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Non-Homothetic Gravity: On the Roles of Per-Capita Income and Country Size in International Trade

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Abstract

Observed data show that trade shares of GDP tend to be positively correlated with the importer's per-capita income and negatively correlated with its size. Moreover these correlations very considerably across sectors. While these features are not captured by standard gravity models, we also lack a theoretical framework to simultaneously analyze the different effects of income and country size on trade. To propose a solution to this issue this paper introduces non-homothetic preferences and Ricardian comparative advantage into a trade model of monopolistic competition and producer heterogeneity. The theory yields a structural gravity equation that identifies each industry with two dimensions: per-capita income and country size elasticities with respect to trade, while explicitly controlling for the supply side effect. Accordingly in the model, the two components of aggregate income – per-capita income and the size of a country – affect bilateral trade in different ways: higher per-capita income increases imports, and country size generates the home-market effect on bilateral trade. These effects vary by sectoral characteristics due to the non-homotheticity of preferences. Empirical analysis supports these theoretical findings and confirms the importance of demand non-homotheticity with respect to both income and country size in understanding some observed puzzles in trade data. The estimation procedure produces estimates of sectoral demand elasticities, as well as other important parameters that are of broad interest in trade studies. As the model explicitly incorporates demand structure and technology of production as shaping factors of bilateral trade patterns, data decomposition is then performed to isolate and quantitatively examine the effects of demand and productivity on trade variation. The results of a case study on U.S. - China trade suggest that the home-market effect is almost three times stronger than comparative advantage in explaining the variation in relative trade between these two countries over time.

Keywords: non-homotheticity, the home-market effect, comparative advantage
JEL Classification: F10, F12, F14, O30

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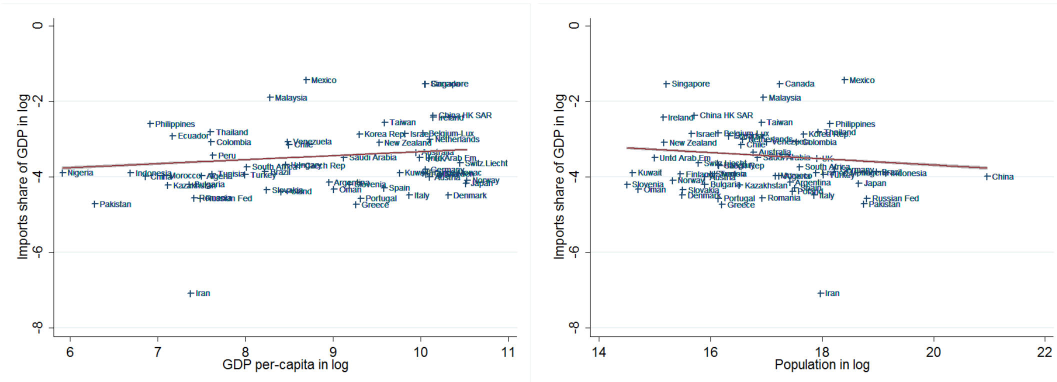
1 Introduction

How much understanding we have about the demand side effect on international trade flows is a question whose answer is much less obvious than one would generally expect. As one of the most successful empirical models to explain trade patterns, the standard gravity equation predicts that trade increases proportionally with the aggregate income of trading partners, and therefore increases in proportion with the two components of total demand – per-capita income and population – as well. Meanwhile, as income elasticity is conventionally assumed to be unity, the income effect is common across industries. However, bilateral trade data show that trade seems to respond differently to per-capita income and the size of a country (in terms of population). For example, in 2000, among countries that import from the U.S., a 1% increase in per-capita income of the importers is associated with on average a 0.1% *increase* in total value of imports as a share of GDP (the left panel of figure 1); on the other hand, a 1% increase in size of the importers is associated with on average a 0.08% *decrease* in imports share of GDP (the right panel of figure 1). While these simple unconditional correlations may also be driven by other factors such as trade costs, they are, as a matter of fact, more profound if I limit the sample to 12 EU countries which tend to face similar trade costs against the U.S.. On average, a 1% increase in per-capita income of these countries is associated with a 1.4% *increase* in import shares of GDP (the left panel of figure 2), and a 1% increase in importer size is associated with on average a 0.21% *decrease* in import shares of GDP (the right panel of figure 2). Moreover, there is much variation in these correlations when looking at the data across industries. As shown in the left panel of figure 3, the correlation between import shares and GDP per-capita (both in log forms) varies from 0.007 for sector ISIC 353 (Petroleum refineries) to 0.652 for sector ISIC 332 (Furniture, except metal); as shown in the right panel of the same figure, the correlation between import shares and importer size (both in log forms) varies from -0.012 for sector ISIC 361 (Pottery, china, earthenware) to -0.367 for sector ISIC 324 (Footwear, except rubber or plastic). These basic patterns in the data are consistent with other empirical evidence on the significant variation of income elasticity across goods,[1] and cannot be explained by the traditional gravity model. Existing work on gravity models has paid very limited attention to investigating these stylized facts and potential explanations both theoretically and empirically.

To propose a solution to this issue, I develop a theoretical framework by introducing non-homothetic preferences into Chaney's (2008) model of heterogeneous firms which itself is a multi-sector version of Melitz (2003). These preferences generate different demand patterns across countries of different income levels. The model identifies two dimensions of a sector which are not often differentiated or simultaneously analyzed in existing literature: per-capita income and country size elasticities with respect to trade. Several important implications follow the theory. On the level of trade volumes, higher per-capita income of the importer increases imports more relative to consumption of domestically produced goods, and larger importer size increases the consumption of domestic production more relative to imports. On the patterns of relative trade between two countries, namely *Home* and *Foreign*, higher relative income of *Home* decreases exports of *Home* relative to *Foreign*, whereas larger relative size of *Home* increases this relative exports making *Home* more likely a net exporter. These effects vary by sectoral characteristics due to the non-homotheticity of preferences. I refer

[1] See Grigg(1994), and Hunter (1991)

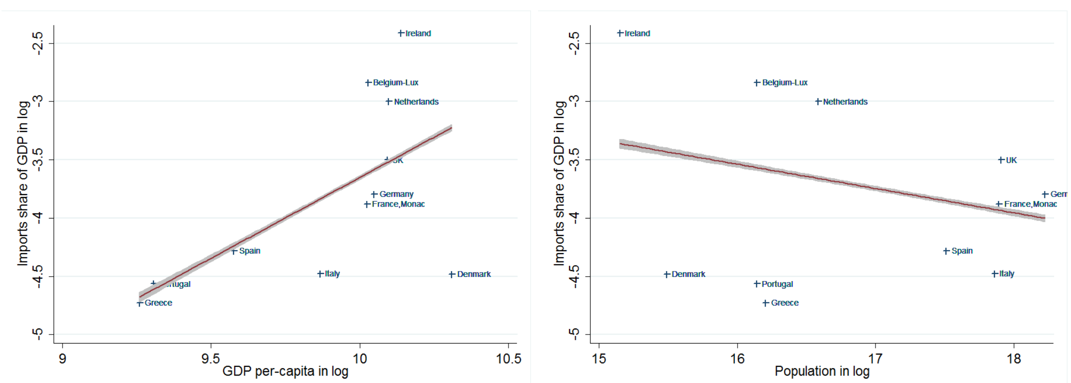
Figure 1: Trade, per-capita income, and country size.



(L) (R)

Notes: Data source: Feenstra et al.(2005). This figure plots the share of imports in GDP in log against the log of GDP per-capita (the left panel), and the log of population (the right panel) for all countries that import from the U.S. in the data in the year of 2000.

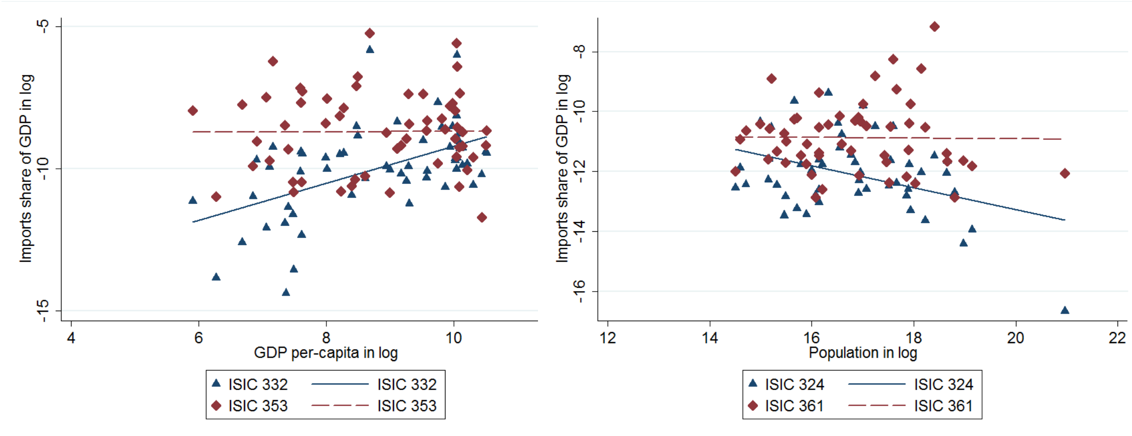
Figure 2: Trade, per-capita income, and country size, cont'd.



(L) (R)

Notes: Data source: Feenstra et al.(2005). This figure plots the share of imports in GDP in log against the log of GDP per-capita (the left panel), and the log of population (the right panel) for 12 EU countries that import from the U.S. in the data in the year of 2000.

Figure 3: Trade, per-capita income, and country size, cont'd.



(L) (R)

Notes: Data source: Feenstra et al.(2005). This figure plots the share of imports in GDP in log against the log of GDP per-capita for sectors 332 and 353 (the right panel), and the log of population (the left panel) for all for sectors 324 and 326, according to 3-digit International Standard Industrial Classification (ISIC) revision 2, for countries that import from the U.S. in the data in the year of 2000.

to the effect of country size on the level of trade as the importer home-market effect, and that on relative trade as the exporter home-market effect. While the analysis focuses on the demand side, I also incorporate Ricardian comparative advantage in the model to control for the supply side effect. Doing so yields a gravity equation in equilibrium consisting of output and income of trading partners, technology of production, as well as trade barriers as determinants of bilateral trade flows.

The theoretical implications of the model are then empirically tested using a rich industry level dataset on bilateral trade, domestic production and consumption. The empirical study delivers estimates of sectoral per-capita income and country size elasticities with respect to trade flows. Moreover, the structural nature of the gravity equation allows one to estimate within- and cross-sector elasticities of substitution, and the sectoral productivity distribution parameter under a unified framework. Applying these estimated parameters to reduced-form analysis confirms the presence of the home-market effect and its interactions with sectoral characteristics. Two thought experiments are also conducted in the paper. First, I construct counterfactual trade data assuming homothetic preferences. Then by comparing the constructed and observed data, I show that allowing for non-homothetic income improves the model's capacity to explain the small volumes of South-South and North-South trade and the lower than predicted openness to trade across countries. Moreover, I show that the new sectoral dimension introduced by the current model – the sector-specific country size elasticity – offers an additional channel to explain these trade puzzles, and it reinforces the effect of income non-homotheticity. Second, as the model explicitly incorporates demand and technology of production as shaping factors of trade, I perform a data decomposition to isolate and examine quantitatively the contributions of demand and production to overall trade variation. A case study on U.S. – China trade suggests that over the 20 years between

1980 and 2000, changes in productivities and expenditure patterns of China explain more than half of the exports growth between these two countries. And on the changes in U.S. exports relative to China, the home-market effect is almost 3 times stronger than comparative advantage.

The current work first adds to the literature on the theory of gravity model by emphasizing the role of demand. The gravity equation starts as a pure empirical model to predict trade flows. Since Anderson (1979), the literature has been paying more attention to the theoretical foundation of the gravity equation. Anderson and van Wincoop (2003) apply the framework of Anderson (1979) by incorporating a measure of "multilateral resistance" of trading partners to explain the famous border puzzle of the bilateral trade between the U.S. and Canada. Chaney (2008) constructs a multi-sector Melitz (2003) model of firm level heterogeneity assuming Pareto distribution of sectoral productivity shocks, and derives a gravity equation revealing the impact of the elasticity of substitution on the extensive margin of bilateral trade. Helpman, Melitz and Rubinstein (2008) extend Chaney's model by using a truncated distribution of productivity to make use of the observed zero trade flows in data. Eaton and Kortum (2002) show that the gravity structure can also be derived from a Ricardian model of perfect competition, and their single-sector model is later extended to a multi-sector version by Costinot, Donaldson and Komunjer (2012). The gravity equation derived from my model, first on the production side, explicitly reflects the role of sectoral productivity. And on the demand side, while bilateral trade is proportional to the total income of trading partners in the standard gravity model, my model shows that this would not hold when the non-homotheticity of preferences is taken into consideration. Specifically, bilateral trade will depend on the per-capita income and the size of the importer differently, the marginal effects of which differ across sectors.

