right\}_{i,j}) \\ &= 1 - \exp(-\Phi_{nm}^s p^\theta) \end{aligned}$$

where

$$\Phi_{nm}^s = (\sum_{j=1}^{N}(\sum_{i=1}^{N}(\frac{\tilde{H}_{ni}^s \tilde{h}_{mj}^s k_{nj}^s t_{nj}^s \Theta_{ji}^s}{A_{ji}^s})^{-\frac{\theta}{1-\rho^s}})^{\frac{1-\rho^s}{1-\delta^s}})^{1-\delta^s}$$

What is the probability nm sources from ji? First consider the marginal probability of

z^s_{nmji}:

$$F_{ji}(z^s_{nmji}) = \theta(z^s_{nmji})^{-\frac{\theta}{1-\rho^s}-1}\left[\sum_{i=1}^{N}(z^s_{nmji})^{-\frac{\theta}{1-\rho^s}}\right]^{\frac{\delta^s-\rho^s}{1-\delta^s}}\left\{\sum_{j=1}^{N}\left[\sum_{i=1}^{N}(z^s_{nmji})^{-\frac{\theta}{1-\rho^s}}\right]^{\frac{1-\rho^s}{1-\delta^s}}\right\}^{-\delta^s}$$
$$\exp\left(\left\{\sum_{j=1}^{N}\left[\sum_{i=1}^{N}(z^s_{nmji})^{-\frac{\theta}{1-\rho^s}}\right]^{\frac{1-\rho^s}{1-\delta^s}}\right\}^{1-\delta^s}\right)$$

Therefore,

$$F_{ji}(z^s_{nmj'i'} = \frac{\frac{H^s_{ni'}h^s_{mj'}k^s_{nj'}t^s_{nj'}\Theta^s_{j'i'}}{A^s_{j'i'}}}{\frac{H^s_{ni}h^s_{mj}k^s_{nj}t^s_{nj}\Theta^s_{ji}}{A^s_{ji}}}z) = \theta z^{-\theta-1}\left[\sum_{i=1}^{N}(\frac{H^s_{ni'}h^s_{mj'}k^s_{nj'}t^s_{nj'}\Theta^s_{j'i'}}{A^s_{j'i'}})^{-\frac{\theta}{1-\rho^s}}\right]^{\frac{\delta^s-\rho^s}{1-\delta^s}}$$
$$\underbrace{\left\{\sum_{j=1}^{N}\left[\sum_{i=1}^{N}(\frac{H^s_{ni'}h^s_{mj'}k^s_{nj'}t^s_{nj'}\Theta^s_{j'i'}}{A^s_{j'i'}})^{-\frac{\theta}{1-\rho^s}}\right]^{\frac{1-\rho^s}{1-\delta^s}}\right\}^{-\delta^s}}_{(\Phi^s_{nm})^{-\frac{\delta^s}{1-\delta^s}}}(\frac{H^s_{ni}h^s_{mj}k^s_{nj}t^s_{nj}\Theta^s_{ji}}{A^s_{ji}})^{-\frac{\theta\rho^s}{1-\rho^s}}$$
$$\exp(-\Phi^s_{nm}(\frac{H^s_{ni}h^s_{mj}k^s_{nj}t^s_{nj}\Theta^s_{ji}}{A^s_{ji}})^{\theta}z^{-\theta})$$

Integrating this from 0 to ∞ gives us the probability nm sources from ji. Note that

$$\int_{z=0}^{\infty}\theta z^{-\theta-1}\Phi^s_{nm}(\frac{H^s_{ni}h^s_{mj}k^s_{nj}t^s_{nj}\Theta^s_{ji}}{A^s_{ji}})^{\theta}z^{-\theta}\exp(-\Phi^s_{nm}(\frac{H^s_{ni}h^s_{mj}k^s_{nj}t^s_{nj}\Theta^s_{ji}}{A^s_{ji}})^{\theta}z^{-\theta}) = 1$$

Therefore,

$$\int_{z=0}^{\infty} F_{ji}(z^s_{nmj'i'} = \frac{\frac{H^s_{ni'}h^s_{mj'}k^s_{nj'}t^s_{nj'}\Theta^s_{j'i'}}{A^s_{j'i'}}}{\frac{H^s_{ni}h^s_{mj}k^s_{nj}t^s_{nj}\Theta^s_{ji}}{A^s_{ji}}}z) = (\frac{H^s_{ni}h^s_{mj}k^s_{nj}t^s_{nj}\Theta^s_{ji}}{A^s_{ji}})^{-\frac{\theta}{1-\rho^s}}$$

$$\left[\sum_{i=1}^{N}(\frac{H^s_{ni'}h^s_{mj'}k^s_{nj'}t^s_{nj'}\Theta^s_{j'i'}}{A^s_{j'i'}})^{-\frac{\theta}{1-\rho^s}}\right]^{\frac{\delta^s-\rho^s}{1-\delta^s}} (\Phi^s_{nm})^{-\frac{1}{1-\delta^s}}$$

To go from quantity shares to expenditure shares requires information about the conditional distribution of prices conditional on the sourcing decision. The probability that $P^s a_{nm}$ is no larger than p, and nm optimally sources ji, equal the following:

$$\int_{z=\frac{H^s_{ni}h^s_{mj}k^s_{nj}t^s_{nj}\Theta^s_{ji}}{A^s_{ji}p}}^{\infty} F_{ji}(z^s_{nmj'i'}$$

$$= \frac{\frac{H^s_{ni'}h^s_{mj'}k^s_{nj'}t^s_{nj'}\Theta^s_{j'i'}}{A^s_{j'i'}}}{\frac{H^s_{ni}h^s_{mj}k^s_{nj}t^s_{nj}\Theta^s_{ji}}{A^s_{ji}}}z) = \int_{z=0}^{\infty} F_{ji}(z^s_{nmj'i'} \qquad = \frac{\frac{H^s_{ni'}h^s_{mj'}k^s_{nj'}t^s_{nj'}\Theta^s_{j'i'}}{A^s_{j'i'}}}{\frac{H^s_{ni}h^s_{mj}k^s_{nj}t^s_{nj}\Theta^s_{ji}}{A^s_{ji}}}z)G^s_{nm}(p)$$

This implies that, the conditional price distribution is the same as the unconditional price distribution. Therefore, similar to Eaton and Kortum (2002), the current setting also yields the result that the quantity shares are the same as the expenditure shares.

Relabel $-\frac{\theta}{1-\rho^s} = 1-\zeta^s$ and $-\frac{\theta}{1-\delta^s} = 1-\sigma^s$. The expenditure share by nm on ji equals:

$$\pi^s_{nmji} = \underbrace{\frac{\sum_{i=1}^{N}(\frac{\tilde{H}^s_{ni}\tilde{h}^s_{mj}k^s_{nj}t^s_{nj}\Theta^s_{ji}}{A^s_{ji}})^{1-\zeta^s})^{\frac{1-\sigma^s}{1-\zeta^s}}}{\sum_{j=1}^{N}(\sum_{i=1}^{N}(\frac{\tilde{H}^s_{ni}\tilde{h}^s_{mj}k^s_{nj}t^s_{nj}\Theta^s_{ji}}{A^s_{ji}})^{1-\zeta^s})^{\frac{1-\sigma^s}{1-\zeta^s}}}}_{\pi^s_{mlj\cdot}} \underbrace{\frac{(\frac{\tilde{H}^s_{ni}\tilde{h}^s_{mj}k^s_{nj}t^s_{nj}\Theta^s_{ji}}{A^s_{ji}})^{1-\zeta^s}}{\sum_{i=1}^{N}(\frac{\tilde{H}^s_{ni}\tilde{h}^s_{mj}k^s_{nj}t^s_{nj}\Theta^s_{ji}}{A^s_{ji}})^{1-\zeta^s}}}_{S^s_{m\cdot ji}}$$

which is exactly the same as Equation (1.6).

A.2.2 Motivating the MNE-specific Sourcing and Selling Efficiencies

This section prove by contradiction that MNE-specific sourcing and selling frictions are necessary conditions for my model to replicate the facts in Section 1.2.

First, consider foreign affiliates' importing relative to local producers. If MNEs have homogeneous sourcing efficiencies, i.e. $h^s_{mj} = 1, \forall m, j$, Equation (1.5) implies for a given combination of n, j, $\pi^s_{nmj\cdot}$ is the same $\forall m$. Label this number $\pi^s_{n\cdot j\cdot}$. Foreign affiliates' share in the host country's total import equals the share of foreign affiliates in the host economy's total intermediate input expenditure, according to the following equation:

$$\frac{IM^s_{nF}}{IM^s_n} = \frac{\sum_{m\neq n}\sum_{j\neq n} X^s_{nm}\pi^s_{nmj}}{\sum_{m=1}^{N}\sum_{j\neq n} X^s_{nm}\pi^s_{nmj}} = \frac{\sum_{m\neq n} X^s_{nm}(\sum_{j\neq n}\pi^s_{n\cdot j})}{\sum_{m=1}^{N} X^s_{nm}(\sum_{j\neq n}\pi^s_{n\cdot j})} = \frac{\sum_{m\neq n} X^s_{nm}}{\sum_{m=1}^{N} X^s_{nm}}$$

The first equality follows from the definition of total import in the model. The second equality changes the order of the sums and takes advantage of the result that $\pi^s_{n\overline{m}j\cdot}$ is the same $\forall m$. The third equality follows by noting that the terms in the brackets are the same. The imported share of intermediate input expenditure of foreign affiliates then equals that of local producers: $\frac{IM^s_{nF}}{\sum_{m\neq n} X^s_{nm}} = \frac{IM^s_{nn}}{X^s_{nn}}$. Without the MNE-specific sourcing frictions, foreign affiliates' intermediate input import share would equal the share of local producers.

Now consider the import by two foreign affiliates headquartered in m and m'. With homogeneous MNE sourcing efficiencies, their sourcing shares on any same origin country j would be the same:

$$\pi^s_{nmj} = \pi^s_{nm'j}$$

The difference in log import from j and from j', by the two foreign affiliates from m and

m' would then equal to each other, by noting that:

$$
\begin{aligned}
&(\log(T^s_{nmj}) - \log(T^s_{nmj'})) - (\log(T^s_{nm'j}) - \log(T^s_{nm'j'})) \\
&= (\log(X^s_{nm}\pi^s_{nmj}) - \log(X^s_{nm}\pi^s_{nmj'})) - (\log(X^s_{nm}\pi^s_{nmj}) - \log(X^s_{nm}\pi^s_{nmj'})) \\
&= (\log(\pi^s_{nmj}) - \log(\pi^s_{nmj'})) - (\log(\pi^s_{nm'j}) - \log(\pi^s_{nm'j'})) = 0
\end{aligned}
$$

This indicates that if the MNE-specific sourcing frictions were homogeneous, conditional on the importing origin and the foreign affiliate (recall the fixed effects in Table A.4), log import does not vary with respect to the bilateral relationship between the headquarter and the sourcing origin. In this case, foreign affiliates do not import more from their headquarters and the countries closer to their headquarters, either. This contradicts the findings in Table A.4.

If MNEs have homogeneous selling efficiencies, i.e. $H^s_{ni} = 1, \forall n, i$, Equation (1.4) implies for a given combination of i, j, $S^s_{n\cdot ji}$ is the same $\forall n$. Label this number $S^s_{\cdot\cdot ji}$. Foreign affiliates' share in the host economy's total export equals the share of foreign affiliates in the host economy's gross output, according to the following equation:

$$
\begin{aligned}
\frac{EX^s_{jF}}{EX^s_{j\cdot}} &= \frac{\sum_{n\neq j}\sum_{i\neq j} T^s_{nj}S^s_{n\cdot ji}}{\sum_{n\neq j}\sum_{i=1}^N T^s_{nj}S^s_{n\cdot ji}} = \frac{(\sum_{n\neq j} T^s_{nj})\sum_{i\neq j} S^s_{\cdot\cdot ji}}{(\sum_{n\neq j} T^s_{nj})\sum_{i=1}^N S^s_{\cdot\cdot ji}} \\
&= \frac{\sum_{i\neq j} S^s_{\cdot\cdot ji}}{\sum_{i=1}^N S^s_{\cdot\cdot ji}} = \frac{(\sum_{n=1}^N T^s_{nj})\sum_{i\neq j} S^s_{\cdot\cdot ji}}{(\sum_{n=1}^N T^s_{nj})\sum_{i=1}^N S^s_{\cdot\cdot ji}} = \frac{\sum_{i\neq j} GO^s_{ji}}{\sum_{i=1}^N GO^s_{ji}} \qquad \text{(A.1)}
\end{aligned}
$$

The first equality follows from the definition of total export. $T^s_{nj}S^s_{n\cdot ji}$ equals the total sales of an MNE headquartered in i, producing in j and selling to n. The second equality changes the order of the summations by noting that $S^s_{n\cdot ji}$ is invariant with respect to the destination n. From the second to the third equality, I drop the same summation in the numerator and in the denominator. The fourth equality multiplies back gross output of country j, which leads to the fifth equality where the numerator has the gross output by all foreign affiliates in j and the denominator has the gross output of country j. The exported share of the output of foreign affiliates then equals that of local producers: $\frac{EX^s_{jF}}{\sum_{i\neq j} GO^s_{ji}} = \frac{EX^s_{jj}}{GO^s_{jj}}$, also contradicting Section 1.2.

Now consider export by a foreign affiliate headquartered in i operating in j. With homogeneous MNE selling efficiencies, its output shares to any destinations, say n and n', would be the same:

$$S^s_{n\cdot ji} = S^s_{n'\cdot ji}$$

The difference in log export to n and to n', by the two foreign affiliates from i and i' would then equal to each other, by noting that:

$$\begin{aligned}
&(\log(T^s_{n\cdot ji}) - \log(T^s_{n'\cdot ji})) - (\log(T^s_{n\cdot ji}) - \log(T^s_{n'\cdot ji})) \\
&= (\log(T^s_{nj} S^s_{n\cdot ji}) - \log(T^s_{n'j} S^s_{n'\cdot ji})) - (\log(T^s_{nj} S^s_{n\cdot ji'}) - \log(T^s_{n'j} S^s_{n'\cdot ji'})) \\
&= (\log(S^s_{n\cdot ji}) - \log(S^s_{n'\cdot ji})) - (\log(S^s_{n\cdot ji'}) - \log(S^s_{n'\cdot ji'})) = 0
\end{aligned}$$

This indicates that if the MNE-specific selling frictions were homogeneous, conditional on the exporting destination and the foreign affiliate (recall the fixed effects in Table A.4), log export does not vary with respect to the bilateral relationship between the headquarter and the exporting destination. In this case, foreign affiliates do not export more to their headquarters and the countries closer to their headquarters, either. This contradicts the findings in Table A.6.

A.2.3 Model in "Hats"

Changes in sourcing capability:

$$\hat{\Theta}_{li}^{s} = (\hat{w}_l)^{\gamma_l^s} \prod_{s'=1}^{S} (\hat{P}_{li}^{s'})^{\gamma_l^{ss'}}$$

Changes in the output shares of i's MNE in country j's sales to n:

$$\hat{S}_{n\cdot ji}^{s} = \frac{(\frac{\hat{\Theta}_{ji}^{s}}{\hat{A}_{ji}^{s}})^{1-\zeta^s} \hat{H}_{ni}}{(\hat{P}_{nj}^{s,p})^{1-\zeta^s}}$$

, where changes in the producer price index for producers hosted by country j selling to n equal the following:

$$(\hat{P}_{nj}^{s,p})^{1-\zeta^s} = \sum_{i=1}^{N} S_{n\cdot ji}^{s} (\frac{\hat{\Theta}_{ji}^{s}}{\hat{A}_{ji}^{s}})^{1-\zeta^s} \hat{H}_{ni}$$

Changes in the expenditure shares on tradable output from country l, by an MNE headquartered in m hosted in n:

$$\hat{\pi}_{nmj\cdot}^{s} = \frac{\hat{h}_{mj} (\hat{P}_{nj}^{s,p} \hat{k}_{nj}^{s} \hat{t}_{nj}^{s})^{1-\sigma^s}}{(\hat{P}_{nm}^{s})^{1-\sigma^s}}$$

, where changes in the composite intermediate input price, for an MNE from m producing in n:

$$(\hat{P}_{nm}^{s})^{1-\sigma^s} = \sum_{j=1}^{N} \pi_{nmj\cdot}^{s} \hat{h}_{mj}^{s} (\hat{k}_{nj}^{s} \hat{t}_{nj}^{s} \hat{P}_{nj}^{s,p})^{1-\sigma^s}$$

The sourcing shares by an MNE headquartered in m, producing in n, on an MNE headquartered in i, producing in l, equal the following:

$$\hat{\pi}^{s}_{nmji} = \frac{\hat{h}_{mj}(\hat{P}^{s,p}_{nj}\hat{k}^{s}_{nj}\hat{t}^{s}_{nj})^{1-\sigma^s}}{(\hat{P}^{s}_{nm})^{1-\sigma^s}} \frac{(\frac{\hat{\Theta}^{s}_{ji}}{\hat{A}^{s}_{ji}})^{1-\zeta^s}\hat{H}_{ni}}{(\hat{P}^{s,p}_{nj})^{1-\zeta^s}} = \hat{\pi}^{s}_{nmj\cdot}\hat{S}^{s}_{n\cdot ji}$$

The counterfactual MNE sourcing and output shares can be constructed with their values in the baseline and in changes: $\hat{\pi}^{s\prime}_{nmj\cdot} = \pi^{s}_{nmlj\cdot}\hat{\pi}^{s}_{nmj\cdot}$, $\hat{S}^{s\prime}_{n\cdot ji} = S^{s}_{n\cdot ji}\hat{S}^{s}_{n\cdot ji}$, as well as $\pi^{s\prime}_{nmji} = \pi^{s}_{nmji}\hat{\pi}^{s}_{nmji}$. The market clearing conditions for labor and composite input in the counterfactual equilibrium equal the following:

$$\hat{w}_j\hat{L}_j w_j L_j = w'_j L'_j = \sum_{s=1}^{S}\gamma^{s}_{j}\sum_{m=1}^{N}\sum_{n=1}^{N}\frac{X'^{s}_{nm}\pi'^{s}_{nmj\cdot}}{t'^{s}_{nj}}$$

$$X'^{s}_{ji} = \begin{cases} I'_j\alpha^{s\prime}_{n} + \sum_{s'=1}^{S}(1-\gamma^{s'}_{j})\gamma^{s's}_{j}\sum_{m=1}^{N}\sum_{n=1}^{N}\frac{X'^{s'}_{nm}}{t'^{s'}_{nj}}\pi'^{s'}_{nmji}\ , & \text{if } i = j \\ \sum_{s'=1}^{S}(1-\gamma^{s'}_{j})\gamma^{s's}_{j}\sum_{m=1}^{N}\sum_{n=1}^{N}\frac{X'^{s'}_{nm}}{t'^{s'}_{nj}}\pi'^{s'}_{nmji}\ , & \text{if } i \neq j \end{cases}$$

where the counterfactual household income equals:

$$I'_n = w_n L_n \hat{w}_n \hat{L}_n + R'_n + D'_n$$

in which the counterfactual tariff revenue equal:

$$R'_n = \sum_{s=1}^{S}\sum_{j=1}^{N}\sum_{m=1}^{N} X'^{s}_{nm}\pi'^{s}_{nmj\cdot}\frac{\tau'^{s}_{nj}}{t'^{s}_{nj}}$$

In order to solve for a counterfactual equilibrium, we have to know the MNE sourcing shares, $\pi^{s}_{nmj\cdot}$, and the MNE output shares, $S^{s}_{n\cdot ji}$, at the baseline equilibrium. On top of that, we have to know the baseline labor income $w_j L_j$ and tariffs. We need to know parameters σ^s, ζ^s, γ^{s}_{j} and $\gamma^{ss'}_{j}$ as well. The shocks to the system of equations are: changes in (1) MNE sourcing efficiency, $\hat{h}_{mj}$ (2) MNE selling efficiency, $\hat{H}_{ni}$ (3) MNE productivity, $\hat{A}^s_{ji}$ (4) non-tariff trade barriers, $\hat{k}^s_{nj}$ (5) tariffs, $\hat{t}^s_{nj}$ (6) final demand shifters, $\alpha^{s\prime}_n$ (7) size of the labor force, L'_n, as well as counterfactual trade deficit, D'_n. Once we know all the variables above, the equilibrium is then characterized by a set of prices, $\{\hat{w}_n\}$, $\left\{\hat{P}^{s,p}_{nj}\right\}$, $\left\{\hat{P}^s_{nm}\right\}$, such that the market clearing conditions hold for the counterfactual equilibrium.

A.2.4 Model without MNE Sourcing and Selling Efficiencies in "Hats"

Changes in sourcing capability equal the following:

$$\hat{\Theta}^s_l = (\hat{w}_l)^{\gamma^s_l} \prod_{s'=1}^{S} (\hat{P}^{s'}_l)^{\gamma^{ss'}_l}$$

, $\forall i$. Note that without heterogeneous MNE sourcing efficiencies, the composite input price is not MNE-specific. Changes in the gross output shares of i's MNE in country j:

$$\hat{S}^s_{ji} = \frac{(\frac{\hat{\Theta}^s_i}{\hat{A}^s_{ji}})^{1-\zeta^s}}{(\hat{P}^{s,p}_j)^{1-\zeta^s}}$$

Without heterogeneous MNE selling frictions, an MNE's output share in the host economy's outward sales is the same regardless of the destination. Changes in country j's producer price index equal the following:

$$(\hat{P}^{s,p}_j)^{1-\zeta^s} = \sum_{i=1}^{N} S^s_{ji} (\frac{\hat{\Theta}^s_j}{\hat{A}^s_{ji}})^{1-\zeta^s}$$

Changes in the sourcing shares on tradable output from country j, by any MNE hosted in n:

$$\hat{\pi}^s_{nj} = \frac{(\hat{P}^{s,p}_j \hat{k}^s_{nj} \hat{t}^s_{nj})^{1-\sigma^s}}{(\hat{P}^s_n)^{1-\sigma^s}}$$

where changes in the composite input price for all MNEs in country n:

$$(\hat{P}_n^s)^{1-\sigma^s} = \sum_{j=1}^{N} \pi_{nj\cdot}^s (\hat{k}_{nj}^s \hat{t}_{nj}^s \hat{P}_j^{s,p})^{1-\sigma^s}$$

The sourcing shares by any MNE in n, on an MNE headquartered in i, producing in j, equal the following:

$$\hat{\pi}_{nji}^s = \hat{\pi}_{nj\cdot}^s \hat{S}_{ji}^s$$

The counterfactual MNE sourcing and output shares are constructed with their values in the baseline and in changes: $\hat{\pi}_{nj\cdot}^{s\prime} = \pi_{nj\cdot}^s \hat{\pi}_{nj\cdot}^s$, $\hat{S}_{ji}^{s\prime} = S_{ji}^s \hat{S}_{ji}^s$, as well as $\pi_{nji}^{s\prime} = \pi_{nji}^s \hat{\pi}_{nji}^s$. Changes in the final expenditure shares equal the following:

$$\hat{s}_n^s = \frac{\hat{\alpha}_n^s (\hat{P}_n^s)^{1-\delta}}{(\hat{P}_n^c)^{1-\delta}}$$

where changes in country n's consumer price index:

$$(\hat{P}_n^c)^{1-\delta} = \sum_{s=1}^{S} s_n^s \hat{\alpha}_n^s (\hat{P}_n^s)^{1-\delta}$$

Counterfactual final expenditure shares equal the following:

$$s_n^{s\prime} = s_n^s \hat{s}_n^s$$

The market clearing conditions for labor and composite input in the counterfactual equilibrium are the following:

$$\hat{w}_j \hat{L}_j w_j L_j = \sum_{s=1}^{S} \gamma_j^s \sum_{n=1}^{N} \frac{X_n^{\prime s} \pi_{nj}^{\prime s}}{t_{nj}^{\prime s}}$$

Expenditure on composite input is not headquarter specific and equals:

$$X_j'^s = I_j'\alpha_j^{s\prime} + \sum_{s'=1}^{S}(1-\gamma_j^{s'})\gamma_j^{s's}\sum_{n=1}^{N}\frac{X_n'^{s'}}{t_{nj}'^{s'}}\pi_{nj}'^{s'}$$

Same as the model without MNE in Section A.2.5. The counterfactual household income equals:

$$I_n' = w_n L_n \hat{w}_n \hat{L}_n + R_n' + D_n'$$

in which the counterfactual tariff revenue equal:

$$R_n' = \sum_{n=1}^{N}\sum_{s=1}^{S}\sum_{j=1}^{N} X_n'^s \pi_{nj}'^s \frac{\tau_{nj}'^s}{t_{nj}'^s}$$

A.2.5 Model without MNEs in "Hats"

Changes in the composite input prices equal the following:

$$(\hat{P}_n^s)^{1-\sigma^s} = \sum_{l=1}^{N}\pi_{nl}^s.(\hat{k}_{nl}^s\hat{t}_{nl}^s\frac{\hat{\Theta}_l^s}{\hat{A}_l^s})^{1-\sigma^s}$$

where changes in the sourcing capability are Cobb-Douglas in changes in nominal wages and the composite input prices:

$$\hat{\Theta}_l^s = (\hat{w}_l)^{\gamma_l^s}\prod_{s'=1}^{S}(\hat{P}_l^{s'})^{\gamma_l^{ss'}}$$

Therefore changes in the expenditure shares by country n on country l equal:

$$\hat{\pi}_{nl}^s = \frac{(\hat{k}_{nl}^s\hat{t}_{nl}^s\hat{P}_l^{s,p})^{1-\sigma^s}}{(\hat{P}_n^s)^{1-\sigma^s}}$$

Labor market clears in the counterfactual equilibrium:

$$\hat{w}_l \hat{L}_l w_l L_l = w'_l L'_l = \sum_{s=1}^{S} \gamma_l^s \sum_{n=1}^{N} \frac{X_n'^s \pi_{nl\cdot}'^s}{t_{nl}'^s}$$

Composite input market clears in the counterfactual equilibrium:

$$X_l'^s = I'_l \alpha_l^{s'} + \sum_{s'=1}^{S} (1-\gamma_l^{s'}) \gamma_l^{s's} \sum_{n=1}^{N} \frac{X_n'^{s'}}{t_{nl}'^{s'}} \pi_{nl}'^{s'}$$

The counterfactual total income/final expenditure equals:

$$I'_n = w_n L_n \hat{w}_n \hat{L}_n + R'_n + D'_n$$

where the tariff revenue equals:

$$R'_n = \sum_{s=1}^{S} \sum_{l=1}^{N} \tau_{nl}'^s \frac{X_n'^s \pi_{nl\cdot}'^s}{t_{nl}'^s}$$

A.2.6 Proof of Proposition 1

First consider whether MNEs in the same host country have heterogeneous exposures in their composite intermediate input prices to trade shocks and domestic shocks. Remember the MNE sourcing shares are: $\pi_{nmj\cdot}^s = \frac{h_{mj}^s (k_{nj}^s P_{nj}^{s,p})^{1-\sigma^s}}{(P_{nm}^s)^{1-\sigma^s}}$, where the MNE-specific composite intermediate input price: $(P_{nm}^s)^{1-\sigma^s} = \sum_{j=1}^{N} h_{mj}^s (k_{nj}^s P_{nj}^{s,p})^{1-\sigma^s}$. If $h_{mj}^s = 1, \forall m, j$, this implies $P_{nm}^s = P_{nm'}^s$ and $\pi_{nmj\cdot}^s = \pi_{nm'j\cdot}^s \ \forall m, m'$.

