

Import Sourcing of Chinese Cities: Order versus Randomness*

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Abstract

We utilize very detailed import information for Chinese cities to assess the empirical validity of prominent trade models. Ricardian comparative advantage, Armington love of variety, and heterogenous firm models predict that all importing cities within a province will purchase a good from the leading foreign source of that good in the province. Using narrowly defined product information, we show that only 65% of cities import from the top source. A model of random sourcing goes part way in explaining the data. Importing firms' orientations towards particular source countries also appear to have a significant impact on the sourcing decisions of cities.

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1 Introduction

Standard trade models make stark predictions about the number of countries from which a country should source goods. Ricardian comparative advantage implies that the low-cost supplier of a product should be the only supplier to that market (single sourcing). On the other hand, in models that assume a love for country-specific varieties (the Armington assumption), and only variable exporting costs, we expect each market to buy from all sources (universal sourcing). More recent models incorporating love of variety, heterogeneous firms, and fixed costs predict sourcing from a subset of supplying countries (partial sourcing).

This paper investigates the extent to which the sourcing decisions of Chinese cities correspond to predictions of different models of trade. In addition to identifying the predictions of the Ricardian comparative advantage and love of variety trade models, we develop a random model and calculate an expected sourcing outcome. We use very detailed import data for Chinese cities to test model predictions. We document that the incidence of single sourcing by cities is rare, even for goods classified as homogeneous. Universal sourcing is also extremely uncommon, even for differentiated goods.

Based on observed import patterns, we model cities as importing through a provincial transportation hub. Our analysis establishes that prominent heterogeneous firm models predict a hierarchy of export sources: All cities that import a variety of a good from a given source country will also buy from sources of lower cost varieties that are available at the provincial hub. An implication of the hierarchy is that all cities import from the source offering the lowest cost variety. This prediction also emerges in a model featuring love of variety, the Armington assumption, and no fixed costs as well as a model with Ricardian comparative advantage. In our random model, the country revealed to host the lowest cost firm is the most likely to be randomly selected but with a probability less than one.

The data strongly reject the proposition that all cities source from a most efficient supplying country, thereby providing support for the random sourcing model. However, we also show that cities have different orientations towards specific sources that lead to systematic deviations from the predictions of the random model. We provide evidence suggesting that city orientation relates to multinational production networks.

Researchers have demonstrated that prominent trade models lead to essentially the same gravity-like equations for aggregate bilateral trade. Eaton and Kortum (2002) show that a gravity equation emerges in a Ricardian

model with Frechet-distributed international heterogeneity in productivity. Anderson and Wincoop (2003) construct a symmetric gravity equation under the Armington assumption and CES love of variety. Chaney (2008) derives his formulation using monopolistic competition between firms with Pareto-distributed productivity. Therefore, research must rely on evidence beyond predictions about aggregate bilateral trade in order to distinguish trade models.

The value of testing trade models may be questioned in light of the Arkolakis et al. (2009) finding that the Ricardian, Armington, and heterogeneous firm models share a common formula for the gains from trade. We believe that there are three reasons why it is important to distinguish between the models. First, testing predictions of competing models is a fundamental part of the scientific process. Second, the mechanisms through which trade liberalization can raise welfare (price reductions, new varieties, reallocation between firms) are model-specific. If we are to measure gains directly rather than just inferring them from import penetrations, we need to know which mechanisms to focus on. Finally, the random model which does the best job of explaining China's import sourcing patterns features heterogeneity in the preferences of importing firms. This violation of the Arkolakis et al. (2009) representative consumer assumption may lead to different welfare implications.

Recent research identifies and tests hierarchy predictions about the export of products to different destinations. Bernard et al. (2009) argue that firms should always ship their strongest products to the destinations where they sell their weaker products but report that the incidence of this is only 67% for US exporters. Eaton et al. (2008) determine that only 52% of French exporters sell to the most popular export market (Belgium), a violation of the proposition that if a product is profitable in one market, it should also be profitable in a more popular market.¹ Bernard et al. (2009) model firms producing different products and thus their hierarchy test implicitly assumes a hierarchy across products. However, product hierarchy may not obtain if the supply and demand for products vary across destinations. Different product market conditions may also lead to violations in the hierarchy tests of Eaton et al. (2008) if firms exporting to Belgium sell different products than those exporting to less popular markets. Our analysis focuses on a hierarchy of varieties within narrow product categories.² Source countries

¹Additional tests evaluating the sets of export destinations indicate more compliance with hierarchy than random entry into export markets based on entry probabilities constructed from overall entry rates.

²Crozet et al. (2009) examine a single narrowly defined good, Champagne. They show

produce different varieties and we evaluate the hierarchy of sources.

Observed departures from hierarchy motivate Eaton et al. (2008) and Bernard et al. (2009) to incorporate source-destination effects into trade models with heterogeneous firms. Source-destination effects suggest random sourcing as an alternative to deterministic models.³ We employ a “balls-and-bins” approach along the lines of Armenter and Koren (2010). Balls are shipments that randomly fall into bins of different sizes depending on the source country. We establish the microeconomic underpinnings of the approach by adapting the random utility model to the context of city sourcing patterns. While the random model with independent shipments has considerable explanatory power in explaining compliance with the hierarchy, we find that allowing shipments to be correlated within firms and oriented towards particular source countries provides a better fit to the data.

Our paper makes a number of contributions to the literature. First, we measure the extent to which key predictions of the Ricardian comparative advantage model and love of variety models (with and without fixed costs) hold using very disaggregated product and geographic information. We also add to research examining hierarchical predictions of trade models by utilizing very disaggregated product information to assess hierarchies in the varieties imported by cities. We propose a simple statistic for evaluating hierarchy compliance and provide a benchmark given by the expected value in a random model. Finally, we document the importance of firm orientation in explaining the pattern of import sourcing.

The next section provides theoretical background for the predictions we examine. Section 3 describes the extent of single and universal sourcing of disaggregated products in Chinese cities and how that varies across good types. Partial sourcing is the most prevalent sourcing pattern, a finding consistent with hierarchy models. However, the probability that a city imports from the top provincial source lies well below one, the value predicted by both the Ricardian comparative advantage and love of variety models. We present a random sourcing model in Section 4 and demonstrate that it provides a reasonable fit to the data. Section 5 reveals that a correlated choice model where firms in cities are oriented towards certain source countries can improve the fit of the random model. The final section summarizes the results and discusses their implications.

that export patterns deviate systematically from the hierarchy prediction of Melitz-based models: The highest quality producers frequently fail to export to markets that are served by lower quality firms.

³Crozet et al. (2009) also specify a random alternative to hierarchical market entry.

2 Theoretical background

Two main approaches have guided theoretical and empirical research in international trade in recent years. The first, based on Ricardian comparative advantage, has been generalized by Eaton and Kortum (2002) to a multi-country, multi-product setting that incorporates trade costs. The second approach, introduced by Krugman (1979) stipulates that consumers love variety. In Krugman’s models, varieties are associated with firms rather than countries. Feenstra (1994) helped launch a literature reintroducing the Armington (1969) assumption that consumers view products from different countries as different varieties. Paraphrasing Broda and Weinstein (2006), sparkling wine is a product, but sparkling wine from France (i.e. Champagne) is a variety. Given their love of variety, consumers are not satisfied by low prices; they also want to buy the different varieties offered by each supplying country. The more recent heterogeneous firm models of trade assume love of variety and generate partial sourcing and hierarchies of exporters and import destinations. In following subsections we outline the predictions of these prominent models of trade for micro-level sourcing decisions.

2.1 Ricardian comparative advantage

In the Ricardian model, generalized to a multi-country model with a continuum of goods by Eaton and Kortum (2002), product characteristics are independent of the country of origin. Hence for each narrowly defined product, a consumer chooses the source country that offers the product at the lowest cost. We specify the delivered cost from source s to destination d as

$$C_{sd} = \tau_{sd}c_s a_s,$$

where τ_{sd} captures trade costs, c_s is the cost of a bundle of inputs, and a_s is unit factor requirements. Assuming that the low-cost country supplies the product elastically, the low cost supplier should take the whole market. Since C_{sd} incorporates transport costs, it is possible that a geographically dispersed country with several neighbors will have the low-cost source for a good vary by region within the importing country. This would result in imports from multiple sources even though each consumption destination within the country buys from a single source country. Panel (a) in Figure 1 portrays three destinations that single source and how this pattern of imports appears to be multisourcing in geographically aggregated data.

The key prediction of the Ricardian model is that within narrowly defined geographic regions and products, imports should be observed from a single source country. Our data seem well-suited to testing this prediction because we have products defined at the 8-digit level and our geography is cities within relatively small provinces.