This paper also relates to the literature on the home-market effect. First proposed by Krugman (1980), the home-market effect suggests that under increasing returns to scale, strong domestic demand of goods in a differentiated sector increases domestic production and generates net exports in that sector. Following this idea, Davis and Weinstein (1999) study regional trade of 18 manufacturing industries in Japan and find statistically and economically significant evidence supporting geographical concentration of production. In their later work Davis and Weinstein (2003), the authors examine the data for a set of OECD countries based on a framework that nests a conventional Heckscher-Ohlin model with increasing returns to scale. Their results confirm the importance of the home-market effect for OECD manufacturing. A similar work is done by Head and Ries (2001), where they estimate country's share of output to its share of demand based on US and Canada data using two alternative models. Their estimates based on variation between industries support the increasing returns model, implying a greater than 1 ratio of the output share to the demand share. More recently, Hanson and Xiang (2004) explicitly estimate the home-market effect using a difference-in-difference structural gravity equation with data covering a large sample of countries and industries. They find that sectors with higher transport costs and lower elasticity of substitution exhibit a stronger home-market effect. My theoretical model implies that the home-market effect exists in both the level of trade volumes and the patterns of relative trade between two countries, and it varies with sectoral characteristics, namely the sectoral country size elasticity with respect to trade.

Following Linder (1961), a small literature has tried to explore the role of demand structure in explaining international trade. Focusing on product quality, Linder shows that rich countries trade more high-quality products with each other due to larger demand for these goods. Based on this rationale, he predicts that countries of similar income levels trade more with each other. Markusen (1986), Hunter and Markusen (1988), and Hunter (1991) argue that trade volumes decrease as the differences of per-capita income of trading partners increase. A recent work by Fieler (2011) extends the Eaton and Kortum (2002) model by incorporating non-homotheticity in the structure of preferences and shows improvement in the model's ability to explain large trade volumes among rich countries and small volumes among poor countries. The same preference structure is also used in Caron, Fally and Markusen (2014), where they provide empirical evidence on the strong positive correlation between income elasticity and skilled-labor intensity across sectors. Finally, Markusen (2013) constructs a general HO model with non-homothetic demand, and derives a rich set of results that are related to the previous literature.

In this paper, I apply the same preferences as Fieler (2011) and Caron et al. (2014) to a monopolistic competition model. [2] Doing so identifies each sector with two dimensions: per-capita income and country size elasticities with respect to trade, the former of which is acknowledged by the Fieler and Caron et al. papers, and the latter is the core contribution of the current paper. I show empirically that, non-homothetic country size, in addition to income, also provides an important channel to explain the small trade volumes among poor countries and the lower than expected trade to GDP ratios through the home-market effect.

Lastly, my paper is not the first to incorporate comparative advantage in an increasing returns to scale model. A recent work by Fan, Lai and Qi (2013), adds to the Melitz (2003) model of monopolistic competition with Ricardian comparative advantage. Their model also shows that trade will be jointly determined by comparative advantage, economies of scale, country sizes and trade barriers. While their focus is on the effect of trade liberalization, I am more interested in investigating the role of demand structure, and am able to derive a structural gravity equation describing bilateral trade flows.

This paper is organized as follows. Section 2 introduces the structure of the theoretical model, solves for the equilibrium, and derives the gravity equation of bilateral trade. I describe the data and carry out the empirical analysis in section 3. Data decomposition and a case study on bilateral trade between the U.S. and China are performed in section 4. Section 5 concludes.

2 The Theoretical Framework

2.1 Model set up

There are N asymmetric countries indexed by i and j, and $H+1$ sectors indexed by h and k. Sector 0 produces a single homogeneous good, and sector $h \in (1, H+1)$ consists of a continuum of firms each producing a differentiated variety. The preferences of a representative consumer are given by:

[2] In Fieler's (2011) main model, she assumes that the same parameter governs both income elasticity and the elasticity of substitution, which implies that income-elastic sectors are more homogeneous. Caron et al. (2014) assume different parameters for these two elasticities. However, since both their models are of Ricardian perfect competition, elasticity of substitution plays no role in shaping trade patterns.

$$U = {q^0}^{1-\alpha}\left(\sum_{h=1}^{H}\mu^h {Q^h}^{\frac{\eta^h-1}{\eta^h}}\right)^{\alpha}$$

$$Q^h = \left(\int_0^{\Omega^h} q^h(\omega)^{\frac{\sigma^h-1}{\sigma^h}} d\omega\right)^{\frac{\sigma^h}{\sigma^h-1}},$$

where Ω^h is the endogenous set of varieties (both domestically produced and imported) in sector h. $\sum_h \mu^h$ is normalized to be 1. The parameter σ^h is the elasticity of substitution between varieties within sector h and is assumed to be greater than 1. Parameter η^h governs the elasticity of substitution between sectors and is normally assumed to be positive. As I will show in the equilibrium, σ^h and η^h will jointly define the sectoral per-capita income and country size elasticities, and since they differs by sector preferences are non-homothetic. These preferences are recently used in Fieler (2011) and Caron et al.(2014) and are referred to as the constant relative income elasticity (CRIE) preferences. I assume that consumers from different countries have the same preferences, however the non-homotheticity of the utility function will generate different demand patterns across countries due to the variation in individual income and country size.

Let p_{ij}^h be the price of a sector h variety produced in country i and sold in country j, and P_j^h be the price index of the sector h good in country j. Maximizing the utility function subject to the budget constraint of the consumer yields the following expressions of the expenditure on an aggregate sector h good by country j consumers (X_j^h) and the expenditure on a sector h variety produced in country i by consumers in country j (x_{ij}^h):

$$X_j^h = {\lambda_j}^{-\frac{\eta^h}{\alpha}} L_j \times \alpha_1^h \times {P_j^h}^{1-\eta^h}, \tag{1}$$

$$x_{ij}^h = X_j^h \times \left(\frac{p_{ij}^h}{P_j^h}\right)^{1-\sigma^h} = {\lambda_j}^{-\frac{\eta^h}{\alpha}} L_j \times \alpha_1^h \times {P_j^h}^{1-\eta^h} \times \left(\frac{p_{ij}^h}{P_j^h}\right)^{1-\sigma^h}. \tag{2}$$

λ_j is the Lagrangian multiplier associated with the budget constraint of the representative consumer, and it is decreasing in per-capita income. $\alpha_1^h \equiv [\alpha(1-\alpha)^{\frac{1-\alpha}{\alpha}}\mu^h \frac{\sigma^h-1}{\sigma^h}]^{\sigma^h}$ is a sector-specific constant. [3]

On the production side, I assume that the homogeneous good 0 is produced under constant returns to scale, freely traded and used as the numeraire. Labor is the only factor of production, and has exogenous productivity of w_i in producing good 0 in country i. Labor market is assumed to be perfectly competitive, therefore the sector 0 productivity pins down the wage rate in country i. Exports from country i to j in the heterogeneous sector h are assumed to be costly with iceberg transport costs $d_{ij}^h \geq 1$.[4] In addition, to sell in country j, each sector h firm from country i must pay a fixed cost of f_{ij}^h in terms of the numeraire. Let z_i^h be the variety-specific productivity which also varies by country and industry, and then

[3]Maximizing the utility function subject to the budget constraint of a country j consumer, I get the individual expenditure on sector h goods:$e_j^h = {\lambda_j}^{-\frac{\eta^h}{\alpha}} \times \alpha_1^h \times {P_j^h}^{1-\eta^h}$. Then the total expenditure by all consumers in country j (X_j^h) is simply $L_j e_j^h$.

[4]d_{ij}^h satisfies the standard assumptions on the iceberg trade costs as in most trade literature, where $d_{ji}^h > 1$ for any $i \neq j$, $d_{ii}^h = 1$, and $d_{ij}^h \leqslant d_{ik}^h \times d_{kj}^h \forall(i,k,j)$.

the total costs of selling q units of a sector h variety in country j by a firm from country i are:

$$C_{ij}^h(q) = \frac{w_i d_{ij}^h}{z_i^h} q + f_{ij}^h,$$

and as a commonly known result of monopolistic competition, I have: $p_{ij}^h = \frac{\sigma^h}{\sigma^h - 1} \frac{w_i d_{ij}^h}{z_i^h}$.

To incorporate the Ricardian comparative advantage in the model, I first assume that there are two components of the labor productivity: $z_i^h \equiv T_i^h \times \varphi^h$. T_i^h is a country- and sector-specific parameter governing the position of sectoral productivity distribution in country i, and it can be taken as a measure of the *fundamental sectoral productivity* across all firms within a sector; the random productivity shock φ^h, following Helpman, Melitz, and Yeaple (2004) as well as Chaney (2008), is assumed to be drawn from a Pareto distribution over $[1, +\infty)$ with the CDF of:[5]

$$P(\varphi^h < \varphi) = G^h(\varphi) = 1 - \varphi^{-\theta^h},$$

where θ^h is a sector-specific parameter measuring the dispersion of productivity distribution.[6] I assume that $\theta^h > \sigma^h - 1$ to ensure a well defined price index. Then there exists a productivity threshold $\bar{\varphi}_{ij}^h$ for a country i sector h firm to profitably exports to country j. I follow Chaney (2008) assuming that the mass of potential entrants of each differentiated sector in country i is proportional to $w_i L_i$, then the sector h price index of the importing country j can be expressed as:

$$P_j^h = \left(\sum_{i=1}^{N} w_i L_i \int_{\bar{\varphi}_{ij}^h}^{\infty} \left(\frac{\sigma^h}{\sigma^h - 1} \frac{w_i d_{ij}^h}{T_i^h \varphi}\right)^{1-\sigma^h} dG^h(\varphi) \right)^{\frac{1}{1-\sigma^h}}. \tag{3}$$

Also following Chaney (2008), I do not impose free entry, and firms generate net profits which will be collected as a global fund. This fund will then be redistributed in terms of the numeraire good to all consumers, where each consumer holds w_i shares of the global fund. The net profits of an operating firm with productivity φ are $\pi_{ij}^h = x_{ij}^h / \sigma^h - f_{ij}^h$. The dividend per share of the global fund can then be defined as:

$$\pi = \frac{\sum_{h=1}^{H} \sum_{j=1}^{N} \sum_{i=1}^{N} w_i L_i \left(\int_{\bar{\varphi}_{ij}^h}^{\infty} \pi_{ij}^h dG^h(\varphi) \right)}{\sum_{i=1}^{N} w_i L_i}, \tag{4}$$

and total income of country i should be the sum of labor income and the dividend the consumers get: $Y_i = w_i L_i (1 + \pi)$.

[5] The productivity distribution used here, where $z_i^h \equiv T_i^h \times \varphi^h$, and φ^h follows Pareto distribution, is essentially the same as the *Fréchet* distribution used in Eaton and Kortum (2002), Fieler (2011) etc. T_i^h governs the level of the distribution, and the Pareto parameter θ^h measures the within sector productivity dispersion.

[6] To be more specific, θ^h is the inverse measure of sectoral productivity dispersion, meaning that sectors with a high θ^h are more homogeneous in terms of productivity.

2.2 The equilibrium

I will now focus on a differentiated sector h, and the analysis of all other sectors follows analogously. The goal is to derive a gravity equation of bilateral trade flows for each differentiated sector h. In the general equilibrium, trade will be balanced through the freely traded homogeneous sector. I start by solving for the selection of firms into different markets.

