The Dynamics of Global Sourcing

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This paper studies a model of heterogeneous importers that incorporates both static cross-country interdependence and dynamic dependence in firm-level decisions. I find that the benefit of importing from one country increases as a firm imports from more countries. Furthermore, using a partial identification approach under the revealed preferences assumption, I provide evidence for the sunk costs of importing, which make establishing relationships with new suppliers costlier than maintaining existing ones. Back-of-the-envelope calculations show that a temporary U.S.-China trade war would persistently reduce Chinese firms' imports both from the United States and from other suppliers.

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Input trade accounts for as much as two-thirds of international trade and one-half of global value chains (Johnson and Noguera, 2012; Antràs and Chor, 2021). A key aspect of the firm-level input imports is that they directly affect the firm's marginal costs, rendering import decisions interdependent across markets (Antràs, Fort and Tintelnot, 2017). In this environment, sunk costs of importing–if they do exist–gain a crucial role, as they would also introduce a history-dependence dimension to sourcing decisions.[1] With the sunk costs, the firm's import decision in one country depends not only on its import decisions in other countries but also on its past import locations. Nonetheless, no previous studies have simultaneously accounted for both features of the firm's import decision in a coherent framework.

My paper fills in this gap in the literature by studying the dynamics of firm-level input imports, with a focus on the dependence of firms' import path over time and across countries. I make three contributions. First, I provide a theoretical framework that unifies the theories from the sourcing literature and the export dynamics literature. Second, using a partial identification approach similar to Morales, Sheu and Zahler (2019), I estimate country-specific sunk costs in the presence of cross-country interdependence. I then show how the combination of both features has important policy implications: Temporary trade policy changes, such as the U.S.-China trade war, would persistently affect Chinese firms' imports both from the United States and from China's other trading partners. Finally, I extend the model to allow for complementarity between exports and imports in a multi-country dynamic trade model, thus highlighting the role of global sourcing in creating interdependence in the firm's export decisions across destinations.

Combining two separate firm-level Chinese data sets from 2000 to 2006, I study Chinese chemical firms and establish two main empirical findings on firm-level input imports. First, a firm's import decision in one market is not independent of its decision in other markets. Second, there is persistence over time regarding where firms import intermediate inputs. Firms are more likely to import from a country if it has imported from the same country in the past, even after accounting for different combinations of firm-country, country, and year fixed effects.

Building on these empirical facts, I propose a dynamic partial equilibrium framework of imports with heterogeneous firms in a multi-country setting. The model incorporates two crucial features of firm-level import decisions: (1) Input sources are interdependent in the marginal cost, and (2) firms pay a sunk entry cost when importing from a new location. The mechanism for interdependence across input sources is similar to that in Antràs, Fort and Tintelnot (2017) (hereafter AFT), which considers the firm's sourcing decision in a static setting. The decision to incur the fixed costs

[1] Such costs arise as firms must incur costs to search for new suppliers, negotiate contracts with foreign partners, or adapt the production process to utilize foreign inputs.

of sourcing inputs from one country gives the firm access to lower cost suppliers, reducing firm production costs and prices. These lower prices, in turn, imply a larger scale of operation, which makes it more likely that the firm will find it profitable to incur the fixed costs of sourcing inputs from other countries. Conversely, sourcing from an additional country leads to market shares shifting away from the current sources, thus diminishing the value of each current source. In a static environment, the firm decision is essentially to balance the gain in static variable profits and the increase in the fixed costs of importing.

In addition to the static interdependence, my model includes sunk entry costs of importing, which introduces an inter-temporal linkage between current and future decisions.[2] The dynamic solution thus depends not only on static profit gains and fixed costs, but also on expected future profit gains and sunk costs. Alternatively, one can interpret firm-specific sunk costs as heterogeneity in firms' information sets. Given the differences in their import histories, firms acquire different information about potential import sources, giving rise to distinct sequential import decisions even if they have the same level of core productivity. In other words, firms are heterogeneous not only in terms of productivity but also in regard to the information set they acquire given their previous import experience.

Estimating the model constitutes a challenging task because of (1) the large dimensionality of the firm choice set (with J countries, the firm faces with 2^J choices), which is complicated by (2) the evaluation of dynamic implications of each choice and (3) the interdependence across markets in the marginal cost. To address (1) and (2), I employ a moment inequality approach based on the revealed preference assumption similar to Morales, Sheu and Zahler (2019) (hereafter MSZ). For each firm in a particular year, I change its import status in each market, one at a time, and compute the difference in observed profits and counterfactual profits to estimate the bounds for the fixed and sunk costs. Consequently, for a firm-year pair, the number of deviations I have to analyze is only J, which sharply contrasts with the standard method. The moment inequality method also avoids estimating the value function for each choice, despite the model's dynamic structure. To address (3), I build on results from AFT's static model to derive the counterfactual static profits. This method allows me to identify the sourcing potential of each import market and thus, the ratio between the firm's marginal cost at the observed import path and its marginal cost at the counterfactual import path. Because of this feature, even in the presence of interdependence across markets, I can estimate the fixed and sunk costs of importing as if markets are independent.

I find that countries are complementary: The marginal revenue gain of a source country increases

[2] In Section V.A, I provide an extension of the model, which allows for dynamic productivity gains from importing. This added feature generates another inter-temporal linkage through which current decisions affect future profits.

with the number of sources from which a firm imports. This result is consistent with previous studies. Moreover, the marginal revenue gain of a source country is correlated with a firm's status in that country. The revenue gain is particularly high for new and continuing importers, at 7.9 million and 6.6 million of 1998 RMB, respectively. For exiting importers and firms that never import, adding a new source increases revenues by about 2.5 million and 3.6 million RMB, respectively. I also find that the fixed cost of importing is between 0.5 and 1.8 million RMB for each market, meaning that firms pay between 10% and 40% of the average marginal revenue gain–i.e., the increase in revenues by importing from a source. Finally, a new importer pays between 1 and 3.2 million RMB for both fixed and sunk entry costs when importing from a new market, which accounts for 20% to 70% of the average marginal revenue.

The coexistence of cross-country interdependence and path dependence implies that temporary trade policy changes can have long-lasting effects on both the targeted and non-targeted markets. Section IV.D illustrates this point by providing back-of-the-envelope calculations for the effects of a U.S.-China trade war that prevents Chinese firms from importing from the United States for one period. I estimate that at least 11.9% of Chinese firms that import from the United States would exit this market and at least 7% of those firms would drop an additional market even after the trade war ends.[3] By contrast, a model without cross-country interdependence would not generate third-market effects, whereas a model without path dependence would overlook the dynamic costs of the trade war.

My paper is related to several strands of literature. First, I build on the existing framework in the import literature, which emphasizes the interdependence across inputs and markets in static settings. For example, Halpern, Koren and Szeidl (2015) and Goldberg et al. (2010) build on an Armington-style model, in which inputs are complementary in production. AFT provide micro-foundations for the interdependence by allowing for countries' technology levels to affect the input prices, and thus firms' choice of import sources and marginal costs. A few exceptions include Lu, Mariscal and Mejia (2016), Ramanarayanan (2017), and Imura (2019), who develop dynamic models of importing with sunk entry costs and find that these costs can be substantial and critical to explaining the slow adjustments of trade flows. Nonetheless, the existing papers on importer dynamics overlook the interdependence across input sources. To my knowledge, this paper is the first to combine both the cross-country interdependence and history dependence in a model of

[3]There is a subtle difference between my model and supply chain frameworks in which trade policy changes imposed on goods in one stage might influence trade at other stages of the value chains (Blanchard, Bown and Johnson, 2016; Erbahar and Zi, 2017; Bown et al., 2020). In my baseline model, the effect takes place across producers at the same stage of production. Nevertheless, Section V provides an extension of the baseline model that accounts for linkages across countries and along the supply chains by allowing firms to import intermediate goods and export final goods.

importing.

Related papers from the literature on export dynamics have found strong support for the presence of sunk entry costs, which in combination with future profit uncertainty introduces an option value in the decision to enter or exit the export market. Early theoretical work by Baldwin (1988), Baldwin and Krugman (1989), Dixit (1989*a*), and Dixit (1989*b*) emphasizes the importance of sunk costs to explain firm-level decisions to participate in export markets. Empirical evidence of exporting sunk costs was initially provided by Roberts and Tybout (1997) in the context of Colombia and Bernard and Jensen (2004) for US manufacturing plants. More recently, Das, Roberts and Tybout (2007) structurally estimate the sunk export costs and find them to be substantial. Nonetheless, most papers in this literature impose independence across export destinations under a constant marginal cost assumption, whereas import decisions are interdependent across markets.

Furthermore, the paper is related to a small but growing number of papers that employ moment inequalities in international trade, including Dickstein and Morales (2018), MSZ, Bombardini, Li and Trebbi (2020), and Ciliberto and Jäkel (2021). The closest to this work is MSZ, in which the authors estimate the effects of extended gravity–i.e., the size of the sunk cost reductions when firms export to destinations with characteristics similar to their previous destinations. Building on MSZ, this paper utilizes Euler perturbations from the observed sourcing decisions to estimate the bounds of the costs of importing. The difference between the two papers is that in MSZ, the interdependence is placed on the sunk costs, which affects only the extensive margin, whereas the interdependence in this setting affects both the intensive and extensive margins. As a result, deviations from a firm's observed path would change both its static and dynamic profits. Indeed, this framework can accommodate both static interdependence and dynamic dependence in the marginal costs. In Section V.A, I provide an example that allows for dynamic productivity gains from importing, which creates a new dynamic linkage in addition to the sunk costs.

Finally, to my knowledge this paper is the first to allow for complementarity between multiple trade margins in a multi-country dynamic trade model. While canonical trade models often focus on one trade margin, strong evidence shows that firms have been increasingly engaged in the global markets through many channels (Bernard et al., 2018). The interaction of these decisions implies that researchers need to be able to study the breadth and richness of the global firm's decisions. Allowing for a multi-country setting with multiple trade margins, nevertheless, gives rise to a complex combinatorial problem, which cannot be addressed with most conventional estimation methods. The partial identification approach in this paper allows for both model complexity and flexible assumptions on the firm's optimization behavior. In Section V.B, I show how this method can be extended to account for multiple trade margins while preserving the range of feasible spatial choices.

The rest of the paper is organized as follows. Section I provides a description of the data sources and several data patterns. Section II presents a model that is consistent with the data patterns. Section III discusses the identifying assumptions. Section IV details the estimation procedures and results. Section V presents two extensions of the baseline model. Section VI concludes.

I. Data and Stylized Facts

A. Description of the Data Sources

To explore the firm's import decisions across global markets and over time, I construct a rich data set that contains detailed firm-level characteristics and trade flows. My sample combines several sources. The information on firm-level trade flows was collected by the General Administration of Customs. The data report the activities of the universe of Chinese firms participating in international trade between 2000 and 2006. They consist of transaction-level information, including trade volumes, partner countries, and free on board values in U.S. dollars. The second crucial data source for my project is National Bureau of Statistics of China (NBS), which conducts annual surveys that cover the population of registered firms with sales greater than 5 million RMB. The data report detailed firm-level information on total sales, export values, intermediate costs, and wages. Other sources include the Centre d'Etudes Prospectives et d'Informations (CEPII) for distance and country characteristics to construct standard gravity variables, Penn World Tables for international exchange rates and capital stocks, World Development Indicators for educational attainment and R&D spending at the national level, the International Labor Organization (ILO) for manufacturing wages, and Barro and Lee (2013) for educational attainment.[4]

A key step in the data construction is to match the customs data with the NBS annual surveys. Because the two data sets do not have a common firm identifier, I follow the procedure in Feng, Li and Swenson (2016) to match the customs data with the firm surveys using firm names, zip codes, and telephone numbers. About 60% of firms in the customs data can be matched with the NBS firm surveys. Data are then aggregated at the firm-country-year level. Monetary values are converted to RMB 1998 using input and output deflators from Brandt, Van Biesebroeck and Zhang (2012).

Importers are defined as firms that imported at least once from 2000 to 2006 and non-importers are defined as those that did not import during any of those years. Because there is not a perfect

[4] See Appendix for a detailed description of variable construction.

match between the customs data and the manufacturing survey, a fraction of importers would be mis-classified as non-importers because they cannot be identified in the customs data.[5] As a result, I restrict my estimation to importers only to prevent biased estimates that come from misclassification of firms, but acknowledge that importers and non-importers may be inherently different and excluding the latter will potentially lead to selection bias.[6] Nevertheless, because the paper focuses on the firm's sourcing decisions and the evolution of these decisions over time, including firms that never import may not add much further information. Furthermore, a proportion of the firms did not start importing until the latter sample years, and exploiting the years when they did not import gives us some information on non-importers' behavior.[7]

Intermediary firms are excluded from the sample, as these firms do not face the same production decisions as the typical manufacturing firms. Following Ahn, Khandelwal and Wei (2011), I identify intermediary firms by searching for Chinese characters in each firm's name that mean "trading", "exporter", or "importer". I also exclude firms that do not report domestic sales or total input costs and focus on ordinary trade.[8]

Because different industries have different production technologies and utilize different input mixes, which might affect firm-level sourcing decisions, the empirical analysis in this paper is restricted to one industry–i.e., the chemicals industry.[9] Chemicals is an important industry to study for a few reasons. In 2007, China became the world's second largest chemicals manufacturer, just behind the United States and ahead of Japan and Germany (Griesar, 2009). In 2017, China's chemical industry accounted for \$1.5 trillion of sales, equivalent to 40% of the global chemical-industry revenue. Furthermore, the industry also provides critical inputs to pharmaceutical and plastic industries, especially in the United States. The chemicals industry accounts for \$10.8 billion of US exports and \$15.4 billion of Chinese exports that are subject to increased tariffs during the current U.S.-China trade war.

The final data set comprises 1,537 unique importers from 2000 to 2006 that imported from the 40 most popular import sources in terms of number of importers. Restricting attention to the top 40 countries ensures sufficient observations per market. Nevertheless, the main results remain the same when I include all 96 import markets that appear in the customs data.

[5]Another reason for why not all importers can be identified in the NBS data is the latter only surveys above-scale firms, and as a result excludes many small importers.

[6]The NBS data does not contain information about firms' import status and thus it is impossible to identify unmatched importers and non-importers in the firm-level surveys.

[7]See Appendix for the number of importers and share of total importers for each year between 2000 and 2006.

[8]For a detailed discussion on sample selection, see Section C.C3.

[9]Chemicals producers are defined based on both the customs data and the firm surveys. I include firms whose chemicals exports account for at least 50% of their total exports and firms that reported to be in the chemical feedstock and chemical manufacturing industry (China Industry Classification code 26).

From 2000 to 2006, China's economy experienced significant growth. The total domestic sales for the chemicals sample grew by 400% from 840 to 4,239 billion RMB, total import values grew from 10 billion to 60 billion, and the number of importers more than doubled between the first and last years of the sample period. This implies that static models under the assumption of a stable aggregate environment might not be suitable to apply to the context of China during this period. Furthermore, the fast growth rate guarantees high turn-over rates and large variation in terms of exit and entry rates to study the dynamics of firms' importing behaviors.[10]

In the next section, I document a number of facts about the importing behavior of Chinese chemical producers during the sample period.

B. Stylized Facts

Stylized fact 1: *There is persistence in firm-level import decisions. Firms are more likely to import from a country if they have imported from the same country in the past, even after accounting for different combinations of firm-country, country, and year fixed effects.*

I present the evidence for the persistence in import status at country level in Table 1. Columns 1 and 2 report transition probabilities in year t for source country j given that firm does not import from country j in year $t-1$. Columns 3 and 4 report the transition probabilities when firms import from country j in the previous year. The probabilities in column 1 are overwhelmingly higher than those in column 2. This pattern implies once a firm chooses not to import from a certain market, it is highly unlikely to enter in the following year. By contrast, once a firm enters an import market, it is more likely to keep importing from that market in the following year. The pattern is consistent across all sample years. The persistence in firm-country level import status implies that there may be country-specific sunk costs of importing.[11]

The persistence we observe in the data, nevertheless, may be caused by persistence in country, or firm-country-specific components.[12] If these characteristics induce a firm to self-select into certain markets but chooses not to enter others, then as long as these characteristics stay constant over time this firm will continue to import from the same set of countries. If this is the case, we might misattribute the path dependence exhibited in the data to sunk costs of importing. To investigate these possibilities, in Table 2 I run a dynamic linear probability model of a firm's current entry

[10]Descriptive statistics are provided in Appendix B.B2.

[11]See Figure B1 for the transition rates for each import source.

[12]Country-specific characteristics such as technology level and labor wages can influence a firm's import decision. Lincoln and McCallum (2018) document that in addition to the entry costs, the development of the internet, trade agreements, and foreign income growth affect the extensive margin of US firms. Furthermore, given the same country characteristics, some firms may be a better match than others due to firm-country-specific factors such as origins of immigrant labor. The persistence in these characteristics can generate the persistence in the firm's import behaviors.

Table 1—: Country-Specific Transition Rates

Status in year $t-1$	No imports		Imports	
Status in year t	No imports	Imports	No imports	Imports
2000–2001	99.62	0.38	34.99	65.01
2001–2002	99.53	0.47	37.27	62.73
2002–2003	99.43	0.57	36.64	63.36
2003–2004	99.38	0.62	38.85	61.15
2004–2005	99.43	0.57	39.79	60.21
2005–2006	99.41	0.59	36.86	63.14
Average	99.47	0.53	37.66	62.34

Note: This table summarizes the transition rates into and out of the average import source. Each column describes the transition from the importing status in a country year $t-1$ to the status in the same country in year t. For example, the last column shows the share of firm-country pairs that have positive import values in year t, among the pairs that also have positive import values in the previous year. The first row shows the transition rates between 2000 and 2001, and the second row shows these rates between 2001 and 2002, and so on. The last row presents the average year-to-year transition rates during the sample period.
Source: General Administration of Customs.

decision in each import market on past entry, while accounting for firm-country fixed effects and country dummies.[13] The inclusion of these fixed effects ensures that the effect of past entry on current entry does not come from time-invariant factors that also affect the firm's import decision. In column 3, I include a set of year dummies to control for macroeconometric trends that might influence the likelihood of importing in a particular year. Yet, this variable may pick up the effect that comes from time-varying characteristics that are correlated with a firm's import history (e.g.: firm's past productivity affects both its past import decision and its current productivity), which leads to omitted variable bias. In column 4, I include domestic sales to proxy for productivity growth that is due to the firm's past import decisions.[14]

Regardless of the specification, the coefficient on past import status remains positive and significant, implying that the persistence in importing cannot be entirely explained by the time-invariant factors or larger economic trends. The estimates range between 0.21 and 0.52, meaning that if a firm imported from country j in the previous period, it is at least 21 percentage points more likely to continue importing from country j. There is a big decrease in the effect of past import status when including firm-country-specific fixed effects. This decline implies that firm-country-specific components might be important in explaining the persistence in firms' importing decisions. In the theoretical framework developed in Section II, I allow for firm-country-specific components that can account for the pattern observed here.