Remember changes in the composite intermediate input price equal the following: $(\hat{P}_{nm}^s)^{1-\sigma^s} = \sum_{j=1}^{N} \pi_{nmj\cdot}^s (\hat{k}_{nj}^s \hat{t}_{nj}^s \hat{P}_{nj}^{s,p})^{1-\sigma^s}$. As trade shocks move $\hat{k}_{nj}^s$ or domestic shocks move $\hat{P}_{nj}^{s,p}$, with the same sourcing shares, all MNEs hosted by the same country will have the same exposure to these shocks, namely, $\hat{P}_{nm}^s = \hat{P}_{nm'}^s, \forall m, m'$.

The composite intermediate input price reflects the MNE's cost. This further implies changes in the sourcing capability, $\hat{\Theta}^s_{nm}$ are the same for all MNEs. Note changes in the output shares are the following: $\hat{S}^s_{n\cdot ji} = \frac{(\frac{\hat{\Theta}^s_{ji}}{\hat{A}^s_{ji}})^{1-\zeta^s}\hat{H}_{ni}}{\sum_{i=1'}^{N}(\frac{\hat{\Theta}^s_{ji'}}{\hat{A}^s_{ji'}})^{1-\zeta^s}\hat{H}_{ni'}}$. These imply that any MNE's output share in the host economy's outward trade follow does not change with trade shocks and domestic shocks, i.e. $\hat{S}^s_{n\cdot ji} = 1$, $\forall i, j, n$. Therefore, without the heterogeneous MNE sourcing frictions, trade shocks and domestic shocks would have limited impact on MP shares.

In the data, foreign affiliates source a larger share from abroad than the host economy's local producers. This requires heterogeneous MNE selling efficiencies.

What is the implication for changes in exporting relative to domestic competitiveness? Consider $\hat{A}^s_{ji} < 1$ for an $i \neq j$, whereas $\hat{A}^s_{ji'} = 1$, $\forall i' \neq i$. In this case, $\frac{(\hat{P}^{s,p}_{nj})^{1-\zeta^s}}{(\hat{P}^{s,p}_{jj})^{1-\zeta^s}} = \frac{1+S^s_{nji}\left(\left(\frac{\hat{\Theta}^s_{ji}}{\hat{A}^s_{ji}}\right)^{1-\zeta^s}-1\right)}{1+S^s_{jji}\left(\left(\frac{\hat{\Theta}^s_{ji}}{\hat{A}^s_{ji}}\right)^{1-\zeta^s}-1\right)}$. If the decline in the foreign affiliate's relative productivity leads to an increase in its factory gate price, $\hat{\Theta}^s_{ji}\hat{A}^s_{ji}$, with $S^s_{nji} > S^s_{jji}$ for $n \neq j$, we may have $\frac{(\hat{P}^{s,p}_{nj})^{1-\zeta^s}}{(\hat{P}^{s,p}_{jj})^{1-\zeta^s}} < 1$. This implies that the a decline in the foreign affiliate's productivity leads to a relative decline in the host economy's exporting competitiveness than the competitiveness in domestic sales.

Now let's turn to the impact of the heterogeneous MNE selling frictions on the responses in a country's export and domestic competitiveness to MNE-relative productivity shocks. The export and domestic competitiveness are measured with the producer price indices. Remember an MNE's output share equals: $S^s_{n\cdot ji} = \frac{H^s_{ni}\left(\frac{\Theta^s_{ji}}{A^s_{ji}}\right)^{1-\zeta^s}}{\sum_{k=1}^{M} H^s_{nk}\left(\frac{\Theta^s_{jk}}{A^s_{jk}}\right)^{1-\zeta^s}}$. Without the heterogeneous MNE selling frictions, the MNE's output shares will be the same in the host economy's sales regardless of the destination, i.e. $S^s_{n\cdot ji} = S^s_{n'\cdot ji}$, $\forall n, n', j, i$. Remember changes in the producer price index for export relative to domestic sales equal:

$\frac{(\hat{P}^{s,p}_{nj})^{1-\zeta^s}}{(\hat{P}^{s,p}_{jj})^{1-\zeta^s}} = \frac{\sum_{i=1}^{N} S^s_{n \cdot ji} \left(\frac{\hat{\Theta}^s_{ji}}{\hat{A}^s_{ji}} \right)^{1-\zeta^s}}{\sum_{i=1}^{N} S^s_{j \cdot ji} \left(\frac{\hat{\Theta}^s_{ji}}{\hat{A}^s_{ji}} \right)^{1-\zeta^s}}$. In the case an MNE has the same output shares in all outward sales of the host economy, $\frac{(\hat{P}^{s,p}_{nj})^{1-\zeta^s}}{(\hat{P}^{s,p}_{jj})^{1-\zeta^s}} = 1$. This means if the MNE selling frictions were homogeneous, MNE relative productivity shocks would not affect the host economy's relative competitiveness for export relative to domestic sales. In the model, total export by country j to country $n \neq j$ equal: $\sum_{m=1}^{N} X^s_{nm} \frac{h^s_{mj}}{(P^s_{nm})^{1-\sigma^s}} (P^{p,s}_{nl})^{1-\sigma^s}$. Use $MS^s_n = \sum_{m=1}^{N} X^s_{nm} \frac{h^s_{mj}}{(P^s_{nm})^{1-\sigma^s}}$ to denote the size of the destination market. Therefore, relative changes in export with respect to home sales equal: $\frac{\hat{MS}^s_n (\hat{P}^{s,p}_{nj})^{1-\zeta^s}}{\hat{MS}^s_j (\hat{P}^{s,p}_{jj})^{1-\zeta^s}} = \frac{\hat{MS}^s_n}{\hat{MS}^s_j}$. In this case, MNE relative productivity shocks will not lead to significant changes in export, unless there were large changes in the relative size of the export destination market to the domestic market.

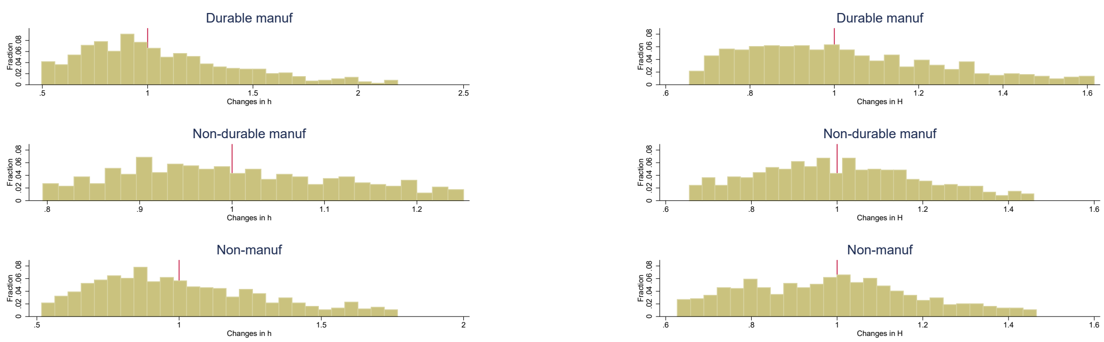
In the data, foreign affiliates engage more in exporting than the host economy's local producers. This requires heterogeneous MNE selling efficiencies. What is the implication for changes in exporting relative to domestic competitiveness? Consider $\hat{A}^s_{ji} < 1$ for an $i \neq j$, whereas $\hat{A}^s_{ji'} = 1$, $\forall i' \neq i$. In this case, $\frac{(\hat{P}^{s,p}_{nj})^{1-\zeta^s}}{(\hat{P}^{s,p}_{jj})^{1-\zeta^s}} = \frac{1 + S^s_{nji} \left(\left(\frac{\hat{\Theta}^s_{ji}}{\hat{A}^s_{ji}} \right)^{1-\zeta^s} - 1 \right)}{1 + S^s_{jji} \left(\left(\frac{\hat{\Theta}^s_{ji}}{\hat{A}^s_{ji}} \right)^{1-\zeta^s} - 1 \right)}$. If the decline in the foreign affiliate's relative productivity leads to an increase in its factory gate price, $\hat{\Theta}^s_{ji} \hat{A}^s_{ji}$, with $S^s_{nji} > S^s_{jji}$ for $n \neq j$, we may have $\frac{(\hat{P}^{s,p}_{nj})^{1-\zeta^s}}{(\hat{P}^{s,p}_{jj})^{1-\zeta^s}} < 1$. This implies that the a decline in the foreign affiliate's productivity leads to a relative decline in the host economy's exporting competitiveness than the competitiveness in domestic sales.

A.3 Computation Appendix

A.3.1 Properties of the Backed-out Shocks

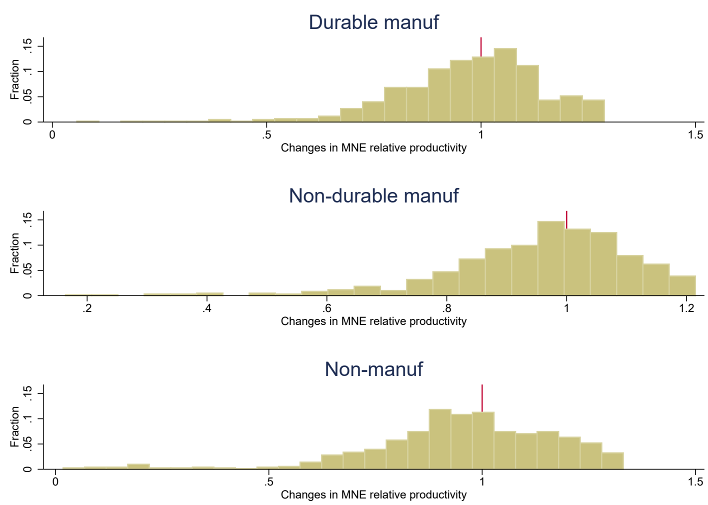
Figure A.2: Distribution of MNE Sourcing and Selling Shocks

(a) Sourcing Shocks (b) Selling Shocks



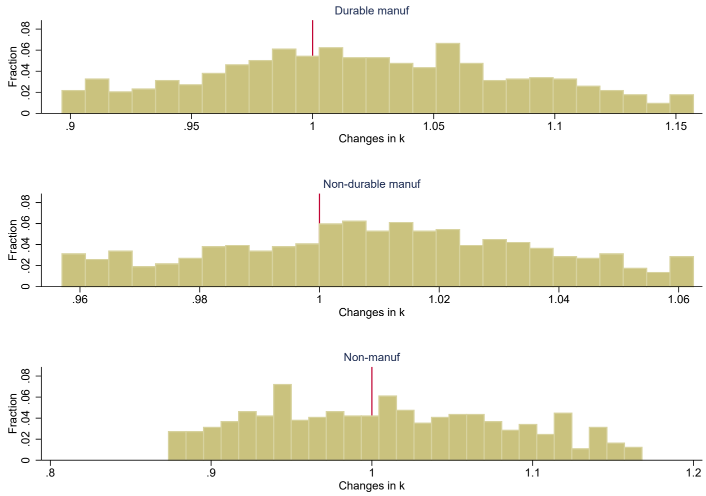
OECD Analytical Activities of Multinationals (AAMNE) Database, 2008-2009. The left panel plots the distribution of backed out MNE sourcing shocks for headquarter-sourcing origin pairs for durable manufacturing, non-durable manufacturing and non-manufacturing sectors. The right panel plots the distribution of backed out MNE selling shocks for headquarter-selling destination pairs durable manufacturing, non-durable manufacturing and non-manufacturing sectors. All distributions are trimmed at top and bottom 5%. Trimming does not affect the conclusion that the median of the distributions are below 1.

Figure A.3: Distribution of MNE Relative Productivity Shocks



OECD Analytical Activities of Multinationals (AAMNE) Database, 2008-2009. The figure plots the distribution of backed out MNE relative productivity shocks for headquarter-host country pairs for durable manufacturing, non-durable manufacturing and non-manufacturing sectors. All distributions are trimmed at top and bottom 5%. Trimming does not affect the conclusion that the median of the distributions are below 1.

Figure A.4: Distribution of Non-tariff Trade Barrier Shocks



OECD Analytical Activities of Multinationals (AAMNE) Database, 2008-2009. The figure plots the distribution of backed out non-tariff trade barrier shocks for headquarter-host country pairs for durable manufacturing, non-durable manufacturing and non-manufacturing sectors. All distributions are trimmed at top and bottom 5%. Trimming does not affect the conclusion that the median of the distributions are below 1.

A.3.2 Real GDP Growth and Model Shocks

Divide real GDP at time $t+\Delta$ with (real) GDP at time t, both measured with time t prices:

$$\begin{aligned}
\frac{RGDP^s_{l,t+\Delta}}{RGDP^s_{l,t}} &= \sum_{i=1}^{N} \frac{P^{y,s}_{li,t} y^s_{li,t+\Delta}}{GDP^s_{l,t}} - \sum_{i=1}^{N}\sum_{s'=1}^{S} \frac{P^{s'}_{li,t} M^{ss'}_{li,t+\Delta}}{GDP^s_{l,t}} \\
&= \sum_{i=1}^{N} \frac{P^{y,s}_{li,t} y^s_{li,t}}{GDP^s_{l,t}} \frac{y^s_{li,t+\Delta}}{y^s_{li,t}} - \sum_{i=1}^{N}\sum_{s'=1}^{S} \frac{P^{s'}_{li,t} M^{ss'}_{li,t}}{GDP^s_{l,t}} \frac{M^{ss'}_{li,t+\Delta}}{M^{ss'}_{li,t}} \\
&= \sum_{i=1}^{N} \frac{GO^s_{li,t}}{GDP^s_{l,t}} \frac{y^s_{li,t+\Delta}}{y^s_{li,t}} - \sum_{i=1}^{N}\sum_{s'=1}^{S} \frac{P^{s'}_{li,t} M^{ss'}_{li,t}}{GDP^s_{l,t}} \frac{M^{ss'}_{li,t+\Delta}}{M^{ss'}_{li,t}}
\end{aligned}$$

Table A.9: Association between MNE Sourcing Shocks and Bilateral Investment/Trade Flow/Distance between the MNE Headquarters and the Host Economy

VARIABLES	(1) $\log(\hat{h}^s_{mj})$	(2) $\log(\hat{h}^s_{mj})$	(3) $\log(\hat{h}^s_{mj})$	(4) $\log(\hat{h}^s_{mj})$	(5) $\log(\hat{h}^s_{mj})$
$\log(I_{mj,07})$	0.00130				
	(0.00105)				
$\log(I_{jm,07})$		0.000753			
		(0.00105)			
$\log(T_{mj,07})$			0.00437		
			(0.00318)		
$\log(T_{jm,07})$				0.00366	
				(0.00318)	
$\log(\text{dist}_{mj})$					-0.00423
					(0.00424)
Observations	2,610	2,610	2,610	2,610	2,610
FE	$j-s;m-s$	$j-s;m-s$	$j-s;m-s$	$j-s;m-s$	$j-s;m-s$

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The table shows the association between changes in MNE sourcing efficiency in the Great Recession, with the pre-Recession bilateral investment, trade flow and distance between the MNE headquarter and the host economy. Bilateral investment is measured with Coordinated Portfolio Investment Survey data from the IMF. $I_{mj,07}$ denotes country j's portfolio investment in country m in 2007.

In the limit with $\Delta \to 0$, and plug in the production function:

$$\begin{aligned} d\log(RGDP^s_l) &= \sum_{i=1}^{N} \frac{GO^s_{li}}{GDP^s_l} d\log(y^s_{li}) - \sum_{i=1}^{N}\sum_{s=1}^{S} \frac{P^{s'}_{li} M^{ss'}_{li}}{GDP^s_l} d\log(M^{ss'}_{li}) \\ &= \sum_{i=1}^{N} \frac{GO^s_{li}}{GDP^s_l} (d\log(A^s_{li}) + \gamma^s_l d\log(L^s_{li}) + \sum_{s=1}^{S} \gamma^{ss'}_l d\log(M^{ss'}_{li})) \\ &- \sum_{i=1}^{N}\sum_{s=1}^{S} \frac{P^{s'}_{li} M^{ss'}_{li}}{GDP^s_l} d\log(M^{ss'}_{li}) \end{aligned}$$

Table A.10: Association between MNE Selling Shocks and Bilateral Investment/Trade Flow/Distance between the MNE Headquarters and the Host Economy

VARIABLES	(1) $\log(\hat{H}^s_{ni})$	(2) $\log(\hat{H}^s_{ni})$	(3) $\log(\hat{H}^s_{ni})$	(4) $\log(\hat{H}^s_{ni})$	(5) $\log(\hat{H}^s_{ni})$
$\log(I_{ni,07})$	0.00155				
	(0.00122)				
$\log(I_{in,07})$		0.00108			
		(0.00122)			
$\log(T_{ni,07})$			0.00915**		
			(0.00370)		
$\log(T_{in,07})$				0.00551	
				(0.00371)	
$\log(\text{dist}_{ni})$					-0.0134***
					(0.00494)
Observations	2,610	2,610	2,610	2,610	2,610
FE	$n-s; i-s$	$n-s; i-s$	$n-s; i-s$	$n-s; i-s$	$n-s; i-s$

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The table shows the association between changes in MNE selling efficiency in the Great Recession, with the pre-Recession bilateral investment, trade flow and distance between the MNE headquarter and the host economy. Bilateral investment is measured with Coordinated Portfolio Investment Survey data from the IMF. $I_{ni,07}$ denotes country i's portfolio investment in country n in 2007.

Note that: $P^{s'}_{li} M^{ss'}_{li} = GO^s_{li} \gamma^{ss'}_l$. As a result,

$$
\begin{aligned}
d\log(RGDP^s_l) &= \sum_{i=1}^{N} \frac{GO^s_{li}}{GDP^s_l}(d\log(A^s_{li}) + \gamma^s_l d\log(L^s_{li})) \\
&= \sum_{i=1}^{N} \frac{GO^s_{li}}{GDP^s_l} d\log(A^s_{li}) + \frac{w^s_l L^s_{li}}{GDP^s_l} d\log(L^s_{li}) \\
&= \sum_{i=1}^{N} \frac{GO^s_{li}}{GDP^s_l} d\log(A^s_{li}) + d\log(L^s_l)
\end{aligned}
$$

A.3.3 Construct Upstream and Downstream Tariffs

Consider country n. $t^s_{nj} = 1 + \tau^s_{nj}$ where τ^s_{nj} denotes the tariff country n imposes on sector s products from j. Following Acemoglu et al. (2016) and Acemoglu et al. (2016), I define

Table A.11: Association between MNE Relative Productivity Shocks, and Bilateral Investment/Trade Flow/Distance between the MNE Headquarters and the Host Economy

VARIABLES	(1) $\log(\hat{A}^s_{ji})$	(2) $\log(\hat{A}^s_{ji})$	(3) $\log(\hat{A}^s_{ji})$	(4) $\log(\hat{A}^s_{ji})$	(5) $\log(\hat{A}^s_{ji})$
$\log(I_{ji,07})$	0.124***				
	(0.0311)				
$\log(I_{ij,07})$		0.0775**			
		(0.0312)			
$\log(T_{ji,07})$			1.050***		
			(0.0924)		
$\log(T_{ij,07})$				1.106***	
				(0.0921)	
$\log(\text{dist}_{ji})$					-1.479***
					(0.123)
Observations	2,610	2,610	2,610	2,610	2,610
FE	$j-s; i-s$	$j-s; i-s$	$j-s; i-s$	$j-s; i-s$	$j-s; i-s$

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The table shows the association between changes in MNE relative productivity in the Great Recession, with the pre-Recession bilateral investment, trade flow and distance between the MNE headquarter and the host economy. Bilateral investment is measured with Coordinated Portfolio Investment Survey data from the IMF. $I_{ji,07}$ denotes country i's portfolio investment in country j in 2007.

sector direct input coefficient matrix A_n of which $s-s'$ element, $a_n^{ss'}$, equals the following:

$$a_n^{ss'} = \frac{\text{Sales}_n^{s\leftarrow s'}}{\text{Sales}_n^s}$$

$a_n^{ss'}$ measures the direct expenditure share sector s spends on sector s' in country n. The total input coefficient matrix, A_n^{tot} is the Leontif inverse of A_n:

$$A_n^{\text{tot}} = (I - A_n)^{-1} \tag{A.2}$$

of which the element $a_n^{ss',\text{tot}}$ measures total (direct + indirect) expenditure share sector s spends on sector s' in country n.

Construct the direct upstream tariff of country n sector s as follows:

$$t_{nj}^{s,\text{direct up}} = \frac{\sum_{s' \neq s} a_n^{ss'} t_{nj}^{s'}}{\sum_{s' \neq s} a_n^{ss'}}$$

The total upstream tariff of country n sector s:

$$t_{nj}^{s,\text{total up}} = \frac{\sum_{s' \neq s} a_n^{ss',\text{tot}} t_{nj}^{s'}}{\sum_{s' \neq s} a_n^{ss',\text{tot}}}$$

Now consider downstream tariffs. I define sector direct output coefficient matrix B_n of which $s' - s$ element, $b_n^{s's}$, equals the following:

$$b_n^{s's} = \frac{\text{Sales}_n^{s \to s'}}{\text{Sales}_n^{s}}$$

$b_n^{s's}$ measures direct output share sector s sells to sector s' in country n. The total output coefficient matrix, B_n^{tot} is the Leontif inverse of B_n:

$$B_n^{\text{tot}} = (I - B_n)^{-1}$$

of which the element $b_n^{s's,\text{tot}}$ measures total (direct + indirect) output share sector s sells to sector s' in country n.