The productivity threshold is defined by the zero cutoff profit condition: $\pi_{ij}^h(\bar{\varphi}_{ij}^h) = 0$. So I have:

$$\lambda_j{}^{-\frac{\eta^h}{\alpha}} L_j \times \frac{\alpha_1^h}{\sigma^h} \times \left(P_j^h\right)^{\sigma^h - \eta^h} \times \left(\frac{\sigma^h}{\sigma^h - 1} \times \frac{w_i d_{ij}^h}{T_i^h \bar{\varphi}_{ij}^h}\right)^{1-\sigma^h} = f_{ij}^h. \tag{5}$$

Solve (3) and (5) simultaneously, I get the following expressions for the price index and $\bar{\varphi}_{ij}^h$:[7]

$$P_j^h = \alpha_2^{h\gamma_1^h} \times \left(\lambda_j{}^{-\frac{\eta^h}{\alpha}} L_j\right)^{\frac{\theta^h - (\sigma^h - 1)}{(\sigma^h - 1)}\gamma_1^h} \times \Phi_j^{h\gamma_1^h}, \tag{6}$$

$$\bar{\varphi}_{ij}^h = \alpha_3^h \times \lambda_j^{-\gamma_3^h} L_j^{\gamma_1^h} \times \frac{w_i d_{ij}^h}{T_i^h} \times \Phi_j^{h\gamma_2^h} \times f_{ij}^{h\,\frac{1}{\sigma^h - 1}}, \tag{7}$$

where $\alpha_2^h \equiv \frac{\theta^h}{\theta^h - (\sigma^h - 1)} \times \left(\frac{\sigma^h}{\sigma^h - 1}\right)^{-\theta^h} \times \left(\frac{\sigma^h}{\alpha_1^h}\right)^{\frac{(\sigma^h - 1) - \theta^h}{\sigma^h - 1}} \times \left(\frac{Y}{1+\pi}\right)$, and $\alpha_3^h \equiv \frac{\sigma^h}{\sigma^h - 1} \times \left(\frac{\sigma^h}{\alpha_1^h}\right)^{\frac{1}{\sigma^h - 1}} \times \alpha_2^{h\gamma_2^h}$ are sector-specific constants. $\Phi_j^h \equiv \sum_{i=1}^N \left(\frac{Y_i}{Y}\right) \times \left(\frac{w_i d_{ij}^h}{T_i^h}\right)^{-\theta^h} \times f_{ij}^{h\,-\frac{\theta^h - (\sigma^h - 1)}{\sigma^h - 1}}$, which measures country j's *closeness* to the rest of the world as it is essentially the reciprocal of the average bilateral trade barriers that country j faces, weighted by the income share of its trading partners. It then *inversely* reflects the measure of the "multilateral resistance" in Anderson (1979) and Anderson and van Wincoop (2003). Y here refers to the world income. And lastly:

$$\begin{aligned}
\gamma_1^h &\equiv \frac{\sigma^h - 1}{\theta^h(\eta^h - \sigma^h) - (\sigma^h - 1)(\eta^h - 1)}, \\
\gamma_2^h &\equiv \frac{\eta^h - \sigma^h}{\theta^h(\eta^h - \sigma^h) - (\sigma^h - 1)(\eta^h - 1)}, \\
\gamma_3^h &\equiv \frac{\eta^h(\sigma^h - 1)}{\alpha[\theta^h(\eta^h - \sigma^h) - (\sigma^h - 1)(\eta^h - 1)]}.
\end{aligned} \tag{8}$$

The sector-specific γ's of (8) are functions of the productivity distribution parameter θ^h and the parameters governing between- and within-sector elasticities of substitution: η^h and σ^h. How the price index and labor productivity threshold vary with total income and Φ_j^h depend on the behavior of these parameters. The estimates from the empirical section show that γ_2^h is positive in general, implying that for many country pairs, being closer to the rest of the world is pulling a country away from it's certain trading partners.

[7] See appendix A1 for derivation.

Assuming that each country is sufficiently small, they take the world output Y and dividend per share π as given, which can be determined in general equilibrium. Plug (7) back to (4), I can show that:[8]

$$\pi = \sum_{h=1}^{H} \alpha_4^h \sum_{j=1}^{N} \left(\lambda_j^{\gamma_3^h \theta^h} L_j^{-\gamma_1^h \theta^h} \times \Phi_j^{h\,1-\gamma_2^h \theta^h} \right), \tag{9}$$

where $\alpha_4^h \equiv \alpha_1^{h\,\frac{\theta^h}{\sigma^h-1}} \times \alpha_2^{h\,-\gamma_2^h\theta^h} \times \left(\frac{\sigma^h}{\sigma^h-1}\right)^{-\theta^h} \times \sigma^{h\,-\frac{\theta^h}{\sigma^h-1}} \times \left[\left(\frac{\sigma^h}{\sigma^h-1}\right)^{\sigma^h-1} - 1\right]$. Accordingly, the world income $Y = \sum_{i=1}^{N} w_i L_i (1+\pi)$.

The only unsolved endogenous variable so far is the Lagrangian multiplier λ_i as it generally does not have a closed-form solution. With these variables in equilibrium, I can then derive the sectoral bilateral trade. Plug the expression of price index in (6) back to the variety demand in (2), I have:

$$x_{ij}^h = \alpha_1^h \alpha_2^{h\,(\sigma^h-\eta^h)\gamma_1^h} \times \lambda_j^{\gamma_3^h(\sigma^h-1)} L_j^{\gamma_1^h(1-\sigma^h)} \times \Phi_j^{h\,(\sigma^h-\eta^h)\gamma_1^h} \times p_{ij}^{h\,1-\sigma^h}.$$

Since the total exports from country i to country j by all firms in sector h are $X_{ij}^h = w_i L_i \int_{\bar{\varphi}_{ij}^h}^{\infty} x_{ij}^h(\varphi) dG^h(\varphi)$, it can be shown that:[9]

$$X_{ij}^h = \alpha_5^h \times \frac{Y_i \times \lambda_j^{\gamma_3^h \theta^h} L_j^{-\gamma_1^h \theta^h}}{Y} \times \left(\frac{T_i^h}{w_i}\right)^{\theta^h} \times D_{ij}^{h\,-\theta^h} \times f_{ij}^{h\,-\frac{\theta^h-(\sigma^h-1)}{\sigma^h-1}}, \tag{10}$$

where $\alpha_5^h \equiv \alpha_1^h \times \alpha_2^{h\,1-\gamma_2^h\theta^h}$, and $D_{ij}^h \equiv d_{ij}^h / \Phi_j^{h\,-\gamma_2^h}$ measures the "bilateral resistance" between country i and j: it depends on trade barriers between i and j (d_{ij}^h), and j's closeness to the rest of the world (Φ_j^h). (10) represents a gravity equation which takes into account the effect of firm-level heterogeneity on aggregate trade flows in a sense which is the same as the gravity equation of Chaney (2008). In addition, equation (10) shows that trade responds differently to changes in the importer's per-capita income and size. These demand elasticities with respect to trade are sector-specific.

Summing up bilateral trade across all exporters then delivers a country's total sectoral spending:[10]

$$\begin{aligned} X_j^h = \sum_i X_{ij}^h &= \alpha_5^h \times \lambda_j^{\gamma_3^h\theta^h} L_j^{-\gamma_1^h\theta^h} \times \Phi_j^{h\,-\gamma_2^h\theta^h} \times \sum_i \left(\frac{Y_i}{Y}\right) \times \left(\frac{w_i d_{ij}^h}{T_j^h}\right)^{-\theta^h} \times f_{ij}^{h\,\frac{1}{\sigma^h-1}} \\ &= \alpha_5^h \times \lambda_j^{\gamma_3^h\theta^h} L_j^{-\gamma_1^h\theta^h} \times \Phi_j^{h\,1-\gamma_2^h\theta^h}, \end{aligned} \tag{11}$$

[8]See appendix A.2 for derivation.
[9]See appendix A3 for derivation.
[10]This expression can also be derived from plugging the price index in (6) to the sectoral demand in (1).

and it follows that the income elasticity is given by:

$$\begin{aligned}\frac{d\ln X_j^h}{d\ln y_j} &= \gamma_3^h \theta^h \times \frac{d\lambda_j}{dy_j} \times \frac{X_j^h}{\lambda_j} \times \frac{y_j}{X_j^h} \\ &= \gamma_3^h \theta^h \times \zeta_j,\end{aligned} \tag{12}$$

where $\zeta_j = d\ln\lambda_j / d\ln y_j < 0$ is the elasticity of the Lagrangian multiplier with respect to per-capita income of country j. In this framework, η^h, σ^h and θ^h jointly define the sectoral income elasticity,[11] and the elasticity of demand with respect to country size $\left(-\gamma_1^h \theta^h\right)$.

2.3 The driving forces of bilateral trade

The same as the standard gravity model, equation (10) indicates that bilateral trade depends on the total income of trading partners, as well as trade barriers. In addition, (10) also incorporates the exporter's productivity in a differentiated sector h relative to the homogeneous sector: $(T_i^h/w_i)^{\theta^h}$, which controls for the supply side effect on trade – the (Ricardian) comparative advantage. And more importantly, the current gravity equation shows that not only the output of the exporter (Y_i) and the income of the importer ($\lambda_j^{\gamma_3^h \theta^h} L_j^{\gamma_1^h \theta^h}$) affect bilateral trade flows asymmetrically, the impacts of two elements of the importer's aggregate demand – per-capita income (λ_j) and country size (L_j) – are also differentiated and vary by sectoral characteristics.

It is worth mentioning that in the model, since $\gamma_3^h = \frac{\eta^h}{\alpha} \times \gamma_1^h$ according to (8), sectors that are more elastic with respect to per-capita income are also more elastic with respect to country size. This theoretical feature is confirmed by the positive correlation between the estimates of income and country size elasticities in the empirical section and implies an important way to explain some observed patterns in trade which will be explicitly studied later in this paper. My analysis focuses on the effects of production and demand structure on bilateral trade flows.[12]

Differentiating X_{ij}^h with respect to the exporter's productivity T_i^h, the importer's per-capita income y_j,[13] and country size of L_j using Leibniz rule, I can decompose the total marginal effects of T_i^h, y_j and L_j into their effects on the volumes of exports by each exporter

[11] It is important to discuss the difference in the measures of income elasticity in my framework and that when this CRIE preferences are applied to a model of perfect competition. In a Ricardian model such as Eaton and Kortum (2002), the price index P_j^h is proportional to Φ_j^h to some exponent. From (1) the sectoral income elasticity will simply be: $\frac{d\ln X_j^h}{d\ln y_j} = -\frac{\eta^h}{\alpha} \times \zeta_j$, and η^h alone measures the relative income elasticity between sectors. However, under the framework of monopolistic competition, per-capita income also enters the expression of price index through the Lagrangian multiplier as in (6), and η^h alone no longer measures the level of income elasticity. In addition, in the EK model, elasticity of substitution σ^h plays no significant role, as it does not enter the expression of bilateral trade. Fieler (2011) thus assumes $\eta^h = \sigma^h$. Caron et al.(2014) explicitly distinguishes these two parameters, but their results do not depend on the elasticity of substitution. In a monopolistic competition model, σ^h affects bilateral trade, so I need to treat η^h and σ^h differently.

[12] For the analysis on trade costs, see Anderson and van Wincoop (2003, 2004) and Chaney (2008).

[13] In the following analysis, while I stick to the notation of per-capita income y_i, it is important to note that it is endogenously determined by wage rate and dividend per share of the global profit fund: $y_i = w_i(1+\pi)$. Since I assume that each country is sufficiently small, there will be no general equilibrium effect of the change in a single country's labor productivity w_i, and each country therefore takes π as given. Then a per-capita income shock is essentially a shock to the exogenous labor productivity in the homogeneous sector.

– the intensive margin, and the effects on the numbers of exporters within an sector – the extensive margin:

$$\frac{dX_{ij}^h}{dT_i^h} = \underbrace{\left(w_i L_i \int_{\bar{\varphi}_{ij}^h}^{\infty} \frac{\partial x_{ij}^h(\varphi)}{\partial T_i^h} dG^h(\varphi) \right)}_{\text{the intensive margin}} - \underbrace{\left(w_i L_i x_{ij}^h(\bar{\varphi}_{ij}^h) G^{h\prime}(\bar{\varphi}_{ij}^h) \frac{\partial \bar{\varphi}_{ij}^h}{\partial T_i^h} \right)}_{\text{the extensive margin}},$$

$$\frac{dX_{ij}^h}{dy_j} = \underbrace{\left(w_i L_i \int_{\bar{\varphi}_{ij}^h}^{\infty} \frac{\partial x_{ij}^h(\varphi)}{\partial y_j} dG^h(\varphi) \right)}_{\text{the intensive margin}} - \underbrace{\left(w_i L_i x_{ij}^h(\bar{\varphi}_{ij}^h) G^{h\prime}(\bar{\varphi}_{ij}^h) \frac{\partial \bar{\varphi}_{ij}^h}{\partial y_j} \right)}_{\text{the extensive margin}},$$

$$\frac{dX_{ij}^h}{dL_j} = \underbrace{\left(w_i L_i \int_{\bar{\varphi}_{ij}^h}^{\infty} \frac{\partial x_{ij}^h(\varphi)}{\partial L_j} dG^h(\varphi) \right)}_{\text{the intensive margin}} - \underbrace{\left(w_i L_i x_{ij}^h(\bar{\varphi}_{ij}^h) G^{h\prime}(\bar{\varphi}_{ij}^h) \frac{\partial \bar{\varphi}_{ij}^h}{\partial L_j} \right)}_{\text{the extensive margin}}.$$

It then follows that, in terms of elasticity, each margin for changes in T_i^h has the following expression:[14]

$$\delta^h \equiv \frac{d\ln X_{ij}^h}{d\ln T_i^h} = \underbrace{\left(\sigma^h - 1\right)}_{\substack{\text{the intensive margin} \\ \text{elasticity } (>0)}} - \underbrace{\left(\sigma^h - 1 - \theta^h\right)}_{\substack{\text{the extensive margin} \\ \text{elasticity } (<0)}} = \theta^h > 0. \tag{13}$$

On the intensive margin, higher productivity decreases the marginal cost of production, and existing exports are able to generate higher revenue from sales; on the extensive margin, higher T_i^h increases the average sectoral productivity and thus increases the number of firms that are able to profitably export given the fixed cost of entering a certain market. This extensive margin effect is in line with Castro et al.(2013) which empirically confirms productivity as an opposite sorting mechanism on exporters to fixed costs. Moreover, the impact of T_i^h is magnified by the elasticity of substitution on the intensive margin, but dampened on the intensive margin. Intuitively, when varieties are more differentiated (with lower σ^h), since demand for varieties tends to be more inelastic, the price advantage due to a higher productivity does not affect sales from exporting much, and the impact of productivity on the intensive margin is weaker. On the other hand, in more differentiated industries, less productive firms are sheltered from competition and are able to capture a certain market share. Therefore when sectoral productivity increases, these firms are more likely to be able to generate sufficiently high profit in foreign markets to overcome the fixed cost of entering and start exporting which means that the impact of productivity on the extensive margin is stronger when σ^h is lower. The opposite applies when σ^h is high – varieties in sector h are more homogeneous. However, in aggregate, the effect of elasticity of substitution on each margin will be canceled out, and the overall impact of sectoral productivity on bilateral trade will only depend on the inverse measure of productivity dispersion θ^h.