Finally, firms may only pay a one-time global sunk cost regardless of the number of countries from which they import and the country-specific past entry variable may simply pick up the effect

[13]Columns 2 to 5 account for firm-country unobserved heterogeneity using the Arellano-Bond (1991) GMM estimator. Results using OLS estimation and under a modified random effects probit model proposed by Wooldridge (2005) are qualitatively similar.
[14]Section V.A provides an extension of the model that accounts for productivity gain of importing.

of previously entering the import market. For this reason, in the last column of Table 2, I include an additional dummy that takes the value of unity if the firm imported from any country in the previous year. I find that the estimated coefficient on this variable is negligible, albeit statistically significant, whereas the effect of importing from country j in year $t-1$ on importing from j in year t is largely unchanged. This suggests that its magnitude might be small compared with country-specific sunk costs.[15] Hence, I focus on the country-specific sunk costs in the main analysis of the paper.

Table 2—: Persistence in Import Status

	(1)	(2)	(3)	(4)	(5)
Import from country j	0.52	0.34	0.34	0.21	0.21
in year $t-1$	(0.005)	(0.01)	(0.01)	(0.02)	(0.02)
Import in year $t-1$					0.01
					(0.005)
Observations	1934730	1612275	1612275	426018	426018
Country Dummies	Yes	Yes	Yes	Yes	Yes
Firm-Country FE		Yes	Yes	Yes	Yes
Year Dummies			Yes	Yes	Yes
Domestic sales				Yes	Yes

Note: This table reports results on regressing current import status on past import status at the firm-country level. Columns 2 to 5 account for firm-country unobserved heterogeneity using the Arellano-Bond (1991) GMM estimator. In the last column, both country-specific and global import status terms are treated as endogenous variables. Results using OLS estimation and under a modified random effects probit model proposed by Wooldridge (2005) are qualitatively similar. Columns 4 and 5 include domestic sales, thus restricting the sample to firms that appear in both the customs and the NBS data.
Source: General Administration of Customs and National Bureau of Statistics of China

Stylized fact 2: *The average importer sources from multiple countries. The set of countries from which a firm sources cannot be explained by random entry.*

On average, a firm imports from one to two countries per year and firms that import in at least two consecutive years import from more than three countries. Table 3 reports the ranking of the top 10 countries by number of importers in 2000 and 2006. Surprisingly, the ranking is stable across years, with the most five common import sources being Japan, United States, Germany, South Korea, and Taiwan in both 2000 and 2006. This pattern is not particular to chemicals producers. Indeed, the ranking constructed from the universe of Chinese importers also shows similar stability over time, despite China's WTO accession at the end of 2001.[16]

In Table 4, I follow Eaton, Kortum and Kramarz (2011) to examine firms importing from different sets of sources. I compute the probability of entry that follows a hierarchy in the sense that firms that import from the $k+1$st most popular source also import from the kst popular source. Columns

[15] Moxnes (2010) and McCallum (2015) find that country-specific sunk costs of exporting are much larger than global sunk cost. Mix (2020) shows that country-specific fixed costs are important in explaining variation in export churning across destinations.
[16] Country rankings using all industries are reported in Table B1.

Table 3—: Top 10 Source Countries by Number of Importers

2000			2006		
Country	**Rank**	**No. of firms**	**Country**	**Rank**	**No. of firms**
Japan	1	128	Japan	1	302
United States	2	113	United States	2	234
Germany	3	89	Germany	3	209
South Korea	4	72	South Korea	4	187
Taiwan	5	67	Taiwan	5	160
Singapore	6	37	Singapore	6	88
France	7	36	India	7	73
United Kingdom	8	32	United Kingdom	8	72
Italy	9	26	Netherlands	9	64
Belgium	10	26	Italy	10	62

Note: This table presents the top 10 source countries based on the number of unique importers in 2000 and 2006. Country rank for all industries are reported in Table B1.
Source: General Administration of Customs.

1 and 3 report the share of firms that import from each set of countries as observed in the data, whereas columns 2 and 4 predict these entry probabilities if firms enter import markets randomly based on the patterns in Table 3. As in Eaton, Kortum and Kramarz (2011) and AFT, under the assumption that a firm's decisions to import from different countries are independent (i.e., random entry), the fraction of firms that follow a pecking order is much lower than what is presented in the data. This pattern implies certain countries or combinations of countries have characteristics that make them more attractive to Chinese firms compared with others.

II. Model

To explain the empirical patterns documented in Section I, I propose a model in which sourcing locations affect firm-level marginal costs. This feature generates interdependence across countries in the spirit of AFT. I further impose that firms have to pay sunk entry costs for each country that they start sourcing from to explain the persistence in firm-country level import status.

A. *Setup*

There are J countries (including home) with standard symmetric constant elasticity of substitution (CES) preferences and two markets: intermediate and final goods. The intermediate goods market is perfectly competitive and firms make zero profit by selling intermediate goods. The final goods market, however, is characterized by monopolistic competition. All final goods producers active in time t are indexed by $i = 1, ..., N_t$. Time is discrete and indexed by t. I focus on the final goods producers located in the home market (i.e., China). The exit and entry of firms in the domestic market is treated as endogenous. The labor wage in the manufacturing sector is pinned

Table 4—: Share of Chinese chemicals firms importing from strings of top 10 countries

	2000		2006	
	Data	**Random entry**	**Data**	**Random entry**
1	13.83	4.92	13.85	4.76
1-2	2.37	3.97	2.84	3.38
1-2-3	1.19	2.15	1.42	2
1-2-3-4	0.40	.86	1.07	.99
1-2-3-4-5	1.98	.31	1.78	.39
1-2-3-4-5-6	0.40	.05	1.07	.07
1-2-3-4-5-6-7	0.40	.01	0.18	.01
1-2-3-4-5-6-7-8	0	0	0.18	0
1-2-3-4-5-6-7-8-9	0	0	0	0
1-2-3-4-5-6-7-8-9-10	0	0	0.71	0
% following pecking order	20.55	12.26	23.09	11.62

Note: This table presents the shares of firms in a given year that follow a pecking order observed in the data versus predicted by a random entry model. Countries are indexed by their ranks reported in Table 3. The first row shows the share of firms that import from the top source country (i.e., Japan). The second row shows the share of firms that import only from the top two countries (i.e., Japan and the United States) in a given year. The random entry predictions are based on the assumption that the unconditional probability of importing from country j is the same as the probability of importing from country j conditional on a firm's import decisions in other countries.
Source: General Administration of Customs.

down by the non-manufacturing sector and is normalized to one.

A firm's optimization problem in each period involves (1) where to source intermediate goods, or its sourcing strategy, (2) how much to source from each market, and (3) how much to charge for each unit of final goods. Throughout the paper, I denote b as the generic set of import sources, $\mathcal{J}$ as the optimal set, and o as the observed set.

Demand

Individuals in country j value the consumption of differentiated varieties of manufactured goods according to a standard symmetric CES aggregator

$$U_{jt} = \left(\int_{\psi \in \Psi_{jt}} q_{jt}(\psi)^{\sigma/(\sigma-1)} d\psi \right)^{\sigma/(\sigma-1)}, \sigma > 1, \tag{1}$$

where Ψ_{jt} is the set of varieties available to consumers in country j in year t, and σ is the elasticity of substitution between varieties. These preferences give rise to the following demand for variety ψ

$$q_{jt}(\psi) = p_{jt}(\psi)^{-\sigma} P_{jt}^{\sigma-1} Y_{jt} \tag{2}$$

where $p_{jt}(\psi)$ is the price of variety ψ, P_{jt} is the standard price index, and Y_{jt} is the aggregate expenditure in country j.

Technology and Market Structure

There exists a measure N_t of final goods producers in year t, and each produces a single differentiated variety. The final goods market is monopolistically competitive, and I assume that the final goods varieties are non-traded.[17]

Production of final goods requires the assembly of a bundle of intermediates, which contains a continuum of measure one of firm-specific inputs. These inputs are imperfect substitutes for each other, with a constant and symmetric elasticity of substitution of ρ. All intermediates are produced with labor under constant return-to-scale technologies. Let $a_{ikt}(v)$ denote the unit labor required to produce firm i's intermediate v in country k in year t. Also let τ^m_{ikt} be the iceberg trade cost firm i pays to offshore in k, while w_{kt} is the labor wage in country k in year t. Because the intermediate goods market is perfectly competitive, a firm will buy from the lowest-price producer for each input v. The price of input v paid by firm i in year t is $z_{it}(v; \mathcal{J}^m_{it}) = \min_{k \in \mathcal{J}^m_{it}} \{\tau^m_{ikt} a_{ikt}(v) w_{kt}\}$ where $\mathcal{J}^m_{it}$ denotes the set of source countries from which firm i imports in year t.

Let φ_{it} denote firm i's productivity in year t. The marginal cost of firm i to produce a final goods variety is

$$c_{it} = \frac{1}{\varphi_{it}} \left(\int_0^1 z_{it}(v; \mathcal{J}^m_{it})^{1-\rho} dv \right)^{1/(1-\rho)} \tag{3}$$

As in Eaton and Kortum (2002), the value of $1/a_{ikt}(v)$ is drawn from a Frechet distribution: $Prob(a_{ikt}(v) \geq a) = e^{-T_k a^\theta}$ with $T_k > 0$. These draws are independent across locations and inputs. T_k governs the state of technology in country k, while θ determines the variability of productivity draws across inputs. Lower θ generating greater comparative advantage within the range of intermediates across countries.

As discussed in Section I, persistence in firm-country-specific characteristics can be important for explaining path dependence in firm-level importing behavior. Here I allow for two sources of heterogeneity at the firm-country level in input prices: variable trade costs τ^m_{ijt} and unit labor required to produce an input variety a_{ijt}. It is possible to impose that either or both components are time invariant. For example, we can assume variable trade costs are constant over time, or that firms get one permanent productivity draw for each input variety in each market. I remain agnostic about the source of heterogeneity. However, each assumption has different implications in equilibrium. Whereas variable trade costs are common across input varieties within each market-

[17] In Section V, I provide an extension of the baseline model in which final goods are also traded. final goods producers determine the set of countries to purchase inputs and at the same time choose the set of destinations to export outputs. The inclusion of export platforms provides an additional channel for the interdependence across markets.

year pair, input production efficiency determines the price of each input variety and thus from which market the firm would purchase an input variety. Nonetheless, only the distribution of a_{ijt} matters for aggregate imports, as shown in the next section.

B. Firm Behavior Conditional on Sourcing Strategy

In this section, I describe the firm's decision once it has chosen the sourcing strategy, $\mathcal{J}_{it}^m$. Under the Frechet distribution, the share of intermediate input purchases sourced from any country j (including the home country) is

$$X_{ijt} = \frac{S_{ijt}}{\Theta_{it}} \tag{4}$$

where $S_{ijt} \equiv T_j(\tau_{ijt}^m w_{jt})^{-\theta}$ captures the country j's sourcing potential in year t. The term $\Theta_{it}(\mathcal{J}_{it}^m) \equiv \sum_{k \in \mathcal{J}_{it}^m} S_{ikt}$ captures the sourcing capacity of firm i in year t. The marginal cost given the firm's sourcing strategy can be rewritten as

$$c_{it}(\mathcal{J}_{it}^m) = \frac{1}{\varphi_{it}} \Big(\gamma \Theta_{it}(\mathcal{J}_{it}^m) \Big)^{-1/\theta} \tag{5}$$

where $\gamma = [\Gamma(\frac{\theta+1-\rho}{\theta})]^{\theta/(1-\rho)}$ and Γ is the gamma function.

The final goods market is monopolistically competitive, and thus, from the demand equation 2 the firm's optimal pricing rule is $p_{it} = \sigma/(\sigma-1)c_{it}$, and the revenue of firm i in its home market in year t is given by

$$r_{iht} \equiv p_{it}q_{it} = \left[\frac{\sigma}{\sigma-1} \frac{c_{it}}{P_{ht}} \right]^{1-\sigma} Y_{ht} \tag{6}$$

Plugging equation 5 in to 6, we can rewrite the firm's revenue given its sourcing strategy:

$$r_{iht}(\mathcal{J}_{it}^m) = \left[\frac{\sigma}{\sigma-1} \frac{1}{\varphi_{it} P_{ht}} \right]^{1-\sigma} Y_{ht} [\gamma \Theta_{it}(\mathcal{J}_{it}^m)]^{\frac{\sigma-1}{\theta}} \tag{7}$$

As can be seen from equation 5 and the definition of Θ_{it}, adding one location increases the firm's sourcing capacity and reduces its marginal cost, which will increase the firm's revenues. Furthermore, the marginal revenue of a location depends on the sourcing potential of the incumbent import locations. The direction of this relationship relies on the term $(\sigma-1)/\theta$.

To see this point, let $r_{ijt}^m(\mathcal{J}_{it}^m)$ denote the marginal revenue of country j to firm i at the set $\mathcal{J}_{it}^m$–i.e., the change in total revenue when switching firm i's import status in country j given its sourcing strategy $\mathcal{J}_{it}^m$. Specifically, $r_{ijt}^m(\mathcal{J}_{it}^m) = r_{iht}(\mathcal{J}_{it}^m \cup j) - r_{iht}(\mathcal{J}_{it}^m)$ if $j \notin \mathcal{J}_{it}^m$ and $r_{ijt}^m(\mathcal{J}_{it}^m) = r_{iht}(\mathcal{J}_{it}^m) - r_{iht}(\mathcal{J}_{it}^m \setminus j)$ if $i \in \mathcal{J}_{it}^m$. With a few derivations, we can express the marginal revenue at the optimal set $\mathcal{J}_{it}^m$ as[18]

$$r_{ijt}^m(\mathcal{J}_{it}^m) = \begin{cases} \left[\left((\Theta_{it}(\mathcal{J}_{it}^m) + S_{ijt})/\Theta_{it}(\mathcal{J}_{it}^m)\right)^{\frac{\sigma-1}{\theta}} - 1\right] r_{iht}(\mathcal{J}_{it}^m) & \text{if } j \notin \mathcal{J}_{it}^m \\ \left[1 - \left((\Theta_{it}(\mathcal{J}_{it}^m) - S_{ijt})/\Theta_{it}(\mathcal{J}_{it}^m)\right)^{\frac{\sigma-1}{\theta}}\right] r_{iht}(\mathcal{J}_{it}^m) & \text{if } j \in \mathcal{J}_{it}^m \end{cases} \tag{8}$$

The marginal revenue $r_{ijt}^m(\mathcal{J}_{it}^m)$ contains two terms. The first term in the square bracket captures the rate of change in marginal cost when we deviate from the set $\mathcal{J}_{it}^m$. The second term is simply the total revenue of the firm at the set $\mathcal{J}_{it}^m$, or $r_{iht}(\mathcal{J}_{it}^m)$. While the rate of change in marginal cost is decreasing in the sourcing capacity $\Theta_{it}(\mathcal{J}_{it}^m)$, the total revenue is increasing in $\Theta_{it}(\mathcal{J}_{it}^m)$. The relative magnitudes of these two forces depend on the size of $(\sigma - 1)/\theta$. Specifically, $r_{ijt}^m(\mathcal{J}_{it}^m)$ is increasing in the term $\Theta_{it}(\mathcal{J}_{it}^m)$ if $(\sigma - 1)/\theta > 1$ and decreasing in $\Theta_{it}(\mathcal{J}_{it}^m)$ when $(\sigma - 1)/\theta < 1$. When $(\sigma - 1)/\theta > 1$, the demand is relatively responsive to price reductions and technology is relatively dispersed across markets, making sourcing from an additional market more beneficial–markets are complementary. When $(\sigma - 1)/\theta < 1$–i.e., demand is inelastic and technology is similar among input sources–the marginal value of a market decreases with the number of countries or the sourcing potential of other countries from which a firm imports. In the knife-edge case when $(\sigma - 1)/\theta = 1$, the marginal revenue of a country is unaffected by the sourcing potential of other countries and $\mathcal{J}_{it}^m$–i.e., markets are independent.

Interestingly, in the case when $(\sigma - 1)/\theta > 1$, the marginal revenue of adding a new source country is larger than the marginal revenue of keeping a country from which firm already imports. In other words, all else being equal, if $j \in o_{it}^m$, $j' \notin o_{it}^m$, and $S_{ijt} = S_{ij't}$, then $|r_{ijt}^m(o_{it})| < |r_{ij't}^m(o_{it})|$. By contrast, when countries are substitutes, $|r_{ijt}^m(o_{it})| > |r_{ij't}^m(o_{it})|$. Keeping an existing source has bigger revenue gain than adding a country with the same sourcing potential.

Finally, for every period for which the firm imports from country j it has to pay a fixed cost, denoted by f_{ijt}. If the firm has not imported from market j in year $t-1$, it has to pay an additional sunk cost s_{ijt}.[19] Furthermore, I assume that the fixed and sunk costs have the following structure: $f_{ijt} = f_{ijt}^o + \epsilon_{ijt}^f$ where $E(\epsilon_{ijt}^f|\Omega_{it}, d_{ijt}) = 0$ and $s_{ijt} = s_{ijt}^o + \epsilon_{ijt}^s$ where $E(\epsilon_{ijt}^s|\Omega_{it}, d_{ijt}) = 0$. f_{ijt}^o and s_{ijt}^o are the observable part of the fixed and sunk costs.[20]

[18] See details in Appendix E.