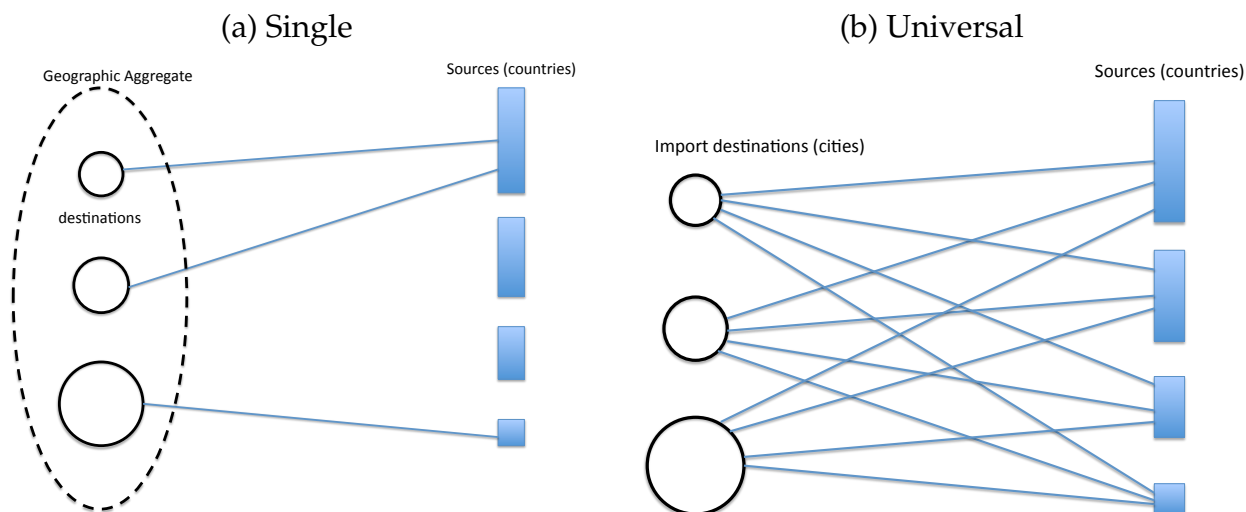


Figure 1: Sourcing in the Ricardian and Armington models

2.2 Armington love of variety

Armington (1969) argued that “products are distinguished not only by their kind—e.g. machinery, chemicals—but also by their place of production.” Armington went on to specify demands for these national varieties using a constant elasticity of substitution. This functional form implies that no matter what the relative prices are, consumers want to purchase from all available sources, rather than just those from the low-cost supplier. In the case of China, most imports are intermediate inputs and capital goods where the importer will not usually be the end-user of the imports. In these cases, love-of-variety is a feature of the production function emphasized by Ethier (1982).

The Armington model generates the “universal sourcing” pattern portrayed in panel (b) in Figure 1. China should buy each good from all the countries that export that good. Within China, cities comprising consumers with Armington preferences should also buy from all countries. However,

the amounts consumed from each source depend on the preference parameter for that country's goods as well as the relative prices of each supply country.

The basic Armington model has the opposite empirical problem of the Ricardian model. Whereas the Ricardian model predicts single sourcing and there only has a hope of working well on very disaggregated data (narrow product classifications and geographies), the Armington model predicts universal sourcing and therefore can be expected to fit better with highly aggregated data. Haveman and Hummels (2004) point out that even at the SITC4 level of product detail, zero bilateral trade flows are extremely common: "...in 99.4% of the cases fewer than half the available varieties [are] purchased...in *none* of the 75,774 cases does an importer avail itself of all varieties."

2.3 Hierarchies of heterogeneous firms

A class of heterogeneous firm models of trade predicts hierarchies of suppliers and destinations in terms of popularity. In these models, the best firms are able to sell profitably in all destinations and the most attractive destinations purchase from all suppliers. These models generally rely upon some form of monopolistic competition in which each supplier offers a differentiated variety. Destination hierarchies exist when a variety sold to the $(d + 1)$ th most popular destination also sells to the d th most popular destination.⁴ Source hierarchies occur when a destination that imports from the $(s + 1)$ th most popular source also buys from the s th most popular source.

Hierarchies appear in popular heterogeneous-firm trade models in which varieties of goods can be ordered according to single firm-specific variable. That variable could be productivity or quality. It can also be a composite of several underlying factors. Here we model the firm variable as quality-adjusted delivered unit costs to a specific market. The second key ingredient of hierarchy models is that not all varieties are sold in every market. Varieties are not sold if they are priced above the level that chokes off all demand or if the destination market is sufficiently small and/or competitive such that some firms cannot cover the fixed costs of entering the export market. These destination hierarchies obtain because if low-cost varieties that are profitably exported into "tough" (small, distant, and/or competitive) markets, then they will also be profitably exported into "easy" (large, nearby, and/or uncompetitive) markets. Similarly, source hierarchies arise because

⁴This definition corresponds to that in Eaton et al. (2008) (page 6).

if a variety from one source country is offered to a particular destination, a variety from a lower cost source will also be offered to that destination.

In models with heterogenous firms linked to varieties, CES preferences and love of variety, consumers purchase all available varieties but producers only export if operating profits exceed the fixed costs of exporting to a destination. In a continuum of firms (varieties) framework, costs cannot be too low or else there will be firms in every country that profitably export to all destinations and universal sourcing (destinations purchase from all source countries) obtains. Eaton and Kortum (2010) substitute an integer number of firms for the assumptions of a continuum of firms and an upper support for the productivity draw to generate zero trade flows between some countries. Melitz and Ottaviano (2008) do not assume fixed costs but their linear demand model yields hierarchy because marginal costs of some varieties exceed the “choke” price where demand is zero. Hierarchy will not occur in models where idiosyncratic variety-destination effects cause varieties to be ranked differently by different destinations.

We formalize the conditions under which hierarchical relationships are predicted to occur. Our framework involves a precise destination d located within a larger jurisdiction that we denote with upper case D . In the empirical work the d are cities and the D are provinces or province-level municipalities (such as Shanghai). All variables are good-specific but we suppress the good g subscripts for now.

Maintaining the notation of Helpman et al. (2008), a_i denotes the number of bundles used per unit of output by firm i , c_s measures the cost of each input bundle in source country s , and τ_{sd} represents an iceberg form transport cost from source s to destination d . Exporter i from s will therefore have delivered unit costs to market d given by $C_{sd}^i = \tau_{sd}c_s a_i$. We choose units such that c_s measures quality-adjusted costs. Thus, differences in the Armington source-country preference parameters are built into C_{sd}^i .⁵

We employ a hub and spoke model for transportation costs from s to d . All goods from s flow to a common point, the hub, in the destination province D and then travel to individual cities via the spokes. The hub could be a large seaport, a regional airport, or a geographical feature such the mouth of the Yangtze river. The key assumption is that no source country has a “short cut” it can take to reach the final destination. Our assumption that goods flow through the provincial hub is very consistent with our

⁵Suppose all consumers in all d in region D assign a common preference parameter β_{sD} to each *physical* unit of production from source s , then C_{sd}^i is given by the marginal cost of a physical unit divided by β_{sD} .

data. Defining the provincial hub at the province-good level as the port that shipments most frequently flow through, we calculate that 87.0% of shipments flow through the hub. The provincial hub is the only entry point for 78.8% of city-good combinations.⁶ For the remaining 21.2% cities that import a good through multiple ports or a single port other than the hub, 77.4% of their imports enter through the provincial hub. Finally, in 59.4% of the cases, the provincial hub accounts for 100% of a province's imports of a good.

Under a hub and spoke system, the iceberg trade cost factor can be expressed as $\tau_{sd} = T_{sD}t_{Dd}$.⁷ Now C_{sd}^i can be expressed as the product of the costs of reaching province D 's hub ($C_{sD}^i = c_s a_i T_{sD}$) and the cost of transporting the good from the hub to city d (t_{Dd}).

The profits of a firm i with unit input requirement a_i selling to city d in province D are given by variable profits minus fixed costs, F_{sd} . Variable profits are a function, $V()$, of delivered unit costs ($C_{sD}^i t_{Dd}$) and a destination demand shifter (Y_d). Thus, profits net of fixed costs are given by

$$\pi_{sd}^i = V(C_{sD}^i t_{Dd}, Y_d) - F_{sd}, \quad (1)$$

where the partial derivative of the first argument of $V()$ is negative and that of the second argument is positive.

Hierarchy predictions require that we solve for a threshold cost level \tilde{C}_d such that $\pi_{sd}^i < 0$ for all i such that $C_{sD}^i > \tilde{C}_d$. This condition implies that a firm i that is good enough to enter market d with \tilde{C}_d will also be good enough to enter every other market, d' , with $\tilde{C}_{d'} > \tilde{C}_d$. To obtain a closed form for \tilde{C}_d we employ more of the structure from Helpman et al. (2008).⁸ Variable profits are given by $\lambda [C_{sD}^i t_{Dd}]^{1-\epsilon} Y_d P_d^{\epsilon-1}$, where ϵ is the elasticity of substitution, Y_d is expenditure on all varieties, P_d is the price index, and $\lambda \equiv \epsilon^{-\epsilon} (\epsilon - 1)^{\epsilon-1}$.

We depart from Helpman et al. (2008) by imposing more structure on the fixed costs of serving each market. In particular, we assume that f_d input

⁶These cities account for 47.2% of shipments, indicating that they tend to have fewer shipments than cities that buy goods through multiple hubs.

⁷Suppose a fraction δ_{sD} of production "melts" on the way to the hub, and of the remaining goods, a further fraction δ_{Dd} melts along the spoke. To deliver one unit to the final destination therefore requires production of $1/[(1-\delta_{sD})(1-\delta_{Dd})]$ units. Thus $T_{sD} = 1/(1-\delta_{sD})$ and $t_{Dd} = 1/(1-\delta_{Dd})$.