Proposition 1: *Other things equal, higher productivity of the exporting country increases sectoral exports by increasing trade volume of existing exporters on the intensive margin*

[14] See appendix A4 for derivation.

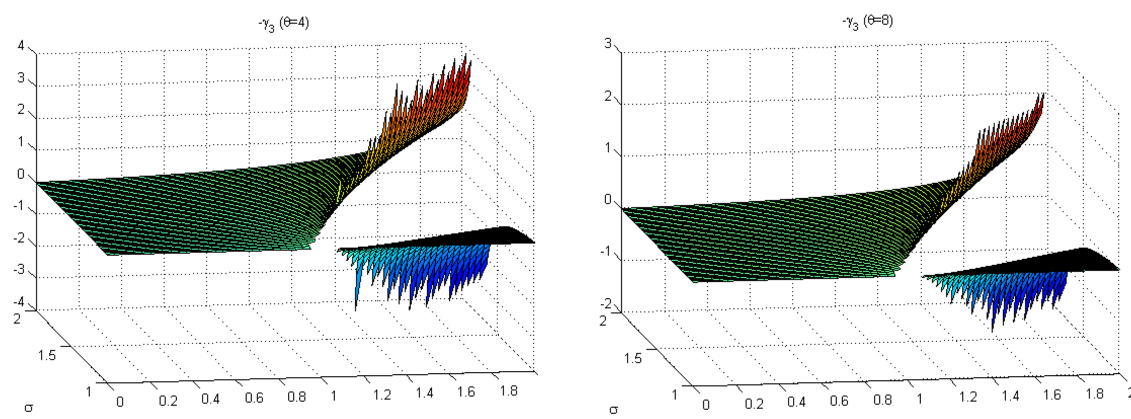
and allowing new entrants to export on the extensive margin; the elasticity of substitution magnifies this effect of productivity on the intensive margin and dampens the effect on the extensive margin.[15]

On the demand side, first note that the per-capita income elasticity on each margin is:

$$\xi_j^h \equiv \frac{d\ln X_{ij}^h}{d\ln y_j} = \underbrace{\gamma_3^h\left(\sigma^h - 1\right) \times \zeta_j}_{\text{the intensive margin elasticity}} - \underbrace{\gamma_3^h\left(\sigma^h - 1 - \theta^h\right) \times \zeta_j}_{\text{the extensive margin elasticity}} = \gamma_3^h \theta^h \times \zeta_j. \tag{14}$$

The impact of the per-capita income of the importing country y_j on each margin depends on the measure of cross-sector elasticity of substitution (η^h), within-sector elasticity of substitution (σ^h), as well as productivity dispersion (θ^h). In the following analysis, I will temporarily drop the sector subscript for the sake of notational clarity. From the expression of the elasticity in (14), the sign of ξ_j depends on the sign of $-\gamma_3$ since ζ_j is negative. Given any θ, $-\gamma_3 = \dfrac{-\eta(\sigma-1)}{\alpha[\theta(\eta-\sigma)-(\sigma-1)(\eta-1)]}$ is a function of η and σ. Figure 4 plots $-\gamma_3$ against η and σ for two different values of θ which are commonly used in related literature: [16] the left panel for $\theta = 4$, and the right panel for $\theta = 8$. Two main observations follow: (1) The surface of $-\gamma_3$ consists of two separate parts, the first part starts from a low η and a high σ (e.g. when $\eta = 0$ and $\sigma = 2$), and $-\gamma_3$ increases as η increases and σ decreases; the second part starts with a high η and a low σ, and $-\gamma_3$ decreases as η decreases and σ increases; the non-monotonicity of $-\gamma_3$ creates a gap between these two parts. (2) Compare the left panel with the right panel, and it is clear to see that lower θ increases the magnitude of $-\gamma_3$ for each combination of η and σ, however θ does not affect the behavior of $-\gamma_3$ qualitatively.

Figure 4: The behavior of $-\gamma_3$.



(L) $\theta = 4$ (R) $\theta = 8$

[15] This effect of sectoral fundamental productivity on bilateral trade is identical to the effect of variable trade costs in Chaney (2008).

[16] Simonovska and Waugh (2010) estimate θ to be 4.03 and 4.12, and in Eaton and Kortum (2002), the estimate is: 8.28. In addition, these two values are consistent with the estimates of θ^h in later sections of this paper.

The picture is more explicit when one looks at the cross-sectional behavior of $-\gamma_3$. In figure 5, I plot $-\gamma_3$ as a function of η for any given σ (and θ).[17] First note that, as shown in the graph, for any given σ I have:

$$-\frac{\partial \gamma_3}{\partial \eta} = \frac{(\sigma-1)\left[\theta\sigma-(\sigma-1)\right]}{\left[\theta(\eta-\sigma)-(\sigma-1)(\eta-1)\right]^2} > 0,$$

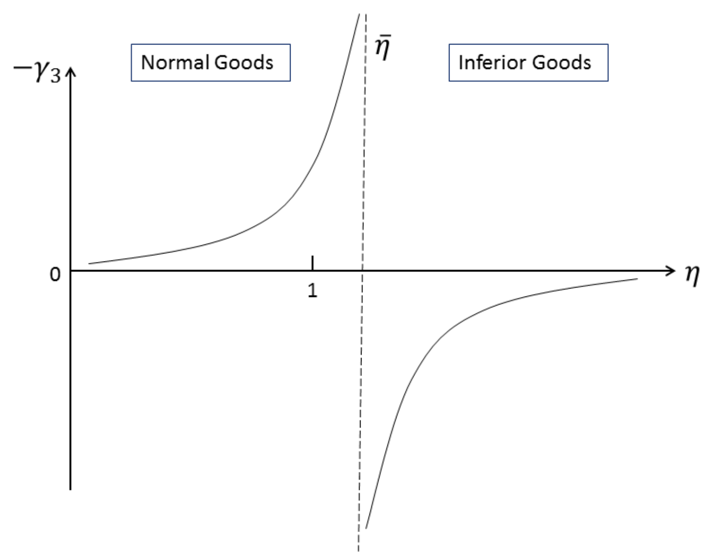
and there exists a threshold value of η:

$$\bar{\eta} = \frac{\theta\sigma-(\sigma-1)}{\theta-(\sigma-1)} > 1, \tag{15}$$

where

$$\begin{cases} -\gamma_3 > 0, & \text{if} \quad \eta < \bar{\eta}, \\ -\gamma_3 < 0, & \text{if} \quad \eta > \bar{\eta}. \end{cases}$$

Figure 5: $-\gamma_3$ for any given σ and θ.



Since $\lim_{\eta\to-\bar{\eta}} = \infty$, and $\lim_{\eta\to\bar{\eta}} = -\infty$, $-\gamma_3$ is not defined at $\eta = \bar{\eta}$. This theoretical framework therefore allows for both normal goods ($\xi_j^h = \gamma_3^h\theta^h \times \zeta_j > 0$) when $\eta < \bar{\eta}$, and inferior goods ($\xi_j^h = \gamma_3^h\theta^h \times \zeta_j < 0$) when $\eta > \bar{\eta}$, while both Fieler (2011) and Caron et al.(2014) preclude the existence of inferior goods since the income elasticity is always positive as long as η is greater than 0.

[17] The picture will look exactly the same if I plot $-\gamma_3$ against σ for any given η and θ, and the later arguments made on η will follow analogously on σ.

I will focus my analysis on normal goods hereafter assuming $\eta < \frac{\theta\sigma-(\sigma-1)}{\theta-(\sigma-1)}$. And from the expression of the elasticity in (14) I have: on the intensive margin, larger demand by country j consumers as they get richer increases the volumes of imports from existing exporters ($\gamma_3^h(\sigma^h-1)\times\zeta_j>0$), and on the extensive margin larger demand decreases the productivity threshold of entry allowing more firms in country i to export ($\gamma_3^h(\sigma_h-1-\theta^h)\times\zeta_j<0$). Thus other things equal, higher per-capita income of the importer increases bilateral trade. And this elasticity is magnified by η^h which governs the elasticity of substitution between the composite goods of each sector.[18]

The other element of aggregate demand is the size of the importer represented by the population of country j. Its marginal impact on bilateral trade depends on the sector-specific exponent: $-\gamma_1^h\theta^h$. Again since $\gamma_1^h=\frac{\alpha}{\eta^h}\times\gamma_3^h$ and moreover:

$$-\frac{\partial\gamma_1^h}{\partial\eta^h}=\frac{(\sigma^h-1)[\theta^h-(\sigma^h-1)]}{[\theta^h(\eta^h-\sigma^h)-(\sigma^h-1)(\eta^h-1)]^2}>0,$$

the behavior of $-\gamma_1^h$ with respect to η^h follows exactly the same pattern as that of $-\gamma_3^h$ which is visually demonstrated in figure 4 and figure 5. Following the previous analysis, the importer size elasticity of trade and its decomposition to the intensive and extensive margins is given by:

$$\kappa^h\equiv\frac{d\ln X_{ij}^h}{d\ln L_j}=\underbrace{-\gamma_1^h\left(\sigma^h-1\right)}_{\substack{\text{the intensive margin}\\ \text{elasticity(>0)}}}-\underbrace{\left[-\gamma_1^h\left(\sigma^h-1-\theta^h\right)\right]}_{\substack{\text{the extensive margin}\\ \text{elasticity(<0)}}}=-\gamma_1^h\theta^h. \tag{16}$$

So when looking at normal goods (that is when $\eta^h<\bar{\eta}^h$ and then $-\gamma_1^h>0$), other things equal, larger importer size increases sales of exporting firms on the intensive margin and decreases productivity threshold of entry on the extensive margin, which jointly increase total sectoral imports. Same as sectoral income elasticity, the country size elasticity is also magnified by η^h.

2.4 The importer home-market effect

The analysis on demand structure in the above section states that, other things equal, larger demand – in terms of both higher per-capita income and/or larger country size – disproportionally increases a country's total expenditure in more income/country size elastic sectors. As this total expenditure consists of two parts – imports from the world market and purchase from domestic market, it is natural to ask the question of *how the composition of total sectoral demand evolves as the aggregate income of a country increases*?

To answer that question, I first define the consumption of domestic production of a country j according to the gravity equation in (10) as:

[18] The magnitude of this elasticity will also depend on the ζ_j as shown in (14). In general, since λ_j is the shadow price of income, it is supposed to be more elastic when y_j is high. However this needs not to hold without knowing the explicit form of λ_j. For the sake of the analysis here, I'll assume ζ_j is small for all y_j, and so the magnitude of ξ_j^h will largely depend on γ_3^h and θ^h.

$$X_{jj}^h = \alpha_5^h \times \frac{Y_j \times \lambda_j^{\gamma_3^h \theta^h} L_j^{-\gamma_1^h \theta^h}}{Y} \times \left(\frac{T_j^h}{w_j}\right)^{\theta^h} \times \Phi_j^{h^{-\gamma_2^h \theta^h}} \times f_{jj}^{h^{-\frac{\theta^h-(\sigma^h-1)}{\sigma^h-1}}}. \tag{17}$$

Applying again Leibniz rule of differentiation, the decompositions of the marginal effects of demand elements on trade are then defined as:

$$\frac{dX_{jj}^h}{dE_j} = \underbrace{\left(\int_{\bar{\varphi}_{ij}^h}^{\infty} \frac{\partial (x_{jj}^h(\varphi) w_j L_j)}{\partial E_j} dG^h(\varphi)\right)}_{\text{the intensive margin}} - \underbrace{\left(w_j L_j x_{jj}^h(\bar{\varphi}_{jj}^h) G^{h\prime}(\bar{\varphi}_{jj}^h) \frac{\partial \bar{\varphi}_{jj}^h}{\partial E_j}\right)}_{\text{the extensive margin}}, \tag{18}$$

where $E_j \in \{y_j, L_j\}$.