[19] I assume the sunk cost advantage fully depreciates after one year. This assumption is standard in the literature of firm dynamics. However, the framework presented here can be extended to account for longer history dependence.

[20] There is no restriction on the costs of domestic versus foreign sourcing in the model. However, in the empirical work, as I only use firms that are active and source inputs, I will impose that there are no fixed or sunk costs of domestic sourcing–i.e.

Conditional on the firm's import history, b_{it-1}, the static firm-level profit after importing from a set b_{it} sources in year t is

$$\pi_{it}(b_{it}, b_{it-1}) = \sigma^{-1} r_{iht}(b_{it}) - f_{it}(b_{it}) - s_{it}(b_{it}, b_{it-1}) \tag{9}$$

where $\sigma^{-1} r_{iht}(b_{it})$ is the firm's operating profits. The term $f_{it}(b_{it}) = \sum_{j \in b_{it}} f_{ijt}$ is the sum of fixed cost firm i pays in year t and $s_{it} = \sum_{\substack{j \in b_{it} \\ j \notin b_{it-1}}} s_{ijt}$ is the sum of sunk cost firm i pays to enter new import markets in year t.[21]

Sourcing from an additional country will increase the firm's sourcing capacity, lower the marginal cost, and hence increase the firm's operating profits. However, the firm has to pay an extra fixed cost for the additional source country. The trade-off between marginal cost saving and fixed cost reductions is the main tension in AFT.

My model departs from their framework by adding sunk costs, which depends on the firm's past import decisions. This simple addition of the sunk costs will indeed complicate the firm's decision, as now the firm avoids paying sunk costs if it continues importing from last year's source countries. The sunk costs also create the differentiation between old sources and new sources. In other words, even in the absence of heterogeneity in fixed costs, firms face different costs of importing from different countries due to the heterogeneity in their import history.

As discussed in Section I, the presence of sunk costs allows us to explain the persistence in import behavior and exploits the differences in the firm's history to account for the heterogeneity in the firm's import strategies. In the next section, I describe the firm's dynamic problem.

C. *Optimal Sourcing Strategy*

For each t, firm i chooses a set of import sources, $b_{it} \in B_{it}$, that maximizes its discounted expected profit stream over a planning horizon L_{it}

$$E[\sum_{\tau=t}^{t+L_{it}} \delta^{\tau-t} \pi_{i\tau}(b_{i\tau}, b_{i\tau-1}) | b_{it}, \Omega_{it}] \tag{10}$$

where B_{it} is the set of all import sources that firm i considers in year t, and Ω_{it} denotes the firm's information set, which includes the firm's past import set b_{it-1}. Finally, δ is the discount factor.

$f_{iht} = 0$ and $s_{jht} = 0$.

[21] An implicit argument in the firm's static profit is its productivity, φ_{it}, which influences the firm's revenue. I do not include it because the model focuses on the firm' import history. However, as in the standard Melitz-styled models, in equilibrium there would be a productivity cutoff for firms to enter each market.

Under Bellman's optimality principle, the optimal set of import sources satisfies:

$$V_{it}(\Omega_{it}) = \max_{b} \overline{\pi}_{it}(b, b_{it-1}) + \delta E[V_{it+1}(\Omega_{it+1})|b, \Omega_{it}] \tag{11}$$

where $\overline{\pi}_{it}(.)$ is the expected value of equation 9. The choice-specific value function for set b is $V_{it}(b, \Omega_{it}) = \overline{\pi}(b, b_{it-1}) + \delta E[V_{it+1}(\Omega_{it+1})|b, \Omega_{it}]$. Given this expression, firm i will choose set b over set b' ($b' \neq b$, $b' \in B_{it}$) during period t if $V_{it}(b, \Omega_{it}) \geq V_{it}(b', \Omega_{it})$. Plugging in the expression for the firm's static profits in equation 9, we can rewrite the above condition in terms of differences in current profits, fixed costs, sunk costs, and future profits as follows

$$\underbrace{\sigma^{-1}E[r_{iht}b - r_{iht}(b')|\Omega_{it}]}_{(1)} + \underbrace{\{\delta E[V_{it+1}(\Omega_{it+1})|b, \Omega_{it}] - \delta E[V_{it+1}(\Omega_{it+1})|b', \Omega_{it}]\}}_{(2)}$$
$$\geq \underbrace{E[\sum_{j\in b} f_{ijt} - \sum_{j \in b'} f_{ijt}|\Omega_{it}]}_{(3)} + \underbrace{E[\sum_{\substack{j\in b \\ j\notin b_{it-1}}} s_{ijt} - \sum_{\substack{j\in b' \\ j\notin b_{it-1}}} s_{ijt}|\Omega_{it}]}_{(4)}$$

Four factors determine the solution to the firm's dynamic problem. The firm balances current and expected future profit gains, captured by the first and second terms, with fixed and sunk cost saving, captured by the last two terms. The addition of the country-specific sunk costs adds an inter-temporal link between last year's sourcing strategy and this year's sourcing strategy.

Whether the dynamic problem implies an increase or decrease in the value of sourcing compared with the static problem is unclear. In a static environment, when sourcing from a new market, the firm benefits from marginal cost reductions and thus increased current variable profits, but pays an additional fixed cost. In a dynamic setting, it incurs the additional startup cost of importing from the new market, but at the same time reduces expected future costs. The dynamic solution may differ from a static one, depending on the size of sunk costs, discount factor, and the expected profit gains from adding a new source.

III. Estimation Approach

Estimating the firm's optimization problem described in equation 10 is challenging for two main reasons. First, the interdependence across input sources gives rise to a combinatorial problem as researchers need to evaluate combinations of countries instead of each country separately. For example, keeping the number of countries at 40 requires evaluation of 1.1×10^{12} choices. Because of the enormous choice set, evaluating every potential choice is computationally infeasible. Second, the dynamic features of the model require computing the expected future value of each choice, which adds to the computational burden of the estimation.

Existing studies deal with these challenges in several ways: (1) reduce the choice set of the firm by restricting the set of feasible source countries, (2) impose strict assumptions on the firm's behavior, or (3) archive partial identification. While the first approach is common in the literature, it may not be ideal in the presence of interdependence across countries.[22] The second approach requires strong assumptions on the firm's optimization behavior, which unavoidably reduces the credibility of inference (Manski, 2003). With the exception of MSZ, most entry models in international trade settings have point-identified structural parameters by specifying a planning horizon L_{it}, imposing the exact content of the information set Ω_{it}, ex-ante determining the set of countries that a firm considers every period B_{it}, and imposing strong parametric assumptions on the unobserved components in the profit function.[23]

For these reasons, I pursue a partial identification approach that both maintains a wide range of feasible choices and requires mild assumptions on the firm's behavior.[24] In the next section, I provide an intuition for the identification strategy and key assumptions to identify the fixed and sunk costs of importing and provide formal statements of these assumptions in Appendix A.

A. Revealed Preferences Approach: Intuition

The key identification assumption is based on revealed preferences: A firm's observed import decision in a given year maximizes its expected profit stream, given its information set in the same year. Following MSZ, I create a series of minor deviations from the firm's observed history by applying a discrete analog of Euler's perturbation method. More specifically, I switch the import status for each firm-country-year pair one-by-one while keeping the firm's import decisions in other years and in other markets intact.[25]

Importantly, by revealed preferences any deviation from the observed import decisions would lower the firm's expected profits. Formally, let $\mathcal{J}_{it+l}b$ denote the optimal set in year $t+l$ given that

[22]When we restrict the set of source countries to a small number–e.g., fewer than 10–most firms would be likely to import from outside that set. As a result, restricting data in such manner would lead to a huge loss of information.

[23]Indeed, MSZ show that misspecifications of model elements such as planning horizons, consideration sets, and information set lead to bias in their estimates.

[24]One main disadvantage of this method is its inability to perform counterfactual experiments due to the multiplicity of admissable parameter values and unidentified distribution of the unobservables. However, Li (2019) develops a method to conduct counterfactual analysis under certain assumptions on the unobservables. In a different paper, Christensen and Connault (2019) provide sensitivity tests for counterfactual results around a neighborhood of the unobservables' distribution.

[25]For example, if a firm imports from the United States and Mexico in 2001, I create multiple alternative paths by dropping either the United States or Mexico from the firm's import set in 2001, or by adding another country to its import set in 2001. See Section III.B for more explanation.

it chooses set b in year t. It can be shown that

$$\begin{aligned} &E(\pi_{it}(o_{it}, o_{it-1}) + \delta\pi_{it+1}(\mathcal{J}_{it+1}(o_{it}), o_{it})|\Omega_{it}) \\ &\geq E(\pi_{it}(b, o_{it-1}) + \delta\pi_{it+1}(\mathcal{J}_{it+1}(o_{it})), b)|\Omega_{it}) \end{aligned} \tag{12}$$

See detailed proof in Appendix A. Intuitively, equation 12 states that given the firm's information set in year t, the firm's expected sum of profits in years t and $t+1$ at the observed decision is larger than that in these two years if it would choose b in year t but in the subsequent year act as if it had chosen o_{it} instead. As shown later, equation 12 provides the inequalities that identify the bounds of the fixed and sunk costs.

This method has three main advantages. First, because equation 12 only involves the comparison of static profits in two periods, I can avoid dealing with the firm's dynamic problem, which substantially decreases the computation burden when estimating the fixed and sunk costs. Second, equation 12 holds under flexible assumptions on the firm's planning horizon L_{it} or the firm's consideration set B_{it}.[26] Finally, I can reduce the number of choices to analyze in each period. While the total number of possible choices in each period is 2^J with J markets, it is sufficient to consider only J deviations.[27]

Finally, note that inequality 12 is conditional on the firm's information set, Ω_{it}. To bring this to the data, researchers often need to fully specify the information set and assume full distributions for the unobserved error terms. Furthermore, using conditional moments implies that the number of potential inequalities is generally large. Instead, I use a set of instrumental variables, Z_{it}, to construct unconditional moment inequalities from equation 12. The transformation from conditional to unconditional moments may lead to a loss of information. However, researchers have to make this trade-off between efficiency and computational feasibility.

I further assume that the firm has knowledge about the set of instruments–i.e., $Z_{it} \in \Omega_{it}$. To simplify notation, let

$$\pi_{idt} = [\pi_{it}(o_{it}, o_{it-1}) - \pi_{it}(b, o_{it-1})] + \delta[\pi_{it+l}(\mathcal{J}_{it+l}(o_{it}), \mathcal{J}_{it+l-1}(o_{it})) - \pi_{it+l}(\mathcal{J}_{it+1}(o_{it})), b)]$$

be the difference between the observed profits and the profits under the alternative choice b. Let

[26] The required assumptions are that $L_{it} \geq 1$ and the consideration set B_{it} includes firm i's observed choice and the one-period deviations that are used to identify the bounds for fixed and sunk costs.

[27] Obviously, there are $2^J - 1$ possible deviations, but researchers can determine how many and which set of deviations to analyze. This creates a trade-off between efficiency and computational feasibility. A larger number of deviations gives us tighter bounds, but requires more computing power.

$g_k(.)$ be a non-negative function. From equation 12, it can be shown that

$$E[g_k(Z_{it})\pi_{idt}] \geq 0. \tag{13}$$

The term $g_k(Z_{it})$ serves as the bridge between the conditional and unconditional moments. Except that $g_k(.)$ is required to be non-negative to preserve the sign of the conditional moment inequalities, there are few restrictions on its functional form. Different functions g_k will generate different moments. Because equation 13 relies only on observables and parameters in the profit function, it can be taken directly to the data.

The next section provides examples of instrument variables Z_{it}, the moment function g_k, and deviations that will generate the profit difference π_{idt}.

B. Deriving Moment Inequalities

Consider a simple example illustrated by Table 5 with four countries: A, B, C, and D. The top panel presents a firm's observed import decisions in each country for three consecutive years. In year $t-1$, the firm imports from A and C but not from B and D–i.e., $o_{it-1}^m = (A, C)$. In year t, this firm imports from countries A and B, but not from countries C and D.–i.e. $o_{it}^m = (A, B)$. Thus, the firm's import status in each country in year t is A–continuing importer, B–new importer, C–exiting importer, D–never import.

The bottom panel shows how we can create four alternate paths in year t by switching the firm's import status in each country one-by-one. Its import decisions in years $t-1$ and $t+1$ are unchanged, however. This procedure is repeated for every year that I observe both the firm's past and future import decisions. As shown in the previous section, the difference in the discounted sum of profits generated by the observed and alternative paths depends only on the difference in static profits in years t and $t+1$. In this example, since this firm does not import in year $t+1$, there is no change in the static profit year $t+1$.

Assume $f_{ijt} = \gamma^f + \epsilon_{ijt}^f$ and $s_{ijt} = \gamma^s + \epsilon_{ijt}^s$. Recall that the marginal revenue $r_{ijt}^m(o_{it}^m)$, or the change in firm i's revenue when we deviate from o_{it}^m, is defined as $r_{ijt}^m(o_{it}^m) = r_{iht}(o_{it}^m \cup j) - r_{iht}(o_{it}^m)$ if $j \notin o_{it}^m$ and $r_{ijt}^m(o_{it}^m) = r_{iht}(o_{it}^m) - r_{iht}(o_{it}^m \setminus j)$ if $i \in o_{it}^m$. Thus, the profit difference, π_{idt} under

Table 5—: Examples of One-Period Deviations

Year	**A**	**B**	**C**	**D**
$t-1$	1	0	1	0
t	1	1	0	0
$t+1$	0	0	0	0

(a) Observed import path

	A	**B**	**C**	**D**	Parameters identified
Deviation 1	0	1	0	0	Upper bound of γ^f
Deviation 2	1	0	0	0	Upper bound of $\gamma^f + \gamma^s$
Deviation 3	1	1	1	0	Lower bound of γ^f
Deviation 4	1	1	0	1	Lower bound of $\gamma^f + \gamma^s$

(b) Deviations in year t

Note: Panel a presents the observed import decisions in three consecutive years, $t-1$, t, and $t+1$, for a hypothetical firm in four countries: A, B, C, and D. The number 1 indicates imports and 0 indicates no imports. Panel b illustrates four possible deviations from the observed path in year t. In each deviation, I switch the firm's import status in one country while maintaining its import status in other countries. Panel b also presents the parameters being identified with each deviation.

each alternative path is

$$\text{Deviation 1} : \pi_{idt} = \sigma^{-1} r^m_{ijt}(o^m_{it}) - \gamma^f - \epsilon^f_{ijt}$$
$$\text{Deviation 2} : \pi_{idt} = \sigma^{-1} r^m_{ijt}(o^m_{it}) - \gamma^f - \epsilon^f_{ijt} - \gamma^s - \epsilon^s_{ijt}$$
$$\text{Deviation 3} : \pi_{idt} = -\sigma^{-1} r^m_{ijt}(o^m_{it}) + \gamma^f + \epsilon^f_{ijt}$$
$$\text{Deviation 4} : \pi_{idt} = -\sigma^{-1} r^m_{ijt}(o^m_{it}) + \gamma^f + \epsilon^f_{ijt} + \gamma^s + \epsilon^s_{ijt}$$

Next, to create the moment inequalities in the form of equation 13, I use the following four moment functions g_1 to g_4:

$$g_1(Z_{it}) = 1(d_{ijt} = 1, d_{ijt-1} = 1) \qquad g_2(Z_{it}) = 1(d_{ijt} = 1, d_{ijt-1} = 0)$$
$$g_3(Z_{it}) = 1(d_{ijt} = 0, d_{ijt-1} = 1) \qquad g_4(Z_{it}) = 1(d_{ijt} = 0, d_{ijt-1} = 0)$$

Thus, $g_1(Z_{it}), g_2(Z_{it}), g_3(Z_{it})$, and $g_4(Z_{it})$ are indicator functions that take the value of one if in year t firm i is a continuing importer, new importer, exiting importer, or never imports from country j. When $g_k(Z_{it}) = g_1(Z_{it})$, equation 13 becomes

$$\begin{aligned} E[g_1(Z_{it})\pi_{idt}] &= E[g_1(Z_{it})(\sigma^{-1} r^m_{ijt} - \gamma^f - \epsilon^f_{ijt})] \\ &= E[g_1(Z_{it})(\sigma^{-1} r^m_{ijt} - \gamma^f)] \geq 0 \end{aligned}$$

The second equality holds under the assumption that $E(\epsilon^f_{ijt}|\Omega_{it}, d_{ijt}) = 0$. Rearranging the terms, we can identify the upper bound for γ^f:

$$\gamma^f \leq \frac{E[g_1(Z_{it})(\sigma^{-1} r^m_{ijt})]}{E[g_1(Z_{it})]} \tag{14}$$

By similar logic, when $g_k(Z_{it}) = g_2(Z_{it}) = 1(d_{ijt} = 1, d_{ijt-1} = 0)$, we have

$$\begin{aligned} E[g_2(Z_{it})\pi_{idt}] &= E[g_2(Z_{it})(\sigma^{-1} r^m_{ijt} - \gamma^f - \epsilon^f_{ijt} - \gamma^s - \epsilon^s_{ijt})] \\ &= E[g_2(Z_{it})(\sigma^{-1} r^m_{ijt} - \gamma^f - \gamma^s)] \geq 0 \end{aligned}$$

As before, the second equality is due to $E(\epsilon^f_{ijt}|\Omega_{it}, d_{it}) = 0$ and $E(\epsilon^s_{ijt}|\Omega_{it}, d_{ijt}) = 0$. Arranging the terms, we can write

$$\gamma^f + \gamma^s \leq \frac{E[g_2(Z_{it})(\sigma^{-1} r^m_{ijt})]}{E[g_2(Z_{it})]} \tag{15}$$

This time γ^s appears as firm i does not import from j in year $t-1$ and thus has to pay the sunk entry cost. The previous two examples provide upper bounds for γ^f and γ^s. When $d_{ijt} = 0$, we can create moment inequalities that identify the lower bounds for these parameters. To be more specific,

$$\gamma^f \geq \frac{E[g_3(Z_{it})(-\sigma^{-1} r^m_{ijt})]}{E[g_3(Z_{it})]} \tag{16}$$

when $g_k(Z_{it}) = g_3(Z_{it}) = 1(d_{ijt} = 0, d_{ijt-1} = 1)$ and

$$\gamma^f + \gamma^s \geq \frac{E[g_4(Z_{it})(-\sigma^{-1} r^m_{ijt})]}{E[g_4(Z_{it})]} \tag{17}$$

when $g_k(Z_{it}) = g_4(Z_{it}) = 1(d_{ijt} = 0, d_{ijt-1} = 0)$.