Construct the direct downstream tariff of country n sector s as follows:

$$t_{nj}^{s,\text{direct down}} = \frac{\sum_{s' \neq s} b_n^{s's} t_{nj}^{s'}}{\sum_{s' \neq s} b_n^{s's}}$$

The total upstream tariff of country n sector s:

$$t_{nj}^{s,\text{total down}} = \frac{\sum_{s' \neq s} b_n^{s's,\text{tot}} t_{nj}^{s'}}{\sum_{s' \neq s} b_n^{s's,\text{tot}}}$$

In the baseline specification, the bilateral upstream and downstream tariffs, $\log(t_{nj}^{s,\text{total up}} t_{jn}^{s,\text{total up}})$ and $\log(t_{nj}^{s,\text{total down}} t_{jn}^{s,\text{total down}})$ are used as instruments for $\log\left(\frac{C_{nj,t}^s}{C_{nn,t}^s}\frac{C_{jn,t}^s}{C_{jj,t}^s}\right)$ in Equation (1.19). The estimated coefficient is robust for measures of upstream and downstream tariffs with the direct shares. The estimation results are reported in Section A.3.4.

A.3.4 Estimation Results

Table A.12 shows the estimated parameters and the implied trade elasticity, σ^s, MNE elasticity ζ^s. The baseline specification is Equation (1.19). The sample includes the entire time span of the OECD AAMNE data (2005-2016) except the Great Recession period (2008-2009). The sample excludes the observations where a country trades with itself, i.e. $n = j$, as these observations do not have any tariff variations. Bilateral upstream and downstream tariffs computed with total shares are used as instruments for $\log\left(\frac{C_{nj,t}^s}{C_{nn,t}^s}\frac{C_{jn,t}^s}{C_{jj,t}^s}\right)$. The baseline specification gives an estimate of $\frac{1-\sigma^s}{1-\zeta^s}$ at 1.12 for the durable manufacturing sector, 1.78 for the nondurable manufacturing sector, and 10.19 for the non-manufacturing sector. The estimate of $1-\sigma^s$ is -11.50 for the durable manufacturing sector, -3.20 for the nondurable manufacturing and -7.36 for the non-manufacturing sector. With a pooled regressions for all sectors, the estimate of $\frac{1-\sigma^s}{1-\zeta^s}$ is 1.02 and the estimate of $1-\sigma^s$ is -7.36. The estimates for both $\frac{1-\sigma^s}{1-\zeta^s}$ and $1-\sigma^s$ are significant in all equations are significant at 1%, except for $1-\sigma^s$ for the service sector, which is marginally significant at 10%.

I test the robustness of the results with the following alternative specifications: (1) I include the Great Recession years back into the sample. (2) Instead of using the destination-year fixed effects, I use a separate destination fixed effect and a year fixed effect. (3) I include all country pairs in the sample and add a dummy to the right hand side denoting a country trading with itself as a way to control the border effect. (4) I replace the total shares in the instruments with direct shares. As noted in Table A.12, the results barely change with the alternative specifications.

Table A.12: Estimated Trade and MNE Elasticities

Specifications	Sector name	ISIC classification	$\frac{1-\sigma^s}{1-\zeta^s}$	$1-\sigma^s$	σ^s	ζ^s
Baseline	Durable manuf	C16,C23-C33	1.12 (0.24)	-11.50 (0.73)	12.50	11.27
	Nondurable manuf	C10-C15,C17-C18,C20-C22	1.78 (0.55)	-3.20 (0.47)	4.20	2.80
	Non-manuf	Other	10.19 (2.37)	-5.46 (3.49)	6.46	1.54
	All	All	1.02 (0.04)	-7.36 (0.26)	8.36	8.21
All years	Durable manuf	C16,C23-C33	1.08 (0.21)	-11.19 (0.65)	12.19	11.32
	Nondurable manuf	C10-C15,C17-C18,C20-C22	1.32 (0.55)	-3.01(0.41)	4.01	3.27
	Non-manuf	Other	13.72 (3.89)	-9.14 (5.28)	10.14	1.67
	All	All	1.02 (0.33)	-7.35 (0.24)	8.35	8.22
Origin, destination, year FE	Durable manuf	C16,C23-C33	1.20 (0.27)	-10.58 (0.70)	11.58	9.84
	Nondurable manuf	C10-C15,C17-C18,C20-C22	2.43 (0.56)	-3.04 (0.51)	4.04	2.25
	Non-manuf	Other	7.72 (1.50)	-1.13 (2.04)	2.13	1.15
	All	All	1.02 (0.04)	-7.09 (0.26)	8.09	7.94
All pairs+ own trade dummy	Durable manuf	C16,C23-C33	1.11 (0.24)	-10.88 (0.69)	11.88	10.84
	Nondurable manuf	C10-C15,C17-C18,C20-C22	1.60 (0.52)	-3.15 (0.44)	4.15	2.98
	Non-manuf	Other	9.46 (2.13)	-4.82 (3.17)	5.82	1.51
	All	All	1.02 (0.04)	-7.33 (0.26)	8.33	8.16
Direct shares	Durable manuf	C16,C23-C33	1.15 (0.23)	-10.94 (0.66)	11.94	10.49
	Nondurable manuf	C10-C15,C17-C18,C20-C22	1.26 (0.47)	-3.10 (0.41)	4.10	3.47
	Non-manuf	Other	9.44 (2.02)	-4.60 (3.02)	5.60	1.49
	All	All	1.02 (0.04)	-7.27 (0.26)	8.27	8.10

Estimated coefficients and implied trade and MNE elasticities under the baseline and alternative specifications. I consider the following robustness tests: including the Great Recession period (2008-2009) back into the sample (Specification "All years"); replacing the destination-year fixed effects with separate, destination fixed effects and year fixed effect (Specification "Origin/destination/year FE"); including all country pairs and introducing a dummy to denote own-trade into the right hand side (Specification "All pairs+own trade dummy"); using direct shares instead of total shares to compute the upstream and downstream tariffs in the instruments (Specification "Direct shares"). Numbers in the brackets denote standard errors.

A.3.5 Implied Aggregate Productivity Shock

To test the external validity of the new method, which I use to back out local productivity shocks, I compare the country-level, year-on-year growth in labor productivity and TFP data from the OECD multi-factor productivity database, to a measure of host-economy aggregate productivity shocks constructed with my results.

I first construct host-country-sector level productivity changes, by aggregating changes in local productivity $d\log(A_{ll}^s)$ and changes in MNE relative productivity $d\log(\frac{A_{li}^s}{A_{ll}^s})$, using MNEs' output shares in host-economy sector gross output $\frac{GO_{li}^s}{GO_l^s}$ as weights. Then

I aggregate the host-country-sector level productivity changes computed in Equation (1.31) to the country level, using sectors' share in the country's gross output $\frac{GO_l^s}{GO_l}$ as weights. I use the same method as in Section 1.4.5 and in Davis et al. (1998) to take the changes in MNE relative productivity and weights to the data, shown in Equation A.3. $d\log(A_{ll}^s)$ is computed with Equation (1.30) in the main text, so I don't put a "tilde" on top of it.

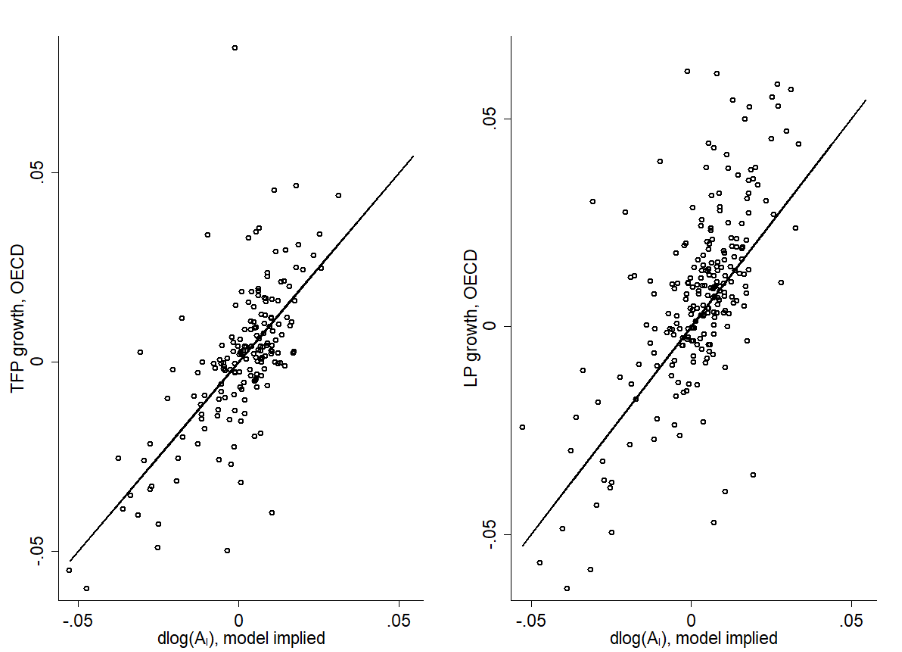
$$d\log(A_l) = \sum_{s=1}^{S} \frac{\overline{GO_l^s}}{\overline{GO_l}} \left(d\log(A_{ll}^s) + \sum_{i=1}^{N} \frac{\overline{GO_{li}^s}}{\overline{GO_l^s}} \widetilde{\frac{A_{li}^s}{A_{ll}^s}} \right) \tag{A.3}$$

The merged data covers 25 countries and 10 years (19 countries and 10 years) for labor productivity growth (TFP growth) from OECD multi-factor productivity database.[2] Figure A.5 shows the model implied host-economy aggregate productivity changes are strongly positively associated with both TFP growth and LP growth data from the OECD multi-factor productivity database. The correlation is 0.69 (0.67) with TFP (LP) growth in the data. The regression coefficient of OECD TFP (LP) growth on model implied host country level aggregate productivity changes is 0.997 (1.027).

A.4 Additional Results

2. The merged OECD LP data includes the following countries: AUS, AUT, BRA, CAN, CHL, DEU, DNK, ESP, FIN, FRA, GRC, HUN, IRL, ITA, JPN, KOR, MEX, NLD, NOR, NZL, PRT, SWE, TUR, USA, ZAF; and years 2005-2014. The merged OECD TFP data includes the following countries AUS, AUT, CAN, DEU, ESP, FIN, FRA, GBR, GRC, IRL, ITA, JPN, KOR, NLD, NOR, NZL, PRT, SWE, USA; and years 2005-2014.

Figure A.5: Implied Aggregate Productivity Shocks vs OECD LP and TFP changes

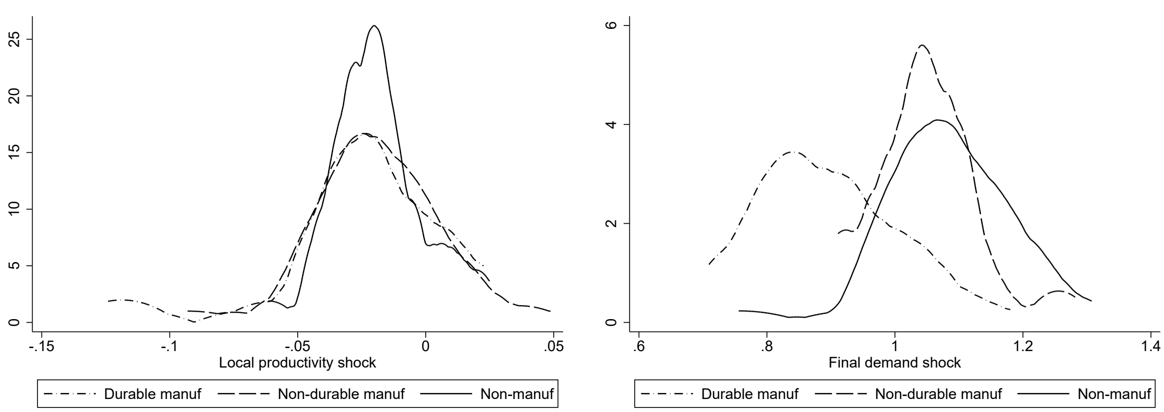


The figures plot the host-economy aggregate productivity changes implied by the model inversion results, against the TFP and LP growth of the countries from the OECD multi-factor productivity database.

Figure A.6: Distribution of Local Productivity Shocks and Sectoral Final Demand Shocks

(a) Density of Local Productivity Shock

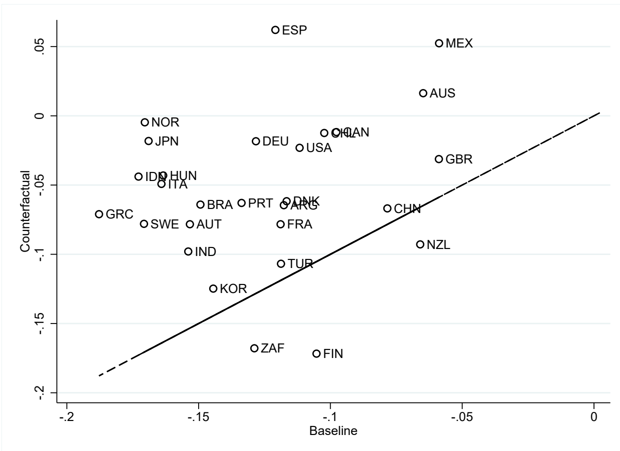
(b) Density of Final Demand shock



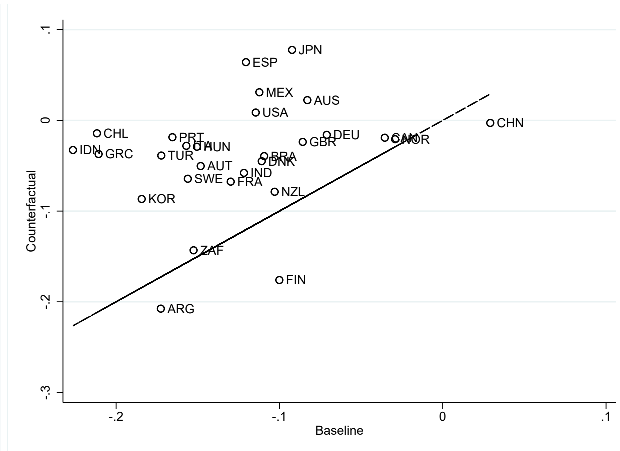
The figure plots the density of local productivity shocks and sectoral final demand shocks across countries for each sector.

Figure A.7: Impact of Trade Shocks on the Trade Collapse and Import by Local Producers and Consumers Relative to GDP

(a) Total Trade



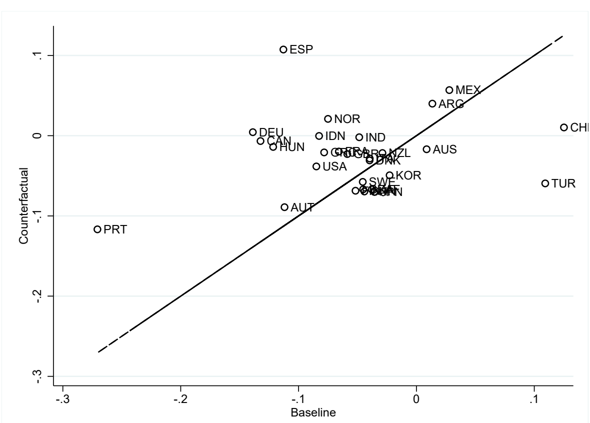
(b) Import by Local Producers and Consumers



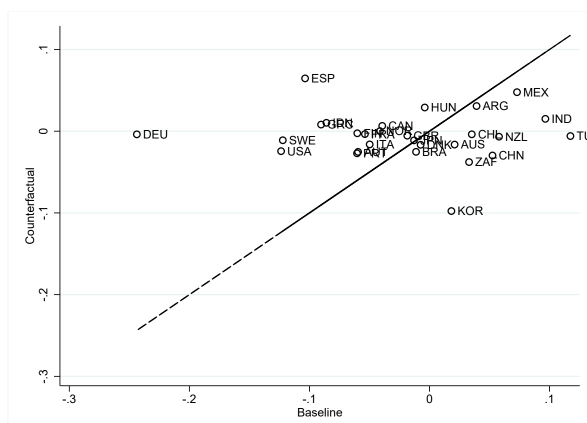
The figure plots the counterfactual declines in total trade and import by local producers and consumers, both relative to GDP.

Figure A.8: Impact of Trade Shocks on the MP Collapse and Foreign Affiliate Domestic Sales Relative to GDP.

(a) Total MP



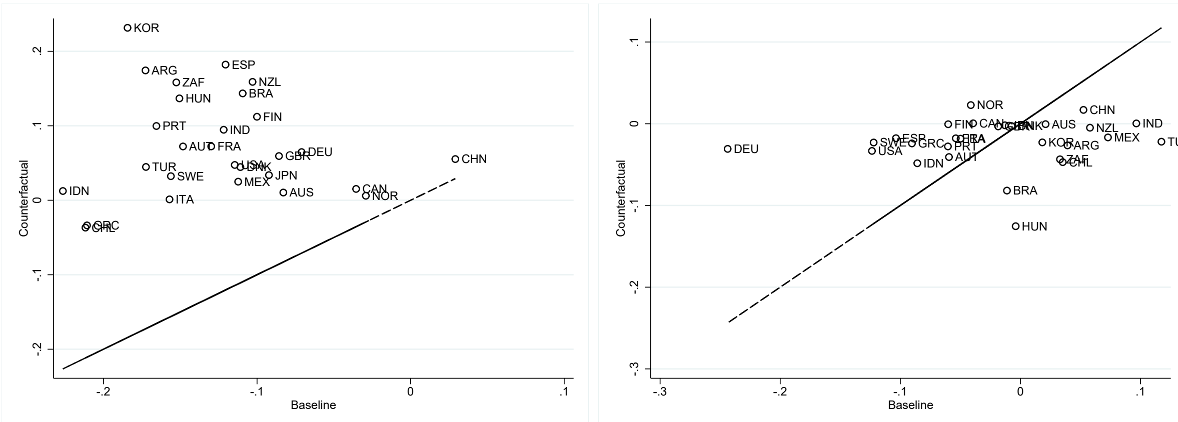
(b) Foreign Affiliate Domestic Sales



The figure plots against the data the counterfactual declines of total MP (left) and foreign affiliate domestic sales, both relative to GDP and in response to trade shocks.

Figure A.9: Impact of MNE-specific Shocks on Import by Local Producers and Consumers and Impact of Domestic Shocks on Foreign Affiliate Domestic Sales

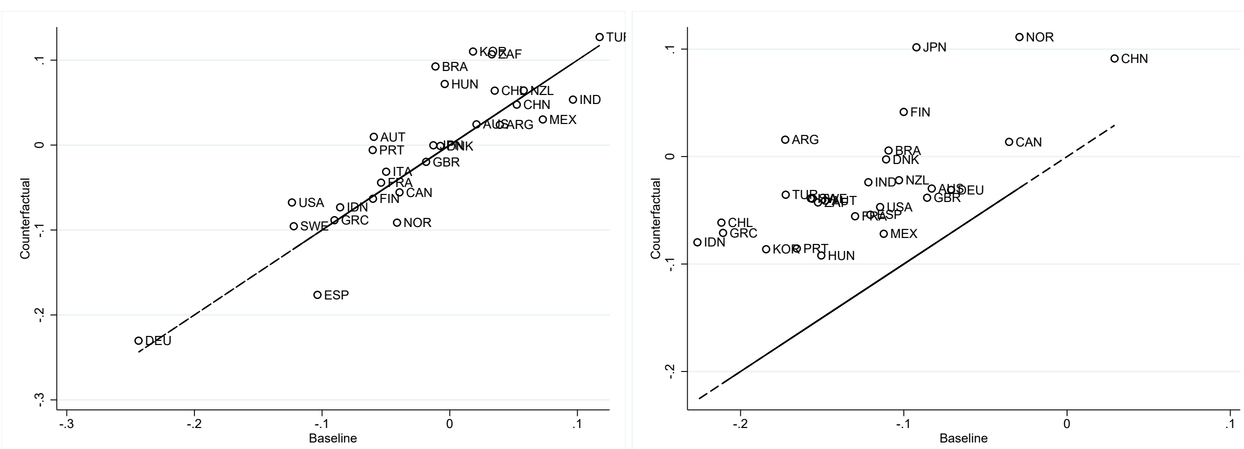
(a) MNE-specific Shocks on Imports by Local Producers and Consumers (b) Domestic Shocks on Foreign Affiliate Domestic Sales



The figure plots against the data the counterfactual declines of import by local producers and consumers in response to MNE-specific shocks (left) and foreign affiliate domestic sales in response to domestic shocks, both relative to GDP.

Figure A.10: Impact of MNE-specific Shocks on Foreign Affiliate Domestic Sales and Domestic Shocks on Import by Local Producers and Consumers

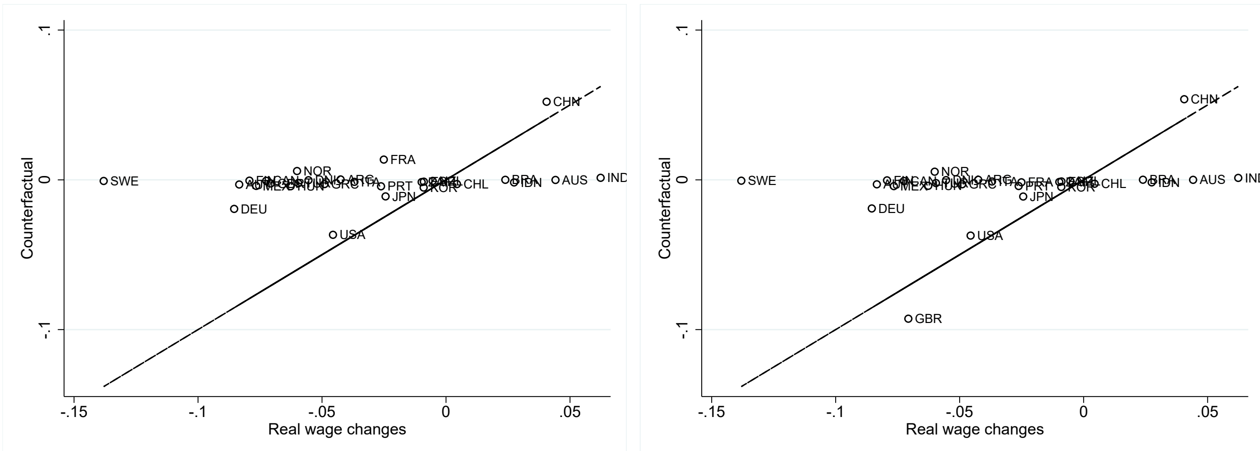
(a) Foreign Affiliate Domestic Sales (b) Import by Local Producers and Consumers



The figure plots the counterfactual foreign affiliate domestic sales relative to GDP with MNE-specific shocks, and import by local producers and consumers relative to GDP with domestic shocks.

Figure A.11: Impact of Domestic Shocks to Important Exporters/Importers on Welfare Changes

(a) Domestic Shocks to Five Largest Exporters (b) Domestic Shocks to Five Largest Importers



The figure plots the counterfactual welfare changes. The left panel shows the impact of domestic shocks to five largest exporters as of 2008 (United States, China, Germany, Japan and United Kingdom, which together account for 51% of world export). The right panel shows the impact of domestic shocks to five largest importers as of 2008 (United States, China, Germany, Japan and France, which together account for 54% of world import).

Table A.13: Explanatory Power of Shocks for Cross-country Variation in MP and Trade Collapse

Full model				
	Total MP	Total trade	Foreign affiliate domestic sales	Local producers and consumers import
MNE-specific shocks	70.92%	19.02%	96.04%	-6.22%
Domestic shocks	6.79%	40.34%	4.17%	67.51%
Trade shocks	12.29%	29.34%	-1.29%	28.45%
MNE relative productivity shocks	84.12%	4.61%	116.07%	8.76%
MNE sourcing shocks	-43.44%	-10.27%	-27.12%	-24.66%
MNE selling shocks	30.76%	27.30%	22.71%	18.50%
Headquarter shocks to USA	16.81%		30.57%	
Host economy shocks to USA	7.63%		1.48%	
Headquarter shocks to top 5 headquarters	41.11%		67.29%	
Host economy shocks to top 5 hosts	23.48%		35.27%	
Domestic shocks to top 5 exporters		0.32%		11.79%
Domestic shocks to top 5 importers		1.02%		12.58%
Model without sourcing and selling efficiencies				
	Total MP	Total trade		
MNE-specific shocks	96.85%	4.83%		
Domestic shocks	4.25%	66.25%		
Trade shocks	-0.35%	34.37%		

The table summarizes the impact of groups of shocks on countries collapse of MP and trade relative to GDP as discussed in Section 1.5.