First in terms of per-capita income y_j, the elasticity decomposition following (18) is:

$$\begin{aligned} \xi_j^{h'} \equiv \frac{d\ln X_{jj}^h}{d\ln y_j} &= \underbrace{\gamma_3^h \left(\sigma^h - 1\right) \times \zeta_j + 2 - \sigma^h}_{\substack{\text{the intensive margin}\\ \text{elasticity}}} - \underbrace{\left[\gamma_3^h \left(\sigma^h - 1 - \theta^h\right) \times \zeta_j + \theta^h - (\sigma^h - 1)\right]}_{\substack{\text{the extensive margin}\\ \text{elasticity}}} \\ &= \gamma_3^h \theta^h \times \zeta_j + 1 - \theta^h. \end{aligned} \tag{19}$$

Comparing (19) with the elasticity of (12), first it is clear that the reaction of the consumption of domestic production to the increase in per-capita income is less sensitive than imports on the extensive margin since $\theta^h > \sigma^h - 1$. This is because although higher income leads to higher revenue of sales to firms, it also increases the costs of production[19] which forces the productivity threshold of entering domestic market to rise. This logic also applies to the intensive margin: on one hand, getting richer tends to increase expenditure by consumers, and on the other hand higher price due to higher costs offsets this tendency on domestically produced goods. However which of these two opposite effects is dominating on the intensive margin depends on the value of σ^h. Overall, whether higher individual income increases X_{ij}^h more or X_{jj}^h (in terms of percent change) depends on $(1 - \theta^h)$. Recall that θ^h inversely measures the within sector productivity dispersion. The existing estimates of θ^h in relevant literature are generally greater than 1,[20] so it is safe to expect that $\theta^h > 1$ which suggests that $\xi_j^{h'} < \xi_j^h$: higher per-capita income increases sectoral imports more relative to the consumption of domestic production.

The case will differ when consider the marginal effect of country size L_j. Intuitively, while larger country size increases expenditure in the same way as higher income, it does not increase marginal cost of domestically produced goods. Formally, the country size elasticity of consumption of domestic production is:

[19] Recall that the increase in per-capita income in the context of this paper is essentially an increase in the wage rate of a country.

[20] The estimates of θ^h in the empirical section of this paper range from about 1.1 to 8.

$$\kappa^{h'} \equiv \frac{d\ln X_{jj}^h}{d\ln L_j} = \underbrace{-\gamma_1^h\left(\sigma^h - 1\right) + 1}_{\text{the intensive margin elasticity}} - \underbrace{\left[-\gamma_1^h\left(\sigma^h - 1 - \theta^h\right)\right]}_{\text{the extensive margin elasticity}} = 1 - \gamma_1^h\theta^h. \tag{20}$$

Compare to the elasticity in (16), while the extensive margin elasticities are the same, the intensive margin elasticity is strictly larger for the demand of domestic production. And overall, $\kappa^{h'} > \kappa^h$: larger country size increases the consumption of domestic production more relative to imports. This result relates to the theory of the home-market effect on trade proposed by Krugman (1980) and studied by a rich body of literature ever since.[21] Most of the studies on the home-market effect focus on the exporter side stating that countries are more likely to become exporters of goods in which they have a large demand, since with the presence of increasing returns to scale production technology and trade costs, it is more profitable for firms to locate and produce in these countries with larger demands and export to other countries. My model suggests that this rationale should also apply to the importers: controlling for other factors affecting trade and the cost of domestic production, large countries attract producers of goods in which they have high demands to produce locally to save trade costs, and this relocation of producers increases spending on domestic production more relative to imports. I will accordingly refer to the home-market effect implied by my model the "importer home-market effect".

Note first that, this "importer home-market effect" does not exist in gravity equations derived from models of constant returns to scale, such as in Eaton and Kortum (2002), Fieler (2011) and Caron et al.(2014), since in those models country size elasticities are fixed at unity for all sectors. Secondly, gravity equation based on increasing returns to scale implies the "importer home-market effect", but it does not vary by sector if preferences are homothetic, such as in Krugman (1980) and Chaney (2008). And in my model, the strength of the "importer home-market effect" depends on sectoral characteristics: when a sector is highly elastic with respect to country size, I shall have $1 \ll -\gamma_1^h\theta^h \approx 1 - \gamma_1^h\theta^h$, meaning that the difference between the elasticities of imports and consumption of domestic production is more neglectable in sectors with higher country size elasticities.

The following two propositions summarize the analysis on per-capita income and country size above:

Proposition 2: *Other things equal, higher per-capita income of the importer increases both imports and the consumption of domestic production, and the former increases more on the margin.*

Proposition 3 (the "importer home-market effect"): *Other things equal, larger size of the importer increases both imports and the consumption of domestic production, and the latter increases more on the margin. And this "importer home-market effect" is weakened by sectoral country size elasticity.*

It is also interesting to investigate the interaction between the elasticity of substitution σ^h and sectoral income/country size elasticity, and its implication on the home-market effect.

[21] See Davis and Weinstein (1996, 1999), Feenstra et al.(2001), Head and Ries (2001), Hanson and Xiang (2004), Crozet and Trionfetti (2008) etc.

The discussion is included in the on-line appendix. [22]

In sum, the gravity equation derived from my model implies that the two elements of aggregate demand – per-capita income and country size – play different roles in shaping bilateral trade patterns. In particular, country size generates "the importer home-market effect": as the the importer size gets larger, demand shifts toward domestically produced goods on the margin relative to imports, *ceteris paribus*. Meanwhile, the model also generates the home-market effect on the exporter in terms of relative trade which is in line with the studies by Krugman (1979, 1980).

2.5 The patterns of relative trade

Since the market follows monopolistic competition, I can define the sectoral exports of country i relative to those of country j as $EX_{ij}^h = X_{ij}^h / X_{ji}^h$. Then from (10) I have:

$$EX_{ij}^h = \underbrace{\left(\frac{Y_i}{Y_j}\right)\left(\frac{\lambda_i}{\lambda_j}\right)^{-\gamma_3^h\theta^h}\left(\frac{L_i}{L_j}\right)^{\gamma_1^h\theta^h}}_{\substack{\text{the demand}\\ \text{system}}} \times \underbrace{\left(\frac{Z_i^h}{Z_j^h}\right)^{\theta^h}}_{\substack{\text{comparative}\\ \text{advantage}}} \times \underbrace{\left(\frac{D_{ji}^h}{D_{ij}^h}\right)^{\theta^h}}_{\substack{\text{variable}\\ \text{trade costs}}} \times \underbrace{\left(\frac{f_{ji}^h}{f_{ij}^h}\right)^{\frac{\theta^h-(\sigma^h-1)}{\sigma^h-1}}}_{\substack{\text{fixed}\\ \text{trade costs}}}, \tag{21}$$

where Z_i^h and Z_j^h are defined as the fundamental productivity of the differentiated sectors relative to the homogeneous sector: $Z_i^h \equiv T_i^h / w_i$ and $Z_j^h \equiv T_j^h / w_j$. Equation (21) incorporates both standard Ricardian comparative advantage and the demand structure as shaping factors of bilateral trade patterns. To avoid any confusion that may rise from the use of notations, I will hereafter refer to country i as *Home*, and country j as *Foreign*.

The last two terms on the right hand side of the equality $(D_{ji}^h / D_{ij}^h)^{\theta^h}$ and $(f_{ji}^h / f_{ij}^h)^{\frac{\theta^h-(\sigma^h-1)}{\sigma^h-1}}$ are relative trade costs of exports *from Foreign to Home*, so higher these costs increase relative exports *from Home to Foreign*. The term $(Z_i^h / Z_j^h)^{\theta^h}$ measures the sectoral technology advantage of *Home* relative to *Foreign*, and thus *the sectoral comparative advantage of Home*. Last but not the least, relative trade also depends on the income of *Home* relative to that of *Foreign* through the term labeled "the demand system". Relative individual income and country size drive relative trade differently.

Since my analysis focuses on normal goods only, note that $-\gamma_3^h > 0$ and $\gamma_1^h < 0$. First, the elasticities of relative trade with respect to the per-capita income of *Home* and *Foreign* have the following expressions respectively:

$$\begin{aligned} \varepsilon_i^h &\equiv \frac{d\ln EX_{ij}^h}{d\ln y_i} = 1 - \theta^h - \gamma_3^h\theta^h \times \zeta_i < 0, \\ \varepsilon_j^h &\equiv \frac{d\ln EX_{ij}^h}{d\ln y_j} = -\left(1 - \theta^h - \gamma_3^h\theta^h \times \zeta_j\right) > 0. \end{aligned} \tag{22}$$

Using these two elasticities in (22), I can calculate the elasticity of relative trade with respect to the relative income of *Home* to *Foreign*, given that:

[22] The on-line appendix can be accessed at `http://weisixie.weebly.com/research.html`.

$$\frac{d\ln EX_{ij}^h}{d\ln(y_i/y_j)} = \frac{d\ln EX_{ij}^h}{d\ln y_i - d\ln y_j} = 1/\left(\frac{d\ln y_i}{d\ln EX_{ij}^h} - \frac{d\ln y_j}{d\ln EX_{ij}^h}\right).$$

It then follows that:

$$\varepsilon_{ij}^h \equiv \frac{d\ln EX_{ij}^h}{d\ln(y_i/y_j)} = \frac{A_{ij}^h}{[2 - 2\theta^h - \gamma_3^h\theta^h(\zeta_i + \zeta_j)]} < 0. \tag{23}$$

where $A_{ij}^h = (1-\theta^h-\gamma_3^h\theta^h\times\zeta_i)(1-\theta^h-\gamma_3^h\theta^h\times\zeta_j) > 0$. This means that relative trade decreases with relative income of *Home* and increases with that of *Foreign*. In addition, relative trade is affected also by income elasticity differently depending on the relative income levels between trading partners. Assume that trade is from a poor country to a rich country, and from (21) I shall have $\lambda_i/\lambda_j > 1$, and EX_{ij}^h is increasing in $-\gamma_3^h$: relative trade is higher in income elastic sectors as *Foreign's* expenditure concentrates on these sectors. When trade is from a rich country to a poor country instead, $\lambda_i/\lambda_j < 1$, and EX_{ij}^h is decreasing in $-\gamma_3^h$: relative trade is higher in income inelastic sectors as *Foreign* consumes more in these sectors. Another way to look at why relative trade moves along with relative income of *Foreign* is that after controlling for trade costs, trade is driven by two types of forces: on the supply side – (Y_i/Y_j) and $(Z_i^h/Z_j^h)^{\theta^h}$, and one the demand side – $(\lambda_i/\lambda_j)^{-\gamma_3^h\theta^h}$ and $(L_i/L_j)^{\gamma_1^h\theta^h}$. Among the supply forces, (Y_i/Y_j) obviously decreases with relative income of *Foreign*, however, $(Z_i^h/Z_j^h)^{\theta^h}$ is increasing in (y_i/y_j), and this effect of *Foreign's* income relative to *Home* outweighs its opposite effect on (Y_i/Y_j) (since $\theta^h > 1$). On the demand forces, (λ_i/λ_j) is always increasing in (y_j/y_i). Therefore, both the supply and demand side forces promote relative trade with higher relative *Foreign* income.

Next I consider the elasticities of EX_{ij}^h with respect to relative country sizes L_i/L_j:

$$\epsilon_{ij}^h \equiv \frac{d\ln EX_{ij}^h}{d\ln(L_i/L_j)} = 1 + \gamma_1^h\theta^h. \tag{24}$$

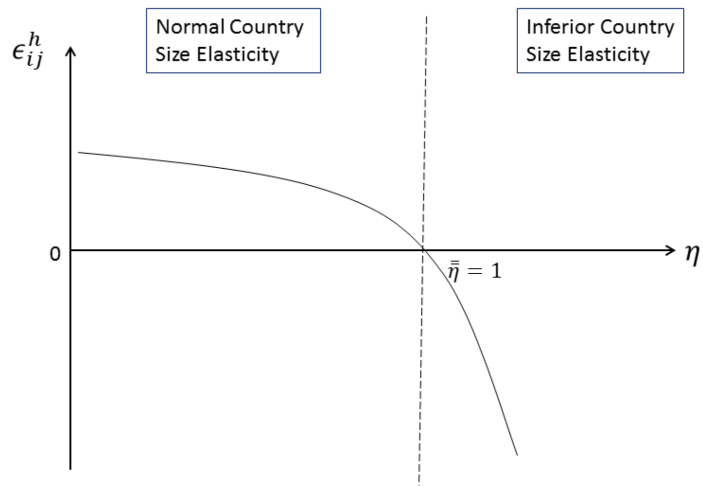
The sign of ϵ_{ij}^h is indeterminate since $\gamma_1^h < 0$ for normal goods. Following the discussion on γ_1^h before, there exists a threshold of η^h denoted by $\bar{\bar{\eta}}^h$ such that:

$$\begin{cases} \epsilon_{ij}^h > 0, & \text{if} \quad \eta^h < \bar{\bar{\eta}}^h, \\ \epsilon_{ij}^h < 0, & \text{if} \quad \eta^h > \bar{\bar{\eta}}^h. \end{cases}$$

So $\bar{\bar{\eta}}^h$ is defined by setting ϵ_{ij}^h equal 0, and therefore $\bar{\bar{\eta}}^h = 1$. This means that, in the model, sectors can be categorized into two groups given the sectoral specific parameter η^h (and thus their country size elasticities). I will therefore identify them as either "normal country size elasticity" sectors (where $\eta^h > 1$) or "inferior country size elasticity" sectors (where $\eta^h < 1$). Figure 6 plots ϵ_{ij}^h against η^h for any given σ^h and θ^h.