In a nutshell, the bounds for the fixed costs are identified using continuing importers and exiting importers (inequalities 14 and 16) as these firms pay only fixed costs to import. The bounds for both fixed and sunk costs are identified using new importers and non-importers (inequalities 15 and 17) as these firms would have to pay both types of costs in order to import. When adding a country from which the firm does not import (inequalities 16 and 17), we identify the lower bounds of the costs, and when dropping a country from which the firm indeed imports (inequalities 14 and 15), we identify the upper bounds. Notice that a key component in inequalities 14 to 17 is the marginal revenues of importing r^m_{ijt}. In Section IV, I describe how to compute this variable and other unknown quantities used to construct the bounds for fixed and sunk costs of importing.

IV. Estimation Procedure and Results

The estimation procedure consists of two steps. In the first step, I compute $r^m_{ijt}(o^m_{it})$, or the predicted changes in revenues when adding or dropping a sourcing location based on equation 8. In the second step, I estimate the bounds and conduct inference for the fixed and sunk cost parameters.

A. Step 1: Marginal Revenues of Importing

To estimate $r^m_{ijt}(o^m_{it})$, recall that we can express this quantity as

$$r^m_{ijt}(o^m_{it}) = \begin{cases} \left[\left((\sum_{k\in o^m_{it}} S_{ikt} + S_{ijt})/(\sum_{k\in o^m_{it}} S_{ikt})\right)^{\frac{\sigma-1}{\theta}} - 1\right] r_{iht}(o^m_{it}) & \text{if } j \notin o^m_{it} \\ \left[1 - \left((\sum_{k\in o^m_{it}} S_{ikt} - S_{ijt})/(\sum_{k\in o^m_{it}} S_{ikt})\right)^{\frac{\sigma-1}{\theta}}\right] r_{iht}(o^m_{it}) & \text{if } j \in o^m_{it} \end{cases}$$

This quantity depends on (1) total revenues at the observed set, $r_{iht}(o^m_{it})$; (2) elasticity of substitution σ; (3) dispersion of technology θ; and (4) firm-country-year-specific sourcing potential S_{ijt}. In the remainder of the section, I briefly describe how to recover the unobserved components required to compute $r^m_{ijt}(o^m_{it})$.

Elasticity of substitution (σ): With the CES preferences and monopolistic competition, the ratio of sales to variable input purchases (or markup) is $\sigma/(\sigma-1)$. The average mark-up is 33%, which implies that the elasticity of substitution σ is about 4.02. This value is within the range documented in previous studies.[28]

Dispersion of technology (θ) and firm-country-year specific sourcing potential (S_{ijt}): I follow a modified version of the estimation procedure in AFT and rely on variation in the share of imported inputs across firm-country-year pairs. Intuitively, the parameter θ plays the role of trade elasticity and can be captured as the elasticity of firm-country level input shares to labor wages. Next, based on the definition of the firm-country-year-specific sourcing potential–i.e. $S_{ijt} = T_j(\tau^m_{ijt} w_{jt})^{-\theta}$–I use observed information on country-level technology, trade costs, and wages to proxy for the sourcing potential.[29]

Results are summarized in Table 6. The estimate for θ is 1.99 (standard error = 0.49) and the average value of S_{ijt} is 2.68 (standard error = 7.19). With respect to the types of countries from

[28]See, for example, Simonovska and Waugh (2014) and Donaldson (2018).
[29]Details of the estimation are provided in Appendix C.C1.

which firms choose to import, it seems that new import markets tend to have higher sourcing potential (3.10) compared with markets firms already have experience with (2.65), whereas firms exit markets with the lowest sourcing potential (1.43).[30] This result is consistent with the sunk cost hypothesis: New importers justify incurring sunk entry costs by importing from high-technology low-cost suppliers, whereas firms exit high-cost markets despite already incurring the entry costs.

Table 6—: Step 1: Predicted Marginal Revenues of Importing

Elasticity of substitution (σ)	Technology dispersion (θ)
4.02	1.99
(31.53)	(0.49)

(a) Parameter Values

	(1) All	(2) Never	(3) Exiting	(4) New	(5) Continuing
Sourcing potential (S_{ijt})	2.68	2.63	1.44	3.11	2.65
	(7.19)	(6.67)	(3.57)	(10.05)	(7.27)
Marginal revenue (r^m_{ijt})	4.44	3.66	2.47	7.99	6.65
	(20.25)	(16.93)	(6.4)	(36.54)	(20.87)
Total revenue (r_{iht})	239.2	179.6	344.9	387.6	504.9
	(386.4)	(298.4)	(478.3)	(520.1)	(594.5)
Rate of MC saving (r^m_{ijt}/r_{iht})	0.024	0.026	0.011	0.023	0.015
	(0.07)	(0.07)	(0.02)	(0.06)	(0.03)
Observations	42994	31128	615	4612	4312

(b) Variable values

Note: Panel a reports estimates for the key parameters to compute the marginal revenues (r^m_{ijt}). Panel b reports the values of marginal revenues and other variables for all firms (column 1) and for different types of importers (columns 2 to 5) based on the firm's import status in each country for a given year. The last two rows of Panel b break down the marginal revenues into two components: the observed total revenues and the estimated rates of change in marginal costs. Monetary values are in millions of 1998 RMB. Sample includes the top 40 popular source countries. Standard errors in parentheses.
Source: General Administration of Customs and National Bureau of Statistics of China

At this point, I have computed all components to predict the marginal revenues $r^m_{ijt}(o^m_{it})$, which captures the change in total revenues for each deviation from the observed import path. On average, when a firm drops or adds a country to its import set, its total revenue changes by 4.44 million RMB. This quantity varies across a firm's import histories in a source country. For example, dropping a new source country reduces the firm's revenues by 7.9 million RMB and dropping a source country that the firm has previous experience with reduces its revenues by 6.6 million RMB. For exiting importers and firms that never import, adding a new source increases revenues by about 2.5 and 3.6 million RMB.

Next, I break down the marginal revenues into two components: the observed total revenues and

[30] Recall that sourcing potential is a combination of technology, trade costs, and wages, and loosely captures the marginal cost saving contribution. Higher sourcing potential reflects lower cost.

the rates of marginal cost saving. The rate of marginal cost saving is similar for new importers and those that never import: Each market saves about 2.3% to 2.6% of total revenues. For exiting and continuing importers, the rate of marginal cost saving is about 1.1% to 1.5%. Regardless, the absolute revenue gain is highest for a new importer: Adding a new source increases revenue by 8 mil RMB, followed by a continued source with 6.6 mil RMB. For exiting importers and firms that never import, adding a new source increases revenue by about 2.5 and 3.6 mil RMB, respectively. Here we see the interaction between the scale and substitution effects: continuing importers already have high sourcing capacity (i.e., they already import from low-cost suppliers) and thus have a lower rate of marginal cost saving (substitution effect). However, their large scale of operation leads to a large absolute gain from each individual import source (scale effect). By contrast, new importers tend to be smaller in size but the marginal cost saving is large, resulting in large absolute revenue gains.

B. *Step 2: Fixed and Sunk Costs*

To estimate the bounds for the fixed and sunk costs, I first assume that these terms have following functional forms: $f_{ijt} = \gamma_o^f + \gamma^f \cdot X_j + \epsilon_{ijt}^f$ and $s_{ijt} = \gamma_o^s + \gamma^s \cdot X_j + \epsilon_{ijt}^s$, where X_j is a vector of country characteristics. Let $\gamma = (\gamma_o^f, \gamma^f, \gamma_o^s, \gamma^s)$ collect the fixed and sunk cost parameters. As the bounds for each element in γ become larger with the dimension of γ, I choose a parsimonious specification for the fixed and sunk costs. Specifically, to capture distance between China and country j, I use a dummy variable, $Border_j$, that equals 1 if the two countries do not share a border. I also include the binary variable $Language_j$ where $Language_j = 1$ if China and country j do not share the same language.

By construction, a continuing importer incurs only the fixed cost f_{ijt} and a new importer pays both the fixed and sunk costs, $f_{ijt} + s_{ijt}$. For the estimation, I will report the cost to a continuing importer and the cost to a new importer. Define $\tilde{\gamma}^s = \gamma^f + \gamma^s$. The vector of parameters is $\gamma = (\gamma_o^f, \gamma^f, \tilde{\gamma}_o^s, \tilde{\gamma}^s)$

I compute the 95% confidence set for γ using the general moment selection method developed by Andrews and Soares (2010). Specifically, I employ the modified method of moment test statistics: $Q_n(\gamma) = \sum_{k=1}^{K} [\bar{m}_k(\gamma)/\hat{\sigma}_k(\gamma)]_-^2$ where $[x]_- = \min\{0, x\}$ and $\bar{m}_k(\gamma) \equiv \frac{1}{N} \sum_{i \in N_i} \sum_{j \in J} \sum_{t \in T} g_k(Z_{it})\pi_{idt}$ is the sample analog of the moment inequalities defined in Section III, and $\hat{\sigma}_k(\gamma)$ is the standard deviation of the observations entering moment k.

Table 7 reports the 95% confidence sets for linear combinations of the fixed and sunk cost parameters under three specifications. In the first one, I include a constant term for both the fixed and sunk costs. Note that this specification does not imply that fixed and sunk costs are homogeneous across firm-country-year triplets, as I allow for the unobserved components of fixed and sunk costs, ϵ_{ijt}^{f} and ϵ_{ijt}^{s}, to be different from zero and heterogenous across firm-year-country triplets. In the next two specifications, I include the country characteristics to proxy for distance and common language.

Table 7 shows that if a firm has import experience in country j, it pays a fixed cost of 0.48 million to 1.80 million RMB to continue importing from the same location, equivalent of 10.8% to 40.5% of average marginal revenue. For a new importer, the total fixed and sunk costs ranges from 0.96 to 3.12 mil RMB, or 21.6% to 71.6% of average marginal revenue. This amount is consistent across specifications, between 1 million to 2.98 million in the second specification and 1.12 and 3.67 million in the last specification. Even though zero is often the lower bound of individual parameters, jointly they are always significantly different from zero. These results are robust to different sample selection criteria, including country group, firm size, and ownership types (see Appendix C.C3).

Table 7—: Step 2: Fixed and Sunk Costs of Importing

	Costs to continuing importers			**Costs to new importers**		
	(1)	(2)	(3)	(4)	(5)	(6)
Const.	[0.48, 1.80]	[0, 1.81]	[0, 1.85]	[0.96, 3.12]	[0.60, 2.94]	[0.39, 2.96]
Const. + language	-	[0, 1.81]	[0, 1.92]	-	[1.00, 2.98]	[0.76, 3.66]
Const. + border	-	-	[0, 1.86]	-	-	[0.39, 3.65]
Const. + language + border	-	-	[0, 1.93]	-	-	[1.12, 3.67]

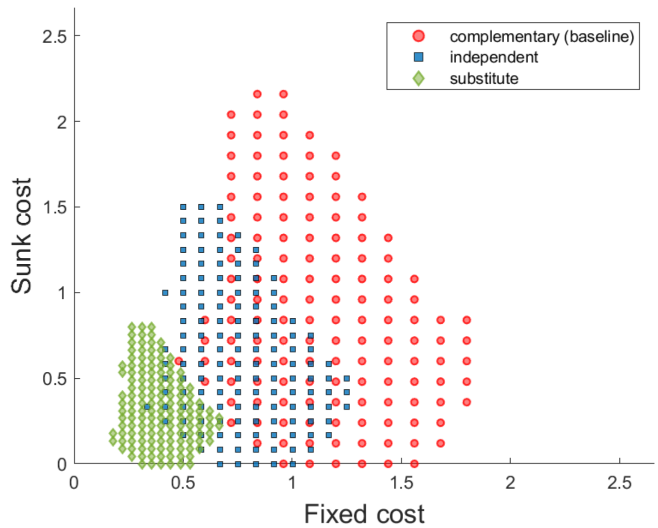
Note: This table reports the projected confidence interval for each parameter using the general moment selection method in Andrews and Soares (2010). The first number in each square bracket corresponds to the lower bound and the second number corresponds to the upper bound. The first three columns report the estimated costs of importing incurred by continuing importers, while the last three columns show the estimated costs incurred by new importers. I report results for three different specifications: (1) in columns 1 and 4, $X_j = \{\emptyset\}$, (2) in columns 2 and 5, $X_j = \{Language_j\}$, and (3) in columns 3 an 6, $X_j = \{Language_j, Border_j\}$ where X_j, $Language_j$, and $Border_j$ are defined in the main text. The discount factor δ is set to 0.9. Monetary values are in million of 1998 RMB.

C. Relationship between Static Interdependence and Sunk Cost Estimates

In this section, I re-estimate the costs of importing if countries are either independent or substitute, in contrast to the baseline finding that countries are complementary. Recall that the direction of interdependence depends on the values of the elasticity of demand σ and technology dispersion θ. Because σ affects the estimate through both the interdependence and markup, I keep σ at the baseline estimate but alter the value of θ. Specifically, to simulate an independent scenario, I set $\theta = 3.02$ so that $(\sigma - 1)/\theta = 1$. To create the substitute scenario, I fix $\theta = 6.04$ and $(\sigma - 1)/\theta = 0.5$.

Figure 1 shows that as θ increases, the estimates for both fixed and sunk costs decrease. The reason is that when there is less dispersion of technology across inputs (i.e., higher θ), the benefit of an additional draw diminishes because the probability firms will find a lower-cost supplier is

Figure 1. : Cost Estimates and Static Interdependence



Note: This figure compares the 95% confidence sets in the baseline model (countries are complementary–i.e., $(\sigma-1)/\theta = 1.52$) versus models in which countries are independent $(\sigma-1)/\theta = 1$, or substitute $(\sigma-1)/\theta = 0.5$. Monetary values are in millions of 1998 RMB.

reduced. This leads to lower marginal revenue from a given import source, thus generating smaller fixed and sunk cost estimates. We can intuitively anticipate that as countries become close to perfect substitutes–i.e. $(\sigma-1)/\theta$ converges to 0, the confidence set for fixed and sunk costs collapses. The intuition is that when countries are perfect substitutes, firms obtain no additional revenue gain from sourcing from more than one market (including the domestic market). Thus, if they choose to import, it must mean that firms are indifferent between importing and not importing, and that the fixed and sunk costs should be close to zero.[31]

However, because the change in θ affects each of the four importer types in the same manner, the ratio of fixed and sunk costs to average marginal revenue is similar across different models, as reflected by the similar shapes of the three confidence regions. In other words, the level of interdependence matters for the static revenue gains and thus the static decision, but does not alter the fundamental relationship between sunk and fixed costs. This exercise also shows that the estimation of fixed and sunk costs here can accommodate different levels of interdependence across import sources in production.

[31]When $(\sigma-1)/\theta$ converges to zero, either σ converges to one or θ becomes extremely large. In the former case, demand is inelastic to price and thus firms have little incentive to reduce costs; they can simply pass higher costs to consumers through higher prices. Firms would then become indifferent between any two sets of import sources. In the latter case, there is no variance in efficiency across inputs, meaning input prices are determined by a country's technology level T_j and should be the same across inputs within each country. Firms would purchase all of their inputs from one single source that provides that lowest price. Other countries beyond that simply provide no additional benefits.

D. Back-of-the-Envelope Calculations: Effect of a Temporary Trade War

At this point, I have provided evidence for the interdependence across import sources and sunk entry costs of importing. To demonstrate how, in the presence of these two features, temporary trade policy changes might create long-lasting and widespread effects on firm-level sourcing decisions, I conduct the following thought experiment. Suppose there is a temporary trade war between China and the United States, which prevents Chinese firms from importing from the United States.[32] I investigate (1) the trade war's direct effect on firms' decisions in the United States after the trade war and (2) its indirect effect on firms' decisions in other countries. Intuitively, the direct effect will depend on the magnitude of the sunk cost of importing from the United States whereas sourcing relationships across international markets will determine the indirect effect.

To quantify these effects, I make two additional assumptions. First, there are only two periods, $t = 0, 1$. The trade war occurs at the beginning of period $t = 0$ and ends before the second period. Second, I treat the trade war as an unanticipated shock, meaning there is no immediate effect and the firms' import status in other markets in the first period remain unchanged. This assumption allows us to focus on its effects after the trade war.

I restrict the sample on firms that would import from the United States in $t = 0$ in the absence of a trade war.[33] Furthermore, I fix the values of the fixed and sunk costs: $\gamma^f = 1$ and γ^s at three different values—0.1, 1.1, and 2.2—which roughly correspond to the lower bound, mid-point, and upper bound of the estimate of the sunk cost.

Table 8 reports the shares of incumbent importers that would switch their import status in the United States after the trade war at these different values of sunk entry cost. In general, the effect is stronger in the earlier years, which results from the fact that firms grew bigger over time during this sample period and thus would be less affected by the trade war. Furthermore, the bigger the sunk cost, the more firms drop the United States from their import set after the trade war has ended. At the lower bound ($\gamma^s = 0.1$), only 11.9% of firms that would have imported from the United States change their status in this country. However, this share sharply rises to 53.8% when I increase the sunk cost to 1.1 million RMB and 62% when sunk cost is 2.2 million RMB.