Table A.14: Impact of Shocks on World Aggregate Trade and MP Declines Relative to World GDP

	Total MP	Total trade	Foreign affiliate domestic sales	Local producers and consumers import
Baseline	-11.02% (100%)	-11.82% (100%)	-9.41% (100%)	-10.1% (100%)
MNE-specific shocks	-5.69% (51.68%)	2.18% (-18.44%)	-8.97% (95.36%)	1.92% (-18.91%)
Domestic shocks	-5.23% (47.46%)	-6.78% (57.36%)	-2.42% (25.73%)	-6.06% (60.00%)
Trade shocks	-3.85% (34.96%)	-2.13% (18.02%)	-1.58% (16.82%)	-1.04% (10.30%)

The table presents the impact of groups of shocks on cross-country variation in world total MP, total trade, foreign affiliate domestic sales, and local producers and consumers import relative to world GDP. Numbers in the bracket equal the fraction of baseline changes that could be explained by the individual group of shocks in the row.

Table A.15: Explanatory Power of Headquarters Shocks to Individual Countries for Cross-country Variation in MP Collapse

Country code	Contribution	Country code	Contribution
ARG	-2.49%	HUN	-1.80%
AUS	4.99%	IDN	3.85%
AUT	2.71%	IND	-5.82%
BRA	1.16%	ITA	3.36%
CAN	2.38%	JPN	1.47%
CHL	-3.24%	KOR	0.38%
CHN	0.14%	MEX	-1.74%
DEU	15.38%	NOR	-0.53%
DNK	-1.36%	NZL	-3.59%
ESP	7.83%	PRT	1.43%
FIN	2.59%	SWE	3.28%
FRA	12.61%	TUR	-5.50%
GBR	5.44%	USA	30.57%
GRC	1.95%	ZAF	-2.67%

The table presents the impact of headquarter shocks to individual countries on cross-country variation in declines of total MP relative to GDP

Table A.16: Explanatory Power of Host Country Shocks to Individual Countries for Cross-country Variation in MP Collapse

Country code	Contribution	Country code	Contribution
ARG	1.47%	HUN	0.65%
AUS	-0.06%	IDN	-2.44%
AUT	-2.09%	IND	8.73%
BRA	-1.13%	ITA	-0.97%
CAN	-0.44%	JPN	-3.90%
CHL	3.17%	KOR	1.83%
CHN	1.37%	MEX	4.30%
DEU	22.64%	NOR	1.21%
DNK	-0.40%	NZL	5.22%
ESP	4.61%	PRT	-1.06%
FIN	-0.46%	SWE	3.35%
FRA	-1.27%	TUR	16.18%
GBR	-1.50%	USA	1.48%
GRC	1.19%	ZAF	4.44%

The table presents the impact of host economy shocks to individual countries on cross-country variation in declines of total MP relative to GDP.

Table A.17: Explanatory Power of Groups of Shocks for Cross-country Variation in Welfare Changes

	Foreign component	Total real wage changes
Trade	-0.30%	1.05%
MP	100.69%	26.40%
Domestic	-2.54%	74.65%
Headquarter shocks to USA	35.96%	0.19%
Host economy shocks to USA	-0.90%	1.41%
Headquarter shocks to top 5 headquarters	67.87%	16.84%
Host economy shocks to top 5 hosts	9.02%	10.72%
Domestic shocks to top 5 exporters	-2.7%	4.7%
Domestic shocks to top 5 importers	-2.9%	-1.6%

The table presents the explanatory power of groups of shocks on cross-country variation in welfare changes.

Table A.18: Impact of Local Productivity Shocks on Welfare Changes in Trade-only Model and Full Model

Country Code	No-MP Model	Full Model	Country Code	No-MP Model	Full Model
ARG	-4.3%	-5.5%	HUN	-5.8%	-11.8%
AUS	1.8%	0.7%	IDN	1.5%	2.2%
AUT	-8.3%	-6.1%	IND	5.8%	5.7%
BRA	1.8%	1.7%	ITA	-6.7%	-5.3%
CAN	-7.1%	-5.5%	JPN	-5.9%	-5.5%
CHL	-2.6%	-3.8%	KOR	0.6%	0.3%
CHN	3.9%	4.4%	MEX	-6.4%	-6.7%
DEU	-10.9%	-5.0%	NOR	-7.8%	-2.5%
DNK	-7.6%	-6.7%	NZL	-0.3%	-2.2%
ESP	-3.8%	-2.8%	PRT	-4.8%	-2.1%
FIN	-12.7%	-10.3%	SWE	-12.9%	-6.5%
FRA	-5.3%	-3.5%	TUR	-4.9%	-5.7%
GBR	-7.5%	-4.9%	USA	-5.5%	-3.5%
GRC	-5.7%	-4.4%	ZAF	-2.9%	-4.8%

The table presents the impact of local productivity shocks on countries' real wage changes in the trade-only model and the full model.

APPENDIX B

APPENDIX TO THE EMPLOYMENT CONSEQUENCES OF ANTI-DUMPING TARIFFS: LESSONS FROM BRAZIL

B.1 Additional Tables and Figures

B.1.1 Statistics of AD Investigations in Brazil

We present the summary statistics of AD measures and investigations taken by Brazil since 1989. Table B.1 shows the number of investigations, investigated products and countries. Treated are the product-country pairs that had an AD tariff applied or price adjustment. 59% of the investigations ended with an AD measure. Of those, 93% was a tariff increase.

Table B.1: Statistics of Brazilian AD Investigations

	Treated	Control	All
# Investigations	765	520	1284
# Products	260	315	498
# Countries	50	57	71
Avg. Tariff	0.45	0	0.23
Shr. Price Adj.	0.07	0	0.04

Notes: This table presents statistics of the Brazilian anti-dumping investigations between 1989 and 2017. Each investigation is applied to a product-country pair. The avg. tariff is calculated using the imposed ad-valorem tariff. In the case that the tariff is per-unit, we calculate the corresponding ad-valorem value with the import unit price (calculated with import values and units) in the preceding year. The data source is the Brazilian Ministry of Commerce.

Figure B.1a shows the number of AD investigations by year. In 1994 a broad complaint was filled which covered 124 artificial and synthetic fabric products from South Korea. As we count investigations on the country-product level (rather than the number of complaints), we observe the large spike in that year. This complaint was rejected for all products. Other than for this spike, control and treatment group are evenly distributed over time. Figure B.1b shows the average AD tariff by year.

Table B.2 show the top 5 countries that faced the most investigations. China was the leader. 80% of the investigations into products from China ended with a tariff increase or price agreement. There is large variation across countries in the magnitude of the AD tariffs imposed.

Figure B.1: Brazilian Anti-Dumping Policy Over-Time

(a) **Investigations by Year** (b) **Average AD Tariff by Year**

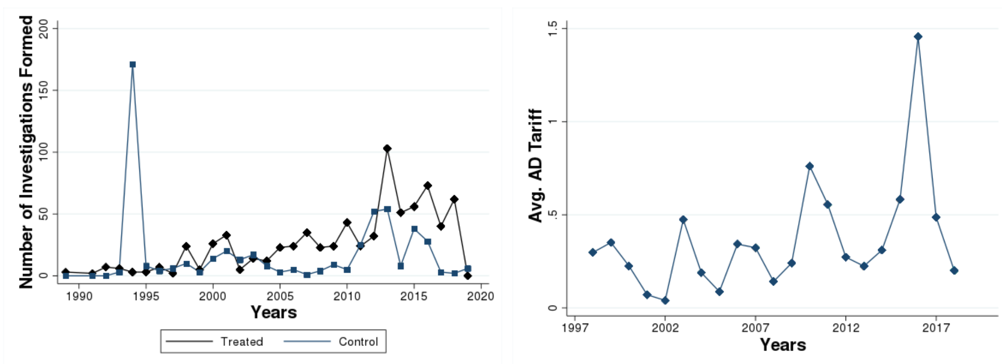


Table B.2: Countries with Most AD Investigations

Country Name	# Investigations	# Treated	Avg. Tariff	% Treated
China	371	299	0.563	0.806
South Korea	166	23	0.0681	0.139
United States	94	51	1.002	0.543
India	50	27	0.0992	0.540
Mexico	49	31	0.175	0.633

B.1.2 AD Investigations: Levels and Trends

In this section, we show that the firms that file complaints and the products that are investigated because of these complaints are different from the rest, both in terms of level and trends. This invalidates the traditional approach that identifies the impact of AD tariffs by comparing the firms and products that receive AD tariffs to those that do not, using an

OLS or a difference-in-differences strategy. Those that receive AD tariffs must have been investigated, whereas most non-tariffed firms and products are not investigated.

Table B.3 shows the association between the probability of an AD complaint filed on an imported product in the next year, with the value of imports and price of the product. Column (1) shows that product-countries that have high volume and low price are more likely to receive a dumping complaint. Column (2) to (4) show that the results are robust to fixed effect controls. In particular, Column (4) shows that the products with complaint are in a downward trend in prices and upward trend in value.

Table B.3: Probability of Receiving Dumping Complaint

	(1) $\mathbb{I}\{$Complaint Filled$\}$	(2) $\mathbb{I}\{$Complaint Filled$\}$	(3) $\mathbb{I}\{$Complaint Filled$\}$	(4) $\mathbb{I}\{$Complaint Filled$\}$
log(Value)	0.000228***	0.000224***	0.000160***	0.000139***
	(0.000)	(0.000)	(0.000)	(0.000)
log(Price)	-0.000147***	-0.000154***	-0.0000523***	-0.0000502***
	(0.000)	(0.000)	(0.000)	(0.000)
Year FE		X	X	
Product X Orig. FE			X	X
Year X Country FE				X
Avg. Dependent	.0004735	.0004735	.0004735	.0004735
N	1542747	1542747	1509536	1508929
R^2	0.001	0.001	0.121	0.125

Notes: This table presents the results of an OLS regression of a dummy that indicates whether a product-country receives a dumping complaint next year on the import value and price of the product. Standard errors are clustered at the product-country level.

Table B.4 helps us understand why firms file dumping complaints. It shows the association between the probability of a firm filing a dumping complaint in the next year with the firm's business statistics. We constrain the sample to the set of firms that have ever filled a complaint. We find that firms are more likely to file complaints when they are opening other establishments. These trends are similar between treatment (the firms that apply for AD investigations and receive tariff hikes) and control (the firms that apply for AD investigations but are denied tariff hikes). This allows us to make the causal statement about AD tariffs.

Table B.4: Probability of Firm Filing Dumping Complaint

	(1)	(2)	(3)	(4)
	$\mathbb{I}$ {Complaint Filled}	$\mathbb{I}$ {Complaint Filled}	$\mathbb{I}$ {Complaint Filled}	$\mathbb{I}$ {Complaint Filled}
log(wage)	0.0106***	-0.00180	-0.00371	-0.00532
	(0.000)	(0.827)	(0.782)	(0.670)
log(# workers)	-0.00799**	-0.00112	-0.0110	-0.0129
	(0.016)	(0.888)	(0.426)	(0.337)
log(# stablishments)	0.0127**	0.0168***	0.0245*	0.0229***
	(0.017)	(0.004)	(0.065)	(0.005)
Year FE		X	X	X
Sector FE			X	X
Firm FE				X
Avg. Dependent	0.062	0.062	0.062	0.062
N	2084	2084	1269	2084
R^2	0.024	0.142	0.159	0.177

Notes: This table presents the results of an OLS regression of a dummy that indicates whether a firm files an dumping complaint in the next year on the firm's business statistics. The sample is constrained to firms that have ever filed a complaint.

B.1.3 Alternative Specification that Studies the Impact of AD Tariffs with Binary Treatment Variation

The empirical model that we present in the main text relies on variations in the magnitude of the AD tariffs. To test the robustness of our results, in this section we take advantage of two alternative tariff variations (both conditional on being investigated). The first variation is between those that receive the tariff and those that do not. The second variation is the magnitude of the AD tariffs among those that receive the tariffs. We show that we get similar results with both variations.

Treatment Dummies

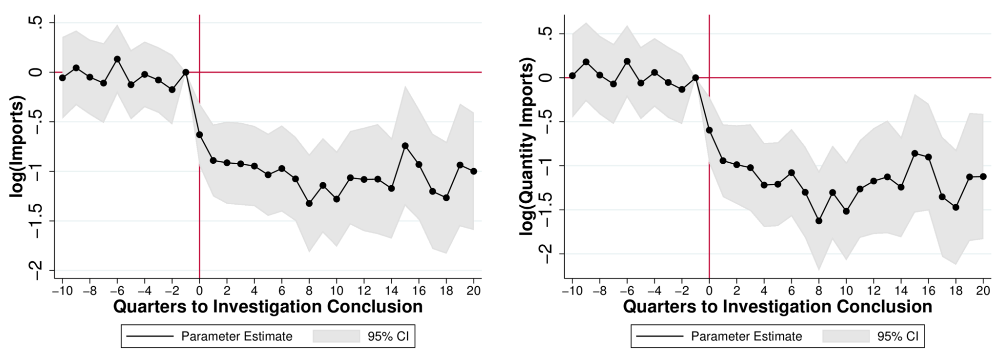
Imports The specification that relies on the comparison between the treatment and control groups is the following:

$$
\begin{aligned}
y_{p,c,q} = & \sum_{j=-\underline{t}}^{\bar{t}} \theta_j \mathbb{I}_{p,c}\{\text{Treatment}\}\mathbb{I}_{p,c,q}\{j \text{ Qrt. to AD}\} \\
& + \sum_{j=-\underline{t}}^{\bar{t}} \beta_j \mathbb{I}_{p,c,q}\{j \text{ Qrt. to AD}\} + \eta_{p,c} + \eta_{q,c} + \epsilon_{p,c,q}
\end{aligned}
\tag{B.1}
$$

where we replace the magnitude of tariff, $\tau_{p,c}$, in Equation 2.2 with a dummy variable $\mathbb{I}_{p,c}\{\text{Treatment}\}$, which takes one if the product-country pair $\{p, c\}$ receives an AD tariff in its first dumping investigation. Figure B.2 displays the results. Similar to the results reported in the main text, it shows that AD tariffs lead to declines in both the value and quantity of imports. We do not observe imports reducing during the quarters that precede the tariff increase, which confirms the parallel trend hypothesis.

Figure B.2: Impact of AD Tariffs on Imports Value and Quantity

(a) **Import Value Using Treatment Model** (b) **Import Quant. Using Treatment Model**



Employment The alternative specification to study the employment effect of AD tariffs is the following:

$$
\begin{aligned}
y_{i,s,t} = & \sum_{j=-\underline{q}}^{\overline{q}} \theta_j \mathbb{I}_s\{\text{Treatment}\} \times \mathbb{I}_{s,t}\{j \text{ Yrs. to AD}\} \\
& + \sum_{j=-\underline{q}}^{\overline{q}} \beta_j \mathbb{I}_{s,t}\{j \text{ Yrs. to AD}\} + \beta_s t + \eta_i + \eta_t + \epsilon_{i,s,t}
\end{aligned}
\tag{B.2}
$$

where $\mathbb{I}_s\{\text{Treatment}\}$ is a dummy that takes 1 if the first AD investigation of sector s leads to an AD tariff. Note that in this specification we also add a sector trend like in Flaaen et al. (2019).

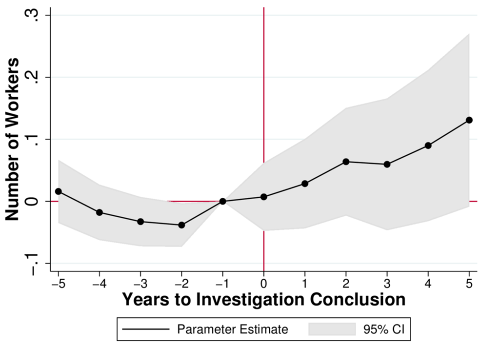
The results are presented in Appendix Figure B.3. We receive the expected signs of coefficients: Tariffs increase employment in the protected sector, increase employment in its upstream, but decrease employment in its downstream. However, the statistical power is less than using variations with both whether a sector is treated and the magnitude of the tariff if the sector is treated.

Tariff Variation in Protected Sectors

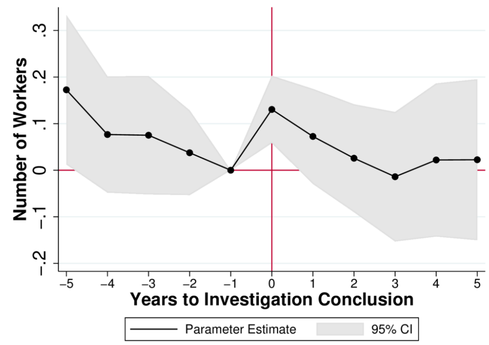
Next we present the impact of AD tariffs estimated with variations in the magnitude of the tariffs among the set of sectors that receive tariff increase in their first investigation. This model relies on parallel trends between high and low AD tariff sectors to make the case for causality. The estimation equation is the same as Equation 2.2 in the main text but constrains the sample to those that have positive tariff changes. The results are presented in Figure B.4 and are similar to the results that we acquire with our preferred specification.

Figure B.3: Impact of AD Tariffs on Employment

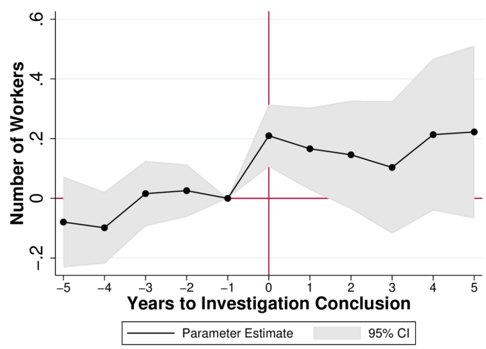
(a) **Employment at the National Producer**



(b) **Employment at the Downstream Sector**



(c) **Employment at the Upstream Sector**



B.1.4 Heterogeneous Effects of AD Tariffs on Upstream and Downstream Firms

We investigate the heterogeneous effects of AD tariffs on downstream and upstream firms in different firm size (measured with sales) and average wage quartiles of the sector firm distribution. We consider the following specification for downstream firms:

$$\begin{aligned} y_{i,d(s),t} = & \sum_{q=1}^{4} \theta_q \mathbb{I}_{i,d(s)}\{\text{quartile q}\}\tau_{s,t}\mathbb{I}_{s,t}\{\text{After AD}\} \\ & + \sum_{q=1}^{4} \beta_q \mathbb{I}_{i,d(s)}\{\text{quartile q}\}\mathbb{I}_{s,t}\{\text{After AD}\} + \eta_i + \eta_t + \epsilon_{i,t} \end{aligned} \tag{B.3}$$

where $d(s)$ denotes the downstream sector that sector s sells the largest value of output to. $y_{i,d(s),t}$ denotes the variable of interest of firm i in downstream sector $d(s)$ year t. $\mathbb{I}_{i,d(s)}\{\text{quartile q}\}$ is a dummy variable that takes 1 if firm i is in quartile q of firm distribution in downstream sector $d(s)$ in the year prior to the AD inspection. In our analysis we consider the distribution of firm size measured with sales and the distribution of firm average wage. θ_q captures the marginal response of downstream, quartile q firms to upstream tariffs. Similarly, we use the following specification for the response of upstream firms:

$$\begin{aligned} y_{i,u(s),t} = & \sum_{q=1}^{4} \theta_q \mathbb{I}_{i,u(s)}\{\text{quartile q}\}\tau_{s,t}\mathbb{I}_{s,t}\{\text{After AD}\} \\ & + \sum_{q=1}^{4} \beta_q \mathbb{I}_{i,u(s)}\{\text{quartile q}\}\mathbb{I}_{s,t}\{\text{After AD}\} + \eta_i + \eta_t + \epsilon_{i,t} \end{aligned} \tag{B.4}$$

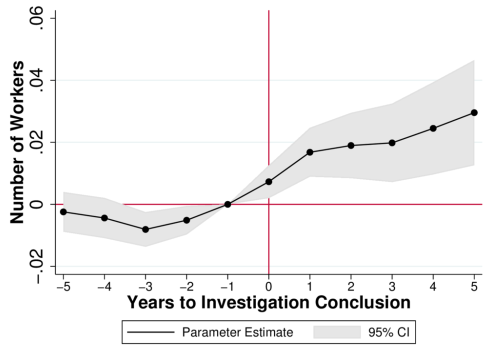
where $u(s)$ denotes the upstream sector that sector s buys the largest value of input from. $y_{i,u(s),t}$ denotes the variable of interest of firm i in upstream sector $u(s)$ year t. $\mathbb{I}_{i,u(s)}\{\text{quartile q}\}$ is a dummy variable that takes 1 if firm i is in quartile q of firm distribution in upstream sector $u(s)$ in the year prior to the AD inspection. In our analysis we consider the distribution of firm size measured with sales and the distribution of firm average wage. θ_q captures the marginal response of upstream, quartile q firms to downstream tariffs.

B.1.5 Firms Filing Complaints

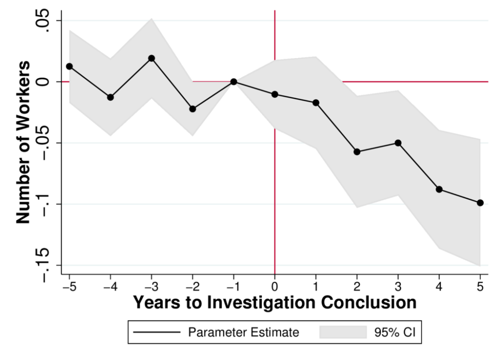
In this section we study how firms that file the dumping complaint adjust their employment. Starting 2008, the Brazilian trade authority records information about the complaining firms. Out of the 96 firms that formed the 250 investigations during this period, we are able to match 93 non-union firms to RAIS using firm names. Figures B.5a and B.5b display the parameters β_j of Equation 2.4, which captures the impact of AD investigations. Despite the large standard errors, it is clear that there is no change in firm employment after the conclusion of an AD investigation.

Figure B.4: Impact of AD Tariffs on Employment

(a) **Employment at the National Producer**



(b) **Employment at the Downstream Sector**



(c) **Employment at the Upstream Sector**

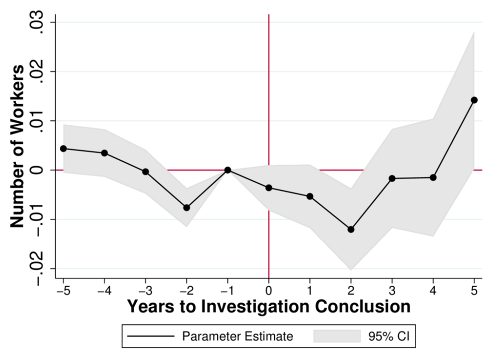
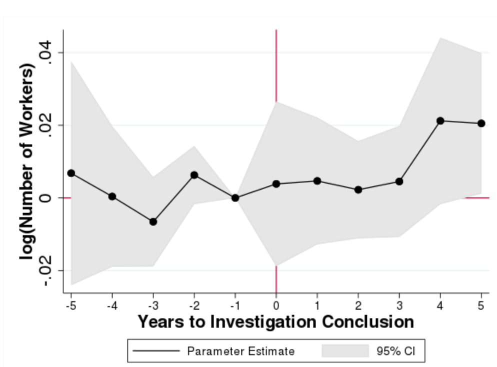
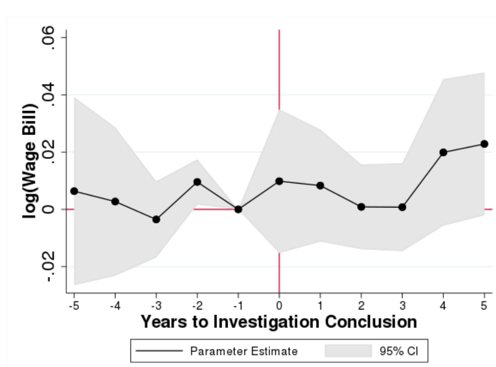


Figure B.5: Impact of AD Investigations

(a) **Number of Workers**



(b) **Wage Bill**



B.1.6 Validation

Our identifying assumptions hinges on that conditional on investigations, the tariff is not correlated with other policies that may affect firms simultaneously to the tariff increase, e.g. political connections. We test the assumption in two ways. On the one hand, in the main text we show that the treatment group does not systematically differ from the control group prior to the treatment, i.e. parallel trends, which likely will persist after the treatment. On the other hand, in this section we show that tariff increase is not correlated with other policy variations after the tariff increase. In particular, we show that firms do not increase political participation, do not receive more loans or contracts from the government, and do not change their societal or financial structure.