For "inferior country size elasticity" sectors, $\epsilon_{ij}^h < 0$ and relative trade decreases with relative size of *Home*, and increases with relative size of *Foreign* in a sense that is similar to inferior goods. In the empirical sections, all sectors in the sample (except for one) however are estimated to have positive country size elasticities and are identified to be "normal country size elasticity" sectors, where $\epsilon_{ij}^h > 0$, and relative trade increases with relative size of *Home* and decreases with relative size of *Foreign*. This happens when the supply side effect of

Figure 6: ϵ_{ij}^h for any given σ^h and θ^h.



the relative country size dominates the demand side effect: domestic production increases disproportionally to the increase of demand as relative size of *Home* increases. This in fact captures the home-market effect on the exporter side (*Home*) following the Krugman's (1980) idea. However, while the supply side effect is constant across sectors (with unitary elasticity), the demand side effect is *increasing in magnitude* with η^h, and therefore with sectoral country size elasticity. Following the terminology used before, this effect will be phrased as the "exporter home-market effect", and furthermore, it is weaker in more elastic sectors with respect to country size, and it disappears after η^h passes the threshold $\bar{\bar{\eta}}^h$, which is when the growth rate of domestic production gets lower than the growth rate of demand as the relative country size increases. These theoretical results of relative trade patterns are summarized in the following propositions.

Proposition 4: *Other things equal, relative exports increases with relative per-capita income of Foreign, and increases more in sectors that are more elastic with respect to per-capita income.*
Proposition 5 (the "exporter home-market effect"): *Other things equal, relative exports increases with relative size of Home in "normal country size elasticity" sectors. And this "exporter home-market effect" is weakened by sectoral country size elasticity.*

It is worthwhile to address that, for the "normal country size elasticity" sectors, following the discussion in the on-line appendix on the interaction between σ^h and country size elasticity, lower σ^h decreases country size elasticity, implying that smaller sectoral elasticity of substitution magnifies the home-market effect. This is consistent with the findings by Hanson and Xiang (2004), where they argue both theoretically and empirically that the home-market effect is stronger in more differentiated sectors.

A final observation on the relative trade of (21) is that in this framework, both demand structure and comparative advantage shape relative trade patterns in addition to trade costs. In section 4, I conduct data decomposition to isolate the effects of relative demand and relative productivity to measure the strength of the "exporter home-market effect" and comparative advantage in shaping relative trade patterns.

3 Estimation

I carry out the empirical analysis in this section, which follows a two-fold procedure: I first estimate the structural gravity equation derived from the theoretical model to obtain estimates of sectoral per-capita income and country size elasticities, and at the same time I will also be able to back out estimates of other key parameters – θ^h, η^h and σ^h; secondly, I test the home-market effect both on the level of bilateral trade and on relative trade and how it varies with sectoral characteristics via reduced-form analysis. I introduce the identification strategies first, then describe the source and construction of the dataset and present the estimation results.

3.1 Identification

Taking the log of the gravity equation of (10) I get:

$$\begin{aligned}\ln X_{ij}^h =& \ln\alpha_5^h + \ln\frac{Y_i}{Y} + \gamma_3^h\theta^h\ln\lambda_j - \gamma_1^h\theta^h\ln L_j + \theta^h\ln Z_i^h - \theta^h\ln d_{ij}^h - \gamma_2^h\theta^h\ln\Phi_j^h \\ & - \frac{\theta^h - (\sigma^h - 1)}{\sigma^h - 1}\ln f_{ij}^h.\end{aligned} \tag{25}$$

In principle, I can structurally estimate the demand elasticities using this equation controlling for supply side effect and trade costs. However, in addition to observed variables such as income and population, I will need data on variable and fixed trade barriers (d_{ij}^h, Φ_j^h and f_{ij}^h), as well as productivity (Z_i^h). For variable trade costs, following the strategy used in existing literature,[23] I assume that bilateral trade costs d_{ij}^h to be a function of physical distance between trading partners, common border, common language, and regional trade agreement (RTA). So that the log of trade costs has the following expression:

$$\begin{aligned}\ln d_{ij}^h =& \beta_{dist}^h \ln Dist_{ij} - \beta_{border}^h Border_{ij} - \beta_{lang}^h CommonLanguage_{ij} \\ & - \beta_{RTA}^h RTA_{ij} + ex_i^h.\end{aligned} \tag{26}$$

An exporter fixed effect is included in the expression of $\ln d_{ij}^h$ following the idea of Waugh (2010), which shows that the exporter fixed effect does a better job at matching data patterns.[24] As for the fixed costs, since there are no direct measures to refer to, there are two potential approaches one could take. First, I could include some country or country-pair fixed effects in the regressions. The benefit of doing so is that I would be able to get estimates of

[23] See, for example, Fieler (2011), Caron et. al (2014), and Levchenko and Zhang (2013).

[24] This exporter fixed effect is essentially the control of home bias in trade costs in Caron et al.(2014).

the fixed costs through these fixed effects. However it considerably increases the number of parameters to estimate, and regressions in many cases are not able to produce fixed effects estimates or only produce insignificant results. Therefore, I take an alternative approach which takes the fixed costs as error terms in all specifications to estimate. While this is definitely not an innocent assumption, I provide two main justifications to it. First, according to the theory, the fixed costs are exogenous and do not correlate with the other independent variables, such as income, country size and productivity in the gravity equation. Second, if I assume certain functional forms of fixed costs faced by different trading partners and across sectors, the zero mean assumption of disturbances can be satisfied by including a constant term in the regressions regardless whether the theory predicts a constant in the equation or not. In particular, I'll assume that fixed costs f_{ij}^h and f_{jj}^h have the following structures:

$$f_{ij}^h = \exp\left(F_j^h + \nu_i^h\right), \quad \nu_i^h \sim N(0, \mu_h^2)$$
$$f_{jj}^h = \exp\left(F_j + \nu^h\right), \quad \nu^h \sim N(0, \mu_j^2).$$

This is to say, the log of the fixed cost facing a country i exporter entering sector h in country j is a importer- and sector-specific mean of F_j^h plus some random exporter- and sector-specific shock ν_i^h which is normally distributed with mean zero and a sector-specific variance μ_h^2. Similarly, the fixed cost of country j firm entering sector h domestically is a country-specific mean F_j plus a sector-specific shock ν^h, and it follows a normal distribution of mean 0 and a country-specific variance μ_j^2. These assumptions allow me to treat the fixed costs as error terms and consistently estimate other parameters in the specifications.[25]

To get the estimates of sectoral productivities which are not observed in data, I divide bilateral trade by the consumption of domestic production:

$$\frac{X_{ij}^h}{X_{jj}^h} = \frac{Y_i}{Y_j} \times \left(\frac{Z_i^h}{Z_j^h}\right)^{\theta^h} \times \left(d_{ij}^h\right)^{-\theta^h} \times \left(\frac{f_{ij}^h}{f_{jj}^h}\right)^{-\frac{\theta^h-(\sigma^h-1)}{\sigma^h-1}}. \tag{27}$$

Replace Z_i^h with T_i^h/w_i, linearize this equation by taking the log on each side of the equality, and plug in the expression of d_{ij}^h of (26), I get the following specification:

$$\begin{aligned}\ln\frac{X_{ij}^h}{X_{jj}^h} =& \ln\frac{Y_i}{Y_j} + \underbrace{\theta^h \ln T_i^h - \theta^h ex_i^h}_{\text{exporter FE}} \underbrace{-\theta^h \ln T_j^h}_{\text{importer FE}} + \theta^h \ln\frac{w_j}{w_i} \\ &- \theta^h \beta_{dist}^h \ln Dist_{ij} + \theta^h \beta_{border}^h Border_{ij} + \theta^h \beta_{lang}^h CommonLanguage_{ij} \\ &+ \theta^h \beta_{RTA}^h RTA_{ij} \underbrace{- \frac{\theta^h - (\sigma^h - 1)}{\sigma^h - 1} \ln\frac{f_{ij}^h}{f_{jj}^h}}_{\text{error term}}.\end{aligned} \tag{28}$$

I estimate the equation in (28) with fixed effects. w_i and w_j are wage rates, and I use per-

[25] However, one does have to note that the estimated error terms then contain information on both the fixed costs as well as any other unobserved and unexplained variance in the data.

capita income as a proxy for wage, to get the estimates of θ^h.[26] And along with the importer fixed effects, I can back out the estimate of sectoral fundamental productivity T_j^h.

Also not observed in data is the measure of a country's proximity to the rest of the world Φ_j^h. Dividing country j's consumption of domestic production by X_j^h of (11), I get the domestic share of country j's sectoral expenditure:

$$\frac{X_{jj}^h}{X_j^h} = \frac{Y_j}{Y} \times Z_j^{h\,\theta^h} \times \Phi_j^{h\,-1} \times f_{jj}^{h\,-\frac{\theta^h-(\sigma^h-1)}{\sigma^h-1}}. \tag{29}$$

Given the estimates of $\hat{\theta}^h$, and $\hat{Z}_j^h$,[27] the linearized equation to estimate is:

$$\ln\frac{X_{jj}^h}{X_j^h} = \ln\frac{Y_j}{Y} + \hat{\theta}^h \ln\hat{Z}_j^h \underbrace{-\ln\Phi_j^h}_{\text{importer FE}} \underbrace{-\frac{\theta^h-(\sigma^h-1)}{\sigma^h-1}\ln f_{jj}^h}_{\text{error term}}, \tag{30}$$

The importer fixed effects then deliver the estimates of $\hat{\Phi}_j^h$.

With these estimates in hand, the complete specification to estimate is:

$$\begin{aligned}\ln X_{ij}^h =& \ln\alpha_5^h + \ln\frac{Y_i}{Y} + \hat{\theta}^h\ln\hat{Z}_i^h + \gamma_3^h\hat{\theta}^h\ln\lambda_j - \gamma_1^h\hat{\theta}^h\ln L_j - \gamma_2^h\hat{\theta}^h\ln\hat{\Phi}_j^h - \hat{\theta}^h\beta_{dist}^h\ln Dist_{ij}\\ &+ \hat{\theta}^h\beta_{border}^h Border_{ij} + \hat{\theta}^h\beta_{lang}^h CommonLanguage_{ij} + \hat{\theta}^h\beta_{RTA}^h RTA_{ij}\\ &\underbrace{-\hat{\theta}^h ex_i^h}_{\text{exporter FE}} \underbrace{-\frac{\theta^h-(\sigma^h-1)}{\sigma^h-1}\ln f_{ij}^h}_{\text{error term}},\end{aligned} \tag{31}$$

Therefore, the country size elasticity estimates are simply $\hat{\kappa}^h = -\hat{\gamma}_1^h\hat{\theta}^h$. As for sectoral per-capita income elasticity, note that the Lagrangian multiplier λ_j is not observed. However, since it is a decreasing function of per-capita income, I replace $\ln\lambda_j$ with $\ln y_j$ in the specification, and the estimated coefficients on $\ln y_j$ will be $\hat{\varepsilon}^h$, the income elasticities.[28]

As by-products of the identification strategy, estimating (31) also generates $\hat{\gamma}_1^h$ and $\hat{\gamma}_2^h$, which can be used to back out two other key parameters of the model: the measure of cross-section elasticity of substitution η^h and within-sector elasticity of substitution σ^h. According the theoretical framework, since γ_1^h and γ_2^h are functions of η^h and σ^h, they are used to calculate these two parameters by solving the first two equations of (8) simultaneously:[29]

$$\begin{aligned}\hat{\eta}^h &= \frac{\hat{\theta}^h\hat{\gamma}_2^h - 1}{\hat{\gamma}_1^h} + 1,\\ \hat{\sigma}^h &= \frac{\hat{\theta}^h\hat{\gamma}_2^h - 1}{\hat{\gamma}_1^h + \hat{\gamma}_2^h} + 1.\end{aligned} \tag{32}$$

[26] According to the theoretical model, per-capita income is proportional to the wage rate: $y_i = (1+\pi)w_i$. So I will have $w_j/w_i = y_j/y_i$.

[27] $\hat{Z}_j^h = \hat{T}_j^h/w_j$.

[28] In the main text of Caron et al.(2014), they are able to get the estimates of λ for each country. In the appendix, they show that replacing λ with individual income in estimation produces the same income elasticities.

[29] See appendix A.5 for derivation.

Consequently, I am able to get the estimates of θ^h, η^h, and σ^h during the estimation of sectoral demand elasticities. These parameters are of much broader interests especially in the literature on gravity models. Usually, they are estimated separately under different theoretical and empirical settings, and my current model provides a way to estimate these parameters within a unified framework.

Additional details on identification will be presented along with the empirical results. Before that, I briefly describe the data source and the construction of the dataset.