The large share of firms affected even after the trade war demonstrates the long-lasting effect of temporary trade policy changes. This outcome also confirms the model prediction that in a static model with no sunk cost, there would be a minimal long-term effect from a temporary trade

[32] In 2021, China imported about \$150 billion of goods from the United States, a substantial amount of which is capital goods and industrial supplies.

[33] About 15% of the firms in my sample imported from the United States at some point during 2000-2006. Since the model abstracts from general equilibrium effects, firms that would not import from the United States in $t = 0$ regardless of the trade war are unaffected in this thought experiment.

war, whereas in a dynamic model with sunk entry costs, the effect of a trade war could remain substantial even when the two countries normalize their trade relations.

Table 8—: Direct Effect of Trade War

	(1) $\gamma^s = 0.1$	(2) $\gamma^s = 1$	(3) $\gamma^s = 2.2$
2001	14.3	62.3	68.8
2002	17.1	60.4	66.7
2003	19.2	66.4	72.8
2004	7.5	48.3	59.2
2005	10.0	49.8	56.9
2006	7.8	45.8	56.6
Average	11.9	53.8	62.0

Note: This table reports the shares of Chinese firms that would drop the United States from their import sets as a result of the trade war. The year corresponds to the year after the hypothetical trade war. Each column corresponds to a different value of the sunk cost. The fixed cost is set at $\gamma^f = 1$.
Source: General Administration of Customs and National Bureau of Statistics

In Table 9, I report the indirect effect–the share of firms that would drop at least one market other than the United States from their import set after the trade war in the complementary case. The model predicts that when countries are complementary, firms may drop additional import sources if they decide to drop the United States. This happens when the synergy between the United States and other countries is large enough to cover the cost of importing from multiple countries, but without the United States, importing from the remaining markets might not be worth it. In other words, when firms cannot find substitutes for the United States, they are subject to higher marginal costs and lower scales, and thus cannot afford importing from other countries.[34]

Consistent with the theory, the results in Table 9 show that a fraction of firms would stop importing from other markets because of the U.S.-China trade war. As the sunk cost increases, the externality of the trade war on other markets also becomes bigger. At the lower bound of the sunk cost, only 6.9% of firms would change their decisions in third markets, whereas 47.4% of firms would alter their decisions at the upper bound of the sunk cost.[35]

In short, the long-lasting effect on third markets of the temporary trade war results from the combination of both the sunk costs and interdependence across import markets. A model with sunk costs alone would not generate third market effects in firm-level decisions, whereas a static

[34] Interestingly, the indirect effect would be different in the independence or substitution case. When countries are independent, the effect of the trade war will be contained to firms' decisions in the United States while their decisions in other markets remain intact. By contrast, when countries are substitutes, firms may be able to replace the United States with a new country that they have not already imported from. In this case, it is unclear whether they will keep the remaining set of import sources.

[35] If we allow for firms to make immediate adjustments in $t = 0$, there will be likely an increase in both the share of firms that drop the United States and other markets in $t = 1$, as the indirect effects happen in both the first and second periods. In the first period, as firms cannot import from the United States, they also drop other markets (due to complementarity), which increases the future costs of importing from the United States and other markets. In short, allowing for a longer planning horizon would potentially dampen the effects of the trade war whereas allowing for intermediate responses would amplify these effects of the temporary trade war.

Table 9—: Indirect Effect of the Trade War on Third Markets

	(1) $\gamma^s = 0.1$	(2) $\gamma^s = 1$	(3) $\gamma^s = 2.2$
2001	8.2	39.3	47.5
2002	9.1	47.5	53.5
2003	13.6	52.7	60.9
2004	4.0	35.5	46.8
2005	5.2	34.1	39.3
2006	4.2	32.4	43.0
Average	6.9	39.2	47.4

Note: This table reports the shares of Chinese firms that would drop at least another market besides the United States from their import sets due to the U.S.-China trade war. Each column corresponds to different values of sunk cost. The year corresponds to the year after the hypothetical trade war. Each column corresponds to a different value of the sunk cost. The fixed cost is set at $\gamma^f = 1$.
Source: General Administration of Customs and National Bureau of Statistics

model that allows for interdependence would overlook the dynamic costs of temporary trade policy changes.

V. Extensions

In the following sections, I discuss two extensions of the baseline model. First, Section V.A provides an estimation approach that can allow for productivity to be affected by the set of countries from which a firm purchases its intermediate goods. In Section V.B, I introduce exporting decisions into the model. In this setting, a firm can choose where to import intermediate goods and export final goods.

A. Productivity Gains from Importing

The baseline model assumes that marginal cost is affected only by changes by input prices when firms change their import sources. However, existing evidence indicates that imported inputs affects firm-level productivity (Kasahara and Rodrigue, 2008; Amiti and Konings, 2007; Halpern, Koren and Szeidl, 2015). A firm's core productivity (φ_{it}) may also be influenced by its choice of import set. For instance, if a firm imports from high-income countries, it may have exposure to more managerial know-how or technological advances embedded in the foreign inputs. While these channels may not change input prices, they may increase the firm's productivity and thus lower marginal costs. Ignoring the productivity channel may lead to biased estimates of the countries' marginal revenue gains in the first stage of estimation because we attribute all of the effect on marginal costs to input price reductions. Furthermore, even if we hold all future import decisions constant, future revenues might be affected through the productivity channel and thus not accounting for productivity gains will bias the estimate of import sunk costs.[36]

Consider the case when productivity is affected by import decisions with a lag. Allowing for the productivity effect substantially complicates the firms' dynamic problem. Apart from sunk costs, productivity gains provide another channel for the inter-temporal linkages between current and future decisions.[37] While the change in future sunk costs alters future profits but has no bearing on future revenues, the change in future productivity will affect future revenues. Thus, when deviating from the firm's observed import path, we need to consider the effects on future productivity to predict the revenue changes.

To fix ideas, let $\varphi_{it+1} = g(\varphi_{it}, X_{it}, \xi_{it})$, where g is some unknown function, X_{it} captures import decisions in the current year, and ξ_{it} captures productivity shock. I use different measures of X_{it}, including number of high-income countries, number of advanced-technology countries, and total number of import markets. Recall that the revenue function in equation 7 can be expressed as $r_{iht} = A_t \times \varphi_{it}^{\sigma-1} \times \Theta_{it}^{\frac{\sigma-1}{\theta}}$ where A_t captures market demand factors that are common across firms. Under the above assumption on productivity, future revenue is then a function of last period's import decision–i.e. $r_{it+1} = k(A_{t+1}, \Theta_{it+1}, \varphi_{it}, X_{it}, \xi_{it})$ for some unknown function k.

To approximate for the effect of current import decisions on future revenue, I estimate the following regression

$$\log r_{it+1} = \lambda_{t+1} + \eta X_{it} + \ln \hat{\Theta}_{it+1} + \nu_{it+1} \tag{18}$$

where $\hat{\Theta}_{it+1}$ is the firm's sourcing capacity estimated using the procedure in Section IV. Note that given the construction of the deviations in Section III, the import decision in year $t+1$ is unchanged and thus the firm's sourcing capacity Θ_{it+1} is not affected.

The coefficient of interest is η, which captures how the current import set affect future revenues. X_{it} is endogenous as it is correlated with the unobserved productivity. To address the endogeneity, I use tariffs on imported inputs in China between 2000 and 2006 as an instrumental variable for X_{it}. The exclusion assumption is that input tariffs affect only firm-level revenues through their choice of input sources.

Once we obtain a reliable estimate of η, I compute the counterfactual variable X'_{it} for each deviation from the observed import set and get the predicted values for r_{it+1} given X'_{it}. The change in future revenue from the productivity channel is then the difference between $r_{it+1}(X_{it})$

[36]On the export side, Timoshenko (2015) shows that the persistence in export status can be explained by both learning and sunk costs, and that once learning is controlled for, the sunk cost estimate becomes smaller.

[37]Nevertheless, because current import decision does not affect current productivity, the static problem remains the same.

and $r_{it+1}(X'_{it})$.

Results

Table 10 reports the result for equation 18 with three different measures to characterize the import set: (1) the total number of import sources, (2) the number of advanced technology countries, and (3) the number of high income countries.[38] The instrumental variable is firm-level input tariffs.[39] As we can see from columns 1, 4, and 7, the coefficients on different measures of X_{it-1} are consistently positive. The estimated coefficient ranges between 0.088 and 0.108, meaning a 10% increase in the number of productivity-enhancing sources leads to an increase in revenues by 8.8% to 10.8%. The remaining columns look at the effects on firms with different levels of initial revenues. The results suggest potential heterogeneous effects of import decisions on revenue by firm size. Smaller firms tend to enjoy bigger productivity gains by importing from more (high income or advanced technology) countries.

Table 11 shows the changes in revenues by import status at the firm-country level when X_{it} is chosen as the number of high-income countries. Similar to the baseline findings, new and continuing importers enjoy bigger total revenue gains than exiting importers and firms that never import. However, when breaking down the total revenue gains into the static changes due to input prices and dynamic changes due to productivity, I find that both components play equally important roles. This evidence suggests that ignoring the dynamic effect of import decisions on productivity can lead to bias in the fixed and sunk cost estimates.

Panel a in Figure 2 shows the new 95% confidence set for the costs of importing when taking into account the productivity effect. As expected, as the gain from importing increases, the estimated costs to both new and continuing importers also increase. To compare costs relative to the revenue gains, in Panel b I scale each point in the confidence sets by the corresponding average marginal revenue.[40] Even after adjusting for revenue gains, I find that new estimates are more likely to produce high estimates for fixed costs, between 19% and 30% of revenue gains, whereas the baseline estimates lie between 13% and 30%. However, the costs to new importers now fall into a lower range (as a percentage of revenue changes). Without the productivity effect, the costs for a new importer can be as much as 40% of marginal revenue, whereas the new upper bound lies around 32% of total revenue gains.

[38] Even though the baseline model does not incorporate export decisions, I also include the number of export destinations to proxy for export revenues.

[39] See Appendix B.B1 for a detailed description of the firm-level input tariffs.

[40] Specifically, the x-dimension values are scaled by the average revenue change for continuing importers, whereas the y-dimension values are scaled by the average revenue change for new importers.

Table 10—: Revenues and Productivity Gains

	# countries			# advanced-tech countries			# high-income countries		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
L.import	0.0884	0.101	0.188	0.0903	0.103	0.190	0.108	0.122	0.225
	(0.0231)	(0.0272)	(0.0684)	(0.0235)	(0.0278)	(0.0694)	(0.0276)	(0.0329)	(0.0829)
L.import × 1(≥ med size)		-0.0228			-0.0239			-0.0269	
		(0.0177)			(0.0182)			(0.0221)	
L.import × initial size			-0.0264			-0.0266			-0.0311
			(0.0139)			(0.0142)			(0.0168)
Log sourcing capacity	-0.576	-0.527	-0.441	-0.577	-0.526	-0.439	-0.489	-0.449	-0.383
	(0.170)	(0.158)	(0.134)	(0.169)	(0.158)	(0.134)	(0.145)	(0.136)	(0.117)
# export markets	0.00369	0.00373	0.00371	0.00374	0.00377	0.00376	0.00400	0.00401	0.00397
	(0.000536)	(0.000533)	(0.000526)	(0.000536)	(0.000533)	(0.000526)	(0.000544)	(0.000541)	(0.000533)
Foreign affiliated	-0.0415	-0.0444	-0.0467	-0.0419	-0.0449	-0.0470	-0.0501	-0.0528	-0.0551
	(0.0155)	(0.0159)	(0.0164)	(0.0155)	(0.0159)	(0.0164)	(0.0169)	(0.0174)	(0.0179)
State owned	-0.000756	-0.00128	-0.00329	-0.00106	-0.00152	-0.00337	-0.00169	-0.00206	-0.00410
	(0.0155)	(0.0153)	(0.0153)	(0.0155)	(0.0153)	(0.0153)	(0.0155)	(0.0154)	(0.0154)
Initial size	0.963	0.969	0.981	0.963	0.969	0.981	0.962	0.968	0.980
	(0.00779)	(0.00842)	(0.00880)	(0.00787)	(0.00846)	(0.00879)	(0.00799)	(0.00864)	(0.00879)
Constant	3.557	3.291	2.816	3.563	3.287	2.809	3.124	2.902	2.535
	(0.862)	(0.803)	(0.676)	(0.861)	(0.800)	(0.675)	(0.738)	(0.691)	(0.590)
Observations	4943	4943	4943	4943	4943	4943	4943	4943	4943
Adjusted R^2	0.901	0.902	0.903	0.901	0.902	0.903	0.899	0.900	0.901

Note: This table reports the effects of past import decisions on current revenues. Columns 1-3 use the total number of import countries as the key independent variable, columns 4 to 6 use the number of advanced technology countries, and columns 7 to 9 use the number of high-income countries. Except for columns 1, 4, and 7, I allow for heterogeneous effects of import decisions on revenue by a firm's initial revenue. 1((≥ med size) takes the value of one if the initial size is equal to or greater than the median value. A set of year dummies is included in all equations. Input tariffs (and interactions with initial size) are used as instrument variables for past import decisions. The first stage results are reported in Table D1. Monetary values are in units of million of RMB 1998.

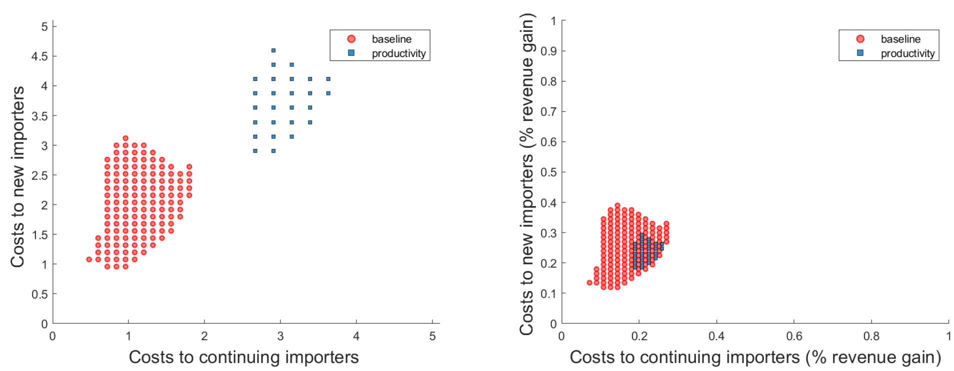
Standard errors in parentheses.
Source: General Administration of Customs and National Bureau of Statistics

Table 11—: Revenue Changes - Number of High-Income Countries

	All	Never	Exiting	New	Continuing
Current revenue changes	6.33	6.13	3.29	7.52	6.65
	(22.50)	(22.34)	(8.08)	(27.54)	(20.28)
Future revenue changes	4.15	2.32	6.01	9.09	8.16
	(11.09)	(5.53)	(6.90)	(19.99)	(16.97)
Total revenue changes	10.07	8.23	8.69	15.70	13.99
	(23.89)	(22.40)	(9.09)	(31.47)	(24.24)
Observations	25793	17325	364	3351	3181

Note: This table reports the average revenue changes for each deviation from the observed path when accounting for productivity effect based on estimates in column (9) in Table 10. The first row presents changes to current revenues due to changes in the firm's current import set and sourcing capacity. The second row shows changes to future revenues due to productivity effect. The first column reports the average revenue changes for all firms, while columns 2 to 5 present the results for each type of importers, defined by the firm's import status in a country for a given year. Monetary values are in units of million of RMB 1998. The future revenue changes are discounted by a factor of 0.9. Standard errors in parentheses.
Source: General Administration of Customs and National Bureau of Statistics

Figure 2. : 95% Joint Confidence Sets - Productivity Gains vs Baseline



(a) Absolute values

(b) Scaled by avg. revenue changes

Note: Panel a illustrates the 95% confidence sets of the total costs to continuing versus new importers. Panel b compares the baseline estimates with the new estimates, both scaled by the corresponding revenue gains. The red region depicts the CI under the baseline model, whereas the blue region depicts the CI when accounting for productivity channel. Monetary values are in million of 1998 RMB.

B. *Export Decisions*

A firm's past experience with exporting in a market can affect import entry costs in the same market, and vice versa. When entering a new export destinations, firms may learn about potential suppliers and distribution networks, which facilitates their initial imports from the same location. Thus, ignoring other channels through which firms participate in foreign markets may bias the estimate of sunk costs of importing.[41] For this reason, I modify the baseline model by allowing

[41]The same argument can be made about other international activities, including multinational production or offshore R&D. I focus on exporting as this channel is still the most common through which firms engage in international markets. However,

firms to choose not only from which countries to source intermediate inputs, but also to which markets to export their outputs. The demand and market structures of the final goods are the same as in the baseline model. However, firm i has to pay a variable trade cost τ^x_{ijt} for each unit of goods it sells in market j at time t. Conditional on the firm's sourcing strategy, $\mathcal{J}^m_{it}$, the export revenue in each market is

$$r^x_{ijt}(\mathcal{J}^m_{it}) = \left[\frac{\sigma}{\sigma-1}\frac{\tau^x_{ijt}}{\varphi_{it}P_{jt}}\right]^{1-\sigma} Y_{jt}(\gamma\Theta_{it}(\mathcal{J}^m_{it}))^{\frac{\sigma-1}{\theta}} \tag{19}$$

Equation 19 depicts the interdependence in the marginal cost between export and import decisions. The choice of input sources affects the marginal cost, which in turns affects the firm's export revenues. However, exporting to more profitable destinations increases the total revenue and thus the marginal revenue gain of an import source. Let $\mathcal{J}^x_{it}$ denote the optimal set of export destinations. Conditional on the optimal export and import decisions, the total revenue of the firm is simply the sum of its domestic revenue and export revenues: $r_{iht}(\mathcal{J}^x_{it}, \mathcal{J}^m_{it}) = r_{iht}(\mathcal{J}^m_{it}) + \sum_{j\in\mathcal{J}^x_{it}} r^x_{ijt}(\mathcal{J}^m_{it})$.