To this end we estimate Equation 2.3 again, but we replace the dependent variable with other variables of interest. The results are reported in Table B.5. Column (1) considers whether the firm is publicly traded. The result shows that the AD tariff is not correlated with other policies that facilitate the firm's access to the stock market. Column (2) and (3) consider whether the firm is owned by the government or foreign firms. The latter aims to capture other financial reforms that facilitate FDI. Again, those parameters are not economically relevant. More importantly, we would like to understand the role of political interference. If, for instance, the treatment group is the firms that are favored by the government and also receive government benefits in the post-period, the estimates would be biased. To rule that out, Column (4) to (6) show that compared to the control group, the treatment group is not more likely to engage in campaign contribution and is not more likely to receive federal contracts or federal loans. These results rule out the possibility that these policies systematically affect the control and treatment groups differently.

Table B.5: Association between Anti-Dumping Tariffs and Other Policies

	(1) $\mathbb{I}$\{Listed\}	(2) $\mathbb{I}$\{Gov. Owned\}	(3) $\mathbb{I}$\{Multinational\}	(4) $\mathbb{I}$\{Campaign Contr.\}	(5) $\mathbb{I}$\{Fed. Contract\}	(6) $\mathbb{I}$\{Fed. Loan\}
AD Tariff	0.000611	-0.00000864	-0.0000695	-0.000173	0.00809***	0.000361**
	(0.000738)	(0.000377)	(0.0000675)	(0.00148)	(0.00120)	(0.000164)
N	110747	110757	110760	14931	110760	110760
R^2	0.532	0.193	0.106	0.519	0.312	0.137
# Firms	5401	5401	5401	5248	5401	5401
Mean Dep. Var	.004	.004	0	.01	.01	.001
Mean Ind. Var	.46	.46	.46	.46	.46	.46
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents the results of an OLS regression of complainer labor market outcomes on a dummy if that firm filled a complaint next year. Standard errors are clustered at the firm level. Data sample is from 1990 to 2016.

B.1.7 Ad-Valorem Tariff Calculation

AD tariffs may differ by the exporting firm of the same product from the same origin country. They may be ad-valorem or per unit. In this section, we describe the procedure to calculate the ad-valorem equivalent tariff at country-product and country-sector level.

If an investigation leads to a firm-specific tariff, we take the median value across firms for each country-product pair. This is done to avoid the influence of extreme values. Since we do not observe firm-level exports to Brazil, the median is not weighted by the relative importance of each firm. 55% of AD measures had firm-specific tariffs.

About 75% of original AD tariffs are per unit. To calculate its ad-valorem counterpart we use import value and quantity data in the year before its implementation. First we calculate the unit price of the imported product. The corresponding ad-valorem tariff equals the ratio of unit tariff to unit price.

We calculate the AD tariff at the country-sector level with the weighted average of country-product level AD tariffs. The weights are the value share of country-product level import in the country-sector level import in the year before the implementation of the tariff.

B.2 Theoretical Results

B.2.1 Real GDP Response to Tariffs

A country's nominal GDP could be written as the product of real GDP and a price index of the real GDP. Alternatively, it could be written as the difference between the country's gross output and total intermediate input used.

$$\mathrm{GDP} = P^{\mathrm{rGDP}}\mathrm{rGDP} = \sum_{s=1}^{S}\left(P_B^s Y^s - \sum_{s'=1}^{S} P^{s'} M^{ss'}\right) \tag{B.5}$$

where P^{rGDP} is the price index for real GDP. Consider changes in real GDP with the first-order approximation. This concerns the log changes in all quantity variables in Equation (B.5) while holding fixed the prices P^{rGDP}, P_B^s and $P^{s'}$:

$$d\log(rGDP) = \sum_{s=1}^{S}\frac{P_B^s Y^s}{GDP} d\log(Y^s) - \sum_{s'=1}^{S}\frac{P^{s'} M^{ss'}}{GDP} d\log(M^{ss'})$$

Note that

$$d\log(Y^s) = d\log(A^s) + \gamma^s d\log(L^s) + \sum_{s'=1}^{S}\gamma^{ss'} d\log(M^{ss'})$$

We set $d\log(A^s) = 0$. Further note that $P^{s'} M^{ss'} = \gamma^{ss'} P_B^s Y^s$ and $w^s L^s = \gamma^s P_B^s Y^s$. These imply:

$$d\log(rGDP) = \sum_{s=1}^{S}\frac{w^s L^s}{GDP} d\log(L^s)$$

Taking the equation to discrete time leads to Equation 2.21.

B.2.2 Real GNI response to tariffs

Nominal GNI equals the following:

$$GNI = \sum_{s=1}^{S} w^s L^s + TD + TR$$

Taking first order approximation:

$$d\log(rGNI) = \sum_{s=1}^{S} \frac{w^s L^s}{GNI}(d\log(w^s) + d\log(L^s)) + \frac{TR}{GNI} d\log(TR) - d\log(P)$$

Fix $TD = 0$

$$dTR = \sum_{s=1}^{S} \sum_{i \in \Xi_F} \sum_{l \in \Omega_i^s} \tau_{il}^s T_{il}^s d\log(T_{il}^s) + \sum_{s=1}^{S} \sum_{i \in \Xi_F} \sum_{l \in \Omega_i^s} X^s s_i^s s_{li}^s d\log(t_{il}^s)$$

where T_{il}^s is CIF (imports excluding tariffs)

$$d\log(P) = \sum_{s=1}^{S} \alpha^s d\log(P^s) = \sum_{s=1}^{S} \alpha^s \left(s_B^s d\log(P_B^s) + \sum_{i \in \Xi_F} \sum_{l \in \Omega_i^s} s_i^s s_{li}^s (d\log(p_{il}^s) + d\log(t_{il}^s)) \right)$$

$$\begin{aligned} X^{s\prime} &= P^{s\prime} C^{s\prime} + \sum_{s'=1}^{S} \gamma^{s's} \left(s_B^{s\prime} X_B^{s\prime} + s_{FB}^{s\prime} E_F^{s\prime} \right) \\ &= P^{s\prime} C^{s\prime} + \sum_{s'=1}^{S} \gamma^{s's} \underbrace{\left(s_B^{s\prime} X_B^{s\prime} + \underbrace{s_{FB}^{s'} E_F^{s'}}_{\text{Factual total export}} (\hat{P}_B^{s'})^{1-\sigma^{s'}} \right)}_{\text{Sector s' output}} \end{aligned}$$

Note

$$\alpha^s = \frac{1}{GNI}(X^s - \sum_{s'=1}^{S} \gamma^{s's}\left(s_B^{s'}X^{s'} + s_{FB}^{s'}E_F^{s'}\right)) = \frac{1}{GNI}(X^s - \sum_{s'=1}^{S}\gamma^{s's}\sum_{j=1}^{N}E_j^s)$$

As a result,

$$\begin{aligned} d\log(P) = &\sum_{s=1}^{S}\frac{X^s}{GNI}\left(s_B^s d\log(P_B^s) + \sum_{i\in\Xi_F}\sum_{l\in\Omega_i^s} s_i^s s_{li}^s (d\log(p_{il}^s) + d\log(t_{il}^s))\right) \\ &- \frac{1}{GNI}\sum_{s=1}^{S}(\sum_{s'=1}^{S}\gamma^{s's}\sum_{j=1}^{N}E_j^{s'})\left(s_B^s d\log(P_B^s) + \sum_{i\in\Xi_F}\sum_{l\in\Omega_i^s} s_i^s s_{li}^s (d\log(p_{il}^s) + d\log(t_{il}^s))\right) \end{aligned}$$

Plugging in:

$$\begin{aligned} d\log(rGNP) = &\sum_{s=1}^{S}\frac{w^sL^s}{GNI}d\log(L^s) + \sum_{s=1}^{S}\frac{w^sL^s}{GNI}d\log(w^s) + \frac{1}{GNI}\sum_{s=1}^{S}\sum_{i\in\Xi_F}\sum_{l\in\Omega_i^s}\tau_{il}^s T_{il}^s d\log(T_{il}^s) \\ &+ \sum_{s=1}^{S}\sum_{i\in\Xi_F}\sum_{l\in\Omega_i^s} X^s s_i^s s_{li}^s d\log(t_{il}^s) \\ &- \sum_{s=1}^{S}\frac{X^s}{GNI}\left(s_B^s d\log(P_B^s) + \sum_{i\in\Xi_F}\sum_{l\in\Omega_i^s} s_i^s s_{li}^s (d\log(p_{il}^s) + d\log(t_{il}^s))\right) \\ &+ \frac{1}{GNI}\sum_{s=1}^{S}(\sum_{s'=1}^{S}\gamma^{s's}\frac{w^{s'}L^{s'}}{\gamma^{s'}})d\log(P^s) \end{aligned}$$

Note

$$\sum_{s=1}^{S}\gamma^{s's}d\log(P^s) = d\log(P_B^{s'}) - \gamma^{s'}d\log(w^{s'})$$

And

$$\sum_{s=1}^{S}\frac{w^sL^s}{GNI}d\log(w^s)+\frac{1}{GNI}\sum_{s=1}^{S}(\sum_{s'=1}^{S}\gamma^{s's}\frac{w^{s'}L^{s'}}{\gamma^{s'}})d\log(P^s)=\frac{1}{GNI}\sum_{s=1}^{S}\sum_{j=1}^{N}E_j^{s'}d\log(P_B^{s'})$$

Finally,

$$d\log(rGNP)=\sum_{s=1}^{S}\frac{w^sL^s}{GNI}d\log(L^s)+\frac{1}{GNI}\sum_{s=1}^{S}\sum_{j=1}^{N}E_j^{s'}d\log(P_B^{s'})$$
$$+\frac{1}{GNI}\sum_{s=1}^{S}\sum_{i\in\Xi_F}\sum_{l\in\Omega_i^s}\tau_{il}^sT_{il}^sd\log(T_{il}^s)$$

B.2.3 Sector Upstreamness

We take advantage of the method in Fally (2011), Antràs et al. (2012), and Antràs and Chor (2013) to compute the sector upstreamness. It measures the relative size of a sector's output used in other sectors' production, both directly and indirectly, to the sector's gross output. If a sector's gross output is only used for final consumption, the ratio will equal zero and the sector's upstreamness is normalized to 1. If a sector sells to other sectors, its upstreamness will be greater than 1. The greater is the upstream measure, the larger fraction of output the sector sells to other sectors and the more upstream is the sector.

To compute the fraction of a sector's output used in other sectors, we rely on the input-output coefficients $\gamma^{ss'}$. We adjust the coefficients for open economy with $\tilde{\gamma}^{ss'}=\gamma^{ss'}\frac{P_B^sY^s}{P_B^sY^s-E_{FB}^s+X^s(1-s_B^s)}$. $P_B^sY^s$ denotes gross output. E_{FB}^s denotes total export in sector s. $X^s(1-s_B^s)$ denotes total import. The denominator is therefore domestic total absorption of sector s. Finally, the sector upstreamness is represented as:

$$\vec{Y}'(I-\tilde{\Gamma})^{-1}./\vec{Y}'$$

where ./ denotes element-wise division. $\tilde{\gamma}^{ss'}$ is the $s-s'$ entry of $\tilde{\Gamma}$.

B.2.4 Equilibrium Solution Algorithm

Let sector 1 denote the service sector. Normalize changes in the service sector wage: $\hat{w}^1 = 1$. Compute exogenous variables - changes in foreign prices and product line level import shares with: $(\hat{P}_i^s)^{1-\zeta^s} = \sum_{l \in \Omega_i^s} s_{il}^s (\hat{p}_{il}^s \hat{\tau}_{il}^s)^{1-\zeta^s}$ (setting $\hat{p}_{il}^s = 1$), and $\hat{s}_{il}^s = \frac{(\hat{p}_{il}^s \hat{\tau}_{il}^s)^{1-\zeta^s}}{(\hat{P}_i^s)^{1-\zeta^s}}$.

1. Guess a vector of changes in wages $\hat{w}^s$ ($s \in \{2, ..., S\}$). Fix unemployment benefit $\hat{b} = 1$.

2. Setting $\hat{L} = 1$. Equation (2.11) gives labor supply to production sectors and the unemployment sector.

3. Guess a vector of domestic prices $\hat{P}^s$

   (a) Iterate with (2.13) and (2.15) until $\hat{P}^s$ converge.

4. Guess tax rate δ'

   (a) Compute counterfactual sector roundabout goods consumption with Equation (2.18).

   (b) Compute counterfactual total sectoral expenditure with Equation (2.17), tariff revenue with Equation (2.19) and trade deficit with Equation (2.20).

   (c) Update δ' with

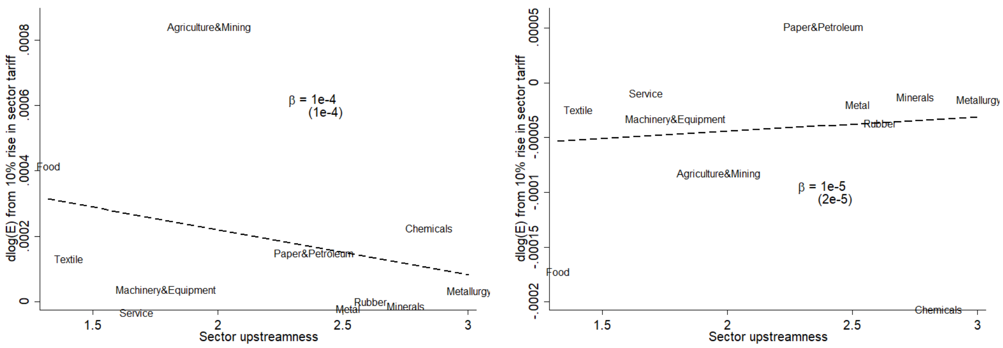
   (d) Iterate until convergence on δ'.

5. Use the labor market clearing condition, Equation (2.16), to update $\hat{w}^s$ until convergence.

B.3 Additional Quantitative Results

Figure B.6: Aggregate Implications of 10% Increase in Sectoral Tariffs

(a) Aggregate GDP Effect (b) Aggregate GNI Effect



APPENDIX C

APPENDIX TO THE LIFE-CYCLE DYNAMICS OF EXPORTERS AND MULTINATIONAL FIRMS

C.1 Computations

C.1.1 Expected Productivity Growth for the Average Exporter

Assume that firm productivity follows a first-order autoregressive process, $z_t = \rho z_{t-1} + \sigma_\epsilon \epsilon_t$, with $\epsilon_t \sim N(0,1)$ and $0 \leq \rho < 1$. The expected value of z_t is zero with variance given by $\sigma_z^2 \equiv \sigma_\epsilon^2/(1-\rho^2)$.

Conditional on a starting productivity value of k, the expected growth for an exporter in t in the model with only left truncation is given by

$$G^L(k) \equiv \mathbb{E}\left(z_t - z_{t-1} \mid z_t > \underline{z}, z_{t-1} = k\right),$$

whereas in a model with left and right truncation, we have that

$$G^{LR}(k) \equiv \mathbb{E}\left(z_t - z_{t-1} \mid \underline{z} < z_t < \bar{z}, \underline{z} = k\right),$$

with $\underline{z}$ and $\bar{z}$ denoting the left and right truncation points, respectively.

After some algebra, we get that

$$G^L(k) = \sigma_\epsilon \frac{\phi(\underline{c}(k))}{1 - \Phi(\underline{c}(k))} - k(1-\rho)$$

and

$$G^{LR}(k) = \sigma_\epsilon \frac{\phi(\underline{c}(k)) - \phi(\bar{c}(k))}{\Phi(\bar{c}(k)) - \Phi(\underline{c}(k))} - k(1-\rho),$$

with $\bar{c}(k) \equiv (\bar{z} - \rho k)/\sigma_\epsilon$, $\underline{c}(k) \equiv (\underline{z} - \rho k)/\sigma_\epsilon$ and $\phi(\cdot)$ and $\Phi(\cdot)$ denoting the probability and cumulative distribution functions, respectively, of a standard normal distribution.

Taking expectations over all exporters yields

$$G^L = \frac{1}{1-F(\underline{z})}\int_{\underline{z}}^{\infty}\left(\sigma_\epsilon \frac{\phi(\underline{c}(k))}{1-\Phi(\underline{c}(k))} - k(1-\rho)\right) dF(k)$$

and

$$G^{LR} = \frac{1}{F(\bar{z})-F(\underline{z})}\int_{\underline{z}}^{\bar{z}}\left(\sigma_\epsilon \frac{\phi(\underline{c}(k))-\phi(\bar{c}(k))}{\Phi(\bar{c}(k))-\Phi(\underline{c}(k))} - k(1-\rho)\right) dF(k).$$

The average exporter grows faster in the model with only left truncation if and only if $G^L > G^{LR}$, which is equivalent to

$$\sigma_\epsilon\left(\int_{\underline{z}}^{\infty}\frac{\phi(\underline{c}(k))}{1-\Phi(\underline{c}(k))}\frac{dF(k)}{1-F(\underline{z})} - \int_{\underline{z}}^{\bar{z}}\frac{\phi(\underline{c}(k))-\phi(\bar{c}(k))}{\Phi(\bar{c}(k))-\Phi(\underline{c}(k))}\frac{dF(k)}{F(\bar{z})-F(\underline{z})}\right) >$$

$$(1-\rho)\left(\int_{\underline{z}}^{\infty} k\frac{dF(k)}{1-F(\underline{z})} - \int_{\underline{z}}^{\bar{z}} k\frac{dF(k)}{F(\bar{z})-F(\underline{z})}\right).$$

The right-hand side is simply

$$(1-\rho)\sigma_z\left(\frac{\phi(\underline{z}/\sigma_z)}{1-\Phi(\underline{z}/\sigma_z)} - \frac{\phi(\underline{z}/\sigma_z)-\phi(\bar{z}/\sigma_z)}{\Phi(\bar{z}/\sigma_z)-\Phi(\underline{z}/\sigma_z)}\right).$$

Hence,

$$\int_{\underline{z}}^{\infty}\frac{\phi(\underline{c}(k))}{1-\Phi(\underline{c}(k))}\frac{dF(k)}{1-F(\underline{z})} - \int_{\underline{z}}^{\bar{z}}\frac{\phi(\underline{c}(k))-\phi(\bar{c}(k))}{\Phi(\bar{c}(k))-\Phi(\underline{c}(k))}\frac{dF(k)}{F(\bar{z})-F(\underline{z})} >$$

$$\sqrt{\frac{1-\rho}{1+\rho}}\left(\frac{\phi(\underline{z}/\sigma_z)}{1-\Phi(\underline{z}/\sigma_z)} - \frac{\phi(\underline{z}/\sigma_z)-\phi(\bar{z}/\sigma_z)}{\Phi(\bar{z}/\sigma_z)-\Phi(\underline{z}/\sigma_z)}\right).$$

C.2 Proofs

C.2.1 Proof of Proposition 2

Firm productivity z follows a first-order autoregressive process, $z' = \rho z + \sigma_\epsilon \epsilon'$ with $\epsilon' \sim N(0,1)$ and $0 \leq \rho \leq 1$. Let $\log \bar{\phi}_e^m \equiv \bar{z}_e^m$, $\log \bar{\phi}^m \equiv \bar{z}^m$, and $\log \bar{\phi}^x \equiv \bar{z}^x$, with $\bar{z}_e^m > \bar{z}^m > \bar{z}^x$.

Let $f^m(a)$ denote the probability of exit from MNE status in $t+1$ for a firm that was not an MNE in $t-1$ and had productivity a in $t-1$,

$$f^m(a) = \frac{\int_{\bar{z}_e^m}^{\infty} \Pr(\rho x + \sigma_\epsilon \epsilon \leq \bar{z}^m \mid x) g(x - \rho a) dx}{1 - G(\bar{z}_e^m - \rho a)}, \tag{C.1}$$

where $g(\cdot)$ and $G(\cdot)$ denote, respectively, the probability and cumulative density functions of a normal distribution with mean zero and dispersion parameter σ_ϵ. Let $f^x(a)$ denote the probability of exit from export status in $t+1$ for a firm that was only domestic in $t-1$ and had a in $t-1$,

$$f^x(a) = \frac{\int_{\bar{z}^x}^{\bar{z}_e^m} \Pr(\rho x + \sigma_\epsilon \epsilon \leq \bar{z}^x \mid x) g(x - \rho a) dx}{G(\bar{z}_e^m - \rho a) - G(\bar{z}^x - \rho a)}. \tag{C.2}$$

Under which conditions is $f^m(a) < f^x(a)$? First, notice that if $\bar{z}^x = \bar{z}^m = \bar{z}$, then

$$\int_{\bar{z}_e^m}^{\infty} \Pr(\rho x + \sigma_\epsilon \epsilon \leq \bar{z} \mid x) g(x - \rho a) dx \leq \int_{\bar{z}}^{\bar{z}_e^m} \Pr(\rho x + \sigma_\epsilon \epsilon \leq \bar{z} \mid x) g(x - \rho a) dx. \tag{C.3}$$

Let $\bar{z}^m = \bar{z}^x + \xi$, with $\xi > 0$. Then,

$$\lim_{\xi \to 0} \int_{\bar{z}_e^m}^{\infty} \Pr(\rho x + \sigma_\epsilon \epsilon \leq \bar{z}^x + \xi \mid x) g(x - \rho a) dx = \int_{\bar{z}_e^m}^{\infty} \Pr(\rho x + \sigma_\epsilon \epsilon \leq \bar{z}^x \mid x) g(x - \rho a) dx,$$

which implies the inequality in (C.3). This means that the numerator in (C.1) is lower than in (C.2). If

$$1 - G(\bar{z}_e^m - \rho a) > G(\bar{z}_e^m - \rho a) - G(\bar{z}^x - \rho a), \tag{C.4}$$

then $f^m(a) < f^x(a)$. Clearly, the inequality is true if $\bar{z}_e^m = \bar{z}^x$. Let $\bar{z}_e^m = \bar{z}^x + \varphi$, with $\varphi > 0$. When $\varphi \to 0$, then $1 - 2G(\bar{z}^x + \varphi - \rho a) > -G(\bar{z}^x - \rho a)$. More generally, there exists φ^* such that for $0 \leq \varphi < \varphi^*$, the inequality in (C.4) holds and $f^m(a) < f^x(a)$.

C.2.2 Proof of Proposition 3

Firm productivity z follows a first-order autoregressive process, $z' = \rho z + \sigma_\epsilon \epsilon'$ with $\epsilon' \sim N(0,1)$ and $0 \leq \rho \leq 1$. Let $\bar{z}_e^m$ and $\bar{z}^m$ be the productivity entry and exit thresholds, respectively. Let $f(a)$ denote the probability of exit from multinational status in $t+1$ for a firm that was not a multinational in $t-1$, and with productivity a in $t-1$, defined by

$$f(a) = \frac{\int_{\bar{z}_e^m}^{\infty} \Pr(\rho x + \sigma_\epsilon \epsilon \leq \bar{z}^m \mid x) g(x - \rho a) dx}{1 - G(\bar{z}_e^m - \rho a)},$$

where $g(\cdot)$ and $G(\cdot)$ denote, respectively, the probability and cumulative density functions of a normal distribution with mean zero and dispersion parameter σ_ϵ.