3.2 Data

Bilateral trade data are from Feenstra et al.(2005), where they compile and clean the United Nation trade database. I use these data instead the raw UN data because the corrections and adjustments made by the authors ensure that the data are comparable across countries and over time. More details on data cleaning are described in the corresponding paper. The trade data are organized by the 4-digit Standard International Trade Classification (SITC) revision 2, covering bilateral trade from 1963 to 2000. I convert the data to the 3-digit International Standard Industrial Classification (ISIC) revision 2 using a concordance developed by Levchenko and Zhang (2013).

Output data are taken from the United Nations Industrial Development Organization (UNIDO) Industrial Statistics Database (INDSTAT3 2004 version), which arranges production data at the 3-digit ISIC level for 29 manufacturing sectors (including total manufacturing) of 179 countries in total, ranging from 1963 to 2002. These data are then matched with the trade data based on a concordance developed by the author of this paper.

Data of GDP and population are taken from the Penn World Table 7.1. Country-pair-specific data (distance, common border, common language, and regional trade agreement) are from the gravity dataset compiled by the French research center in international economics (CEPII). The construction of this dataset is presented in Head et al.(2010).

The final dataset used in this paper then contains information on bilateral trade, production, income and measures of trade costs of 28 3-digit ISIC manufacturing sectors for 150 countries from 1963 to 2000 the availability of which varies by year. Data of trade, output and income are measured in current price of 1,000 US Dollars, and data on population are measured in thousands.

3.3 The estimates

In order to keep full flexibility both across sectors and over time, most of the specifications stated in previous section are estimated for each sector and decade.[30] Specifically, I will have the estimates of the sectoral productivities T_j^h and a country's openness measure Φ_j^h for each decade as they are expected to evolve over time by nature. The within sector productivity distribution parameter θ^h are estimated using pooled data of all years for each sector. While in principle the sectoral demand elasticities should vary with the income level and the size of a country at a specific point in time, I also use pooled data to estimate them to get the *average* income and country size elasticities for each sector over time and across countries.

[30]The first decade covers the eight years from 1963 to 1970 due to data availability.

I first estimate (28) using OLS with exporter and importer fixed effects.[31] Table 1 reports the estimates of θ^h for each sector. All estimates are significant at 1% level. Several papers in the literature have attempted to estimate θ following different approaches. A benchmark case is given by the Ricardian model estimation in Eaton and Kortum (2002) whose estimate of θ is 8.28, and this is close to the upper bound of my estimates. In more recent work, Costinot et al.(2012) provides a preferred estimate of 6.53, and in Simonovska and Waugh (2010) the estimates are 4.12 and 4.03 which are basically the mean of my estimates. While most of the work assumes θ to be constant across sectors, Caliendo and Parro (2012), similar to my work, allow θ to vary by sector, and their estimates ranges from 0.31 to 51.08, with an average for manufacturing sectors of 8.22.[32] In general, my estimates of θ^h are consistent with existing references in the literature.

With the $\hat{\theta}^h$'s in hand, the importer fixed effects of (28) are then used to back out sectoral fundamental productivity T_j^h. Given the available degrees of freedom, a reference country is omitted for both the exporter and the importer, and in my case the reference country is the United States. So essentially the estimated importer fixed effects are a country's sectoral productivity relative to the U.S.:

$$\text{importer FE} = -\theta^h \ln \frac{T_j^h}{T_{us}^h}.$$

To extract T_j^h from the fixed effects, I need to obtain the sectoral productivity of the U.S. first. I use the NBER-CES Manufacturing Industry Dataset (Bartelsmand and Gray, 1996) to estimate the U.S. productivities.[33]

The estimates of θ_j^h and productivity $\hat{T}_j^h$ are then used to construct $\hat{\theta}^h \ln \hat{Z}_j^h$, which is used in estimating (30) to get $\hat{\Phi}_j^h$, the measure of a country's closeness to the world market for each sector and decade.

Lastly, I estimate (31) to obtain the demand elasticities, and $\hat{\gamma}_1^h$ and $\hat{\gamma}_2^h$. Table 2 reports the estimates of γ_1^h and γ_2^h along with their standard errors. 27 out 28 $\hat{\gamma}_1^h$'s are negative, and according to the model, the sectoral income elasticities of these sectors are positive, indicating that commodities from these manufacturing sectors in my sample are identified as normal goods. The estimate of sector ISIC 322 is positive, implying a negative income elasticity of

[31] Linearizing the equation using log transformation requires both bilateral trade X_{ij}^h and the consumption of domestic production X_{jj}^h to be positive. Two related issues arise. First, zero bilateral trade flows are dropped from the sample. In principle, one can apply Poisson regression instead of OLS to make use these zeros in trade. However, with the large sets of fixed effects included, often times non-linear estimation method does not converge, and fails to generate estimates of interests. So my OLS estimation procedure only applies to positive trade flows in the data. Second, the consumption of domestic production is calculated as: (sectoral output - sectoral exports). In theory, a country can have positive exports in a sector even when the sectoral output is zero making the consumption of domestic production negative, simply because of the existence of intermediate goods and re-exports, which are not captured in the theoretical model. In the data, negative X_{jj}^h accounts for about 13.82% of the observations, and dropping them will therefore lead to selection bias of the estimates. To solve this issue, I use the following data transformation: Whenever $X_{jj}^h < 0$, I use $-1/X_{jj}^h$ instead of X_{jj}^h in estimation. Thus, a negative X_{jj}^h that is large in magnitude, is transformed to be a small positive number, indicating small or no domestic consumption.

[32] In Caliendo and Parro (2010), their lowest estimate of θ 0.37 is for sector "Other Transport", and the second lowest estimate is 1.01 for sector "Auto". On the other hand, the highest estimate 51.08 is an outlier, and is for the sector "Petroleum". Their second highest estimate is for sector "Office", with a value of 12.79.

[33] Details and results of the U.S. estimates are described in the on-line appendix.

Table 1a: Estimated sectoral productivity dispersion

ISIC code	Description	$\hat{\theta}^h$	Std. error
311	Food products	4.932***	0.316
313	Beverages	3.659***	0.495
314	Tobacco	3.707***	0.168
321	Textiles	4.489***	0.317
322	Wearing apparel, except footwear	2.349***	0.575
323	Leather products	7.663***	0.675
324	Footwear, except rubber or plastic	7.012***	0.673
331	Wood products, except furniture	1.854***	0.111
332	Furniture, except metal	5.239***	0.132
341	Paper and products	1.064***	0.467
342	Printing and publishing	2.332***	0.105
351	Industrial chemicals	1.231***	0.573
352	Other chemicals	2.408***	0.093
353	Petroleum refineries	4.214***	0.741
354	Misc. petroleum and coal products	5.181***	0.169
355	Rubber products	3.767***	0.476
356	Plastic products	5.374***	0.561
361	Pottery, china, earthenware	6.928***	0.731
362	Glass and products	2.931***	0.629
369	Other non-metallic mineral products	1.876***	0.512
371	Iron and steel	6.046***	0.610
372	Non-ferrous metals	5.838***	0.108
381	Fabricated metal products	5.836***	0.080
382	Machinery, except electrical	8.022***	0.483
383	Machinery, electric	7.614***	0.108
384	Transport equipment	2.604***	0.464
385	Professional & scientific equipment	2.218***	0.112
390	Other manufactured products	2.537***	0.132

Notes: OLS estimates of θ^h are obtained by estimating (28) using pooled data over 38 years from 1963 to 2000 for each sector. *** p<0.01, ** p<0.05, * p<0.1.

Table 1b: Summary stats of $\hat{\theta}^h$

	Observations	Min	Mean	Max	Std. dev.
$\hat{\theta}^h$	28	1.064	4.247	8.022	2.087

this sector, and therefore, sector "Wearing apparel, except footwear" is identified as inferior in the data, the existence of which is allowed in the theoretical framework. However in later analysis, the focus will be put on the other 27 "normal" sectors and be silent on this "inferior" sector. Secondly, 6 out of 28 $\hat{\gamma}_2^h$'s are also negative, suggesting that being closer to the rest of world decreases the productivity threshold of entering the market in a given country, and it also decreases the bilateral resistance between trading partners and therefore increases bilateral trade in these sectors, *ceteris paribus*. And it is the opposite for the rest sectors.

Table 2: Estimates of γ_1^h and γ_2^h

ISIC code	Description	$\hat{\gamma}_1^h$	Std. error	$\hat{\gamma}_2^h$	Std. error
311	Food products	-0.189***	0.002	0.023***	0.000
313	Beverages	-0.235***	0.005	0.014***	0.000
314	Tobacco	-0.020**	0.008	-0.009***	0.003
321	Textiles	-0.250***	0.003	0.037***	0.000
322	Wearing apparel, except footwear	0.132***	0.012	0.083***	0.002
323	Leather products	-0.108***	0.003	0.033***	0.001
324	Footwear, except rubber or plastic	-0.126***	0.005	0.001***	0.000
331	Wood products, except furniture	-0.393***	0.011	0.137***	0.003
332	Furniture, except metal	-0.306***	0.005	0.077***	0.001
341	Paper and products	-0.650***	0.009	0.123***	0.005
342	Printing and publishing	-0.435***	0.007	0.312***	0.002
351	Industrial chemicals	-1.524***	0.020	0.141***	0.002
352	Other chemicals	-0.594***	0.008	0.120***	0.002
353	Petroleum refineries	-0.242***	0.006	0.035***	0.001
354	Misc. petroleum and coal products	-0.414***	0.008	0.053***	0.001
355	Rubber products	-0.357***	0.006	0.015***	0.001
356	Plastic products	-0.168***	0.005	-0.046***	0.000
361	Pottery, china, earthenware	-0.100***	0.003	-0.020***	0.000
362	Glass and products	-0.305***	0.005	-0.078***	0.001
369	Other non-metallic mineral products	-0.518***	0.009	0.042***	0.002
371	Iron and steel	-0.187***	0.004	-0.025***	0.000
372	Non-ferrous metals	-0.217***	0.004	-0.021***	0.000
381	Fabricated metal products	-0.194***	0.002	0.007***	0.000
382	Machinery, except electrical	-0.135***	0.002	-0.059***	0.000
383	Machinery, electric	-0.130***	0.002	0.002***	0.000
384	Transport equipment	-0.462***	0.005	0.086***	0.001
385	Professional & scientific equipment	-0.678***	0.014	0.386***	0.004
390	Other manufactured products	-0.488***	0.010	0.169***	0.002

Notes: OLS estimates of γ_1^h and γ_2^h are obtained by estimating (31) with exporter fixed effects. *** p<0.01, ** p<0.05, * p<0.1.

Then I calculate $\hat{\eta}^h$ and $\hat{\sigma}^h$ using the estimates of γ_1^h, γ_2^h and θ^h according to (32) and report them in table 3. Recall that several constraints are imposed on η^h and σ^h by the theory: $\eta^h > 0$, $\sigma^h > 1$, and $\theta^h > \sigma^h - 1$. While I do not explicitly control for these constraints during the estimation process, the outcomes largely satisfy these constraints which does justification to the structural validity of the model. It is worth noting that σ^h in my model is the elasticity of substitution between varieties within each sector and not between composite goods across sectors. Most empirical studies take the elasticity of exports with respect to trade costs as an estimate of σ^h, and this is only corrected based on the Krugman model of representative firms. As stated in Chaney (2005), in a model of within sector heterogeneity, actual within sector elasticity of substitution will be inversely related to the elasticity of exports with respect to trade barriers. For that reason, there's not much comparability between my $\hat{sigma}^h$ and the estimates of existing empirical studies. However, a potentially better reference would be Broda and Weinstein (2006). They extend the framework of Feenstra (1994), and estimate the elasticity of substitution using data at a sufficiently fine level of disaggregation to take into account the firm level heterogeneity within sectors. They estimate σ^h at different levels of disaggregation, and closest to my sample are sectors at the 3-digit SITC level where the estimates of σ^h have means of 6.8 and 4.0 for two time periods: 1972-1988 and 1990-2001 respectively. My estimates are clearly within reasonable range comparing to theirs.

As reviewed before, the measure of productivity dispersion θ^h, cross- and within-sector elasticity of substitutions η^h and σ^h, are of central interest of empirical studies on international trade, and existing works have developed various methods to estimate these parameters based on different models. My theoretical model provides a unified framework to generate estimates of these parameters based on a single structural gravity equation. The estimates described in this section satisfy theoretical constraints and are also consistent with other related works in the literature.

3.4 The home-market effect

Both the "importer home-market effect" and "exporter home-market effect" predicted by the model are essentially the results of the interactions between the supply-side effect and the demand-side effect on bilateral trade. The demand side effect is governed by per-capita income and country size elasticities. The demand elasticity estimates are reported in table 4a through 4c. Setting aside sector ISIC 322, sector "Tobacco" exhibits the lowest per-capita income elasticity while sector "Misc. petroleum and coal products" exhibits the highest. The mean across the 27 "normal" sectors is over 1.9. Country size elasticities are reported in increasing order in table 4b. For most sectors country size elasticities are different from unity with an average of 1.1. The sectors that exhibit the lowest and highest country size elasticities are the same as the sectors that have the lowest and highest per-capita income elasticities. An important feature of the demand elasticities is that, according to the theory, sectors that are more elastic with respect to individual income are also more elastic with respect to country size, and this theoretical prediction is confirmed by the estimates: the correlation between ε^h and κ^h is about 0.6. This positive relationship between this two demand elasticities provides a potential channel to explain some observed puzzles in trade, which will be discussed in a later section.