Similar to the import problem, firms will have to pay a fixed cost of each country to which they export, and a sunk cost if they enter the market for the first time. Denote f^m_{ijt} and s^m_{ijt} as firm i's fixed and sunk cost of importing from j in year t and f^x_{ijt} and s^x_{ijt} as firm i's fixed and sunk costs of exporting to j in year t. Furthermore, I allow for potential complementarity between export and import in the sunk costs. Simply put, the sunk entry cost of importing that firm i has to pay to enter country j is reduced if it already exported to j in the previous year–i.e., $s^m_{ijt} - d^x_{ijt-1}e^m_{ijt}$, where e^m_{ijt} captures the reduction in importing sunk cost due to past export experience. And vice versa, past import experience with j also reduces the sunk entry cost of exporting to j–i.e. $s^x_{ijt} - d^m_{ijt-1}e^x_{ijt}$, where e^x_{ijt} is the reduction in exporting sunk cost.[42]

Conditional on the firm's import history, denoted by b^m_{it-1}, and export history, denoted by b^x_{it-1}, the static firm-level profit after importing from set b^m_{it} sources and exporting to set b^x_{it-1} destinations in year t is

$$\begin{aligned}\pi_{it}(b^m_{it}, b^m_{it-1}, b^x_{it}, b^x_{it-1}) = \sigma^{-1}r_{iht}(b^m_{it}, b^x_{it}) - f^m_{it}(b_{it}) - s^m_{it}(b^m_{it}, b^m_{it-1}, b^x_{it-1})\\ - f^x_{it}(b_{it}) - s^x_{it}(b^x_{it}, b^x_{it-1}, b^m_{it-1})\end{aligned} \tag{20}$$

where $\sigma^{-1}r_{iht}(b^m_{it}, b^x_{it})$ is the firm's operating profits. The term $f^m_{it}(b^m_{it}) = \sum_{j\in b^m_{it}} f^m_{ijt}$ is the sum of fixed costs of importing the firm i pays in year t. Analogously, $f^x_{it}(b^x_{it}) = \sum_{j\in b^x_{it}} f^x_{ijt}$ is the

the estimation framework can be adapted to account for more trade margins.

[42]Allowing for complementarity in the fixed costs of exporting and importing is also feasible. As the focus is on the sunk entry costs, I choose the more simple fixed cost structure.

sum of fixed costs of exporting that firm i pays in year t. Furthermore, $s^m_{it}(b^m_{it}, b^m_{it-1}, b^x_{it-1}) = \sum_{\substack{j\in b^m_{it} \\ j\notin b^m_{it-1}}} (s^m_{ijt} - d^x_{ijt-1}e^m_{ijt})$ is the sum of sunk costs firm i pays to enter new import markets in year t and $s^x_{it}(b^x_{it}, b^x_{it-1}, b^m_{it-1}) = \sum_{\substack{j\in b^m_{it} \\ j\notin b^m_{it-1}}} (s^x_{ijt} - d^m_{ijt-1}e^x_{ijt})$ denotes the sum of sunk costs firm i pays to enter new export markets in year t.

We now turn to the dynamic problem with both export and import decisions. In each period t, firm i chooses a sequence of import sources and export destinations, $\{(b^m_{i\tau}, b^x_{i\tau}) : b^m_{i\tau}, b^x_{i\tau} \in B_{it}\}^{t+L_{it}}_{\tau=t}$, that maximizes its discounted expected profit stream over a planning horizon L_{it}

$$E[\sum_{\tau=t}^{t+L_{it}} \delta^{\tau-t}\pi_{i\tau}(b^m_{it}, b^m_{it-1}, b^x_{it}, b^x_{it-1})|\Omega_{it}] \tag{21}$$

where B_{it} is the set of all import sources and export destinations that firm i considers in year t, and Ω_{it} denotes the firm's information set, which includes the firm's past import and export sets (b^m_{it-1} and b^x_{it-1}).[43]

Despite the interdependence between export and import decisions in both the marginal costs and sunk costs, under the revealed preferences assumption we can indeed estimate the export and import parameters separately. Intuitively, I assume that the observed export and import path is the optimal, and thus any deviation from the observed path will lower the firm's expected profits. The implication is that we can keep the export decision intact and deviate from the observed import path to estimate import parameters, and keep the import path fixed while changing the export path to get the bounds for the export parameters. Under the same deviation construction, the number of choices to analyze for each firm-year-country pair is $2J$. As the one-period dependency in the static profits is preserved, this method again reduces the dynamic problem to a static problem as explained in Section III.

The same logic can be applied to a large class of multi-country models that incorporate multiple trade margins, such as multinational production as in Tintelnot (2017) or offshore R&D as in Fan (2019). The key lies in the ability to compute the marginal value of a location with respect to one trade activity, while keeping other markets intact. The method is flexible enough to allow for interdependence across locations and/or among trade margins.

To estimate the model, I assume the following structures on the fixed and sunk costs: $f^x_{ijt} = \gamma^{f,x} + \epsilon^{f,x}_{ijt}$, $f^m_{ijt} = \gamma^{f,m} + \epsilon^{f,m}_{ijt}$, $s^x_{ijt} = \gamma^{s,x} + \epsilon^{s,x}_{ijt}$, $s^m_{ijt} = \gamma^{s,m} + \epsilon^{s,m}_{ijt}$ where $E(\epsilon^{g,x}_{ijt}|\Omega_{it}, d^x_{ijt}, d^m_{ijt}) = 0$ and $E(\epsilon^{g,m}_{ijt}|\Omega_{it}, d^x_{ijt}, d^m_{ijt}) = 0$, with $g = f, s$. Finally, $e^x_{ijt} = \gamma^{e,x}$ and $e^m_{ijt} = \gamma^{e.m}$. Let γ collect all

[43]Here I allow the consideration sets to be different for export destinations and import sources. We can think of B_{it} as the union of the two consideration sets–i.e., $B_{it} = B^m_{it} \cup B^x_{it}$.

the parameters in the fixed and sunk costs: $\gamma = (\gamma^{f,m}, \gamma^{s,m}, \gamma^{f,x}, \gamma^{s,x}, \gamma^{e,m}, \gamma^{e,x})$.

Following MSZ, I compute predicted export revenues as a function of domestic revenues. The average predicted revenues for exiting, continuing, never, and new exporters are 0.45, 2.29, 1.39, and 1.94 mil RMB, respectively.[44]

Next, I apply the same deviation procedure in Section III to create the moment inequalities from both export and import decisions. Figure 3 illustrates the confidence regions of the cost that an average importer/exporter pays in the first year of importing/exporting. If a firm has neither export nor import experience in a market, it pays between 0.98 and 4.89 mil RMB to start importing (computed as the bounds on $\gamma^{f,m} + \gamma^{s,m}$), and between 0.39 and 0.95 mil RMB to export in the initial year ($\gamma^{f,x} + \gamma^{s,x}$). However, if the firm exported to the same country in the previous year, then it may enjoy a substantial reduction in the sunk cost of importing, up to 3.7 mil RMB. Likewise, a new exporter experiences a reduction on its sunk cost of exporting if it imported from the same market previously. The results document high degree of complementarity between exporting and importing.

One interesting pattern is that the upper bounds of the confidence intervals for the γ^m parameters are much bigger than those for γ^x, indicating that importing is more costly for some firms. Note that what is captured here is the cost firms pay *per* market. Indeed, I find that the number of export destinations tends to be higher than the number of import sources. Conditional on importing, the median firm imports from two countries, whereas conditional on exporting, the median exporter sells to six markets.[45] As a result, when accounting for the number of countries that a firm imports from or exports to, I find that the total costs of importing for the median firm is indeed similar to the total costs of exporting.[46]

VI. Conclusion

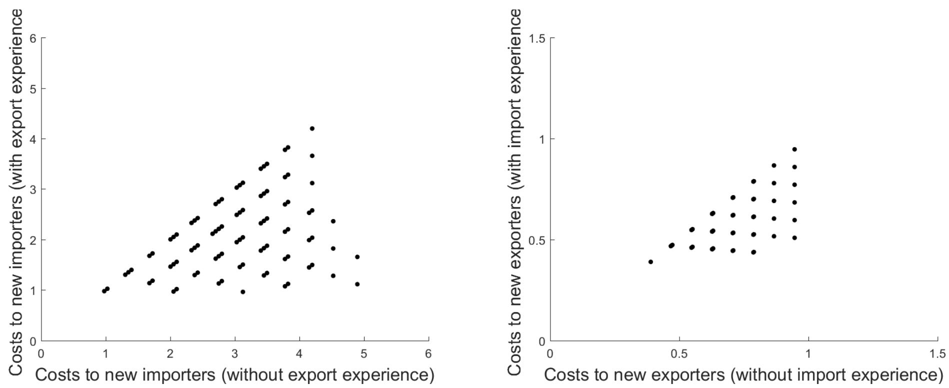
This paper introduces and estimates a dynamic multi-country model of imports with heterogeneous firms. The main findings show that it is more costly for firms to establish new import relationships than to maintain their existing import sources, implying there are sunk costs of importing from a new location. Furthermore, import decisions are interdependent across countries–i.e., the benefits of importing from one location increases as firms import from more locations. These two features of the import decisions together imply that there might be complicated responses to

[44]See Table D3 for the export revenue prediction regression results.

[45]The same pattern is observed for new exporters and importers. The median importer purchases from one new country, whereas the median exporter sells to three new destinations.

[46]This evidence explains the difference between my estimates and the results in Kasahara and Lapham (2013), in which the authors find the the costs of exporting are comparable to the costs of importing.

Figure 3. : 95% Joint Confidence Sets



(a) Import costs (b) Export costs

Note: This figure illustrates the 95% confidence sets of the total costs to new importers (top panel) and new exporters (bottom panel). The horizontal axis presents the costs when the new importer (exporter) does not have prior export (import) experience, whereas the vertical axis presents the costs when the firm has prior experience in the other trade margin. Monetary values are in million of 1998 RMB.

targeted trade policies. Reducing trade barriers in one market not only affects entry in its own country, but also affects trade flows in other markets. Moreover, temporary trade policy changes might have long-run effects due to path dependence in the firm-level decisions.

Other mechanisms can generate similar predictions to those from the baseline model. In terms of persistence in firm-level import decisions, firms may obtain productivity gains from importing which increase the likelihood of importing from the same set of input sources in subsequent periods. Section V.A proposes a modified estimation procedure that accounts for such productivity gains. In addition to the interdependence in marginal costs, the interdependence across countries might also be inherent in the sunk costs through extended gravity. As in MSZ, firms learn about new markets from their previous experience with similar markets. The current framework can be adjusted to account for these extended gravity factors.

Finally, although the baseline model focuses on the import side, Section V.B demonstrates an extension that incorporates the firm's export decision. The extended model preserves the interdependence across locations while introducing complementarity between importing and exporting in both the marginal costs and the fixed and sunk costs. Though adding export platforms complicates the firm's optimization problem, it does not require substantial modification to the estimation approach due to its flexibility and mild restrictions on the firm's behavior. This is an important feature because firms are likely to engage in the global economy through multiple channels. The next step is to expand the current framework to allow for other trade margins and provide a comprehensive picture of firm-level global supply chains.

Appendices

Identification Appendix

A1. Identification Assumptions

ASSUMPTION 1: *(Revealed preferences) Let o^m_{it} be firm i's observed import set in year t. Then o^m_{it} is the solution to*

$$\text{(A1)} \qquad \max_{b \in B_{it}} E[\pi_{it}(b, b_{it-1}) + \sum_{l=1}^{L_{it}} \delta^l \pi_{it+l}(\mathcal{J}_{it+l}b, \mathcal{J}_{it+l-1}b)|\Omega_{it}]$$

where $\mathcal{J}_{it+l}b$ denotes the optimal set in year $t+l$ given that it chooses set b in year t.

ASSUMPTION 2: *(Planning horizon) $L_{it} \geq 1$.*

ASSUMPTION 3: *(Consideration set) $A_{it} \subseteq B_{it}$, where $A_{it} = o_{it} \cup \{o_{it} \cup j, \forall j \notin o_{it}\} \cup \{o_{it} \setminus j, \forall j \in o_{it}\}$.*

ASSUMPTION 4: *(Information set) $Z_{it} \subseteq \Omega_{it}$, where Z_{it} is a vector of observed covariates.*

Essentially, Assumption 1 states a firm's observed import decision in year t is optimal given its current information set. Assumption 2 imposes that firms are forward looking and plan at least one period in advance. Assumption 3 states that the deviations considered by researchers are also in the firm's consideration set. Assumption 4 implies that the instrument variables used to create unconditional moment inequalities are known to the firms.

A2. Proof and Discussion of Equation 12

Let $\Pi_{ibt} \equiv \pi_{it}(b, o_{it-1}) + \sum_{l=1}^{L_{it}} \delta^l \pi_{it+l}(\mathcal{J}_{it+l}b, \mathcal{J}_{it+l-1}b)$ be the discounted sum of profits if the firm chooses b in year t. Let $\Pi_{io_{it}t} \equiv \pi_{it}(o_{it}, o_{it-1}) + \sum_{l=1}^{L_{it}} \delta^l \pi_{it+l}(\mathcal{J}_{it+l}(o_{it}), \mathcal{J}_{it+l-1}(o_{it}))$. Then, $\forall b \in B_{it}$, we should have $E(\Pi_{io_{it}t}|\Omega_{it}) \geq E(\Pi_{ibt}|\Omega_{it})$.[47] Recall that $\mathcal{J}_{it+l}b$ is the firm's optimal choice in year $t+l$ should it choose b in year t. It follows that $E(\Pi_{ibt}|\Omega_{it}) \geq E(\pi_{it}(b, b_{it-1}) + \sum_{l=1}^{L_{it}} \delta^l \pi_{it+l}(\mathcal{J}_{it+l}(o_{it}), \mathcal{J}_{it+l-1}(o_{it}))|\Omega_{it})$ as the second expectation is over the profits of the firm if it would choose b in year t but in the subsequent periods act as if it had chosen o_{it} instead. By

[47]Note that we keep the same import history on both sides of the inequality. If we also allow for the decision in year $t-1$ to be different from the observed path, the inequality is no longer valid.

transitivity of preferences,

$$
\begin{aligned}
&E(\Pi_{io_{it}t}|\Omega_{it}) \\
&= E(\pi_{it}(o_{it}, o_{it-1}) + \sum_{l=1}^{L_{it}} \delta^l \pi_{it+l}(\mathcal{J}_{it+l}(o_{it}), \mathcal{J}_{it+l-1}(o_{it}))|\Omega_{it}) \\
&\geq E(\pi_{it}(b, o_{it-1}) + \sum_{l=1}^{L_{it}} \delta^l \pi_{it+l}(\mathcal{J}_{it+l}(o_{it}), \mathcal{J}_{it+l-1}(o_{it}))|\Omega_{it})
\end{aligned} \tag{A2}
$$

Because of the one-period dependency of π_{it}, static profits for years $t+l$ where $l \geq 2$ will be the same on both sides of the inequalities. Thus, $\forall b \in B_{it}$, equation A2 is reduced to

$$
\begin{aligned}
&E(\pi_{it}(o_{it}, o_{it-1}) + \delta\pi_{it+1}(\mathcal{J}_{it+1}(o_{it}), o_{it})|\Omega_{it}) \\
&\geq E(\pi_{it}(b, o_{it-1}) + \delta\pi_{it+l}(\mathcal{J}_{it+1}(o_{it})), b)|\Omega_{it})
\end{aligned}
$$

The same logic applies if the sunk cost investment fully depreciates after a finite number of periods. I impose the one-period dependency assumption for two reasons. First, allowing for a longer horizon would generate more loss of information, which is not ideal given the short panel data. Second, strong empirical evidence supports that the sunk cost investment depreciates quickly after the first period (Roberts and Tybout, 1997; Das, Roberts and Tybout, 2007). Thus, any bias created by the one-period dependency assumption would be minimal.

Data Appendix

B1. Variable Construction

Wages

Data on wages for the countries in my sample are downloaded from the ILO. I use reported data on monthly wages for the manufacturing sector, divided by the total number of hours worked in a month. In a few occasions, a single country multiple reported values in the same year, which come from different survey data sources. To address this problem, I relied on the surveys' description of reference group and methodology to ensure consistency across countries. The ILO does provide a harmonized series; however, many missing data would compromise the range of countries I can include.

The ILO differentiates between employees and employed persons. In the main analysis, I use data for employees (wages data only for employees) but also conduct a robustness check using total work hours for each person employed. Moreover, I converted the wages in local currency to U.S. dollars using exchange rates from the Penn World Tables. I use official instead of purchasing power exchange rates, as the goal is to capture the differences in cost of production across countries.

Finally, as in Eaton and Kortum (2002), I adjust hourly wages for human capital by multiplying wages in country j by $\exp^{-gH_j}$ where $g = 0.06$ is the return to education and H_j is the years of schooling in country j in the initial year (2000). I set $g = 0.06$, which Bils and Klenow (2000) suggest is a conservative estimate. Data on schooling come from Barro and Lee (2013).

Country Characteristics

Data on language and contiguity come from the CEPII. Countries' income bracket is based on World Bank classification and the World Development Indicators. I construct binary variables that take the value of unity if the import source does not share the corresponding characteristics with China. In other words, when $language_j = 1$, Chinese is not the official language in country j. Similarly, $border_j = 1$ implies country j and China do not share the same border.