Let $\xi \to 0$, with $\xi > 0$. We will show that $f(.)$ is a decreasing function—that is, $f(a) - f(a-\xi) < 0$. Replacing, we get that

$$f(a) - f(a-\xi) = \frac{\int_{\bar{z}_e^m}^{\infty} \Pr(\rho x + \sigma_\epsilon \epsilon \leq \bar{z}^m \mid x) g(x - \rho a) dx}{1 - G(\bar{z}_e^m - \rho a)} - \frac{\int_{\bar{z}_e^m}^{\infty} \Pr(\rho x + \sigma_\epsilon \epsilon \leq \bar{z}^m \mid x) g(x - \rho a + \rho \xi) dx}{1 - G(\bar{z}_e^m - \rho a + \rho \xi)},$$

which, after some algebra, becomes

$$f(a) - f(a-\xi) = \frac{\int_{\bar{z}_e^m}^{\infty} \Pr(\rho x + \sigma_\epsilon \epsilon \leq \bar{z}^m \mid x) \left[g(x - \rho a)(1 - G(\bar{z}_e^m - \rho a + \rho \xi) - g(x - \rho a + \rho \xi)(1 - G(\bar{z}_e^m - \rho a)) \right] dx}{\left[1 - G(\bar{z}_e^m - \rho a)\right]\left[1 - G(\bar{z}_e^m - \rho a + \rho \xi)\right]}.$$

Since the denominator is always positive, we need to show that the numerator is negative. Note that $\Pr(\rho x + \sigma_\epsilon \epsilon \leq \bar{z}^m \mid x)$ is decreasing in x and that

$$\frac{\int_{\bar{z}_e^m}^{\infty} g(x - \rho a) dx}{1 - G(\bar{z}_e^m - \rho a)} - \frac{\int_{\bar{z}_e^m}^{\infty} g(x - \rho a + \rho \xi) dx}{1 - G(\bar{z}_e^m - \rho a + \rho \xi)} = 0.$$

We then need to show that there exists only one point $m \in [c, \infty]$ such that for $x < m$,

$$g(x-\rho a)\left[1-G(\bar{z}_e^m-\rho a+\rho\xi)\right]-g(x-\rho a+\rho\xi)\left[1-G(\bar{z}_e^m-\rho a)\right]<0,$$

and for $x > m$,

$$g(x-\rho a)\left[1-G(\bar{z}_e^m-\rho a+\rho\xi)\right]-g(x-\rho a+\rho\xi)\left[1-G(\bar{z}_e^m-\rho a)\right]>0.$$

Since for $\xi > 0$ and $\xi \to 0$, $G(x-\xi) = G(x) - \xi g(x)$ and $g(x-\xi) = g(x) - \xi g'(x)$, replacing, we get that

$$\begin{aligned}
& g(x-\rho a)\left[1-G(\bar{z}_e^m-\rho a+\rho\xi)\right]-g(x-\rho a+\rho\xi)\left[1-G(\bar{z}_e^m-\rho a)\right] \\
= \; & g(x-\rho a)\left[1-G(\bar{z}_e^m-\rho a)-\rho\xi g(\bar{z}_e^m-\rho a)\right]-\left[g(x-\rho a)+\rho\xi g'(x-\rho a)\right]\left[1-G(\bar{z}_e^m-\rho a)\right] \\
= \; & -\rho\xi g(x-\rho a)g(\bar{z}_e^m-\rho a)-\rho\xi g'(x-\rho a)\left[1-G(\bar{z}_e^m-\rho a)\right] \\
= \; & \rho\xi g(x-\rho a)\left\{-g(\bar{z}_e^m-\rho a)+\frac{x-\rho a}{\sigma_\epsilon^2}\left[1-G(\bar{z}_e^m-\rho a)\right]\right\}, \qquad \text{(C.5)}
\end{aligned}$$

where, in the last equality, we use that $g'(x-\rho a) = -g(x-\rho a)(x-\rho a)/\sigma_\epsilon^2$.

Denote the function inside the curly brackets in (C.5) as

$$k(x) \equiv -g(\bar{z}_e^m-\rho a)+\frac{x-\rho a}{\sigma_\epsilon^2}\left[1-G(\bar{z}_e^m-\rho a)\right].$$

For $x = m$, $k(m) = 0$, with $m = c\sigma_\epsilon^2 + \rho a$ where $c \equiv g(\bar{z}_e^m - \rho a)/\left[1 - G(\bar{z}_e^m - \rho a)\right] > 0$ (since $[1 - G(\bar{z}_e^m - \rho a)]$ and $g(\bar{z}_e^m - \rho a)$ are positive constants). It remains to show that for $x < m$, $k(x)$ is negative, and for $x > m$, $k(x)$ is positive. Taking the derivative of $k(\cdot)$ with respect to x yields

$$k'(x) = \frac{1-G(\bar{z}_e^m-\rho a)}{\sigma_\epsilon^2},$$

which is positive for all x. Thus, $k(x) < k(m)$, for $x < m$, and $k(x) > k(m)$, for $x > m$, which implies that the expression in (C.5) is decreasing, proving that $f(a)$ is a decreasing function.■

C.2.3 Proof of Proposition 4

Firm productivity z follows a first-order autoregressive process, $z' = \rho z + \sigma_\epsilon \epsilon'$ with $\epsilon' \sim N(0,1)$ and $0 \leq \rho \leq 1$. Let $\bar{z}$ denote the exit cutoff and $\bar{z}_e$ the entry cutoff into an international activity. Let c be a constant in the interval $[\bar{z}_e, \infty)$. Let

$$f(a) = \frac{\int_{\bar{z}_e}^{c} \Pr(\rho x + \sigma_\epsilon \epsilon \leq \bar{z} \mid x) g(x - \rho a) dx}{G(c) - G(\bar{z}_e - \rho a)}$$

denote the probability of exit from status i in $t+1$ for a firm that is not yet in status i in $t-1$ and that has a productivity level of a in t-1. The functions $g(\cdot)$ and $G(\cdot)$ denote, respectively, the probability and cumulative density functions of a normal distribution with mean zero and dispersion parameter σ_ϵ.

Let ξ and φ be two positive constants, with $\xi \leq \varphi$. Without loss of generality, the entry cutoff is $\bar{z}_e = \bar{z} + \varphi$. We want to show that when we increase the exit cutoff from $\bar{z}$ to $\bar{z} + \xi$, the exit probability increases more when sunk costs are zero—that is, $\varphi = 0$,

$$f(a; \xi > 0; \varphi = 0) - f(a; \xi = 0; \varphi = 0) > f(a; \xi > 0; \varphi > 0) - f(a; \xi = 0; \varphi > 0).$$

The first term is given by

$$f(a; \xi > 0; \varphi = 0) - f(a; \xi = 0; \varphi = 0) = \frac{\int_{\bar{z}}^{c} \Pr(\rho x + \sigma_\epsilon \epsilon \leq \bar{z} + \xi \mid x) g(x - \rho a) dx}{G(c) - G(\bar{z} - \rho a)} - \frac{\int_{\bar{z}}^{c} \Pr(\rho x + \sigma_\epsilon \epsilon \leq \bar{z} \mid x) g(x - \rho a) dx}{G(c) - G(\bar{z} - \rho a)}, \quad \text{(C.6)}$$

and the second one is

$$f(a;\xi>0;\varphi>0)-f(a;\xi=0;\varphi>0) = \frac{\int\limits_{\bar{z}+\varphi}^{c} \Pr(\rho x+\sigma_\epsilon\epsilon \leq \bar{z}+\xi \mid x)g(x-\rho a)dx}{G(c)-G(\bar{z}+\varphi-\rho a)} - \frac{\int\limits_{\bar{z}+\varphi}^{c} \Pr(\rho x+\sigma_\epsilon\epsilon \leq \bar{z} \mid x)g(x-\rho a)dx}{G(c)-G(\bar{z}+\varphi-\rho a)}. \quad \text{(C.7)}$$

Rearranging, we get that

$$f(a;\xi>0;\varphi=0)-f(a;\xi>0;\varphi>0) > f(a;\xi=0;\varphi=0)-f(a;\xi=0;\varphi>0),$$

which, after some algebra, yields

$$\frac{\int\limits_{\bar{z}}^{c} \Pr(\rho x+\sigma_\epsilon\epsilon \leq \bar{z}+\xi \mid x)g(x-\rho a)dx - \int\limits_{\bar{z}+\varphi}^{c} \Pr(\rho x+\sigma_\epsilon\epsilon \leq \bar{z}+\xi \mid x)g(x-\rho a)dx}{(G(c)-G(\bar{z}-\rho a))(G(c)-G(\bar{z}+\varphi-\rho a))}$$

$$> \frac{\int\limits_{\bar{z}}^{c} \Pr(\rho x+\sigma_\epsilon\epsilon \leq \bar{z} \mid x)g(x-\rho a)dx - \int\limits_{\bar{z}+\varphi}^{c} \Pr(\rho x+\sigma_\epsilon\epsilon \leq \bar{z} \mid x)g(x-\rho a)dx}{(G(c)-G(\bar{z}-\rho a))(G(c)-G(\bar{z}+\varphi-\rho a))}.$$

Denominators are always positive and simplify. The numerators can be written as

$$\int\limits_{\bar{z}}^{\bar{z}+\varphi} \Pr(\rho x+\sigma_\epsilon\epsilon \leq \bar{z}+\xi \mid x)g(x-\rho a)dx + \int\limits_{\bar{z}+\varphi}^{c} \Pr(\rho x+\sigma_\epsilon\epsilon \leq \bar{z}+\xi \mid x)g(x-\rho a)dx$$

$$-\int\limits_{\bar{z}+\varphi}^{c} \Pr(\rho x+\sigma_\epsilon\epsilon \leq \bar{z}+\xi \mid x)g(x-\rho a)dx = \int\limits_{\bar{z}}^{\bar{z}+\varphi} \Pr(\rho x+\sigma_\epsilon\epsilon \leq \bar{z}+\xi \mid x)g(x-\rho a)dx,$$

and analogously for the numerator in the right-hand side of the inequality. Hence,

$$\int_{\bar{z}}^{\bar{z}+\varphi} \Pr(\rho x + \sigma_\epsilon \epsilon \leq \bar{z} + \xi \mid x) g(x - \rho a) dx \quad > \quad \int_{\bar{z}}^{\bar{z}+\varphi} \Pr(\rho x + \sigma_\epsilon \epsilon \leq \bar{z} \mid x) g(x - \rho a) dx.$$

Because $\Pr(\rho x + \sigma_\epsilon \epsilon \leq \bar{z} + \xi \mid x) > \Pr(\rho x + \sigma_\epsilon \epsilon \leq \bar{z} \mid x)$, we show that when we increase the exit cutoff, the probability of exit upon entry increases by less with the presence of sunk costs. ■

C.2.4 Proof of Proposition 5

Let $\phi(\cdot)$ and $\Phi(\cdot)$ denote the probability and cumulative density functions, respectively, of a standard normal distribution. Then,

$$\begin{aligned}
G^L &\equiv \mathbb{E}\left(z_t - z_{t-1} \mid z_t > \underline{z}, z_{t-1} = \underline{z}\right) = \mathbb{E}\left(z_t \mid z_t > \underline{z}, z_{t-1} = \underline{z}\right) - \underline{z} \\
&= \mathbb{E}\left(\rho z_{t-1} + \sigma_\epsilon \epsilon_t \mid z_t > \underline{z}, z_{t-1} = \underline{z}\right) - \underline{z} = \rho \underline{z} + \mathbb{E}\left(\sigma_\epsilon \epsilon_t \mid z_t > \underline{z}, z_{t-1} = \underline{z}\right) - \underline{z} \\
&= \rho \underline{z} + \sigma_\epsilon \mathbb{E}\left(\epsilon_t \mid \epsilon_t > \underline{z}(1-\rho)/\sigma_\epsilon\right) - \underline{z} = \sigma_\epsilon \mathbb{E}\left(\epsilon_t \mid \epsilon_t > \underline{c}\right) - \sigma_\epsilon \underline{c} \\
&= \sigma_\epsilon \left(\frac{\phi(\underline{c})}{1 - \Phi(\underline{c})} - \underline{c} \right),
\end{aligned}$$

where $\underline{c} \equiv (1-\rho)\underline{z}/\sigma_\epsilon$. Similar calculations yield

$$G^{LR} \equiv \mathbb{E}\left(z_t - z_{t-1} \mid \underline{z} < z_t < \bar{z}, z_{t-1} = \underline{z}\right) = \sigma_\epsilon \left(\frac{\phi(\underline{c}) - \phi(\bar{c})}{\Phi(\bar{c}) - \Phi(\underline{c})} - \underline{c} \right),$$

where $\bar{c} \equiv (1-\rho)\bar{z}/\sigma_\epsilon$.

Growth is higher with left (L) than with left and right (LR) truncation when

$$\frac{\phi(\underline{c})}{1-\Phi(\underline{c})} > \frac{\phi(\underline{c})-\phi(\bar{c})}{\Phi(\bar{c})-\Phi(\underline{c})},$$

or equivalently,

$$\frac{\Phi(\bar{c})-\Phi(\underline{c})}{1-\Phi(\underline{c})} > \frac{\phi(\underline{c})-\phi(\bar{c})}{\phi(\underline{c})}.$$

The expression on the left-hand side (l.h.s.) of the inequality has the following properties:

$$\lim_{\bar{c}\to\underline{c}} \frac{\Phi(\bar{c})-\Phi(\underline{c})}{1-\Phi(\underline{c})} = 0; \quad \lim_{\bar{c}\to\infty} \frac{\Phi(\bar{c})-\Phi(\underline{c})}{1-\Phi(\underline{c})} = 1; \quad \frac{dl.h.s.}{d\bar{c}} = \frac{\phi(\bar{c})}{1-\Phi(\underline{c})}. > 0.$$

With $\bar{z} > \underline{z}$, and $\bar{c} > 0$, the expression on the right-hand side (r.h.s.) of the inequality has the following properties:

$$\lim_{\bar{c}\to\underline{c}} \frac{\phi(\underline{c})-\phi(\bar{c})}{\phi(\underline{c})} = 0; \quad \lim_{\bar{c}\to\infty} \frac{\phi(\underline{c})-\phi(\bar{c})}{\phi(\underline{c})} = 1; \quad \frac{dr.h.s.}{d\bar{c}} = \bar{c}\frac{\phi(\bar{c})}{\phi(\underline{c})} > 0.$$

Both functions have the same limits, and both are increasing with $\bar{c}$. The left-hand side, however, grows faster than the right-hand side when

$$\bar{c} < \frac{\phi(\underline{c})}{1-\Phi(\underline{c})}.$$

Therefore, there exists $\bar{c}^*$—and consequently, $\bar{z}^*$—such that for all $\underline{c} < \bar{c} < \bar{c}^*$, $G^L > G^{LR}$, with $G^L = G^{LR}$ for $\bar{c} = \bar{c}^*$.

C.3 Quantitative Model

We extend the model in Section 3.4 to include sunk export costs, $F^x > 0$, paid in units of labor and $F^m > F^x$. Additionally, we assume that all fixed and sunk costs are heterogeneous across firms but fixed over time for each firm. Fixed and sunk costs distributions are independent of the firm productivity distribution and follow a log-normal distribution,

$$\log(F_e^s) \sim N(\mu_e^s, (\sigma_e^s)^2) \quad \text{and} \quad \log(f^s) \sim N(\mu_f^s, (\sigma_f^s)^2),$$

where $s = m, x$. In practice, we calibrate the model country by country, and we allow the parameters μ_e^s, σ_e^s, μ_f^s, σ_f^s to vary across origin-destination pairs, as noted in Section C.3. Here we abstract from the country subscript, fixing one pair as an example.

Firms have three possible states: producing in the domestic market for home consumers only(D); producing in the domestic market for home and foreign consumers (X); or producing in the domestic market for home consumers and in the foreign market for foreign consumers (M).

The value of being an MNE with productivity ϕ is given by

$$\begin{aligned}
&V(\phi, F_e^m, F_e^x, f^m, f^x, M) = \frac{X^d(\phi)}{\sigma} \\
&+ \max\left\{\frac{X^m(\phi)}{\sigma} - f^m + \beta E_{\phi'} V(\phi', F_e^m, F_e^x, f^m, f^x, M \mid \phi)\right., \\
&\left.\beta E_{\phi'} V(\phi', F_e^m, F_e^x, f^m, f^x, D \mid \phi), \frac{X^x(\phi)}{\sigma} - f^x - F_e^x + \beta E_{\phi'} V(\phi', F_e^m, F_e^x, f^m, f^x, X \mid \phi)\right\}.
\end{aligned}$$

An MNE chooses among continuing its operations abroad and incurring the per-period fixed cost f^m; shutting down the affiliate and becoming an exporter into the foreign market, incurring a per-period fixed cost f^x and sunk cost F^x; or abandoning the foreign market altogether.

The value of being an exporter with productivity ϕ is given by

$$\begin{aligned}
&V(\phi, F_e^m, F_e^x, f^m, f^x, X) = \frac{X^d(\phi)}{\sigma} \\
&+ \max\left\{\frac{X^x(\phi)}{\sigma} - f^x + \beta E_{\phi'} V(\phi', F_e^m, F_e^x, f^m, f^x, X \mid \phi)\right., \\
&\left.\beta E_{\phi'} V(\phi', F_e^m, F_e^x, f^m, f^x, D \mid \phi), \frac{X^m(\phi)}{\sigma} - f^m - F_e^m + \beta E_{\phi'} V(\phi', F_e^m, F_e^x, f^m, f^x, M \mid \phi)\right\}.
\end{aligned}$$

An exporter can choose to become an MNE in the foreign market and pay the per-period fixed cost f^m and the entry sunk cost F^m; continue exporting to the foreign market and pay the per-period fixed cost f^x; or operate in and serve only its home market.

The value of being a domestic firm with productivity ϕ is given by

$$V(\phi, F_e^m, F_e^x, f^m, f^x, D) = \frac{X^d(\phi)}{\sigma} + \max\left\{\frac{X^m(\phi)}{\sigma} - f^m - F_e^m + \beta E_{\phi'} V(\phi', F_e^m, F_e^x, f^m, f^x, M \mid \phi)\right.,$$
$$\left.\beta E_{\phi'} V(\phi', F_e^m, F_e^x, f^m, f^x, D \mid \phi), \frac{X^x(\phi)}{\sigma} - f^x - F_e^x + \beta E_{\phi'} V(\phi', F_e^m, F_e^x, f^m, f^x, X \mid \phi)\right\}.$$

A domestic firm can choose to become an MNE in the foreign market and pay the per-period fixed cost f^m and the entry sunk cost F^m; export to the foreign market and pay the per-period fixed cost f^x and sunk cost F^x; or operate in and serve only its home market.

C.4 Numerical Implementation

We describe here the numerical algorithm used in the paper, proceeding in three steps. Appendix Section C.4.1 discusses the numerical methods to solve the model. Appendix Section C.4.2 describes how we calculate the moments from the model. Appendix Section C.4.3 provides details on the implementation of the simulated method of moments (SMM) to search for a set of parameters that minimize the differences between the model and data moments for each of our 32 origin-destination pairs.[1]

C.4.1 Solving the Model

For each firm, the sunk and fixed costs of multinational production and exporting, F_e^s and f^s ($s = m, x$), do not vary over time. These costs are independent from each other and across firms, each following a log normal distribution with parameters (μ_e^s, σ_e^s) or (μ_f^s, σ_f^s), where $s = m, x$. With the goal of simplifying notations, we use a 4×1 vector $\overrightarrow{F}$ to collect these

1. 16 destinations for French firms and 16 destinations for Norwegian firms. See Section 3.5.

costs. We simulate I draws of the costs, denoted with $\left\{\overrightarrow{F_i}\right\}_{i=1}^{I}$. In order for the draws to get a good coverage in the space of the costs, we take the following approach. Conditional on a set of model parameters, μ_e^s, σ_e^s, μ_f^s and σ_f^s $(s = m, x)$, we make $I = 150$ scrambled Halton quasi-random draws (Halton, 1960) for each of the four CDFs of MNE and exporter sunk and fixed costs.[2] To get the actual draws of $\left\{\overrightarrow{F_i}\right\}_{i=1}^{I}$, we use the inverse CDF transformation.

Given a vector of fixed and sunk cost draws, for each firm we have a problem with one exogenous state variable (productivity ϕ), and one endogenous state variable (firm status $S = D, X$ or M). To solve a firm's problem, we first construct the discretized productivity grid and the Markovian productivity transition probability matrix with the Tauchen method (Tauchen, 1986). Then for each draw $\overrightarrow{F_i}$, we solve the Bellman equations in Appendix Section C.3 with value function iteration. We can parallelize solving the problems across the I draws $\left\{\overrightarrow{F_i}\right\}_{i=1}^{I}$.

The solution to each firm's problem is characterized by a policy function $\mathbf{1}(S'|S, \phi_j, \overrightarrow{F_i})$ (the firm's decision that chooses the status for next period, conditional on the status today, productivity and the sunk and fixed cost draw), as well as the stationary distribution, $\Pr(S, \phi_j|\overrightarrow{F_i})$ (the joint probability of status and productivity in the stationary equilibrium, conditional on the sunk and fixed cost draw). Here S denotes the firm's status today $(S = D, X$ or $M)$ and S' the firm's status in the next period.

C.4.2 Calculation of Moments

We describe the approach to compute the model moments (see Section 3.5.1) for the extended model described in Appendix Section C.3. We present the calculation of the **average exporter exit rate** as an example. The other five moments are computed in an analogous manner.

The average exporter exit rate (in the stationary distribution) equals the joint mass of

2. Scrambled Halton quasi-random draws have nice properties for simulating high-dimensional integrals. See Train (2009).

firms being an exporter and exiting in the next period, divided by the mass of firms being an exporter, denoted as

$$\frac{\Pr(S' \neq X, S = X)}{\Pr(S = X)}. \tag{C.8}$$

Expanding the numerator of (C.8) yields

$$\Pr(S' \neq X, S = X) = \int \Pr(S' \neq X | S = X, \phi, \overrightarrow{F}) \Pr(S = X | \phi, \overrightarrow{F}) f(\phi, \overrightarrow{F}) d\phi d\overrightarrow{F}.$$

The expression $f(\phi, \overrightarrow{F})$ denotes the joint density of the firm's productivity ϕ, and the vector of fixed and sunk costs of exporters and MNEs, $\overrightarrow{F}$. The joint mass of exiting exporters integrates over all levels of productivity and sunk and fixed costs, using their respective probability densities $f(\phi, \overrightarrow{F})$, multiplied by the mass of exporters conditional on productivity and sunk and fixed costs, $\Pr(S = X|\phi, \overrightarrow{F})$ (in the steady state), as well as exporters' probability to exit exporting in the next period conditional on their productivity and sunk and fixed costs, $\Pr(S' \neq X|S = X, \phi, \overrightarrow{F})$ (again, in the steady state).

Because ϕ and $\overrightarrow{F}$ are independent, we can write $f(\phi, \overrightarrow{F}) = f_1(\phi) f_2(\overrightarrow{F})$, where f_1 and f_2 are densities of productivity and sunk and fixed costs, respectively.

Let $g(S = X, \phi|\overrightarrow{F})$ denote the stationary joint distribution of exporters and productivity levels conditional on costs $\overrightarrow{F}$.[3]

Note that $\Pr(S = X|\phi, \overrightarrow{F}) f_1(\phi) = \Pr(S = X|\phi, \overrightarrow{F}) f_1(\phi|\overrightarrow{F}) = g(S = X, \phi|\overrightarrow{F})$.

Conditional on other state variables, the exporter's exiting policy function follows a productivity cutoff rule. As a result, the probability $\Pr(S' \neq X|S = X, \phi, \overrightarrow{F})$ is actually the

3. $g(S = X, \phi|\overrightarrow{F})$ is the continuous object of the discretized stationary distribution $\Pr(S = X, \phi_j|\overrightarrow{F_i})$ defined in the previous section.

policy function $\mathbf{1}(S' \neq X | S = X, \phi, \overrightarrow{F})$. Consequently,

$$\Pr(S' \neq X, S = X) = \int \left(\int \mathbf{1}(S' \neq X | S = X, \phi, \overrightarrow{F}) g(S = X, \phi | \overrightarrow{F}) d\phi \right) f_2(\overrightarrow{F}) d\overrightarrow{F}. \quad \text{(C.9)}$$

Similarly, the denominator of (C.8) equals

$$\Pr(S = X) = \int \left(\int g(S = X, \phi | \overrightarrow{F}) d\phi \right) f_2(\overrightarrow{F}) d\overrightarrow{F}. \quad \text{(C.10)}$$

Armed with the model solution in Appendix Section C.4.1, the interior integrals over ϕ in (C.9) and (C.10) are numerically evaluated as follows:

$$\int \mathbf{1}(S' \neq X | S = X, \phi, \overrightarrow{F}) g(S = X, \phi | \overrightarrow{F}) d\phi \approx \sum_j \mathbf{1}(S' \neq X | S = X, \phi_j, \overrightarrow{F}) \Pr(S = X, \phi_j | \overrightarrow{F}),$$

$$\int g(S = X, \phi | \overrightarrow{F}) d\phi \approx \sum_j \Pr(S = X, \phi_j | \overrightarrow{F}).$$

Further, note that the exterior integrals over $\overrightarrow{F}$ for both (C.9) and (C.10) are the simple average across all Halton draws for fixed and sunk costs. These lead up to the model moments in (C.8),

$$\frac{\Pr(S' \neq X, S = X)}{\Pr(S = X)} \approx \frac{\frac{1}{I} \sum_i \sum_j \mathbf{1}(S' \neq X | S = X, \phi_j, \overrightarrow{F_i}) \Pr(S = X, \phi_j | \overrightarrow{F_i})}{\frac{1}{I} \sum_i \sum_j \Pr(S = X, \phi_j | \overrightarrow{F_i})}.$$

C.4.3 Estimation

Conditional on a set of model parameters (means and standard deviations of exporters and μ_e^s, σ_e^s, μ_f^s, σ_f^s, where $s = m, x$), we compute the model moments as indicated in the previous sections. We next describe the SMM method to search for the parameters that minimize the distances between model and data moments.