⁸While we have not undertaken a full exploration of the necessary conditions for hierarchical sourcing, we believe it would arise in other single-dimension heterogeneous firm models such as Melitz and Ottaviano (2008)

bundles are required as fixed costs to support positive levels of exporting.⁹ Each fixed cost bundle combines inputs from the home country and inputs from the destination market according to a Cobb-Douglas form with share parameter α . We assume that the same home factor prices, c_s , and unit factor requirements, a_i , that govern production costs also apply to fixed costs. The destination-level factor costs are denoted w_d . To avoid excess notation, we also assume that the cost of supplying factor services from home country s remotely in d is governed by the same trade costs, τ_{sd} , that apply to shipments of goods. Taking these assumptions together we obtain

$$F_{sd} = f_d(C_{sD}^i t_{Dd})^\alpha w_d^{1-\alpha}. \quad (2)$$

The key feature of this specification is that fixed costs are multiplicative in a factor that is sD -specific and a factor that is d -specific.¹⁰ It admits the case where fixed costs are independent of s as assumed by Melitz (2003) and Helpman et al. (2004) (when $\alpha = 0$). Substituting the variable and fixed costs formulas into equation (1) we obtain

$$\pi_{sd}^i = \lambda [C_{sD}^i t_{Dd}]^{1-\epsilon} Y_d P_d^{\epsilon-1} - f_d(C_{sD}^i t_{Dd})^\alpha w_d^{1-\alpha}. \quad (3)$$

We focus on sourcing outcomes of the set of cities in a particular Chinese province and drop the D subscript. Setting equation (3) equal to zero and solving for costs determines the critical level of delivered unit costs, \tilde{C}_{sd} , where profits of serving a particular city d equal zero:

$$\tilde{C}_d = \frac{1}{t_d} \left[\frac{\lambda Y_d P_d^{\epsilon-1}}{f_d w_d^{1-\alpha}} \right]^{\frac{1}{\alpha+\epsilon-1}} \quad (4)$$

The critical cost level for exporting to city d depends only on d -specific attributes. In particular \tilde{C}_d is increasing in the demand shifter Y_d and the price index P_d but decreasing in local wages and the transport costs from the provincial hub. Based on these characteristics we can order destinations within a province from easiest (highest \tilde{C}_d) to toughest (lowest \tilde{C}_d). The basic idea of hierarchical sourcing is that a supplier that is efficient enough to export to a tough destination, will export to all easier destinations. We can therefore infer the most efficient supplier by counting the number of markets to which it exports.

⁹Variance in f_d across cities might arise due to differences in city size or economic development.

¹⁰Arkolakis (JPE, forthcoming) appears to be the first to introduce the assumption that fixed “marketing” costs are Cobb-Douglas in home and foreign labour.

The key conditions required to generate hierarchy are that the profit function is decreasing in costs, C_{sD}^i , the hub and spoke nature of trade costs, and the separable form for fixed costs.¹¹ The latter two assumptions allow for separating the s -specific and d -specific terms. Without them, the threshold cost for entering a market could depend on s characteristics, leading to breakdown of hierarchical ordering. For example, if a source country had an advantage over its rivals in serving market d but that advantage did not apply to the other markets, then it could export to a market that appeared to be hard but fail to export to easier markets.

Lacking data on the individual firms who export to city d we focus on which source countries supply which destination cities. To determine whether source s sells to a city in province D , it is sufficient to focus on whether it is profitable for the most productive firm in s to sell there. For each s , therefore, we define the delivered unit costs to province D 's hub of the most profitable (lowest cost) firm in each s as C_{sD}^L . Therefore, source s sells to city d if $C_{sD}^L \leq \tilde{C}_d$.

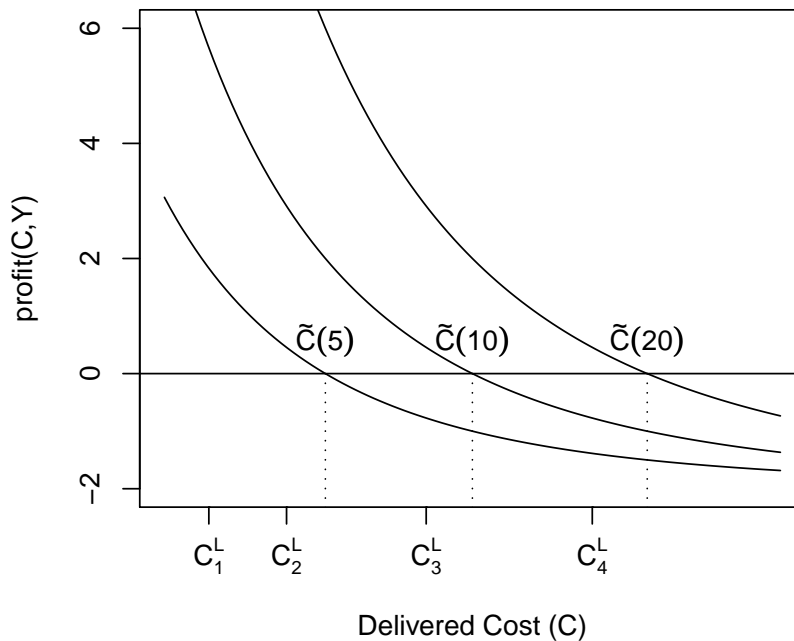


Figure 2: Hierarchy

¹¹The Cobb-Douglas form is not necessary: a fixed cost function that sums s and d terms would also work.

Figure 2 depicts hierarchy. The vertical axis shows profits and the horizontal axis shows delivered unit costs C_s to a specific province, D . The figure also displays the profit schedules for three cities located in the province with different market conditions, represented by d -specific terms set equal to 5, 10, or 20. The intersection of each profit schedule and the horizontal zero line identifies the critical level of costs that generate zero profits to that particular destination, \tilde{C}_s . The figure also identifies the lowest cost firm, C_s^L , in source countries 1, 2, 3 and 4. The figure shows that the largest destination imports from all four source countries because $\tilde{C}_s(20) > C_i^L$ for $i=1,2,3,4$. Smaller markets import from fewer sources. We observe source hierarchy: All destinations that import from the lowest-cost source country and if a destination imports from the the $(s+1)$ th most popular source, it also sources from the s th most popular source. Destination hierarchy is also evident: If a source finds it profitable to sell to $(d+1)$ th the most popular destination in terms of the number of sources that sell there, it also sells to the d th most popular destination.

3 Empirical evidence

The Ricardian comparative advantage model predicts that goods should be single-sourced. The Armington love of variety model predicts universal sourcing whereas heterogeneous-firm models can lead to partial sourcing and hierarchies. We examine the predictions of the models using data on import transactions collected by the Chinese Customs Office for 2006. On a monthly basis, we observe each firm's imports by detailed product classification (cn8 level), origin country, port of entry, and destination city in China.¹²

Table 1 lists information on China's top 20 imported products according to value. We show the 2006 import value, the number of source countries (#Src), the system of national accounts (SNA) categorization of products (as intermediate, capital, or consumption), the Rauch (1999) classification of differentiated (Dif), reference price (Ref), or organized exchange (Org), and the detailed product description.¹³ Eight-digit product classifications are quite detailed: the table shows five separate CN8 categories for integrated

¹²The harmonized system establishes harmonized classifications out to six digits. Thus, the first six digits in the CN8 correspond to the harmonized system. The last two digits are China-specific classifications.

¹³Details on how we attached SNA and Rauch classifications to our data are contained in Appendix A.

Table 1: Top Products, 2006

CN8	\$bil	#Src	SNA	Rauch	Description
27090000	66.4	46	Int	Org	Petroleum oils (crude)
85422119	39.5	64	Int	Dif	Mon. integ. circuits, digital, $\leq 0.18 \mu\text{m}$
90138030	25.8	47	Cap	Dif	Liquid crystal display panels
85422900	15.7	82	Int	Dif	Monolithic integrated circuits, not digital
85422129	12.2	65	Int	Dif	Mon. int. circ., dig., $0.18 < \text{wid.} \leq 0.35 \mu\text{m}$
26011120	11.8	27	Int	Org	Iron ores and concentrates, non-agglomerated
85422199	10.5	69	Int	Dif	Mon. integ. circuits, dig., $> 0.35 \mu\text{m}$
27101922	9.0	27		Dif	Fuel oils number 5–7
12010091	7.5	8	Int	Org	Soya beans, whether or not broken
84733090	7.1	71	Int	Dif	Computer parts and accessories
85426000	6.9	59	Int	Dif	Hybrid integrated circuits
85299020	6.4	42	Int	Dif	Hand-held wireless telephone parts
85422121	6.3	28	Int	Dif	Mon. int. circ., dig., $0.18 < \text{wid.} \leq 0.35$, orig. film
29173610	6.1	18	Int	Dif	Terephthalic acid and its salts
88024010	6.1	4	Cap		Aircraft between 15 and 45 tons
84717010	6.1	46	Cap	Dif	Computer hard drives
26030000	5.9	35	Int	Ref	Copper ores and concentrates
84798990	5.7	52	Cap	Dif	Machines and mechanical appliances N.E.S.
74031100	4.9	34	Int	Org	Cathodes of unwrought copper
52010000	4.8	61	Int	Org	Cotton, not carded/combed

circuits. The largest imported product is petroleum and China sourced it from 46 different countries. Indeed, we see no single sourcing of any of the top items and most were sourced from a large number of countries. Exceptions are soy beans and aircrafts between 15 and 45 tons which were sourced from 8 and 4 countries, respectively.

Table 1 indicates that the majority of Chinese imports are intermediate goods. Table 2 reveals that the share of intermediates in Chinese imports in 2006 was about 75%. The last column of the table is compiled from the Chinese Customs data used in this study. For comparison, we also show the figures using the United Nations' Comtrade data base. We observe that information from the two sources closely correspond. The first column shows the breakdown of world exports. Intermediates account for 56% of world exports. Relatively little of Chinese imports are consumption goods—3% compared to 17% for the world.¹⁴ Capital goods account for about 19% of China's imports and 16% of world imports.

In our analysis of the sourcing decisions of Chinese cities, we exclude imports into bonded warehouses. 6.1% of 2006 imports are entrepot and not destined for the Chinese market. Another 4.1% go to other types of bonded warehouses and may not be consumed in the city where the warehouse is located.¹⁵ Excluding this trade, our sample includes 7.9 million monthly shipments of 118,468 firms that import from at least one foreign country. Our primary unit of analysis will be imports of individual cities for specific goods. We have data for 521 cities and 7077 products. The total number of city-product combinations with positive imports is 334,955.

3.1 The extent of single and universal sourcing in cities

At the national level 95% of the CN8 products and 99.9% of all imports are not single sourced. This suggests that CN8 are differentiated by source country (Armington). Alternatively, China could be too geographically dispersed to be thought of as a single importing entity. Our data is well-suited to addressing this hypothesis since we observe imports destined to 31 provinces and 521 cities within China.

Table 3 provides information on single and universal sourcing of Chinese cities. The unit of observation is a city-good. The last column of the

¹⁴On the other hand, the Chinese customs data shows that 31% of Chinese *exports* are consumption goods.