The U.S. Census Bureau defines 10 categories of Advanced Technology Products (ATP) including (1) biotechnology (2) life science (3) opto-electronics (4) information and communication (5) electronics (6) flexible manufacturing (7) advanced materials (8) aerospace (9) weapons and (10) nuclear technology. I merge this list of products with HS codes at the six-digit level and group countries into those with a high share of ATP imports and those with a low share of ATP imports to proxy for the level of technology embedded in goods from each country. I use both U.S. and Chinese import data to construct the variable. Data on ATP imports in the United States are from the U.S. Census Bureau.[48]

The share of ATP imports is calculated with respect to total ATP imports and total imports. Let AT_{jt} denote the measure of advanced technology level of country j in year t. I employ different approaches to construct this variable

$$AT_{jt}^{(1)} = \frac{ImportAT_{jt}}{ImportAT_t}$$

$$AT_{jt}^{(2)} = \frac{ImportAT_{jt}}{Import_{jt}}$$

$ImportAT_{jt}$, $ImportAT_t$, and $Import_{jt}$ denote the import values of ATP, total ATP import, and total imports from country j in year t. The first measures compares the shares of ATP imports

[48]The list of ATPs changed overtime, though the bulk of the products remained in the list. I use the list of imported ATPs in 2004.

across countries, whereas the second measure compares the relative share of ATP imports versus other imports from the same country. The larger $AT_{jt}^{(2)}$ is, the higher the likelihood that firms import ATPs if they import from country j.

Input Tariffs

I construct measures of firm-level input tariffs by computing average tariffs weighted by firm-level input imports. Let Z_{it} denote firm i's total import value in year t, Z_{ipt} denote firm i's import value of input p, and τ_{pt} is the tariffs on input p in China.[49] The firm-level input tariffs are defined as

$$\tau_{it}^{(1)} = N_p^{-1} \sum_p 1(Z_{it} > 0)\tau_{pt}$$

$$\tau_{it}^{(2)} = \sum_p \frac{Z_{ipt}}{Z_{it}} \tau_{pt}$$

$$\tau_{it}^{(3)} = \sum_p \frac{Z_{ipt-1}}{Z_{it-1}} \tau_{pt}$$

$$\tau_{it}^{(4)} = \sum_p \frac{Z_{ip0}}{Z_{i0}} \tau_{pt}$$

where N_p is the number of products and $\tau_{it}^{(1)-(4)}$ are average tariffs with different weights. The first one is unweighted, the second and third are weighted by current and lagged import values, and the fourth one is weighted by initial import values.

One issue with this approach to measuring firm-level input tariffs is that we observe import values for only the years that firms imported, implying using observed import values will lead to selection bias. The last measure of input tariffs, $\tau_{it}^{(4)}$, relies on the initial input import structure and thus avoids the endogeneity issue. Nevertheless, using only the initial year leads to a loss of observations because not every firm imported in the first sample year. For these reasons, I replace Z_{ipt}/Z_{it}–i.e., the share of input p over total input costs for firm i in year t–with firm i's average share over the entire sample period. More specifically, for each input p, the average share for firm i is computed as

$$\overline{\frac{Z_{ip}}{Z_i}} = N_T^{-1} \sum_t \frac{Z_{ipt}}{Z_{it}}.$$

[49] Input tariffs are downloaded from the World Integrated Trade Solution and are average tariffs across markets.

The final measure of firm-level input tariffs is

$$\tau_{it} = \sum_p \frac{\overline{Z_{ip}}}{Z_i} \tau_{pt}.$$

In a sense, the weight for the input tariffs is unchanging over time for each firm and hence the time-series variation comes solely from changes in input tariffs in China.

B2. Descriptive Statistics

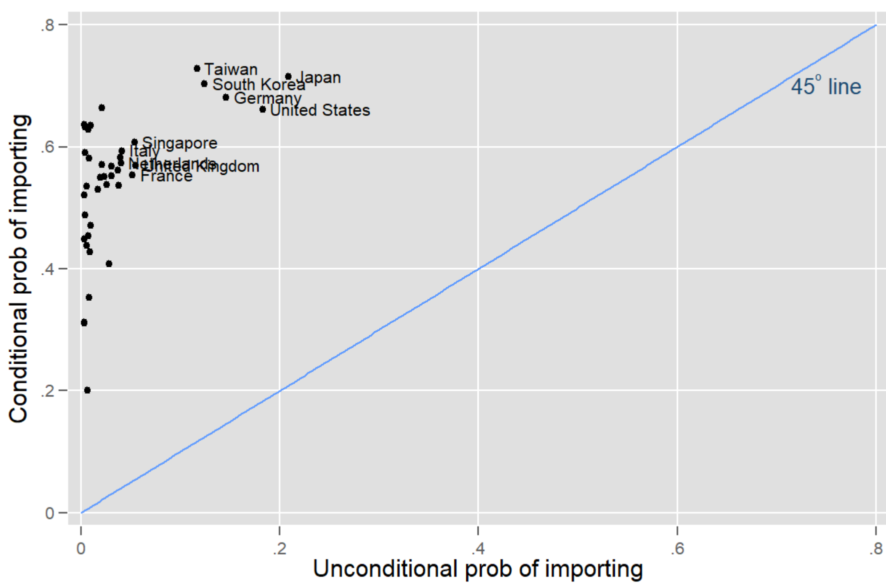


Figure B1. : Persistence in Import Status

Note: This figure presents the scatter plot of the unconditional probability of importing from a certain country (x-axis) and the probability of importing conditional on having previous import experience in the same country (y-axis). Source: General Administration of Customs.

Table B1 reports the country ranking by number of importers in 2000 and 2006 for all industries. The top 10 countries remain in the exact position in both years. Correlation between the 2000 and 2006 ranking for all countries is 0.94.

Table B2 reports the growth rates between 2000 and 2006 for the sample of Chinese chemical producers in terms of domestic revenues, import values, and number of importers. As can be seen from the table, there was tremendous growth during this period. Domestic sales grew by 400%, imports by 500%, and the number of importers in 2006 was more than double that in 2000.

Table B3 provides descriptive statistics for the sample of chemical producers in the main analysis.

Table B1—: Country Ranking and Number of Importers in 2000 and 2006 - All Industries

Country	Rank	2000	2006
Japan	1	12824	30204
United States	2	10999	27367
Taiwan	3	9212	21044
Germany	4	8239	20633
South Korea	5	7993	18841
Hong Kong	6	6307	13851
Italy	7	4660	11632
United Kingdom	8	4436	9946
France	9	4104	8680
Singapore	10	3682	7749

Table B2—: Growth Rates between 2000 and 2006 for The Chemicals Sample

	Domestic revenues	Import values	# Importers
2000	840	10	268
2006	4,239	60	618
Rate of change (%)	404.5	502.7	130.6

Note: This table provides nominal domestic revenues, import values, and number of importers for 2000 and 2006. The last row reports the percentage change between the two years. Monetary values are in billions of RMB.

Table B3—: Firm-Level Summary Statistics

	Mean	Std. dev.	Min.	Max.
Log domestic revenues	10.534	1.734	-0.169	16.341
Log import values	7.627	3.284	-4.794	15.201
Log export values	8.223	2.199	-4.110	13.722
Import status	0.173	0.378	0	1
Export status	0.312	0.463	0	1
Number of import markets	0.582	1.873	0	23
Number of export markets	2.764	6.523	0	71
State-owned	0.164	0.370	0	1
Private	0.327	0.469	0	1
Foreign	0.115	0.319	0	1
Joint venture	0.205	0.404	0	1

Note: This table provides the firm-year-level descriptive statistics for the main sample. Import values capture the average total values that a firm imports in a year. A firm's import status takes the value of one if a firms imports in that year from any country. The export variables are defined in the same way.

Estimation Appendix

C1. Estimating θ and S_{ijt}

To estimate the dispersion of technology, θ, and firm-country-year specific sourcing potential, S_{ijt}, I follow a modified version of the estimation procedure in AFT. Specifically, from the share of imported intermediate inputs equation 4, we get $X_{ijt}/X_{iht} = S_{ijt}/S_{iht}$. I assume that $S_{iht} = S_{ht}$– i.e., the domestic sourcing potential is constant across firms in a year but varies over time. Taking

Table B4—: Country List

Australia	Germany	Malaysia	South Africa
Austria	Hong Kong	Mexico	South Korea
Belgium	Hungary	Netherlands	Spain
Brazil	India	New Zealand	Sweden
Canada	Indonesia	Norway	Switzerland
Chile	Iran	Philippines	Taiwan
Czech Republic	Ireland	Poland	Thailand
Denmark	Israel	Russia	Turkey
Finland	Italy	Saudi Arabia	Ukraine
France	Japan	Singapore	United Kingdom
			United States

Note: This table lists the source countries used in my analysis. Countries are ranked by the total number of importers from 2000 to 2006 and the top 40 are included. (Forty-one countries are included in the list due to a tie.)

log on both sides of the above equation

$$\log X_{ijt} - \log X_{iht} = \log S_{ijt} - \log S_{ht} + \epsilon^x_{ijt} \tag{C1}$$

where ϵ^x_{ijt} is some unobserved firm-country-year-specific shock, assumed to be mean independent of the countries' sourcing potential. This term can also be considered as measurement error in the observed values of imported input shares. The firm-country-year sourcing potential and shocks together are the residuals after regressing the dependent variable on a set of year fixed effects, which capture the time-varying domestic sourcing potential S_{ht}.[50] To get predicted values of S_{ijt}, I face two issues. First, it is impossible to separately identify $\log S_{ijt}$ from ϵ^x_{ijt}.[51] Second, the sparsity of the import data at the firm-country-year level means I cannot recover S_{ijt} for all possible pairs from equation C1.

To address these problems, I employ the definition of the firm-country-year-specific sourcing potential–i.e. $S_{ijt} = T_j(\tau^m_{ijt} w_{jt})^{-\theta}$–in combination with the information from equation C1 to recover the predicted values of the sourcing potential. Let $\hat{\lambda}_t$ denote the estimated domestic sourcing potential for each year t, and $\hat{\xi}_{ijt} = (\log X_{ijt} - \log X_{iht}) - \hat{\lambda}_t$ is the composite residual term from equation C1. I then regress that residual terms $\hat{\xi}_{ijt}$ on proxies for technology T_j, wage rates w_{jt}, and variable trade costs τ^m_{ijt}.

$$\hat{\xi}_{ijt} = \beta_0 + g(X^T_{jt}\beta^T) - \theta h(X^\tau_{ijt}\beta^\tau) - \theta \ln w_{jt} + \lambda_t + \nu_{ijt} \tag{C2}$$

[50] An implicit assumption to get unbiased estimates of $\log S_{ht}$ is that S_{ijt} is uncorrelated with S_{ht}.

[51] One can make a simplifying assumption that $S_{ijt} = S_{jt}$, meaning the sourcing potential is constant across firms. Nonetheless, under this approach we will be unable to separately identify those terms from the domestic sourcing potential S_{ht}, unless we further assume that S_{ht} is constant across time and normalize this term to unity. In addition, the ability of sourcing potential to vary at the firm-country-specific level is consistent with the data patterns in Table 2.

where X_{jt}^T is a set of technology proxies, including R&D expenditure and capital stock. X_{ijt}^{τ} is a set of controls to proxy for variable trade costs, which includes the firm's ownership type and size, distance, GDP, common language, contiguity, whether the country is landlocked, and GATT/WTO membership. g and h are two non-parametric functions to allow for flexible estimation of technology and trade costs. $\ln w_{jt}$ is the log of human capital-adjusted hourly wages.[52] In the final specification, I also include a set of years fixed effects, λ_t, to account for anytime time-varying factors that are common across firms that can influence the trade elasticity (θ).

By definition, the term ξ_{ijt} contains both the sourcing potential and the unobserved component– i.e., $\xi_{ijt} = \log S_{ijt} + \epsilon_{ijt}^x$. However, under the assumption that ϵ_{ijt}^x is uncorrelated with $\log S_{ijt}$, it will not bias the estimates of β^T, β^τ and θ, though it will increase standard errors.[53] As a result, I can recover the values of sourcing potential for each firm-country-year pair as the predicted values in equation C2.

The last component in the revenue change is θ, which is the coefficient on log wages in C2. Column 1 in table C1 reports the ordinary least squares results. In column 2, I follow AFT and instrument log wages with population to account for unobserved factors that are correlated with countries' productivity. The IV specification implies that θ is about 1.99. The estimated values of θ and σ confirm that input sources are complementary in production as in AFT.[54]

Table C1—: Predicting Sourcing Potential

	OLS (1)	IV (2)
log hourly wage	-0.28	-1.99
	(0.06)	(0.49)
log R&D	-0.04	0.65
	(0.05)	(0.20)
$\log k$	-0.002	0.005
	(0.0004)	(0.002)
Landlocked	-0.57	0.24
	(0.16)	(0.28)
GDP	0.07	0.26
	(0.01)	(0.06)
log distance	-0.69	-0.24
	(0.04)	(0.13)
Observations	9341	9341
Adjusted R^2	0.11	0.05

Note: This table reports regression results for equation C2 in Section IV. Column 1 shows OLS coefficients while column 2 shows results when the variable log hourly wage is instrumented by log population. Other variables are listed in the main text. Sample includes the top 40 popular source countries. Standard errors in parentheses.
Source: General Administration of Customs and National Bureau of Statistics

[52]See Appendix B.B1 for a detailed description of the construction of human-capital-adjusted wage rates.
[53]These terms can be interpreted as either measurement error or expectational errors. As long as firms do not observe the shocks before choosing a sourcing strategy, these terms will not bias our estimates in equation C2.
[54]$(\sigma - 1)/\theta = 1.52 > 1$.

C2. Alternative Procedure to Predict Sourcing Potential S_{ijt}

Instead of predicting S_{ijt} through two steps as described in Section IV, I propose a different procedure to back out S_{ijt} directly through the imported input share X_{ijt}/X_{iht}.

I maintain the assumption that $S_{iht} = S_{ht}$–i.e., the domestic sourcing potential is constant across firms but can vary across years. Additionally, S_{ht} is mean independent of S_{ijt}–i.e., $E(S_{ht}|S_{ijt}) = E(S_{ht})$. As before, I assume there may be a multiplicative measurement error in the share of imported input over total inputs X_{ijt}, denoted by ϵ^x_{ijt}. We can also assume there is a multiplicative measurement error in the share of domestic inputs X_{iht}. In that case ϵ^x_{ijt} is treated as the ratio of the two measurement errors.

$$\frac{X_{ijt}}{X_{iht}} = \frac{S_{ijt}}{S_{ht}}\epsilon^x_{ijt}$$

Next, suppose we run a linear regression of $\log X_{ijt} - \log X_{iht}$ on the set of independent variables in equation C2:

$$\log X_{ijt} - \log X_{iht} = \beta_0 + g(X^T_{jt}\beta^T) - \theta h(X^\tau_{ijt}\beta^\tau) - \theta \ln w_{jt} + \lambda_t \tag{C3}$$

Under the new specification, the estimated values of the year dummies λ_t will be reduced by $E(\log S_{ht})$, assuming $E(\log \epsilon^x_{ijt}) = 0$. If we restrict S_{ht} to be constant across time, then the constant coefficient β_0 is affected. In either case, other coefficient estimates should still be consistent, though the predicted values of $\log S_{ijt}$ will be biased by $E(\log S_{ht})$.

Because what we want to obtain is the predicted values for S_{ijt}, the log-linearized model may not be ideal as $\ln E(S_{ijt}) \neq E(\ln S_{ijt})$. For that reason, I run a Poisson regression

$$\frac{X_{ijt}}{X_{iht}} = \exp\left(\beta_0 + g(X^T_{jt}\beta^T) - \theta h(X^\tau_{ijt}\beta^\tau) - \theta \ln w_{jt} + \lambda_t\right) \tag{C4}$$

In principle, the Poisson regression allows us to include zeros on the left hand side. That said, recall the definition of sourcing potential: $S_{ijt} = T_j(\tau^m_{ijt}w_{jt})^{-\theta}$. This means $S_{ijt} = 0$ if either country-level technology, variable trade costs, or wages is 0. In practice, this scenario seems implausible that any of these terms is actually zero. For this reason, I exclude observations with zero imported inputs. Note that the Poisson regression is still subject to the previous issue with a predicted value of S_{ijt} being biased, now by a scale of $E(S_{ht})$.

Table C2 reports results for different methods of estimating country-level sourcing potential. The first two columns are the baseline results reported in Section IV. The next two columns report results for equation C3 under a log-linearized model. As expected, except for the year dummies

Table C2—: Robustness Check - Predicting S_{ijt}

	Residuals		log X_j/X_h		X_j/X_h	
	OLS	IV	OLS	IV	Poisson	IV Poisson
	(1)	(2)	(3)	(4)	(5)	(6)
log wages	-0.299	-1.985	-0.299	-1.985	0.0137	-0.596
	(0.0639)	(0.478)	(0.0639)	(0.478)	(0.0586)	(1.252)
R&D expenditure	-0.0332	0.643	-0.0332	0.643	-0.0505	0.262
	(0.0469)	(0.196)	(0.0469)	(0.196)	(0.0515)	(0.693)
$\log k$	-0.00168	0.00515	-0.00168	0.00515	0.000996	0.00335
	(0.000380)	(0.00196)	(0.000380)	(0.00196)	(0.000371)	(0.00529)
landlocked	-0.576	0.242	-0.576	0.242	-1.070	-0.793
	(0.161)	(0.284)	(0.161)	(0.284)	(0.274)	(0.580)
GDP	0.0692	0.255	0.0692	0.255	0.0257	0.0967
	(0.0145)	(0.0542)	(0.0145)	(0.0542)	(0.0156)	(0.159)
log distance	-0.683	-0.246	-0.683	-0.246	-0.459	-0.304
	(0.0448)	(0.131)	(0.0448)	(0.131)	(0.0421)	(0.346)
2001	0.0610	-0.117	0.152	-0.0263	-0.154	-0.250
	(0.142)	(0.155)	(0.142)	(0.155)	(0.143)	(0.394)
2002	0.0814	-0.200	0.0846	-0.196	0.241	0.0733
	(0.137)	(0.162)	(0.137)	(0.162)	(0.134)	(0.411)
2003	0.259	0.235	0.216	0.193	-0.0937	-0.169
	(0.133)	(0.137)	(0.133)	(0.137)	(0.137)	(0.427)
2004	0.177	0.0287	0.435	0.286	0.545	0.420
	(0.127)	(0.138)	(0.127)	(0.138)	(0.123)	(0.489)
2005	0.112	0.233	0.0916	0.213	-0.604	-0.650
	(0.130)	(0.138)	(0.130)	(0.138)	(0.141)	(0.382)
2006	0.254	0.449	0.361	0.556	0.102	0.0605
	(0.132)	(0.148)	(0.132)	(0.148)	(0.132)	(0.411)
Constant	5.413	4.956	0.287	-0.170	2.169	1.897
Observations	9341	9341	9341	9341	9341	9341
Adjusted R^2	0.114	0.047	0.115	0.049		
Pseudo R^2					0.117	

Note: This table provides estimation results for the country-level sourcing potential equation under different specifications. Columns 1 and 2 report the baseline results. Columns 3 and 4 report results for the log-linearized model with $\log(X_{ijt}/X_{iht})$ on the left hand side. Finally, columns 5 and 6 report the estimation results for a Poisson regression with X_{ijt}/X_{iht} as the dependent variable. The independent variables are the same in all regressions. In columns 2, 4, and 6, log population is used as IV for log wages. The last equation is estimated via generalized method of moments.