We denote the six data moments (see Section 3.5.1) with column vector $\overrightarrow{m}$ and the model counterparts with $\overrightarrow{\hat{m}}$. In order to account for the size differences across model moments, we normalize the distances between the data and model moments with the levels of the corresponding data moments. As described in the main text, we also reduce the number of estimated parameters from eight to six by imposing the assumption that the coefficient of variation for sunk and fixed costs (in logs) is the same for each mode, $|\sigma_e^s/\mu_e^s| = |\sigma_f^s/\mu_f^s|$ $(s \in x, m)$. The estimation problem is the following:

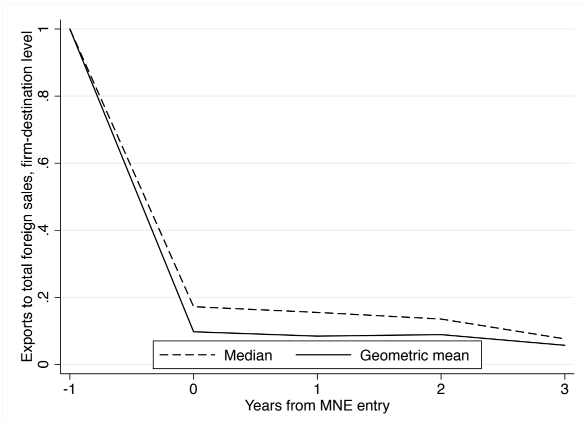
$$\min_{\mu_e^m,\sigma_e^m,\mu_f^m,\mu_e^x,\sigma_e^x,\mu_f^x} \left((\overrightarrow{m} - \overrightarrow{\hat{m}})./\overrightarrow{m}\right)' \mathbf{W} \left((\overrightarrow{m} - \overrightarrow{\hat{m}})./\overrightarrow{m}\right) \tag{C.11}$$

where ./ represents element-wise matrix division and $\mathbf{W}$ is the weighting matrix for the moments, which we set to identity matrix. To minimize this objective, we use the MATLAB derivative-free nonlinear solver $fminsearch$, augmented with bound constraints on parameters. We solve the problem for each of our 32 origin-destination pairs. To reduce the possibility that the solver gets stuck in a local optimum, for every origin-destination pair, we kick off the solver from multiple starting values.

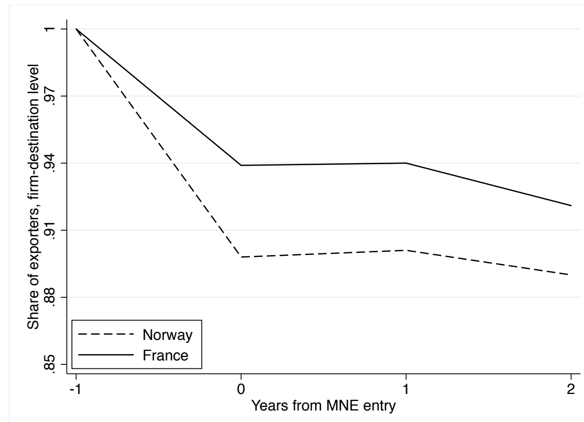
C.5 Additional Tables and Figures

Figure C.1: Life-cycle Dynamics of Exports for New MNEs.

(a) Export-to-foreign Sales Ratio



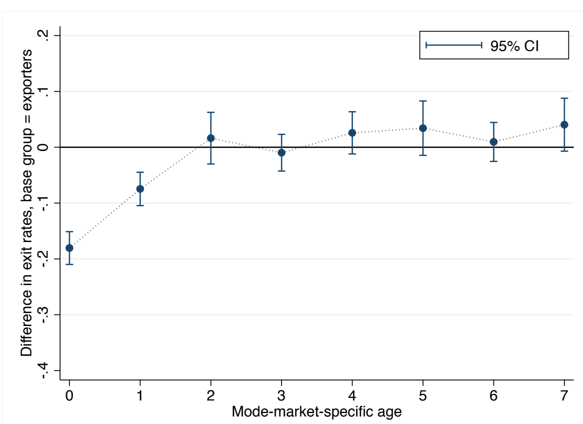
(b) Share of Exporters, MNEs with Export Experience



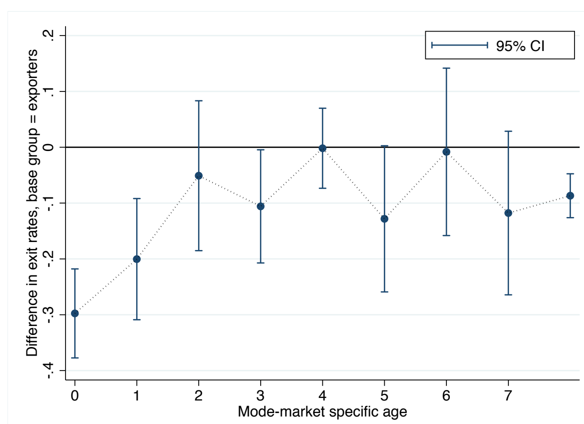
Notes: Data on MNE sales are available only for Norway. (C.1a): ratio of exports to foreign sales, by years from MNE entry, at the firm-destination-year level, average over MNE-destination pairs with at least four years in the market and with positive exports before MNE entry. (C.1b): share of exporters among MNEs that export (to the market of the affiliate) in the year before MNE entry, by years from MNE entry, for firm-destination pairs that survive at least four years as MNEs in a market.

Figure C.2: Exit Rates by Age: MNEs versus Exporters, OLS.

(a) France



(b) Norway



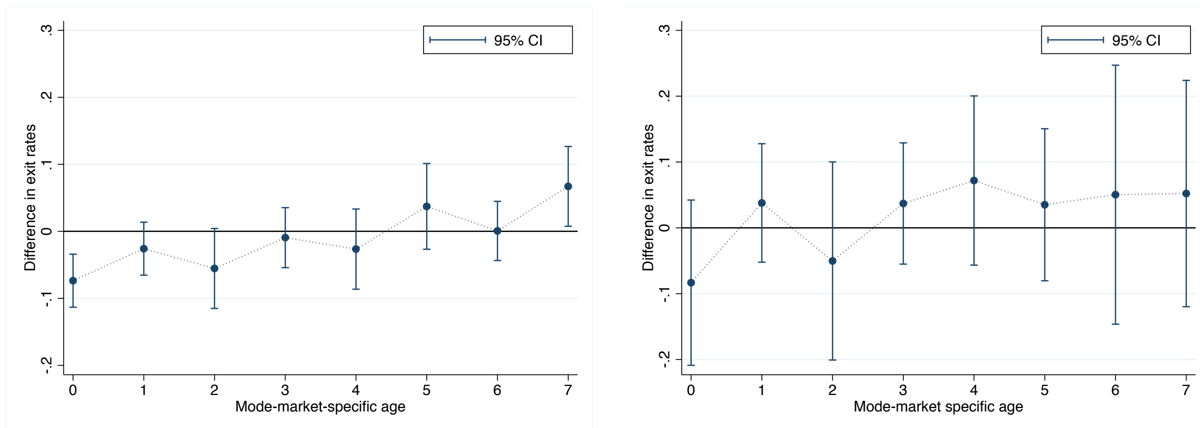
Notes: Difference in coefficients and 95% confidence bands from estimating, by OLS,

$$D(Exit_{inmta}) = \beta_0 MNE_{inta} + \sum_a \beta_1^a D(age_{inmt} = a) + \sum_a \beta_2^a MNE_{inta} \times D(age_{inmt} = a) + \epsilon_{inmta},$$

where $D(Exit_{inmta})$ is a dummy equal to one in the year t in which firm i of age a exits mode m in market n, and zero otherwise; MNE_{inta} is one if firm i at age a is active in market n and year t as an MNE, and zero otherwise; and $D(age_{inmt} = a)$ equals one if firm i in market n and mode m at time t is of age a, and zero otherwise. We include year, industry, country fixed effects, and the log of home sales as a control. Standard errors are clustered by industry. Exporters are the base group. Observations are at the firm-destination-year level. Exporters refers to non-MNE exporters.

Figure C.3: Exit Rates by Age: Experienced versus Non-experienced MNEs, OLS.

(a) France (b) Norway



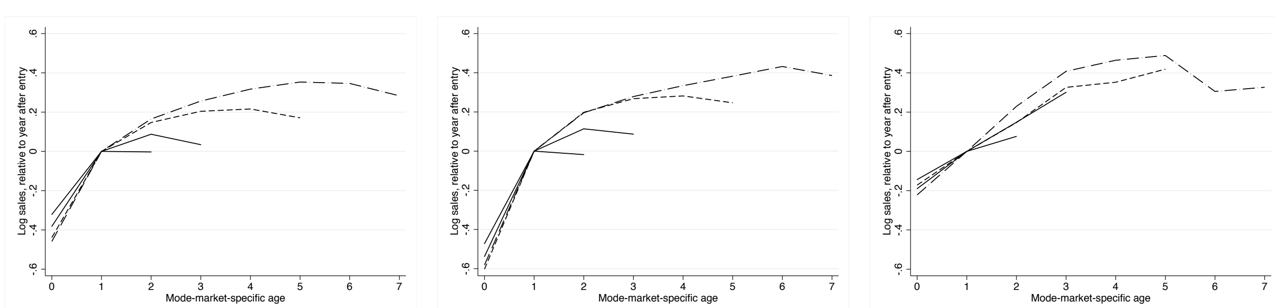
Notes: Number of exits from a mode-market relative to the number of firms active in a mode-market, by mode-market-specific age. Experienced MNEs are new affiliates of MNEs that exported to a foreign market for one or more years before opening an affiliate there. Difference in coefficients and 95% confidence bands from estimating, by OLS,

$$D(Exit_{inmta}) = \beta_0 MNE_{inta} + \sum_a \beta_1^a D(age_{inmt} = a) + \sum_a \beta_2^a MNE_{inta} \times D(age_{inmt} = a)$$
$$+\beta_3 exp.mne_{inmta} + \sum_a \beta_4^a exp.mne_{inmta} \times D(age_{inmt} = a) + \beta_5 exp.mne_{inmta} \times MNE_{inta}$$
$$+\sum_a \beta_6^a D(age_{inmt} = a) \times MNE_{inta} \times exp.mne_{inmta} + \epsilon_{inmta},$$

where $D(Exit_{inmta})$ is a dummy equal to one in the year t in which firm i of age a exits mode m in market n, and zero otherwise; MNE_{inta} is one if firm i at age a is active in market n and year t as an MNE, and zero otherwise; and $D(age_{inmt} = a)$ equals one if firm i in market n and mode m at time t is of age a, and zero otherwise. $exp.mne_{inmta}$ indicates the years of export experience before MNE entry in market n, for firm i at age a and year t. We include year, industry, country fixed effects, and the log of home sales as a control. Standard errors are clustered by industry. Non-experienced MNEs are the base group. Observations at the firm-destination-year level.

Figure C.4: Sales Growth by Age and Cohort.

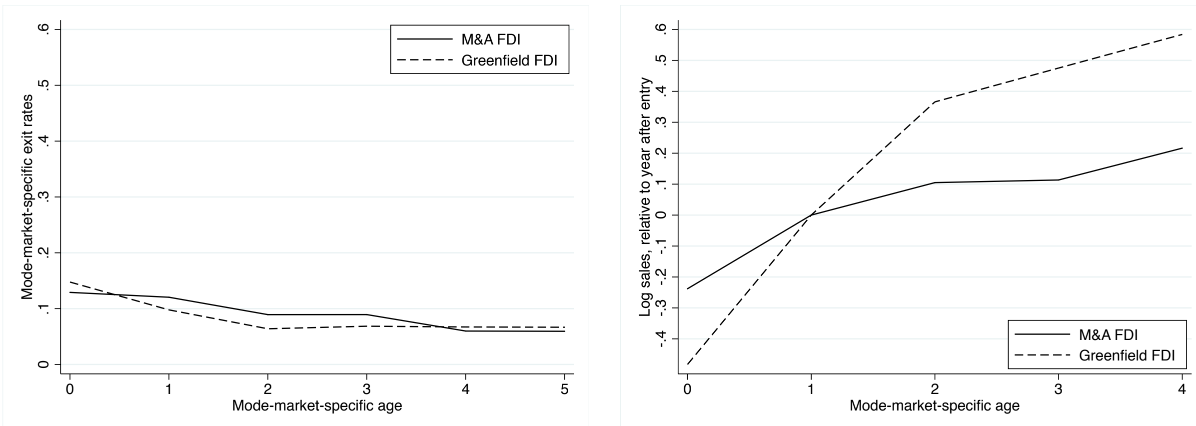
(a) Exporters, France (b) Exporters, Norway (c) MNEs, Norway



Notes: Log of firm-destination export (affiliate) sales with respect to firm-destination export (MNE) sales in the year after entry, firms with at least t years in the market, selected cohorts in each mode. Observations are at the firm-destination-year level. We show averages across destinations weighted by each destination's share of export (MNE) firms. Log of sales are first demeaned by industry, year, and destination fixed effects. Exporters refers to non-MNE exporters.

Figure C.5: Greenfield versus M&A FDI, Germany.

(a) Exit rates by age (b) Sales growth by age



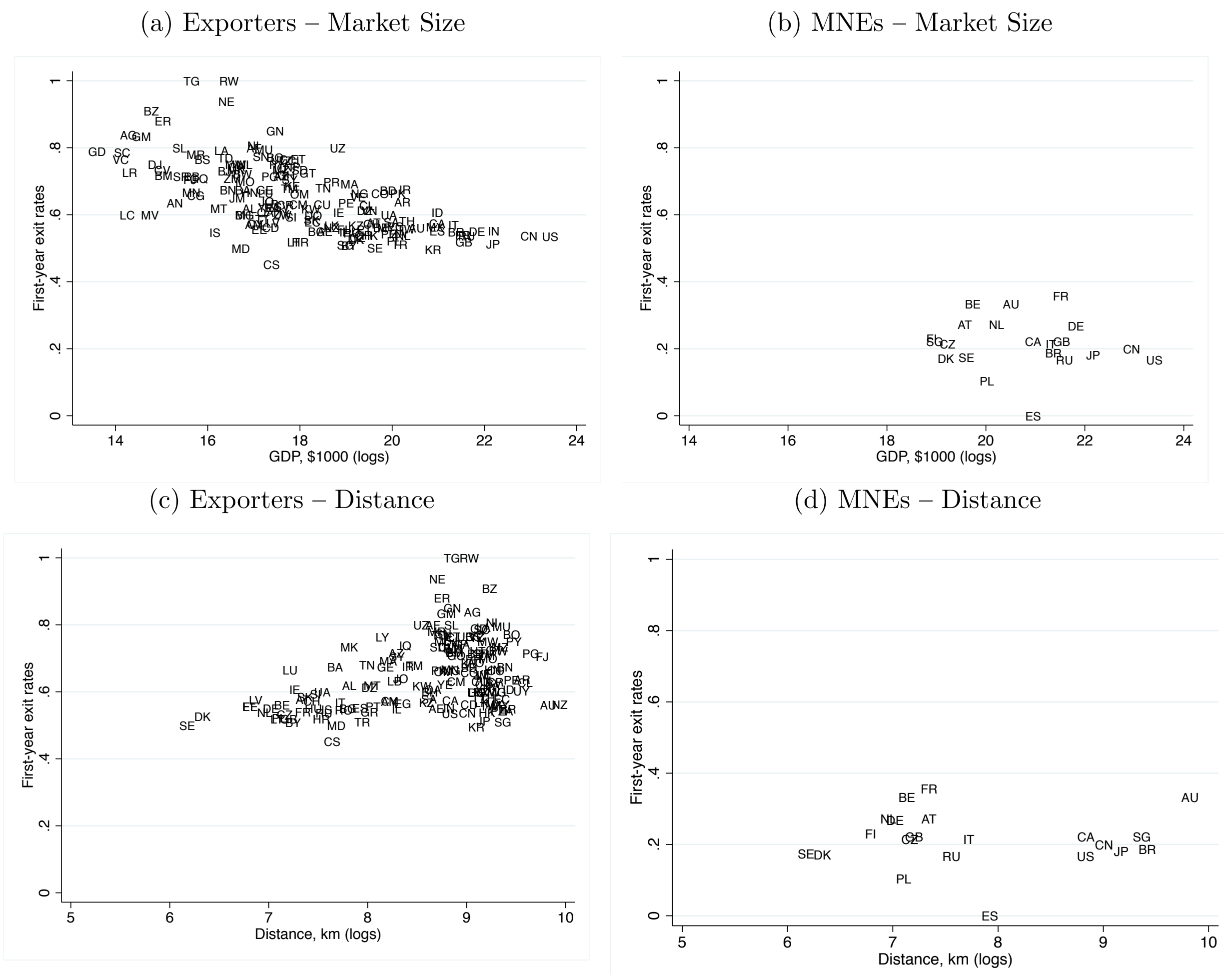
Notes: (C.5a): number of exits from a mode-market relative to the number of firms active in a mode-market, by mode-market-specific age. (C.5b): log of firm-destination MNE sales with respect to firm-destination MNE sales in the year after entry, firms with five or more years in the market. Observations are at the firm-destination-year level. We show averages across destinations weighted by each destination's share of MNE firms. Log of sales are first demeaned by industry, year, and destination fixed effects. The sample period is 2005-2011 (no information on FDI entry mode available before 2005). Source: Deutsche Bundesbank Research Data and Service Centre, Microdatabase Direct investment, own calculations.

Table C.1: Summary Statistics.

	France			
	share of revenues	share of employment	share of firm-year obs	firm-year obs
Domestic firms	0.076	0.116	0.697	671,283
Non-MNE exporters	0.289	0.317	0.287	276,499
Non-exporter MNEs	0.005	0.010	0.001	1,007
Exporter MNEs	0.630	0.557	0.015	14,589
	Norway			
	share of revenues	share of employment	share of firm-year obs	firm-year obs
Domestic firms	0.153	0.235	0.622	55,359
Non-MNE exporters	0.625	0.630	0.364	32,376
Non-exporter MNEs	0.002	0.002	0.002	136
Exporter MNEs	0.220	0.133	0.013	1,147

Notes: Non-MNE exporters are exporters that do not have MNE activities. Non-exporter MNEs are MNEs that are not exporters. Exporter MNEs are MNEs that also export.

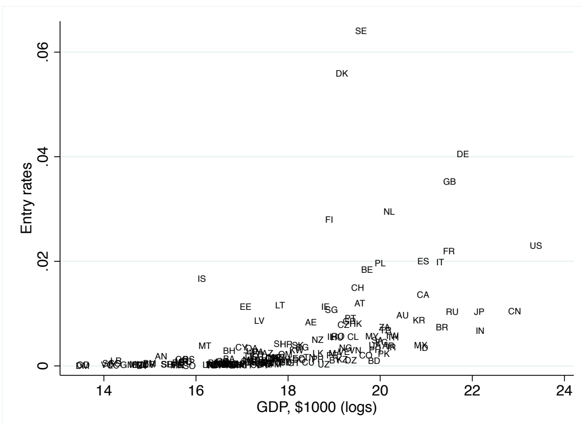
Figure C.6: First-year Exit Rates and Market Characteristics, Norway.



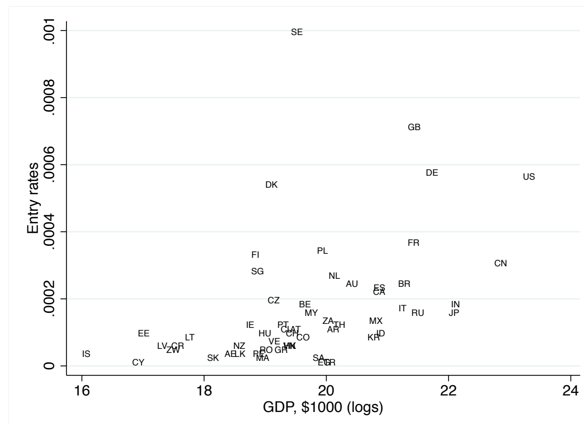
Notes: Number of exits from a mode-market relative to the number of firms active in a mode-market, for exporters and MNEs, in the first year upon market-mode entry. Destinations with ten or more firm-year observations and with available GDP data. Exporters refers to non-MNE exporters. GDP data from *International Financial Statistics* (IMF). Distance data from *CEPII* (Mayer and Zignago, 2011).

Figure C.7: Entry Rates and Market Characteristics, Norway.

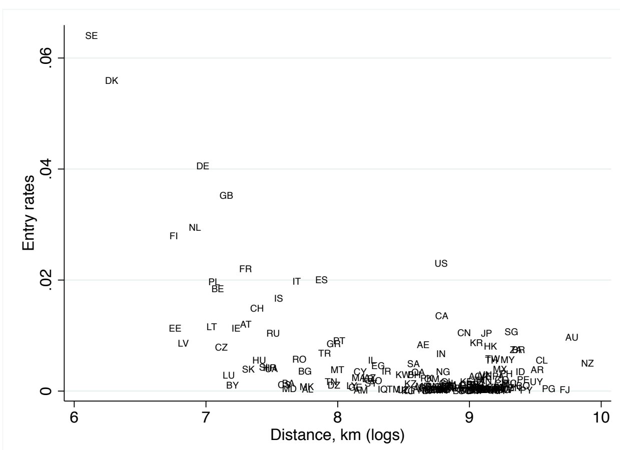
(a) Exporters – Market Size



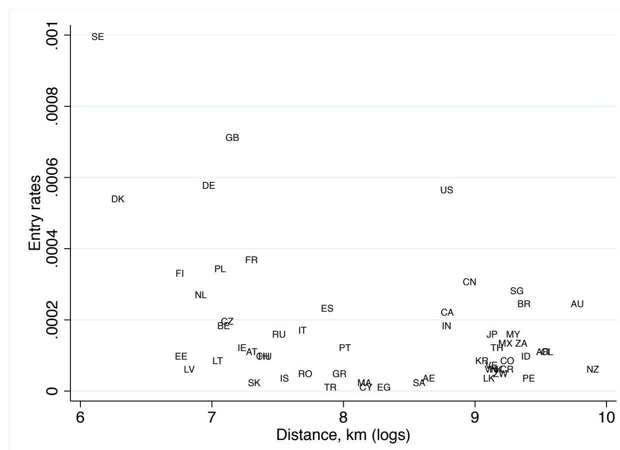
(b) MNEs – Market Size



(c) Exporters – Distance



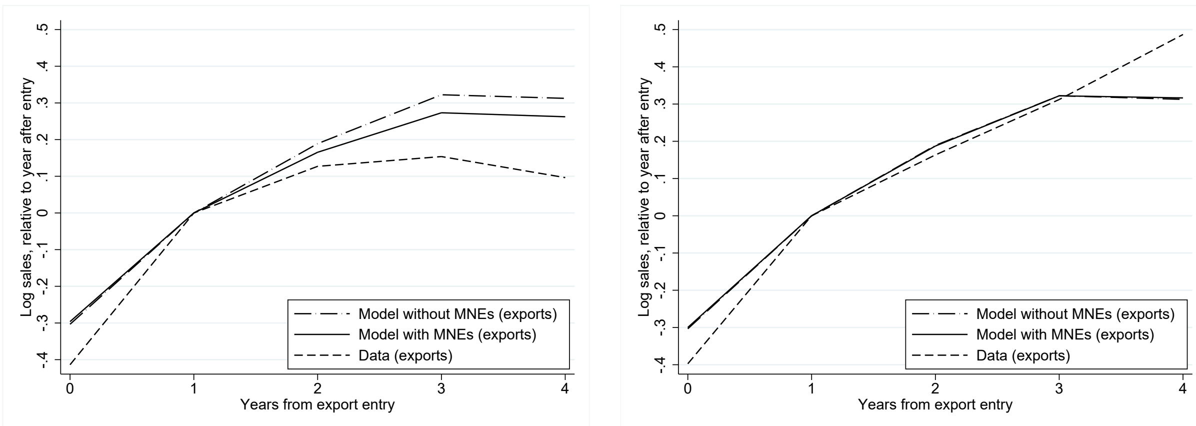
(d) MNEs – Distance



Notes: Number of entries to a mode-market relative to the number of domestic firms (MNEs) active in the home market. Destinations with ten or more firm-year observations and with available GDP data. Exporters refers to non-MNE exporters. GDP data from *International Financial Statistics* (IMF). Distance data from *CEPII* (Mayer and Zignago, 2011).