¹⁵We also exclude observations corresponding to re-imports where the source country was listed as China.

Table 2: Shares of imports by good type (in %)

Type	Comtrade		Customs
	World	China	China
Consumption	17.0	3.3	3.2
Intermediate	55.7	74.1	75.6
Capital	15.5	19.1	18.1
Unclassified	11.8	3.6	3.2

Table 3: Single and universal sourcing of cities

Type of Good:	Dif	Ref	Org	All
Share (%) of singlesourced imports:				
City-good observations	46.8	50.4	54.3	47.3
Goods singlesourced by all cities	11.0	17.7	26.1	12.9
Value singlesourced relative to total	6.1	7.4	8.5	7.0
Number of sources per city-cn8:				
Median	2	1	1	2
Mean	3.1	2.7	2.2	3.0
Import-weighted avg.	16.3	11.1	11.4	14.4
Share (%) of universally sourced imports:				
City-good observations	12.2	16.4	24.1	12.9
with at least 2 sources in the province	4.7	5.9	9.2	4.9
sources with at least 1% of the province imports	19.1	23.6	31.1	19.8
both	10.1	11.1	14.3	10.3

first line of results reveals that imports obtained from just one source country account for almost half these observations. The share is above half for relatively homogeneous goods (Ref and Org). While goods are frequently single-sourced, often a good that is single sourced by one city is not single sourced by other cities: Only 12.9% of all goods are exclusively single-sourced (each city importing the good chooses one source, but not necessarily the same source as other cities that import the good). The total value of imports accounted for by single sourcing cities is quite small: 6.1% for differentiated goods and 8.5% for the goods sold on organized markets. The next three rows reinforce these results by showing that as we move from medians to simple averages to import-weighted averages that the number of sources per city rises. This tells us that single sourcing is common but there are a small number of cities that source from large numbers of countries and those cities account for a relatively large share of total imports. The Rauch (1999) classification appears to predict the relative amount of single sourcing very successfully. More homogeneous goods are more likely to be single sourced. The problem for the Ricardian model is that if these goods were really homogeneous then they should be *exclusively* single sourced.

The data in the lower half of Table 3 consider the extent of universal sourcing, defined as the share of cities that import from all sources of the good in the province. Overall, 12.9% of cities universally source the goods they import. Surprisingly, universal sourcing is less frequent for differentiated goods. Some of this “universal” sourcing is a city that imports from the only source in the province (these cities could be the only city that sources the good in the province and only purchase from one source). When we confine the analysis to goods with at least two sources in the province, the incidence of universal sourcing falls by more than half. Some sources in the province may supply a very small amount of imports and, therefore, it is unlikely that all cities will source from them. When we eliminate sources that supply less than 1% of provincial imports, universal sourcing rises to 19.8.

Overall, we find that goods exclusively single sourced are rare, a result that is inconsistent with Ricardian comparative advantage. Even for goods Rauch classifies as homogeneous, only one-quarter of goods are exclusively single sourced. This implies that multisourcing is common. However, a vast majority of cities do not import the same good from all the sources of that available at the province level. The rarity of universal sourcing could be reconciled with the representative consumer love-of-variety model if there were city-specific fixed costs. To test whether such a reconciliation would be supported by the data, we now introduce a statistic to measure the ex-

tent that cities comply with the source hierarchy established at the province level.

3.2 A hierarchy statistic

We develop a hierarchy statistic to measure the extent that import patterns comply with the hierarchical sourcing prediction of the models. It is calculated as the share of cities that import from the top provincial source of the good. The hub-and-spoke assumption implies that under Ricardian comparative advantage, all cities should source from the same low-cost source country. Under the Armington assumption, destinations import from all sources (including the low-cost source). In heterogeneous firm models, a hierarchy emerges where all destinations purchase from the source hosting the producer with the lowest cost.

Since we do not have information on which country is the source of the lowest-cost supplier, we must infer it from the data. Table 4 summarizes information on sources of goods for each province. The first column lists the provinces ordered by total imports in 2006, shown in column (2). Guangdong is the largest importer, importing \$171 billion. Column (3) and column (4) contain the number of goods imported by the province and the number of cities that import goods. We observe that provinces with more cities tend to import more goods with a higher total value.

We identify the top supplying country (“source 1”) in each province in two ways. First, we calculate source-country shares of provincial imports for each good to identify the top importer of each good in a province. We then deem the country that is most frequently the top source of goods in the province as source 1. Second, for each good we identify the source that is most often chosen by the cities in the province. The country that is most frequently observed as the most frequent source of goods in a province is considered source 1. These rankings may differ because of differences in source-country size. A large source with many firms will sell the highest value of goods but may not necessarily host the lowest cost firm.

Column (5) in Table 4 lists source 1 for each province based on highest market share for each good whereas column (7) reveals results based on frequency of being sourced. Japan is the top source for Guangdong in terms of market share for 20.6% of the 6184 goods imported into Guangdong. However, Hong Kong is top in Guangdong based on frequency, being the most commonly chosen source of Guangdong cities for 25.6% of the products. Across the provinces, the top sources tend to be large traders—the United States, Japan, and Germany. We observe some economic geography influ-

encing the choice of top source as Nepal is the top source for Tibet. The top sources are the same in 27 out of 31 provinces across the two identification methods. The few differences that emerge indicate the role of size in the determination of source 1 by value. For example, Japan has the highest market share in Guangdong but the smaller Hong Kong is the top source based on frequency. In Jilin, Germany is supplanted by smaller Korea when frequency is used instead of value. While the top source in each province does not change much across the value and frequency methods, there is much more variation for individual goods. Column (8) reveals that for the large importing provinces, the top source is often only the same across the methods about two-thirds or three-quarters of the time.

We now calculate the share of cities that import a narrowly defined good from the top source of that good in the province. Define y_{dg} as a binary variable equal to 1 if d imports good g from the top source in region D and zero otherwise and let I_{dg} be an indicator that city d imports positive amounts of g from any source. We can express the hierarchy statistic, h_{1g} , for each good g as the share of all importing cities that source from country 1:

$$h_{1g} = \frac{\sum_d y_{dg}}{\sum_d I_{dg}}. \quad (5)$$

As previously discussed, the source of the highest value of imports may not necessarily host the low-cost firm whereas the source with the lowest-cost firm will be most frequently chosen. Thus, the theoretically consistent way to identify the top source country for each good is to see which country is most frequently chosen by cities in a province. In order to have a sufficient number of cities to reliably identify the top source, we impose the restriction that for each good, there must be at least four cities that import the good in the province.¹⁶ This procedure reduces the number of goods from 7077 to 5239. The final sample accounts for 82.5% of Chinese imports.

Figure 3 presents two histograms of the hierarchy statistic. In the left panel, the good-specific statistic is calculated for all cities in the sample while the right panel reflects the statistic for the subset of cities that only obtain the good via the provincial hub (a subsample representing of 78.8% of city-good combinations). There are 5239 and 5235 goods reflected in left and right histograms, respectively. Under the Ricardian comparative advantage, Armington differentiated product, and the heterogeneous firm hierarchy models, the expected value of hierarchy compliance is one. For the

¹⁶In cases where sources are tied for most frequently sourced, we break the tie based on highest shipments. When top sources were also tied in terms of total shipments, we use import value and then alphabetical order if necessary.

Table 4: Top Sources

Province	\$mn	#(cn8)	#(city)	By value		By frequency		Same %
				Country	%	Country	%	
Guangdong	176.1	6184	24	Japan	20.6	Hong Kong	25.6	61.6
Jiangsu	115.8	5532	27	Japan	29.1	Japan	40.3	66
Shanghai	73.4	6136	22	Japan	29	Japan	41.9	63.5
Shandong	45.2	5109	30	Korea	37.4	Korea	44.8	75.9
Zhejiang	45.1	5007	24	Japan	27.3	Japan	32.1	72
Beijing	41.1	5584	19	Japan	19.2	USA	22.7	70.5
Tianjin	26.5	4812	19	Japan	25.2	Japan	31.7	75.9
Liaoning	21.8	4833	21	Japan	38.9	Japan	39.3	79.5
Fujian	18.9	4657	12	Taiwan	33.5	Taiwan	45.9	76.4
Hebei	8.2	3113	12	Japan	21.9	Japan	24.2	84.8
Heilongjiang	7.1	2132	21	USA	18.9	USA	19.6	90.6
Hubei	6.1	2655	18	Japan	21.6	Japan	21.4	87.5
Jilin	5.5	2495	17	Germany	22.8	Korea	26.1	88.7
Anhui	5.4	2317	18	Japan	21.1	Japan	24.1	87.2
Sichuan	4.8	2592	24	USA	24	USA	25.3	89.2
Henan	3.7	1887	23	Japan	21.9	Japan	22.4	90.5
Guangxi	3.7	1648	15	Taiwan	15.4	Taiwan	16.6	91.9
Inner Mongolia	3.4	1118	15	USA	20.8	USA	22.4	93.8
Yunnan	3.2	1493	21	USA	19.8	USA	20	94.1
Jiangxi	3.2	1722	13	Japan	17.6	Japan	18.1	91.7
Xinjiang	3.2	1171	16	USA	30.3	USA	30.8	93.3
Shanxi	2.9	1352	12	USA	19.5	Germany	20.9	91.1
Hunan	2.8	1787	20	Japan	22.2	Japan	24.5	90.2
Gansu	2.7	663	13	Germany	23.8	Germany	25.8	95.2
Shaanxi	2.5	1958	11	USA	24.3	USA	23.7	89.8
Hainan	2.2	1315	3	USA	15.8	USA	16.6	93.9
Chongqing	2.2	1806	27	Japan	25.5	Japan	31.6	86.8
Guizhou	0.9	754	10	Japan	20.2	Japan	21.8	95.1
Ningxia	0.5	451	4	Germany	28.8	Germany	28.8	97.1
Qinghai	0.4	346	5	Germany	22.8	Germany	22.5	97.7
Tibet	0	188	5	Nepal	50	Nepal	50	99.5