Standard errors in parentheses.

and constant term, the two sets of estimates are identical.

C3. Sample Selection and Potential Data Issues

Country list: Table B4 presents the list of all 40 countries included in the data. Though the firms in my sample imported from 96 countries, more than half of the countries had fewer than 20 importers during the sample period. To avoid sources with few observations, I included only the top 40 countries ranked by the number of importers. The main results are not affected by choosing a different cutoff point (see Figure C1).

Processing firms: In China, there is a dual trade regime: ordinary trade and processing trade.[55] Existing studies have documented that Chinese firms selecting into processing trade make different sourcing choices from those engaged in ordinary trade (Koopman, Wang and Wei, 2012; Manova and Yu, 2012; Jarreau and Poncet, 2012; Wang and Yu, 2012). Several reasons can explain the difference in sourcing behaviors. First, the latter regime exempts from import duties on foreign inputs used for further processing and assembling and re-exporting. Processing firms are not allowed to sell in the domestic market. Apart from the import duty exemptions, other policies favor pure exporters, such as the attraction of foreign-invested enterprises, the promotion of processing trade enterprises and the establishments of free-trade zones (Defever and Riaño, 2012). There are potentially differences in foreign contracts, capacity and credit constraints, and lack of input flexibility in the assembling process between processing and other firms. Furthermore, the lack of import duties incurred by these firms is problematic because variation in input tariffs is used as an IV for the analysis in Section V.A For these reasons, I exclude firms that engage in processing trade from the sample.

Trade intermediaries: Because I am matching firms in the NBS data with the customs data, I exclude transactions conducted by intermediaries.[56] However, some firms that are classified as non-importers in the data might import indirectly through trade intermediaries. Because the NBS data set does not report domestic firm-level transactions and import values, I cannot differentiate between non-importers and indirect importers.[57]

This misclassification can affect the sunk cost estimates in several ways. First, firms that use intermediaries may have more information about the foreign sourcing countries and thus pay a lower sunk cost to directly import in subsequent periods.At the same time, firms that have access to foreign inputs may enjoy higher future productivity. Both channels increase the likelihood of importing in subsequent periods conditional on using intermediaries.[58] Nonetheless, while the first one introduces an attenuation bias, the second channel creates an upward bias in the sunk cost estimate. It is, therefore, unclear which direction of the bias would be.

However, there are several reasons why this might not be a concern for my study. First, because I focus on country-specific sunk costs, the bias might not be severe if the countries from which firms indirectly import are not the same as those with which they directly trade. Second, I limit

[55]For more institutional background about trading regimes in China, see Manova and Yu (2012), Jarreau and Poncet (2012), Brandt and Morrow (2017), and Manova and Yu (2016).

[56]About 19.7% of firms in the customs data that exported chemical products between 2000 and 2006 are intermediaries. Those firms accounted for 24.7% of total import values.

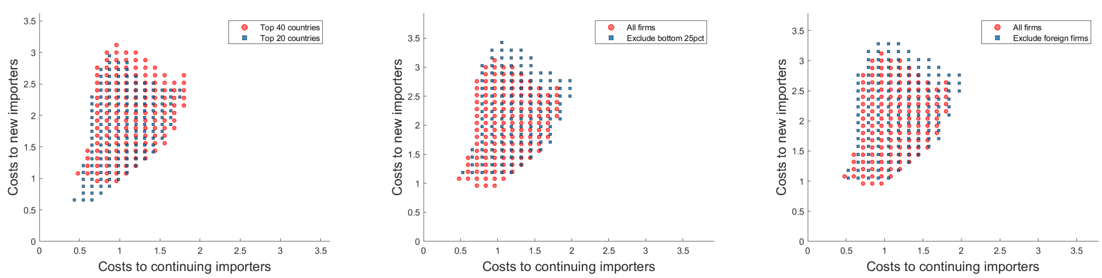
[57]Bai, Krishna and Ma (2017) are able to identify direct and indirect exporters based on the total export values reported in the NBS data–i.e., if a firm reports export values but does not appear in the customs data, it is classified as an indirect exporter. Since import values are not reported, I cannot use the same method to identify indirect importers.

[58]Ahn, Khandelwal and Wei (2011) find suggestive evidence that once small firms export indirectly by using intermediary services, they could switch to exporting directly.

the sample to those that imported at least once, meaning that the sample does not contain firms that only indirectly imported from 2000 to 2006. Yet some firms might indirectly import in the earlier years and then switch to direct importing later. To address this problem, I exploit the fact that intermediation is used mostly by small firms. For example, Ahn, Khandelwal and Wei (2011), Akerman (2018) and Blum, Claro and Horstmann (2010) show that smaller firms matched with intermediaries to avoid the cost of direct exporting. Thus, I conduct a robustness check that excludes firms with average sales in the bottom 25 percentiles. The new sunk cost estimate is slightly bigger, indicating that firms that use intermediaries may incur small costs of directly importing later. However, the difference in the two estimates is negligible.

Intra-firm trade: Foreign firms in China might import from their parent countries and thus do not pay the full sunk cost of importing. Though I do not observe the foreign suppliers and cannot identify whether a firm is purchasing from its parent company, I conduct a robustness check that excludes foreign firms from the main analysis. As expected, the sunk cost estimate is bigger, but not by a large extent.

Figure C1. : Robustness Checks - Sample Selection



(a) Top 20 countries (b) Exclude small firms (c) Exclude foreign firms

Note: This figure illustrates the 95% confidence sets of the total costs to continuing versus new importers for different samples. The baseline result is presented by the red region. Panel a reports estimates for the top 20 countries, panel b reports estimates when small firms are excluded from the sample, and panel (c) reports results when foreign firms are excluded. Monetary values are in million of 1998 RMB.

Additional Tables and Figures

Table D1—: Productivity Gain - First Stage

	# countries			# advanced-tech countries			# high-income countries		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
L.Input tariffs	0.0706	-0.0290	-0.729	0.0691	-0.0285	-0.709	0.0580	-0.0222	-0.591
	(0.00918)	(0.00585)	(0.121)	(0.00883)	(0.00565)	(0.111)	(0.00695)	(0.00444)	(0.0954)
L.Input tariffs ×1(≥ med size)		0.145			0.142			0.116	
		(0.0110)			(0.0107)			(0.00839)	
L.Input tariffs × initial size			0.283			0.276			0.231
			(0.0428)			(0.0392)			(0.0332)
Log sourcing capacity	6.837	5.672	30.52	6.710	5.593	30.02	4.806	3.966	21.34
	(0.338)	(0.357)	(1.612)	(0.338)	(0.357)	(1.611)	(0.271)	(0.271)	(1.259)
# export markets	-0.00313	-0.00134	-0.0103	-0.00353	-0.00157	-0.0116	-0.00539	-0.00331	-0.0208
	(0.00249)	(0.00243)	(0.0114)	(0.00241)	(0.00236)	(0.0111)	(0.00209)	(0.00200)	(0.00959)
Foreign affiliated	0.383	0.138	1.335	0.380	0.136	1.322	0.395	0.163	1.412
	(0.0455)	(0.0410)	(0.196)	(0.0444)	(0.0400)	(0.191)	(0.0381)	(0.0334)	(0.163)
State owned	0.0956	0.0393	0.320	0.0970	0.0435	0.332	0.0872	0.0420	0.299
	(0.0496)	(0.0477)	(0.222)	(0.0482)	(0.0463)	(0.215)	(0.0413)	(0.0397)	(0.186)
Initial size	0.229	0.0826	0.00354	0.229	0.0827	0.0270	0.199	0.0829	0.0593
	(0.0241)	(0.0276)	(0.206)	(0.0236)	(0.0275)	(0.192)	(0.0209)	(0.0221)	(0.161)
year=2002	-0.562	-0.538	-2.623	-0.549	-0.526	-2.563	-0.405	-0.384	-1.885
	(0.103)	(0.0976)	(0.454)	(0.101)	(0.0958)	(0.444)	(0.0860)	(0.0790)	(0.377)
year=2003	-0.556	-0.598	-2.627	-0.552	-0.587	-2.605	-0.377	-0.417	-1.788
	(0.110)	(0.101)	(0.477)	(0.108)	(0.100)	(0.471)	(0.0922)	(0.0827)	(0.400)
year=2004	1.253	0.994	5.599	1.228	0.982	5.505	0.888	0.694	3.935
	(0.103)	(0.100)	(0.469)	(0.101)	(0.0981)	(0.459)	(0.0852)	(0.0808)	(0.385)
year=2005	-0.258	-0.284	-1.174	-0.261	-0.285	-1.190	-0.163	-0.189	-0.758
	(0.102)	(0.0954)	(0.445)	(0.100)	(0.0939)	(0.438)	(0.0841)	(0.0768)	(0.366)
year=2006	0.609	0.393	2.634	0.589	0.382	2.555	0.441	0.275	1.893
	(0.0972)	(0.0896)	(0.428)	(0.0948)	(0.0871)	(0.417)	(0.0801)	(0.0726)	(0.353)
Constant	-35.67	-29.10	-155.6	-35.01	-28.69	-153.1	-25.21	-20.42	-109.0
	(1.689)	(1.796)	(8.239)	(1.686)	(1.795)	(8.202)	(1.353)	(1.364)	(6.419)
Observations	4943	4943	4943	4943	4943	4943	4943	4943	4943
R-squared	0.461	0.452	0.484	0.462	0.454	0.485	0.390	0.397	0.419
F-statistic	102.8	76.81	83.15	101.5	75.98	81.95	87.33	66.28	71.95

Note: This table provides results on the first-stage estimation in Table 10. Standard errors in parentheses.

Table D2—: Productivity Gain - OLS

	# countries			# advanced-tech countries			# high-income countries		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
L.import	0.0179	0.0252	0.0442	0.0180	0.0256	0.0446	0.0184	0.0259	0.0428
	(0.00369)	(0.00689)	(0.0149)	(0.00375)	(0.00718)	(0.0154)	(0.00397)	(0.00749)	(0.0163)
L.import $\times$ $\times 1(\geq$ med size)		-0.00980			-0.0102			-0.0104	
		(0.00661)			(0.00686)			(0.00743)	
L.import $\times$ initial size			-0.00612			-0.00620			-0.00575
			(0.00305)			(0.00315)			(0.00339)
Log sourcing capacity	-0.0829	-0.0766	-0.0746	-0.0811	-0.0745	-0.0724	-0.0488	-0.0429	-0.0421
	(0.0467)	(0.0460)	(0.0459)	(0.0466)	(0.0459)	(0.0459)	(0.0423)	(0.0419)	(0.0417)
# export markets	0.00376	0.00377	0.00376	0.00377	0.00378	0.00377	0.00381	0.00382	0.00381
	(0.000513)	(0.000513)	(0.000513)	(0.000514)	(0.000513)	(0.000513)	(0.000514)	(0.000514)	(0.000514)
Foreign affiliated	-0.00952	-0.0117	-0.0122	-0.00947	-0.0118	-0.0122	-0.00976	-0.0117	-0.0119
	(0.0103)	(0.0105)	(0.0105)	(0.0103)	(0.0105)	(0.0105)	(0.0104)	(0.0105)	(0.0105)
State owned	0.00925	0.00873	0.00820	0.00924	0.00872	0.00821	0.00949	0.00910	0.00871
	(0.0146)	(0.0146)	(0.0147)	(0.0146)	(0.0146)	(0.0147)	(0.0146)	(0.0146)	(0.0147)
Initial size	0.980	0.982	0.983	0.980	0.982	0.983	0.980	0.982	0.983
	(0.00538)	(0.00562)	(0.00575)	(0.00539)	(0.00562)	(0.00575)	(0.00537)	(0.00562)	(0.00574)
year=2002	0.0710	0.0699	0.0697	0.0707	0.0697	0.0695	0.0681	0.0672	0.0671
	(0.0212)	(0.0212)	(0.0212)	(0.0212)	(0.0212)	(0.0212)	(0.0212)	(0.0212)	(0.0212)
year=2003	0.183	0.181	0.181	0.183	0.181	0.181	0.180	0.178	0.178
	(0.0203)	(0.0202)	(0.0202)	(0.0203)	(0.0202)	(0.0202)	(0.0202)	(0.0201)	(0.0201)
year=2004	0.217	0.218	0.218	0.217	0.218	0.219	0.222	0.223	0.223
	(0.0207)	(0.0207)	(0.0207)	(0.0207)	(0.0207)	(0.0207)	(0.0204)	(0.0204)	(0.0204)
year=2005	0.425	0.424	0.424	0.425	0.424	0.424	0.423	0.422	0.422
	(0.0192)	(0.0192)	(0.0192)	(0.0192)	(0.0192)	(0.0192)	(0.0192)	(0.0192)	(0.0192)
year=2006	0.578	0.577	0.577	0.578	0.577	0.578	0.580	0.580	0.580
	(0.0208)	(0.0208)	(0.0208)	(0.0208)	(0.0208)	(0.0208)	(0.0208)	(0.0207)	(0.0208)
Constant	0.470	0.430	0.416	0.461	0.419	0.405	0.296	0.259	0.252
	(0.238)	(0.235)	(0.234)	(0.238)	(0.234)	(0.234)	(0.215)	(0.214)	(0.213)
Observations	4943	4943	4943	4943	4943	4943	4943	4943	4943
Adjusted R^2	0.910	0.910	0.910	0.910	0.910	0.910	0.910	0.910	0.910

Note: This table provides OLS estimates on the effect of past import decisions on current revenues. See Table 10 for IV estimates.

Standard errors in parentheses.

Table D3—: Predicting Export Revenues

Dep. variable	Export revenues
log domestic revenues	0.18
	(0.00007)
Export to other markets	-28.89
	(608.5)
Landlocked	-0.29
	(0.001)
GDP	0.11
	(0.00003)
GATT/WTO member=1	0.29
	(0.001)
log distance	-0.23
	(0.0001)
Constant	6.41
	(0.002)
Observations	43598
Pseudo R^2	0.15

Note: This table reports the PPML regression results of export revenues. The independent variables include log of domestic revenues, ownership types, whether firms export to other markets, destination characteristics such as distance, GDP, landlocked, and GATT/WTO membership, and a set of year dummies. Standard errors in parentheses.
Source: General Administration of Customs.and National Bureau of Statistics

Table D4—: Descriptive Statistics

	All	Never	Exiting	New	Continuing
# advanced tech countries	2.181	1.017	2.691	5.547	6.787
	(3.460)	(1.974)	(3.105)	(4.254)	(4.597)
# high income countries	1.717	0.816	2.148	4.269	5.291
	(2.771)	(1.653)	(2.532)	(3.343)	(3.780)
# import countries	2.243	1.049	2.774	5.696	6.979
	(3.577)	(2.046)	(3.218)	(4.383)	(4.843)
Observations	42998	31128	615	4612	4312

Note: This table reports the number of advanced technology countries, high income countries, and total number of countries from which an average firm imports. Definitions for advanced-technology countries are provided in Appendix B.B1. Standard errors in parentheses.
Source: General Administration of Customs and National Bureau of Statistics

Derivation of Equation 8

From equation 7 and the definition of $\Theta_{it}(\mathcal{J}_{it}^m)$, the firm's revenue when we add country j ($j \notin \mathcal{J}_{it}^m$) is

$$r_{iht}(\mathcal{J}_{it}^m \cup j) = \left[\frac{\sigma}{\sigma-1}\frac{1}{\varphi_{it}P_{ht}}\right]^{1-\sigma} Y_{ht}\left[\gamma\left(\sum_{k\in\mathcal{J}_{it}^m} S_{ikt} + S_{ijt}\right)\right]^{\frac{\sigma-1}{\theta}}$$

The marginal revenue of country j to firm i at the set $\mathcal{J}_{it}^m$, for $j \notin \mathcal{J}_{it}^m$, is then

$$\begin{aligned} r_{ijt}^m(\mathcal{J}_{it}^m) &\equiv r_{iht}(\mathcal{J}_{it}^m \cup j) - r_{iht}(\mathcal{J}_{it}^m) \\ &= r_{iht}(\mathcal{J}_{it}^m)\Big(r_{iht}(\mathcal{J}_{it}^m \cup j)/r_{iht}(\mathcal{J}_{it}^m)\Big) - r_{iht}(\mathcal{J}_{it}^m) \\ &= r_{iht}(\mathcal{J}_{it}^m)\Big((\sum_{k\in\mathcal{J}_{it}^m} S_{ikt} + S_{ijt})/(\sum_{k\in\mathcal{J}_{it}^m} S_{ikt})\Big)^{\frac{\sigma-1}{\theta}} - r_{iht}(\mathcal{J}_{it}^m) \\ &= \Bigg[\Big((\sum_{k\in\mathcal{J}_{it}^m} S_{ikt} + S_{ijt})/(\sum_{k\in\mathcal{J}_{it}^m} S_{ikt})\Big)^{\frac{\sigma-1}{\theta}} - 1\Bigg] r_{iht}(\mathcal{J}_{it}^m) \end{aligned}$$

The derivations for $r_{ijt}^m(\mathcal{J}_{it}^m)$ when $j \in \mathcal{J}_{it}^m$ are similar.

*

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