Figure C.8: Sales Growth, by Age and Exporter Type.

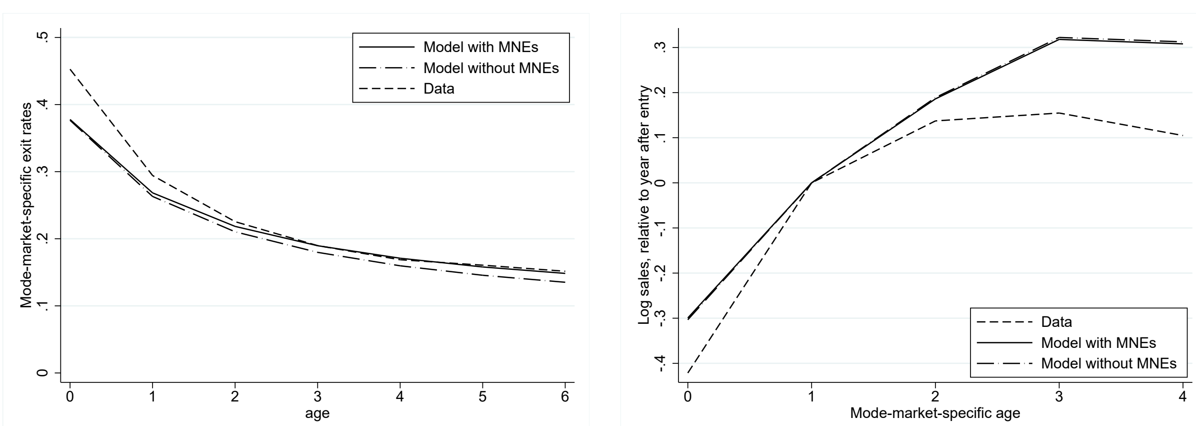
(a) Never-MNE Exporters (b) Ever-MNE Exporters



Notes: Models calibrated to French data. Log of firm-destination export sales with respect to firm-destination export sales in the year after export entry, an average over firms with five or more years in the market as exporters. Observations are at the firm-destination-year level. We show averages across destinations included in the calibration, weighted by each destination's share of export firms. Never-MNE exporters are exporters that, in our sample period, do not change to MNE status. Ever-MNE exporters are exporters that become MNEs after export entry. Exports for ever-MNE exporters are computed for the years before MNE entry. Exporters in the data refers to non-MNE exporters.

Figure C.9: Exporters Exit Rates and Sales Growth, by Age.

(a) New Exporters' Exit Rates (b) New Exporters' Sales Growth



Notes: Models calibrated to French data. (C.9a): number of exits from a mode-market relative to the number of firms active in a mode-market, by mode-market-specific age. (C.9b): log of firm-destination export sales with respect to firm-destination export sales in the year after entry, an average over firms with five or more years in the market. In the data, log of sales are first demeaned by industry, year, and destination fixed effects. Observations are at the firm-destination-year level. We show averages across destinations included in the calibration, weighted by each destination's share of export firms. Weights are data-based (model-based) for data (model) variables. Exporters in the data refers to non-MNE exporters.

Table C.2: Exit Rates and Growth Rates, OLS.

Dep variable	$D(Exit_{inmta})$		$D(Exit_{inta})$	$D(Exit_{inmt\hat{a}})$	$S_{inmt,a}/S_{inmt,1}$						
Dep variable			D(exit)				Sales, relative to age one				
	market-mode		market	market age	calendar yr		12-mo yr	"never MNEs"		"ever MNEs"	
	FRA	NOR	FRA	FRA	FRA (exp)	NOR	FRA (exp)	FRA	NOR	FRA	NOR
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
MNE	-0.181***	-0.211***	-0.273***	-0.177***		-0.079**					
	(0.015)	(0.038)	(0.014)	(0.016)		(0.045)					
$D(age = 0)$	-0.172***	-0.218***	-0.171***	-0.172***	-0.436***	-0.686***	-0.109***	-0.436***	-0.683***	-0.448***	-2.540**
	(0.003)	(0.008)	(0.003)	(0.003)	(0.011)	(0.045)	(0.010)	(0.011)	(0.045)	(0.089)	(1.059)
$\times MNE$	0.106***	0.116***	0.126***	0.106***		0.469***					
	(0.015)	(0.039)	(0.015)	(0.017)		(0.109)					
$D(age = 1)$	-0.246***	-0.270	-0.246***	-0.246***							
	(0.004)	(0.011))	(0.004)	(0.004)							
$\times MNE$	0.197***	0.257***	0.229***	0.198***							
	(0.029)	(0.045)	(0.029)	(0.025)							
$D(age = 2)$	-0.283***	-0.316***	-0.283***	-0.283***	0.154***	0.178***	0.126***	0.154***	0.179***	0.204**	0.929
	(0.004)	(0.016)	(0.004)	(0.004)	(0.008)	(0.024)	(0.009)	(0.008)	(0.0249)	(0.080)	(0.972)
$\times MNE$	0.171***	0.236***	0.207***	0.179***		0.021					
	(0.019)	(0.044)	(0.018)	(0.020)		(0.102)					
$D(age = 3)$	-0.308***	-0.334***	-0.308***	-0.308***	0.209***	0.277***	0.164***	0.209***	0.280***	0.361***	1.376
	(0.006)	(0.013)	(0.006)	(0.006)	(0.012)	(0.042)	(0.014)	(0.012)	(0.043)	(0.086)	(1.509)
$\times MNE$	0.207***	0.250***	0.246***	0.214***		0.071					
	(0.021)	(0.044)	(0.020)	(0.026)		(0.140)					
$D(age = 4)$	-0.316***	-0.343***	-0.316***	-0.317***	0.157***	0.241***	0.088***	0.157***	0.245***	0.460***	2.671
	(0.008)	(0.015)	(0.008)	(0.008)	(0.020)	(0.054)	(0.020)	(0.020)	(0.055)	(0.125)	(2.166)
$\times MNE$	0.214***	0.283***	0.248***	0.216***		0.132					
	(0.025)	(0.050)	(0.024)	(0.026)		(0.143)					
	(0.008)	(0.017)	(0.008)	(0.008)							
	(0.018)	(0.056)	(0.017)	(0.019)							
	(0.007)	(0.019)	(0.007)	(0.007)							
Observations	1,044,855	74,119	1,044,855	1,044,855	405,009	25,887	297,896	405,009	24,902	2,632	104

Notes: Dummy equals one if firm i exits. Cols 1-2: mode-market by mode-market age; col 3: market by mode-market age. Col 4: mode-market by market age. Cols 5-11: Log of firm-destination export sales with respect to firm-destination export sales in the year after export entry, firms with five or more years in the market-mode. Col 7: adjusted by partial-year effects. Cols 8-9: Never-MNEs are exporters that, in our sample period, do not change to MNE status. Cols 10-11: Ever-MNEs are exporters that become MNEs after export entry. Exports for ever-MNE exporters computed for the years before MNE entry. All regressions with year, industry, and country fixed effects. Regressions for exit rates include log of home sales and age dummies (and interactions) to age 6. Standard errors, clustered by industry, are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. Observations are at the firm-destination-year level. Exporters refers to non-MNE exporters.

Table C.3: Foreign-to-domestic Sales Ratio, by Country.

	France			Norway	
	r_n^x	r_n^m		r_n^x	r_n^m
Austria	0.003	0.024*	Austria	0.009	0.432
Benelux	0.068	0.135*	Belgium	0.029	0.086
Switzerland	0.011	0.064	Canada	0.010	0.130
China	0.014	0.213*	Germany	0.087	0.456
Germany	0.123	0.181	Denmark	0.030	0.501
Denmark	0.003	0.017*	Spain	0.031	0.051
Spain	0.044	0.119	Finland	0.025	0.546
Great Britain	0.040	0.181	France	0.045	0.231
Italy	0.054	0.100	Great Britain	0.069	0.193
Morocco	0.004	0.037	Italy	0.034	0.094
Portugal	0.006	0.019*	Netherlands	0.031	0.178
Poland	0.013	0.038	Poland	0.016	0.088
Sweden	0.012	0.037*	Sweden	0.065	0.918
Tunisia	0.004	0.008*	Singapore	0.018	0.382
United States	0.038	0.427*	United States	0.056	0.749
RoW	0.067	0.074	RoW	0.009	0.110

Notes: r_n^x refers to the export-to-domestic sales ratio, and r_n^m refers to the MNE affiliate-to-domestic sales ratio, for market n. Ratios are aggregated across firms serving market n in each mode using weights given by the firm's domestic sales. (*) imputed values. RoW refers to the rest of the world, a weighted average among the remaining countries in the sample. Observations are at the firm-destination-year level.

Table C.4: Targeted Moments, Model and Data, by Country.

	Data						Model					
	shares		1st-yr exit rates		avg exit rates		shares		1st-yr exit rates		avg exit rates	
	exp	MNEs	exp	MNEs	exp	MNEs	exp	MNEs	exp	MNEs	exp	MNEs
France												
Benelux	0.155	0.004	0.339	0.299	0.269	0.209	0.119	0.004	0.339	0.270	0.200	0.200
Switzerland	0.133	0.003	0.501	0.223	0.354	0.166	0.118	0.003	0.501	0.210	0.197	0.185
Germany	0.128	0.005	0.418	0.250	0.284	0.174	0.116	0.005	0.418	0.243	0.204	0.186
Spain	0.118	0.005	0.416	0.249	0.285	0.187	0.108	0.005	0.416	0.250	0.209	0.188
Italy	0.111	0.004	0.438	0.295	0.297	0.192	0.094	0.004	0.438	0.281	0.207	0.207
G. Britain	0.105	0.004	0.429	0.297	0.291	0.194	0.096	0.004	0.429	0.288	0.211	0.203
USA	0.078	0.006	0.511	0.238	0.362	0.175	0.071	0.006	0.511	0.239	0.227	0.166
Portugal	0.070	0.002	0.455	0.235	0.316	0.157	0.064	0.002	0.455	0.211	0.231	0.183
Morocco	0.057	0.002	0.543	0.218	0.391	0.162	0.052	0.002	0.543	0.200	0.244	0.190
Tunisia	0.052	0.001	0.529	0.298	0.379	0.213	0.049	0.001	0.529	0.290	0.240	0.227
Austria	0.054	0.001	0.462	0.258	0.318	0.182	0.050	0.001	0.462	0.230	0.233	0.210
Poland	0.051	0.003	0.455	0.223	0.307	0.185	0.049	0.003	0.455	0.222	0.251	0.189
Sweden	0.049	0.001	0.445	0.235	0.307	0.154	0.047	0.001	0.445	0.194	0.243	0.200
Denmark	0.050	0.001	0.452	0.195	0.311	0.137	0.047	0.001	0.452	0.161	0.242	0.181
China	0.036	0.003	0.521	0.188	0.353	0.146	0.034	0.003	0.521	0.177	0.262	0.164
RoW	0.194	0.008	0.488	0.273	0.327	0.188	0.162	0.004	0.488	0.227	0.169	0.169
Norway												
Austria	0.031	0.001	0.527	0.263	0.282	0.180	0.032	0.001	0.527	0.081	0.268	0.144
Belgium	0.055	0.001	0.552	0.214	0.313	0.129	0.054	0.001	0.552	0.181	0.240	0.162
Canada	0.039	0.001	0.549	0.222	0.318	0.117	0.037	0.001	0.549	0.138	0.264	0.173
Germany	0.135	0.004	0.541	0.182	0.285	0.166	0.121	0.004	0.541	0.181	0.204	0.168
Denmark	0.193	0.004	0.511	0.163	0.270	0.139	0.168	0.004	0.511	0.153	0.181	0.161
Spain	0.060	0.001	0.533	0.059	0.299	0.131	0.066	0.001	0.533	0.062	0.229	0.125
Finland	0.099	0.002	0.544	0.192	0.273	0.141	0.103	0.002	0.544	0.134	0.208	0.151
France	0.073	0.003	0.524	0.310	0.276	0.168	0.070	0.003	0.524	0.261	0.240	0.206
G. Britain	0.123	0.006	0.506	0.179	0.268	0.131	0.113	0.006	0.506	0.166	0.208	0.152
Italy	0.062	0.002	0.553	0.154	0.297	0.119	0.077	0.001	0.553	0.148	0.221	0.151
Netherlands	0.100	0.002	0.528	0.238	0.274	0.136	0.092	0.002	0.528	0.180	0.217	0.187
Poland	0.055	0.002	0.504	0.071	0.303	0.086	0.053	0.002	0.504	0.057	0.246	0.127
RoW	0.005	0.000	0.572	0.204	0.364	0.168	0.005	0.000	0.572	0.115	0.339	0.197
Sweden	0.249	0.007	0.484	0.158	0.239	0.151	0.215	0.007	0.484	0.159	0.166	0.146
Singapore	0.035	0.002	0.505	0.150	0.280	0.120	0.034	0.002	0.505	0.126	0.271	0.162
USA	0.077	0.004	0.519	0.130	0.262	0.128	0.074	0.004	0.519	0.125	0.227	0.140

Notes: Share of exporters (MNEs) to market n relative to all firms. Exporter (MNE) exit rates are calculated relative to all exporters (MNEs) in the market. First-year exit rate refers to exit at age zero. RoW refers to the rest of the world, a weighted average among the remaining countries in the sample. Exporters in the data refers to non-MNE exporters. Observations are at the firm-destination-year level.

Table C.5: Calibrated Parameters, by Country.

	Model with MNEs				Model without MNEs	
	$\log(f_n^x)$	$\log(f_n^m)$	$\log(F_n^x)$	$\log(F_n^m)$	$\log(f_n^x)$	$\log(F_n^x)$
France						
Benelux	-1.77 (1e-03)	-0.24 (0.16)	-139.37 (0.11)	25.81 (17.87)	-1.84 (1e-04)	-58.16 (5e-03)
Switzerland	-3.43 (0.03)	-0.59 (0.36)	-82.54 (0.82)	18.61 (11.33)	-3.41 (1e-03)	-189.52 (0.07)
Germany	-1.01 (0.01)	-0.01 (0.01)	-15.71 (0.20)	13.43 (10.44)	-0.98 (3e-03)	-32.63 (0.11)
Spain	-1.96 (3e-03)	0.06 (0.04)	-77.98 (0.13)	12.61 (10.21)	-1.91 (1e-03)	-79.74 (0.05)
Italy	-1.67 (5e-03)	-0.34 (0.26)	-52.15 (0.15)	25.20 (18.76)	-1.63 (4e-03)	-39.93 (0.10)
Great Britain	-1.92 (0.04)	0.39 (0.26)	-18.44 (0.35)	31.70 (21.50)	-1.87 (4e-05)	-96.53 (2e-03)
United States	-1.89 (0.08)	1.13 (0.74)	-58.19 (2.57)	46.67 (30.42)	-1.58 (1e-03)	-106.38 (0.09)
Portugal	-3.37 (0.02)	-1.12 (0.79)	-13.98 (0.10)	19.74 (13.84)	-3.32 (2e-03)	-84.62 (0.04)
Morocco	-3.54 (0.02)	-0.66 (0.40)	-86.74 (0.47)	15.56 (9.50)	-3.50 (1e-03)	-234.12 (0.10)
Tunisia	-3.43 (0.01)	0.48 (1.64)	-32.80 (0.07)	2.20 (7.49)	-3.41 (1e-03)	-248.04 (0.09)
Austria	-3.78 (0.01)	-0.61 (0.37)	-42.21 (0.14)	16.34 (9.88)	-3.75 (1e-03)	-2357.28 (0.73)
Poland	-2.30 (4e-05)	-0.32 (0.30)	-130.28 (2e-03)	6.87 (6.34)	-2.24 (1e-03)	-15.95 (0.01)
Sweden	-2.28 (0.04)	-0.74 (0.38)	-9.73 (0.17)	21.25 (11.07)	-2.28 (6e-04)	-81.00 (0.02)
Denmark	-3.66 (0.17)	-1.48 (0.77)	-10.70 (0.49)	19.01 (9.92)	-3.68 (8e-04)	-219.66 (0.05)
China	-2.03 (0.03)	1.83 (1.12)	-52.38 (0.74)	10.68 (6.50)	-1.82 (1e-03)	-54.85 (0.04)
RoW	-2.03 (0.01)	-0.34 (1.09)	-47.84 (0.33)	5.13 (16.55)	-2.07 (1e-03)	-148.95 (0.08)
Norway						
Austria	-3.53 (0.01)	1.04 (0.65)	-13.57 (0.04)	19.60 (12.14)	-3.51 (1e-03)	-147.29 (0.04)
Belgium	-2.70 (1e-03)	-0.91 (0.59)	-50.03 (0.02)	11.94 (7.73)	-2.68 (1e-03)	-211.12 (0.08)
Canada	-3.63 (0.01)	-0.82 (0.41)	-135.28 (0.23)	12.61 (6.29)	-3.53 (1e-03)	-201.36 (0.04)
Germany	-2.24 (0.04)	0.10 (0.06)	-35.65 (0.70)	10.38 (6.55)	-2.22 (1e-03)	-80.27 (0.04)
Denmark	-3.59 (5e-04)	0.18 (0.10)	-10.66 (2e-03)	10.42 (6.03)	-3.58 (1e-03)	-147.82 (0.03)
Spain	-2.70 (0.03)	-0.83 (0.88)	-180.63 (2.17)	3.79 (4.02)	-2.68 (5e-06)	-244.65 (5e-04)
Finland	-3.27 (0.15)	0.18 (0.08)	-13.28 (0.61)	15.21 (7.13)	-3.24 (8e-04)	-55.40 (0.01)
France	-2.48 (0.02)	-0.53 (0.34)	-53.13 (0.33)	25.19 (16.01)	-2.44 (1e-03)	-248.24 (0.08)
Great Britain	-2.43 (0.01)	-0.84 (0.61)	-78.16 (0.47)	14.52 (10.43)	-2.39 (1e-03)	-112.52 (0.06)
Italy	-2.64 (0.02)	-1.00 (0.68)	-33.77 (0.21)	10.91 (7.43)	-2.61 (1e-03)	-177.11 (0.09)
Netherlands	-3.07 (0.02)	-1.16 (0.59)	-76.33 (0.46)	37.87 (19.11)	-3.04 (9e-03)	-31.83 (0.10)
Poland	-3.47 (0.03)	1.28 (1.64)	-79.50 (0.68)	2.12 (2.72)	-3.28 (1e-03)	-1796.41 (0.65)
RoW	-2.57 (0.01)	0.25 (0.12)	-208.04 (1.00)	8.22 (3.86)	-2.54 (1e-03)	-182.73 (0.08)
Sweden	-3.06 (0.03)	0.90 (0.61)	-24.46 (0.24)	11.33 (7.72)	-3.03 (1e-03)	-49.66 (0.02)
Singapore	-2.93 (0.02)	0.59 (0.35)	-74.33 (0.62)	7.20 (4.30)	-2.89 (6e-04)	-142.51 (0.03)
United States	-2.30 (0.05)	1.49 (1.03)	-42.18 (0.89)	10.40 (7.19)	-2.27 (9e-05)	-95.28 (4e-03)

Notes: We report the mean across firms and the standard deviation in parentheses. f_n^x are per-period fixed export costs; f_n^m are per-period fixed MNE costs; F_n^x are sunk export costs; and F_n^m are sunk MNE costs. RoW refers to the rest of the world, a weighted average among the remaining countries in the sample. Observations are at the firm-destination-year level.

Table C.6: The Size of Calibrated Costs, by Country.

	as % of sales, for median firm				in U.S. dollars, for median firm			
	f_n^x	f_n^m	F_n^x	F_n^m	f_n^x	f_n^m	F_n^x	F_n^m
France								
Benelux	11.01	6.79	0.00	21.06	8,830	205,842	0.00	638,135
Switzerland	11.31	8.66	0.00	55.71	12,553	33,159	0.00	213,276
Germany	11.39	5.22	0.00	18.20	4,352	80,915	2e-03	282,359
Spain	11.57	7.63	0.00	32.03	8,287	92,670	0.00	389,021
Italy	11.63	6.66	0.00	15.97	5,777	213,567	0.00	512,280
Great Britain	11.70	9.39	0.00	26.30	8,370	22,514	6e-04	63,046
United States	11.78	8.99	0.00	31.07	4,974	40,516	0.00	139,986
Portugal	12.46	6.40	3e-04	23.23	14,266	60,584	0.35	219,868
Morocco	12.84	9.16	0.00	56.99	17,386	52,341	0.00	325,568
Tunisia	13.01	2.91	0.00	5.40	17,960	18,348	0.00	34,035
Austria	12.91	9.71	0.00	42.02	20,201	85,821	0.00	371,341
Poland	13.08	7.57	0.00	31.17	7,957	31,397	0.00	129,220
Sweden	13.03	8.21	8e-03	40.79	5,732	130,430	3.00	648,281
Denmark	12.81	7.81	0.01	56.84	17,469	133,961	17.0	974,969
China	13.27	5.39	0.00	31.83	6,631	9,798	0.00	57,832
RoW	10.59	0.66	0.00	0.75	6,978	4,823	0.00	5,473
Norway								
Austria	16.83	13.26	7e-04	24.11	30,496	77,831	1.00	141,491
Belgium	16.18	10.44	0.00	28.02	13407	94436	0.00	253,452
Canada	16.44	12.67	0.00	48.47	30,546	265,412	0.00	1,015,487
Germany	14.88	12.02	0.00	35.39	8,630	105,001	0.00	309,053
Denmark	14.17	12.53	0.01	48.70	19,603	142,325	17.0	553,133
Spain	16.04	5.37	0.00	10.24	18,407	39,316	0.00	75,000
Finland	15.07	12.77	8e-04	53.01	21,411	109,579	1.00	454,963
France	15.76	13.51	0.00	20.58	14,444	171,443	0.00	261,018
Great Britain	14.94	9.34	0.00	22.56	13,655	159,250	0.00	384,529
Italy	16.02	9.47	0.00	30.21	17,626	265,489	0.00	847,150
Netherlands	15.26	13.05	0.00	31.85	21,429	397,897	0.00	971,450
Poland	15.84	7.12	0.00	34.89	36,785	58,509	0.00	286,703
Sweden	18.24	13.93	0.00	30.93	10,684	99,398	0.00	220,688
Singapore	13.50	10.61	0.00	30.28	15,358	44,970	0.00	128,388
United States	16.77	12.27	0.00	39.89	24,313	100,846	0.00	327,887
RoW	15.70	8.56	0.00	19.51	12,670	56,992	0.00	129,848

Notes: f_n^x are per-period fixed export costs; f_n^m are per-period fixed MNE costs; F_n^x are sunk export costs; and F_n^m are sunk MNE costs. The fixed and sunk export (MNE) cost values in each destination are means across random draws, conditional on positive measure of exporters (MNEs). Median firm refers to the firm with median export (MNE) sales in destination n. The values in U.S. dollars for different percentiles are calculated using the values of sales in the data, transformed to U.S. dollars using an average of the annual exchange rate observed over our sample period, from Penn World Tables 9.0 (Feenstra et al., 2015). Monetary values for French MNEs are estimated assuming that the median pc of the MNE sales distribution is proportional to the median pc of the export sales distribution, with the proportionality factor calculated using the ratio of export to MNE sales for each percentile, for Norway. RoW refers to the rest of the world, a weighted average among the remaining countries in the sample.