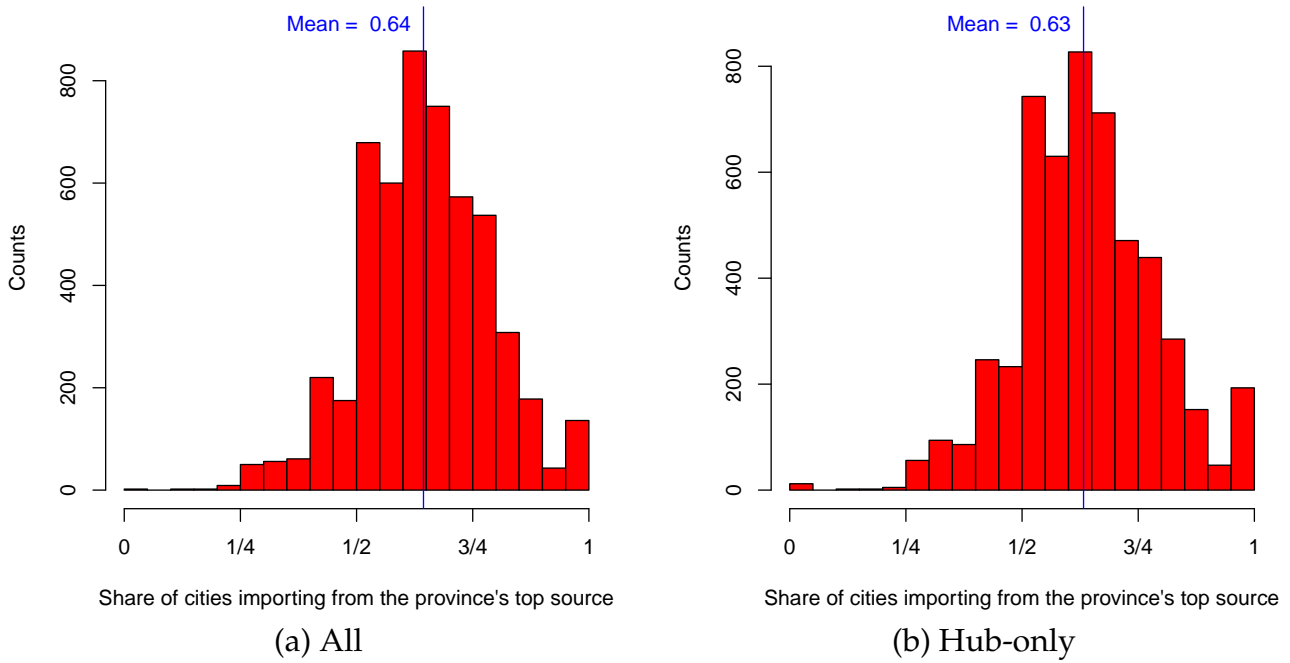


Figure 3: Distribution of hierarchy statistics (h_1) for detailed (cn8) goods

full sample shown in the left panel, we find only 133 goods with $h_{1g} = 1$. The other 97.5% of the goods do not comply. Mean compliance is 0.64. The right panel shows that the number of goods with perfect compliance rises to 190 for the sample of cities that source only through the provincial hub. However, the share of $h_1 < 1$ is 96.4% and the average hierarchy index actually falls to 0.63. The distributions of the hierarchy statistic is very similar in the two samples. The only noticeable difference is we observe 12 goods in the subsample with compliance of zero. For the full sample, zero compliance is impossible: Since the top source is based on the frequency that cities import the good from different sources, some cities must comply by importing from the top source. However, zero compliance can obtain in the subsample if the top source is determined by cities that import through multiple ports and cities that only import from the hub do not import from this source.

Overall, we observe substantial deviation from the prediction of Ricardian, Armington, and heterogeneous firm hierarchy models that all firms should import from the top source in the province. This high incidence of non-compliance holds even for cities that obtain a good only through the provincial hub. Eaton et al. (2008) also find widespread departures from hi-

erarchy in their study of French exporters. However, they argue that there is considerably more compliance in the French exporter data than would be predicted by independent choices. In the next section, we evaluate our observed hierarchy statistics relative to a model incorporating an element of randomness in sourcing decision.

4 Random sourcing model

A natural way to model non-compliance with hierarchy is to introduce a random element into the choice. A model with randomness does not have to be truly stochastic so long as it contains an idiosyncratic term in the buyer’s objective function. The most straightforward way to model this is to employ results from logit random utility models (LRUM) analyzed by Anderson et al. (1992).

Individual shipments of goods can be thought of as the smallest potentially independent units of trade. We imagine a “procurement agent” in each city d that selects the lowest cost source country for each shipment j . The delivered cost perceived by the agent for shipment j in city d is the sum of a common term and an idiosyncratic term. To keep the model as simple as possible, we assume that each country s competitively supplies a homogeneous good with a production cost of c_s . The common delivered cost also includes a transport cost, τ_{sd} . In contrast to the hierarchy model where we retained the multiplicative functional forms of Helpman et al. (2008), analytical tractability in the random sourcing model is helped by assuming additive transport costs. In this case, the hub and spoke structure sets total transport costs equal to the sum of the costs of reaching the hub, T_{sD} and the transport costs from the hub to the destination, t_{Dd} . Combining production and transport costs, the common delivered cost component for city d in province D from source s is given by $c_s + T_{sD} + t_{Dd}$.

The key assumption of the random sourcing model is that individual shipments have idiosyncratic costs, ν_s^j , associated with each source. We can think of the ν_s^j as shipment-specific transaction costs, which are presumably the outcome of a prior history of search and experience between the agent firms from each potential source country.¹⁷ The delivered cost inclusive of the random transaction cost is given by

$$C_{sd}^j = c_s + T_{sD} + t_{Dd} + \nu_s^j. \quad (6)$$

¹⁷In a work-in-progress appendix we will show that the results extend to a model of monopolistic competition between heterogeneous firms.

For now, we assume ν_s^j terms are independent draws from a Gumbel distribution with scale parameter μ .¹⁸ The probability that country s is viewed as lower cost source than any alternative s' for any shipment j in city d in province D is given by

$$x_{sd} \equiv \mathbb{P}[C_{sd}^j < C_{s'd}^j \forall s' \neq s] = \frac{\exp(-(c_s + T_{sD})/\mu)}{\sum_h \exp(-(c_h + T_{hD})/\mu)}. \quad (7)$$

The assumption of additive hub-and-spoke transport costs resulted in the t_{Dd} term dropping out, leaving an expression that lacks any d -specific terms. This because the supplier who has the lowest cost at the hub in province D maintains its advantage when the cost of transporting to the spoke city d is added on. As a result $x_{sd} = x_{sD}$ for all $d \in D$. That is, no matter which city in a province a shipment order emanates from, it has the same probability of being filled by a supplier from source country s .

The random sourcing model provides microeconomic foundations for the “balls-and-bins” model that Armenter and Koren (2010) use to explain the incidence of zeros in United States product-country trade flows. We apply the balls-and-bins approach to measure the likelihood that a city will import a good from the top provincial source. Imagine that cities randomly assign (throw) shipments (balls) to source countries (bins). The likelihood that at least one ball from a city will fall into a bin depends on the number of balls and the size of the bins. If n balls are tossed at a bin of size x the probability at least one of them will land in the bin is $1 - (1 - x)^n$.

For good g , we denote the bin size of the top source in province D as x_{1Dg} . It is measured as source 1’s share of total shipments of g in province D and reflects the probability shown in equation (7). There is also a city-specific measured number of shipments, denoted n_d . Suppressing the g notation, expected h_1 is

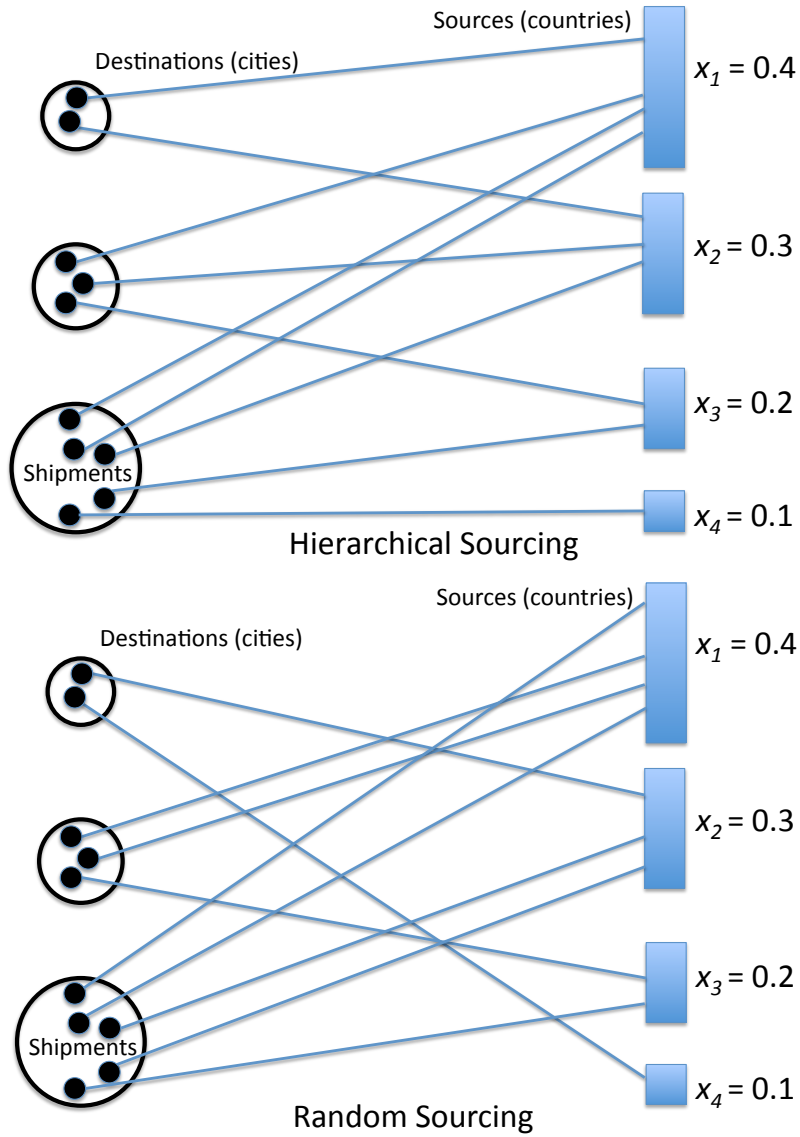
$$\mathbb{E}[h_1] = \frac{\sum_d 1 - (1 - x_{1D})^{n_d}}{\sum_d I_d}. \quad (8)$$

This expected value is increasing in both x_{1D} (the probability a shipment of g to city d in province D will select source 1) and n_d (the total number of shipments of good g destined for city d).

The hierarchy and random sourcing models are portrayed in Figure 4. There are three import destinations and four source countries. As shown in panel (a), under hierarchy, all destinations import from source 1. Thus, the

¹⁸Later, we allow shipments from the same city d to have correlated ν_s^j , which leads to city “orientations” towards specific sources.

Figure 4: Sourcing patterns consistent with the same shares (x)



hierarchy model predicts $\mathbb{E}h_1 = 1$. Because a market has to be sufficiently large to compensate for the fixed costs of exporting to a market, only the larger two destinations import from source 2. The largest destination is the only one that imports from sources 3 and 4.

Panel (b) shows one possible realization of the random sourcing data generating process. The two largest destinations have balls landing in the top country bin (which receives 40% of the balls). However, neither of the balls of the smallest import destination lands in the top country bin. Thus, observed $h_1 = 2/3$ in this example. Plugging in the x_s and n_d into (8) we find $\mathbb{E}h_1 = (1 - (1 - 0.4)^5 + 1 - (1 - 0.4)^3 + 1 - (1 - 0.4)^2)/3 = 0.78$.

To implement the random sourcing model, we identify source 1 and its bin size, x_{1D} . The number of balls “thrown” towards the bin, n_d , are based on information from each city. This allows us to calculate $\mathbb{E}h_1$ and compare it to the actual sourcing behaviour.

In Table 4, we identified source 1 for each province based on the source with the highest market share for each good as well as the frequency of city sourcing. We use the latter method here because the former may incorrectly identify large countries as lowest cost. To see this, consider equation (6) in Helpman et al. (2008),

$$M_{sd} = C_{sd}^{1-\epsilon} P_d^{\epsilon-1} Y_d N_s V_{sd},$$

where V_{sd} is a factor based on the distribution of productivities and N_s is the number of firms in s . A high volume of imports, M_{sd} could result from low costs, C_{sd} , peculiarities in the distribution of productivities, V_{sd} , or a large number of varieties in the exporting country, N_s . In a heterogeneous firm, hierarchy model, all destinations will purchase from the source with the lowest cost firm. This will be the source with the lowest C^L , which may not be the source with the greatest volume of exports. By counting the frequency with which cities source positive amounts from each source, we have a popularity rating that will order countries reliably in terms of their least cost suppliers.

In order to calculate x_{1D} and n_d , we need to measure shipments. We define a shipment by disaggregating imports by month, country of origin, CN8 good classification, importing firm, route, transport mode, and city-zone. Thus, shipments of good g from source s to city d would be counted separately if they occurred in a different month, were received by a different firm, entered a different port, were routed through a different country along the way to China, were transported by a different mode (air, sea, ground), or ended up in a different zone in the city (e.g. Shenzhen SEZ vs Shenzhen

city). This measure will be more aggregated than the individual customs declarations used by Armenter and Koren (2010) since it lumps together all shipments that occurred in the same month. All together our 2006 data contain 8.4 million shipments (as we define them) compared to 21.6 million customs declarations for the US in 2005. The median size of our shipments is \$3,278, about twice the \$1,800 value in the US data.¹⁹ Given this definition of shipments, we calculate the probability of choosing source 1 under randomness as

$$x_{1D} = \frac{\sum_d n_{1d}}{\sum_s \sum_d n_{sd}} = \frac{n_{1D}}{\sum_s n_{sD}}.$$

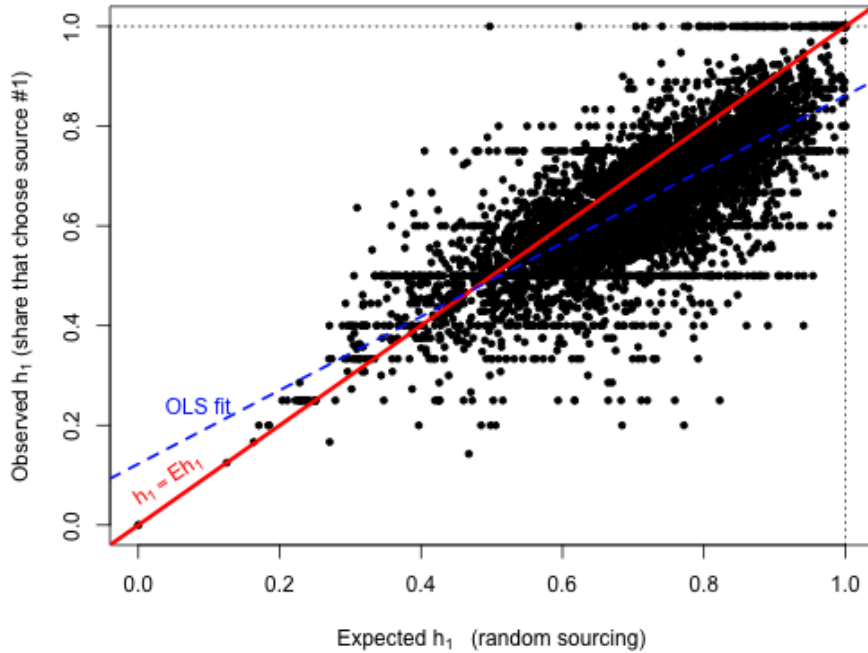


Figure 5: h_1 and $\mathbb{E}h_1$ for 5239 goods

We plug x_{1D} and n_d (measured as city shipment) into equation (8) to calculate $\mathbb{E}h_1$. We then average the values across the provinces to provide an average estimate for the 5239 goods in the sample and compare this expectation to the hierarchy statistic, h_1 generated earlier. Figure 5 presents a scatter plot of the two variables. While $\mathbb{E}h_1$ appears to be a good predictor of h_1 it is imperfect. $\mathbb{E}h_1$ tends to be greater than actual h_1 (most balls are

¹⁹We thank Miklos Koren for providing us the US shipment size data.

Table 5: Hierarchy statistics and their expected values

Type of good	#goods	h_1	$\mathbb{E}h_1$	x_1	#shm
All	5239	0.65	0.72	0.41	4.81
Consumption	1,075	0.61	0.67	0.40	3.71
Intermediate	3,290	0.66	0.75	0.42	5.58
Capital	845	0.62	0.66	0.39	3.23
Differentiated	4,160	0.64	0.71	0.41	4.68
Reference	803	0.65	0.75	0.42	5.27
Organized	142	0.71	0.79	0.48	5.59

The figures in the last four columns are calculated as follows: For h_1 , $\mathbb{E}h_1$, and x_1 , we generate the average across importing cities for each good. For #shm, we calculate the median number of shipments. The table reports the average of these values across the 5239 goods. There are 29 and 134 cn8 categories that we could not assign a SNA and Rauch classification.

to the right of the 45-degree line). Moreover, the slope a regression line is less than one and has an intercept greater than zero. Average $\mathbb{E}h_1$ across the 5239 goods is 0.72, a higher value than the actual h_1 mean of 0.65.

We showed earlier that intermediates comprise 75% of Chinese imports. Many of these goods are likely to be imported by multinationals who have dedicated relationships to specific source countries, either their home countries or countries where their affiliates reside. Rather than a universal preference for products of one source country, cities hosting different sets of multinationals may each have different preferences over source countries. Thus, compliance to the hierarchy may be less likely for intermediates.

Table 5 shows average of h_1 and $\mathbb{E}h_1$ for different subsets of the data based on types of goods. We consider consumption, intermediate and capital goods according to the SNA as well as differentiated, reference, and organized exchange goods as classified by Rauch. We observe that compliance ranges from 0.61 to 0.71, being highest for organized exchange goods and lowest for consumption goods. Across goods, the incidence of non-compliance with the hierarchy is high.

The role of multinationals in intermediate goods trade is a possible explanation for low h_1 . Multinational companies of different nationalities may locate in different cities and source intermediate from different countries. This would lead to low h_1 and still be consistent with love of variety:

Table 6: Hierarchy statistics and their expected values, Robustness

Sample constraint	#goods	#cn8-city	h_1	$\mathbb{E}h_1$	x_1	#shm
≥ 3 cities	5767	275887	0.65	0.72	0.44	4.36
≥ 5 cities	4769	227477	0.65	0.72	0.39	5.28
≥ 4 cities & hub only	5017	184201	0.63	0.71	0.42	4.40
≥ 4 cities & no frequency ties	4906	193707	0.69	0.73	0.42	5.03

The figures in the last four columns are calculated as follows: For h_1 , $\mathbb{E}h_1$, and x_1 , we generate the average across importing cities for each good. For #shm, we calculate the median number of shipments. The table reports the average of these values across goods.

Once the factories produce final products they can be shipped to consumers throughout China. The low h_1 for consumption goods seems more damning for the love of variety model. The Chinese customs authority defines the destination city as “known place within China for consumption, usage, or the final destination of the trip.” Since the product from the top provincial source is only imported into 61% of the cities in the case of consumption goods, we can infer that this final good is not available in 39% of the cities.

Table 5 shows that $\mathbb{E}h_1$ generated by the random sourcing model varies across good types. It is relatively high when there is a dominant supplier in the province (large x_{1D}) or there are many shipments in cities. The last two columns in the table show average x_{1D} and the average number of balls. Organized exchange goods have high x_{1D} and this leads to high values of $\mathbb{E}h_1$. Comparing actual h_1 to the expectation, we observe that compliance with the hierarchy is always less than what is expected in the random sourcing model. Overall, imports are less likely to be purchased from source 1 than random occurrence predicts under the assumption that shipments are independent.

To investigate robustness, Table 6 reports average h_1 and $\mathbb{E}h_1$ for different subsets of cities and methods of identifying the top source. In the first two rows, we consider samples with at least 3 or 5 importing cities for each good-province combination. In the third row, we confine the analysis to the cities that only import a good through the provincial hub. In the last row, we only consider good-province combinations for which the frequency method of determining top source does not result in a ties for the top source. The table reveals that average h_1 and $\mathbb{E}h_1$ do not change very much across these samples. Average compliance is somewhat below two-thirds and always

less than $\mathbb{E}h_1$.

5 Cities with source-orientations

The random model assumes that the idiosyncratic terms in the random utility model are independent. This assumption implies that cities in a province have common perceptions about the fundamental attractiveness of individual supplying countries and deviations from the common perception are random. We can extend the random model by allowing cities to have orientation towards particular source countries. We model this orientation as a consequence of heterogeneity in the orientation of importing firms residing in the cities. We can show that cities with orientations towards particular source countries can result in $\mathbb{E}[h_1]$ being lower than what obtains under independent idiosyncratic terms.

Here we focus on a specific province and drop the D subscript. Let the idiosyncratic term associated with shipment j from firm f for source s be denoted $\nu_s^{jf} = u_s^f + e_s^j$. Let e_s^j be distributed Gumbel with scale parameter μ . Using the expression for trade costs developed in section 4, the cost to firm f located in city d of importing a shipment from source s is $C_s^{jf} = c_s + T_s + t_d + \nu_s^{jf}$. The probability that g imports from s is

$$x_s^f \equiv \mathbb{P}[C_s^{jf} < C_{s'}^{jf} \forall s' \neq s] = \frac{\exp(-(c_s + T_s + u_s^f)/\mu)}{\sum_h \exp(-(c_h + T_h + u_h^f)/\mu)}. \quad (9)$$

Note that this probability does not depend on which city in the province that the firm is located. The probability that city d purchases the shipment from from source 1 is the shipment-weighted average of the probability that firms located the city purchase from source 1:

$$x_{1d} = \sum_f \frac{n_d^f}{n_d} x_1^f, \quad (10)$$

where n_d^f is the number of shipments of firm f in city d .

To obtain some insight into the consequences of firm-specific shocks for hierarchy compliance indices, we consider the case of K cities each with $n_d = n$ shipments. Since each city has a $1/K$ share of shipments in the province, source 1's share of provincial shipments is

$$x_1 = \sum_{d=1}^K x_{1d}/K. \quad (11)$$

If $u_s^f = u_s$, $x_{1d} = x_1$ and the expected number of cities that comply is

$$\mathbb{E}[h_1]^{\text{iid}} = \sum_{d=1}^K \frac{[1 - (1 - x_1)^n]}{K} = 1 - (1 - x_1)^n. \quad (12)$$

In the case of cities with different orientations towards source 1, the expectation is

$$\mathbb{E}[h_1]^{\text{orient}} = \sum_{d=1}^K \frac{[1 - (1 - x_{1d})^n]}{K}. \quad (13)$$

Let $\phi(x) = 1 - (1 - x)^n$ which is a concave function when $n > 1$.

$$\mathbb{E}[h_1]^{\text{iid}} = \phi(x_1) = \phi\left(\sum_{d=1}^K x_{1d}/K\right). \quad (14)$$

$$\mathbb{E}[h_1]^{\text{orient}} = \sum_{d=1}^K \phi(x_{1d})/K. \quad (15)$$

Jensen's inequality implies

$$\phi\left(\sum_d \alpha_d x_d\right) \geq \sum_d \alpha_d \phi(x_d).$$

In our application, $\alpha_d = 1/K$. Thus, by Jensen's inequality,

$$\mathbb{E}[h_1]^{\text{iid}} \geq \mathbb{E}[h_1]^{\text{orient}}.$$

City orientation to particular source countries can explain why h_1 is lower than the $\mathbb{E}h_1$ generated by the IID random sourcing model.

Extreme source orientation is depicted in Figure 6. Here cities are oriented towards different source countries. While the shares of source countries, x_{iD} , are identical to those in the diagrams portraying hierarchy and random sourcing (Figure 4), the share of cities that comply with the hierarchy is low, 0.33, in contrast to 1 under hierarchy and 0.67 under random with independent balls. Thus, for the same set of x_{iD} , we observe very different h_1 depending on the model.

One source of differences in city orientation may be heterogeneity in the country of origin of foreign-owned firms residing in each city. A city with a high share of firms originating in the province's top source country would be expected to have a higher import orientation towards that country than the province average.

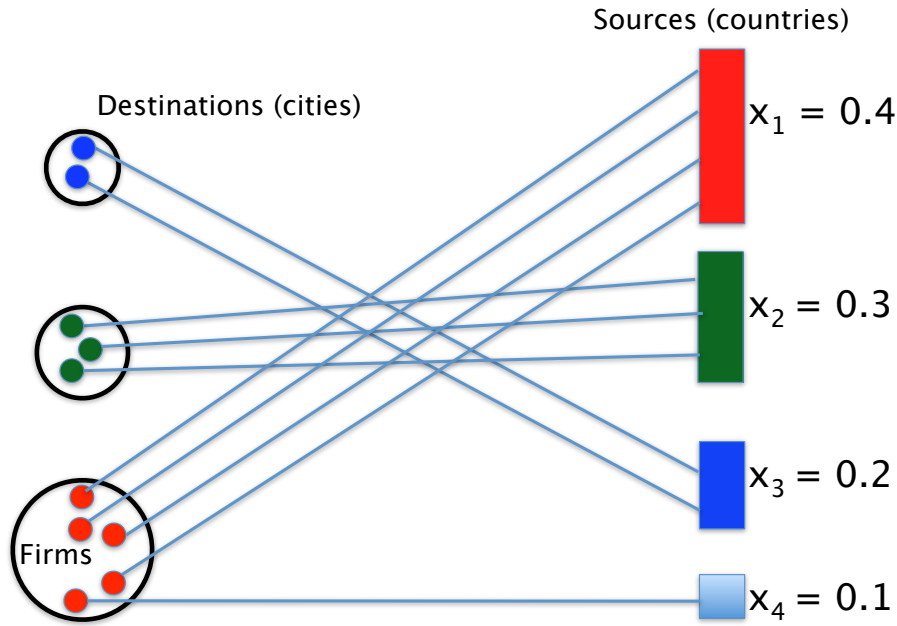


Figure 6: Source orientation

We investigate the empirical relevance of differences in city-source orientations by determining the share of firms in each city that are oriented towards source 1. We then use a linear probability model to estimate whether cities that host a higher share of firms oriented towards the province’s top source are more likely to comply with the hierarchy by importing from that country.

Since the data do not identify the origin-country for firms, we have to infer it using their import patterns. We determine orientation based on each firm’s aggregate sourcing patterns across cities and goods. We begin by calculating the source country import shares for each firm-city-good combination. The source country with the highest share is deemed to have received a “vote” in the contest to be the country of orientation for the firm. Then, for each firm, we sum the votes and calculate vote shares for each candidate country. We have a choice of assigning country orientation based on a plurality of votes or a majority of votes.²⁰

Table 7 shows the results of our assignment. The first two columns re-

²⁰If the total votes equal one, then we consider this firm to have no orientation. In the case of ties for the top spot, we also conclude no orientation.

Table 7: Percentages of firms by orientation (sorted by last column)

Source	Plurality-Rule		Majority-Rule	
	Domestic	Foreign	Domestic	Foreign
Japan	11.0	16.9	8.5	15.4
Taiwan	4.9	17.7	3.4	15.3
Korea	5.9	10.7	4.9	10.1
United States	9.5	7.0	6.2	5.3
Hong Kong	2.6	6.5	1.7	5.1
Germany	6.0	4.4	3.9	3.3
other orientation	17.0	9.9	12.7	7.1
no orientation	43.2	26.7	58.8	38.5

flect outcomes based on the plurality rule whereas the last two columns use the majority rule. We are able to construct orientation for both domestic and foreign firms, the latter comprising both wholly owned and joint ventures. The bottom row reveals that we identify orientations for the majority of foreign firms. We identify orientation for 62.5% of foreign firms under the majority rule and 73.3% under a plurality rule. We are less successful at determining orientation for domestic firms, finding no orientation in 58.8% and 43.2% of the cases under majority and plurality, respectively. The countries to whom Chinese importers are most oriented are Japan, Taiwan, Korea, and the US.

Table 8 shows results of using a linear probability model to explain compliance to the hierarchy and the effect of firm orientation. The dependent variable is the binary variable, y_{d1} , indicating whether city d imports from the top source in the province. Columns (1) and (2) contain results of a bivariate regression of h_1 on $\mathbb{E}h_1$, with and without province-good fixed effects. If the random sourcing model is correct, we expect the coefficient on $\mathbb{E}h_1$ to be one and the intercept to be zero.²¹ We add the firm orientation variables in specifications (3). In column (1), the coefficient on $\mathbb{E}h_1$ is 0.712 and the intercept is 0.153, indicating that the random model tends to under-predict for low values of $\mathbb{E}h_1$ and over-predict for higher values. We observed this relationship in Figure 5. Thus, the random model does not appear to be an unbiased predictor of h_1 . Adding province-good fixed ef-

²¹This bivariate specification is the disaggregated analogue to the prediction that observed h_1 should line up in Figure 5 with $\mathbb{E}h_1$. Each dot in the scatter plot corresponds to a single good, whereas each observation in this regression is a city-good within a province.

Table 8: Probability of compliance

	(1)	(2)	(3)
Prob(comply)	0.712	0.742	0.746
$1 - (1 - x_{1D})^{n_d}$	(0.003)	(0.004)	(0.003)
Foreign Or. (share)			0.697 (0.003)
Domestic Or. (share)			0.647 (0.004)
Intercept	0.153 (0.003)	0.131 (0.003)	-0.044 (0.003)
CN8-province FE	no	yes	yes
Observations	250393	250393	250393
R^2	0.198	0.154	0.373
rmse	0.419	0.398	0.342

Standard errors (clustered by CN8-province) in parentheses. All coefficients are statistically significant at the 1% level. R^2 is within for specs (2) and (3).

fects pushes the slope closer to one (0.742) and the intercept closer to zero (0.131).

The variables measuring the share of foreign and domestic firms in a city that are orientated towards the top source country in the province substantially improve the fit of the regressions. We use the majority rule to identify orientation. Both variables enter with positive and significant coefficients in column (3). The result for foreign firms may be expected if affiliates are importing intermediates from their parent companies. If there is a high share of Japanese affiliates in Dalian, the city is more likely to source from Japan. Multinational connections may also underlie the result for domestic firms—they may tend to import from their affiliates abroad. We observe that the effect of orientation for foreign firms is slightly higher than domestic firms, indicating stronger economic ties. It also may reflect errors in variables as, on average, we have less information (fewer “votes”) to use when assigning the country of orientation in the case of domestic firms.

Table 9 contains results for the different subcategories of goods where we use $\mathbb{E}h_1$ based on firm balls. The estimates vary little across types of goods. The coefficient on $\mathbb{E}h_1$ tends to be around 0.75 and the intercept close to zero. The magnitudes of the estimates for foreign orientation and domestic orientation are broadly similar. Orientation plays a relatively small role for

Table 9: Hierarchy compliance by type of good

	(1)	(2)	(3)	(4)	(5)	(6)
	Con	Int	Cap	Dif	Ref	Org
Prob(comply)	0.734	0.735	0.795	0.753	0.702	0.629
$1 - (1 - x_{1D})^{n_d}$	(0.010)	(0.004)	(0.007)	(0.004)	(0.011)	(0.034)
Foreign Or. (share)	0.724 (0.009)	0.681 (0.004)	0.736 (0.007)	0.701 (0.003)	0.666 (0.009)	0.529 (0.036)
Domestic Or. (share)	0.663 (0.010)	0.641 (0.005)	0.640 (0.011)	0.653 (0.005)	0.596 (0.015)	0.540 (0.036)
Intercept	-0.016 (0.007)	-0.051 (0.003)	-0.033 (0.005)	-0.049 (0.003)	-0.010 (0.009)	0.134 (0.029)
Observations	32326	164304	53866	214595	27438	3480
R^2	0.342	0.377	0.389	0.383	0.321	0.226
rmse	0.360	0.336	0.347	0.340	0.358	0.347

All regressions estimated *within* CN8-province and R^2 is within. Standard errors (clustered by CN8-province) in parentheses. All coefficients are statistically significant at the 1% level except the intercept for Org.

firms purchasing goods trading on organized exchanges, especially foreign orientation. This makes sense if firm networks are less important for these types of goods.

6 Conclusion

The assumption that consumers love variety and products are differentiated by place of origin has proven very useful in international trade. It allows trade models to conform to the fact that even very detailed products are usually sourced from multiple countries. The model is also intuitively appealing for many familiar consumer goods—think of Swiss cheese or Italian olive oil. However, the simplest Armington love of variety model prediction that each importing region will buy from all available sources is clearly refuted by the data. By adding fixed market entry costs to heterogeneous trade models, we can explain why regions import from only a subset of the potential suppliers. Combining love of variety with fixed costs carries a further prediction that source countries should be added in a specific order, starting with the strongest countries and adding less desirable sources only as the market becomes large enough to accommodate them. We show this hierarchy prediction that all Chinese cities import from the top provincial source is violated about one-third of the time. Of course such stark predictions rarely hold up in the data. More surprisingly, we find that hierarchy is observed substantially less often than a random sourcing model predicts. We modify the random model to allow for shipments to be correlated within and across firms in a city to explain this less-than-random compliance with hierarchy. Our empirical results reveal that patterns of firm location within China imply that some cities exhibit strong orientations towards particular source countries. These correlated firm orientations reduce hierarchy compliance.

We see two implications of our work. First, the microeconomic foundations underlying the welfare effects of Armington love-of-variety should not be taken literally. At the level of cities, representative-consumer love of variety is not supported by the data, even allowing for fixed market entry costs. There may still be gains from trade from adding extra import source countries. However, these gains derive from creating better matches to the specific preferences of importing firms. One reason for firms to differ in their preferred sources is foreign ownership. In China foreign-owned firms handle the majority of Chinese imports and about two thirds of these firms exhibit strong orientations towards countries that we infer to be their home

bases. Thus, a second implication of our results is that future work should take into account heterogeneity in the preferences of importing firms in addition to considering heterogeneity in the capabilities of exporting firms.

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A Data

A.1 China imports data

The trade data is based on customs declarations. The variables we use in this paper are (1) the value of imports (which we aggregate from monthly

to annual basis), (2) an 8-digit product classification, (3) the destination city within China.

China's 8-digit classification (which we refer to as the "cn8") is used for imports and exports. For the year we analyze, 2006, the first 6-digits are the 2002 version of the harmonized system. Customs declaration forms ask importers to report the "destination within borders." The official website for the national exam for customs brokers defines this item as the *known place within China for consumption, usage, or the final destination of the trip*. It need not be the port of entry, which is listed separately.

A.2 Classification of goods

We use two different approaches to determine which goods are differentiated and which are homogeneous. The first method relies on the classification carried out by Rauch (1999). The second relies on elasticities of substitution between origin countries estimated by Broda and Weinstein (2006).

A.3 Rauch classification

The Rauch classification is based on SITC rev. 2, at the 4-digit level (but with a few discrepancies from the SITC rev. 2 shown in UN concordance tables). To pass this classification to HS2002, it is necessary to first pass the 4-digit codes to 5-digits in the SITC system because this is the level of detail in the conversion and correlation tables between HS2002 and SITC rev. 2. We use two methods. Method 1 relies on the conversion table, which assigns each HS2002 to a single SITC. In cases where one HS2002 was constructed from many SITC, the conversion table lists the principle or best-matching SITC.²²

We assign a 4-digit Rauch code to all the subordinate 5-digit SITCs and then the conversion table provides a unique Rauch code for each HS2002. Method 1 yields a Rauch code for 95% of the HS2002. However, it has a conceptual flaw. If multiple SITC are aggregated into a single HS2002, then it is problematic to view that HS2002 as single homogeneous good even if its main component SITC is homogeneous. For example, the HS2002 170191 comprises raw sugar (SITC 0611) and sugars with added flavours (0612). Method 1 applies the organized market classification Rauch assigned to 0612 (presumably because 0612 was larger than 0611) to 170191. Arguably,

²²See documentation at <http://unstats.un.org> Comtrade conversions page for a complete explanation.

the good should be considered differentiated since the SITC regards raw and flavoured sugars as distinct.

Method 2 relies on the “correlation table.” This table characterizes the relationship between SITC (at the 5-digit level) and HS2002 as “1 to 1,” “n to 1,” “1 to n,” or “n to n.” For the first two cases SITC codes comprise one or more HS2002. Hence, Method 2 proceeds exactly as Method 1, applying the Rauch code for the SITC to all the associated HS2002. For “1 to n” and “n to n” relationships, an HS2002 draws on more than one SITC. In these cases Method 2 treats the composite HS2002 as differentiated, no matter what the classification of the set of underlying SITC. Thus Method 2 classifies 17091 as differentiated. It also classifies 711011 as differentiated even though it is based on 68123 and 68125 even though both are parts of 6812, which Rauch classifies as organized. The first (68123) is unwrought or powdered platinum and the second (68125) is semi-manufactured platinum. Method 2 obtains a Rauch code for 97% of the HS2002. Naturally, this method leads to many more goods being classified as differentiated. Under the most liberal classification of goods, “lib1,” 40.7% of all HS2002 are deemed to be homogeneous (organized or reference) goods. Under the most conservative classification, “con2,” 24.3% are homogeneous. The most detailed classification possible in our data is the CN8, China’s export and import commodity nomenclature. Since it has “n to 1” relationship with HS2002, we simply apply the Rauch classification of an HS2002 to its subordinate CN8.

A.4 SNA classification

Most of the current trade literature are based on the assumption that the importers are the final consumers. However, with regard to China’s imports, raw materials and equipments account for a large proportion. In order to make sure our analysis results are not driven by the different behaviors between producers and final consumers, we need to classify all cn8 according to their end-use purposes. The broad economic categories (BEC) designed by UNSD provides such a tool. All BEC groups are meaningful in the framework of the System of National Accounts (SNA), and they are classified to three basic classes: consumption goods, intermediate goods, and capital goods. The correlation table of the HS2002 to BEC are downloaded from UN’s website. Each HS2002 6-digit code is matched with one BEC code. The HS2002 items are unique and complete. The correspondence of the BEC categories with the basic classes of goods in the SNA (capital goods, intermediate goods and consumption goods) is summarized from a revision proposal *Future revision of the Classification by Broad Economic Categories*

(BEC) by UNSD.