The supply-side effect, on the other hand, is governed by the elasticities of aggregate output and productivity of the exporter with respect to trade, the former of which is 1 and the latter is θ^h. To avoid putting too much structure on the data, I do not impose any

Table 3a: The calculated $\hat{\eta}^h$ and $\hat{\sigma}^h$

ISIC code	Description	$\hat{\eta}^h$	$\hat{\sigma}^h$
311	Food products	5.689	6.343
313	Beverages	5.033	5.291
314	Tobacco	52.418	36.635
321	Textiles	4.335	4.909
323	Leather products	7.880	10.904
324	Footwear, except rubber or plastic	8.848	8.933
331	Wood products, except furniture	2.901	3.916
332	Furniture, except metal	2.943	3.600
341	Paper and products	2.336	2.648
342	Printing and publishing	1.624	3.206
351	Industrial chemicals	1.542	1.598
352	Other chemicals	2.199	2.502
353	Petroleum refineries	4.515	5.114
354	Misc. petroleum and coal products	2.752	3.009
355	Rubber products	3.645	3.760
356	Plastic products	8.419	6.824
361	Pottery, china, earthenware	12.445	10.514
362	Glass and products	5.020	4.204
369	Other non-metallic mineral products	2.778	2.934
371	Iron and steel	7.157	6.431
372	Non-ferrous metals	6.191	5.726
381	Fabricated metal products	5.943	6.140
382	Machinery, except electrical	11.916	8.595
383	Machinery, electric	8.569	8.714
384	Transport equipment	2.676	3.062
385	Professional & scientific equipment	1.213	1.495
390	Other manufactured products	2.169	2.792

Notes: Sectoral values of $\hat{\eta}^h$ and $\hat{\sigma}^h$ are calculated using estimates of γ_1^h, γ_2^h and θ^h according to the equations in (32).

Table 3b: Summary stats of $\hat{\eta}^h$ and $\hat{\sigma}^h$

	Observations	Min	Mean	Max	Std. dev.
$\hat{\eta}^h$	27	1.213	6.784	52.418	9.624
$\hat{\sigma}^h$	27	1.495	6.289	36.635	6.603

Table 4a: Per-capita income elasticities

ISIC code	Description	ξ^h	Std. error
314	Tobacco	0.050	0.031
341	Paper and products	0.932***	0.012
311	Food products	1.180***	0.013
331	Wood products, except furniture	1.237***	0.024
342	Printing and publishing	1.240***	0.020
384	Transport equipment	1.354***	0.015
351	Industrial chemicals	1.432***	0.024
383	Machinery, electric	1.559***	0.020
369	Other non-metallic mineral products	1.783***	0.019
321	Textiles	1.820***	0.013
362	Glass and products	1.884***	0.017
372	Non-ferrous metals	1.968***	0.028
352	Other chemicals	1.974***	0.020
361	Pottery, china, earthenware	2.003***	0.023
382	Machinery, except electrical	2.073***	0.022
381	Fabricated metal products	2.100***	0.014
353	Petroleum refineries	2.180***	0.028
356	Plastic products	2.192***	0.030
371	Iron and steel	2.194***	0.024
313	Beverages	2.198***	0.023
385	Professional & scientific equipment	2.260***	0.028
355	Rubber products	2.381***	0.024
323	Leather products	2.630***	0.032
332	Furniture, except metal	2.788***	0.033
324	Footwear, except rubber or plastic	3.128***	0.041
390	Other manufactured products	3.133***	0.031
354	Misc. petroleum and coal products	4.014***	0.041

Notes: Estimates of sectoral income elasticity (ε^h) are obtained by estimating equation (31) for each sector, with $\ln\lambda_j$ being replaced by per-capita income of the importer – country j.

Table 4b: Market size elasticities

ISIC code	Description	κ^h
314	Tobacco	0.074
361	Pottery, china, earthenware	0.690
341	Paper and products	0.692
331	Wood products, except furniture	0.728
323	Leather products	0.831
313	Beverages	0.860
324	Footwear, except rubber or plastic	0.885
362	Glass and products	0.895
356	Plastic products	0.904
311	Food products	0.932
369	Other non-metallic mineral products	0.972
383	Machinery, electric	0.987
342	Printing and publishing	1.016
353	Petroleum refineries	1.021
382	Machinery, except electrical	1.083
321	Textiles	1.124
381	Fabricated metal products	1.129
371	Iron and steel	1.130
384	Transport equipment	1.204
390	Other manufactured products	1.237
372	Non-ferrous metals	1.264
355	Rubber products	1.344
352	Other chemicals	1.430
385	Professional & scientific equipment	1.503
332	Furniture, except metal	1.603
351	Industrial chemicals	1.876
354	Misc. petroleum and coal products	2.146

Notes: Estimates of sectoral country size elasticity (κ^h) are obtained by estimating equation (31) for each sector.

Table 4c: Summary stats of demand elasticities

	Observations	Min	Mean	Max	Std. dev.
ε^h	27	0.050	1.988	4.014	0.780
κ^h	27	0.074	1.095	2.146	0.401

Notes: ***Corr(ε^h, κ^h)=0.596*** constraints on the output elasticity of trade when estimating all the specifications,[34] and it turns out that this elasticity significantly differs from unity according to the estimates.

I first consider the level of bilateral trade assuming that the aggregate output elasticity of trade is some sector-specific constant a^h. It follows that the elasticity of the consumption of domestic production with respect to per-capita income and the size of the importer are:

$$\begin{aligned} \varepsilon_j^{h'} &\equiv \frac{d\ln X_{jj}^h}{d\ln y_j} = \gamma_3^h \theta^h \times \zeta_j + a^h - \theta^h, \\ \kappa^{h'} &\equiv \frac{d\ln X_{jj}^h}{d\ln L_j} = a^h - \gamma_1^h \theta^h. \end{aligned} \tag{33}$$

Clearly, the "importer home-market effect" is present as long as $a^h > 0$. Table 5a presents the estimates of a^h for each sector which are the unconstrained coefficients on $\ln\frac{Y_i}{Y}$ from estimating the gravity equation of (31). 26 estimates out of 27 "normal" sectors are significantly positive, and by theory, these sectors exhibit the "importer home-market effect" with respect to country size.

I also use reduced form regressions to test the home-market effect and how it varies with sectoral characteristics. Note that this "importer home-market effect" identified in bilateral trade is of second order: it is the elasticity of the consumption of domestic production relative to that of imports as the demand pattern changes. The following specifications are used to test the hypotheses of propositions 2 and 3:

$$\ln\frac{X_{jj}^h}{X_{ij}^h} = \alpha + \beta_y \times \ln y_j + \beta_{income} \times \varepsilon_j^{h'} + \beta_{y,income} \times (\ln y_j \times \varepsilon_j^{h'}) + C + error_{ij}^h, \tag{34}$$

$$\ln\frac{X_{jj}^h}{X_{ij}^h} = \alpha + \beta_L \times \ln L_j + \beta_{size} \times \kappa^{h'} + \beta_{L,size} \times (\ln L_j \times \kappa^{h'}) + C + error_{ij}^h. \tag{35}$$

where C is the set of control variables, which includes estimated sectoral technology as controls for comparative advantage, as well as controls for trade barriers. All β's are assumed

[34] The unitary elasticity is obtained by the assumption imposed on the theoretical model that the mass of potential entrants of each sector is proportional to a country's total labor income $w_i L_i$ (therefore a country's total output Y_i), implying that richer countries have more potential entrants in *every* sector. Then removing this constraint is essentially equivalent to assuming the mass of entrants in each differentiated sector varies as a country's total income changes. Although incorporating this supply side non-homotheticity in the theoretical model is beyond the scope of current paper, there is a rich body of literature, especially the one concerning structural change and economic growth, supporting this idea. For instance, Gollin et. al (2002) examine the data of 62 developing countries between 1960 and 1990, and report the shrink of agriculture sector during the process of growth, and this phenomenon is also observed for the UK during its early stage of development. This decline in agricultural employment is usually associated with increases in agricultural productivity, and eventually leads to national industrialization and growth across countries. On the other hand, Fiorini et. al (2014) have documented the constant labor flow from manufacturing to service sectors in the U.S. since the 1980's even after controlling for the 2001 and 2008 recessions, and indicate that during the later stage of economic growth, manufacturing employment of the developed countries decreases due to offshoring jobs to the developing world, and remaining domestic service sectors become the main driving force of development. Although I will only be looking at data on manufacturing sectors, the same logic applies as well: as countries grow and their comparative advantages evolve, labor force (therefore potential entering firms) adjusts across sectors, generating various sectoral trade elasticities.

Table 5a: Estimates of a^h in (35)

ISIC code	Description	a^h	Std. error
311	Food products	4.964***	0.070
313	Beverages	3.987***	0.135
314	Tobacco	5.454***	0.263
321	Textiles	6.882***	0.074
322	Wearing apparel, except footwear	-3.531***	0.290
323	Leather products	8.604***	0.190
324	Footwear, except rubber or plastic	9.574***	0.305
331	Wood products, except furniture	1.313***	0.175
332	Furniture, except metal	4.886***	0.252
341	Paper and products	1.771***	0.075
342	Printing and publishing	1.002***	0.093
351	Industrial chemicals	5.674***	0.134
352	Other chemicals	4.218***	0.130
353	Petroleum refineries	7.632***	0.203
354	Misc. petroleum and coal products	4.353***	0.368
355	Rubber products	8.462***	0.152
356	Plastic products	10.988***	0.187
361	Pottery, china, earthenware	6.308***	0.134
362	Glass and products	4.155***	0.110
369	Other non-metallic mineral products	-0.181	0.133
371	Iron and steel	7.865***	0.128
372	Non-ferrous metals	2.179***	0.140
381	Fabricated metal products	6.954***	0.089
382	Machinery, except electrical	13.122***	0.138
383	Machinery, electric	12.115***	0.153
384	Transport equipment	1.670***	0.087
385	Professional & scientific equipment	6.803***	0.142
390	Other manufactured products	5.418***	0.185

Notes: OLS estimates of a^h are obtained by estimating the gravity equation in (31), and a^h are the estimated coefficients of $\ln(Y_i/Y)$. *** p<0.01, ** p<0.05, * p<0.1.

Table 5b: Summary stats of a^h

	Obs	Min	Mean	Max	Std. Dev.
a^h	28	-3.531	5.451	13.122	3.763

to be the same across sectors, and thus β_L captures the average "importer home-market effect" when positive.

Results on per-capita income are reported in table 6a. Columns (1) and (2) includes sector fixed effects which absorb the main effect of sectoral income elasticity, since it does not vary over time. Overall, the estimates of β_y are significantly negative, implying that higher income shifts consumers expenditure towards imports relative to domestic production. The significant and negative main effect of income elasticity when it is included in columns (3) and (4) implies that consumers preferences of imports over domestically produced goods are weaker in more elastic sectors with respect to income. These results are consistent with proposition 2.

Results on country size are shown in table 6b. I estimate (35) based on three samples, and controls for comparative advantage and trade barriers are included for all samples. Panel (1) of table 6b reports the estimates when full sample is used. The estimates of β_L are significantly positive and large in magnitude when the full set of controls is included. This can then be seen as evidence of the "importer home-market effect" as stated in proposition 3 since it indicates that larger country size shifts consumption towards domestically produced goods relative to imports. As shown in table 5a, I expect to observe this home-market effect as long as a^h is positive. 2 sectors, ISIC 322 and ISIC 369 have negative estimates. Therefore, I estimate (36) in panel (2) of table 6b based on data excluding the inferior and negative a^h sectors which I refer to as the "HME sample". The same patterns of the "importer home-market effect" are observed, and moreover, the effect is stronger in magnitude as expected. Finally in panel (3), I estimate (36) using only data from sectors ISIC 322 and ISIC 369. The estimates of β_L are negative as expected, suggesting the absence of the home-market effect. Also interesting is how the home-market effect varies with sectoral country size elasticity. Note that the strength of the "importer home-market effect" identified in the theory is again the *difference* between the elasticities of imports and consumption of domestic production which is simply a^h. Therefore, it is the relative importance of the home-market effect that is decreasing as the country size elasticity increases. So when both the main effect of country size elasticity and its interaction with $\ln L_j$ are included in the regression, I should expect the main effect estimates to be negative instead of the interaction terms. In panels (1) and (2) of table 6b where the home-market effect is present, the main effect estimates of country size elasticity are all negative and statistically significant which is consistent with the second half of proposition 3: higher country size elasticity weakens the "importer home-market effect".

Next I turn to examine the "exporter home-market effect" in relative exports. Note that if the elasticity of relative trade (EX_{ij}^h) with respect to relative income (Y_i/Y_j) is some constant (greater than 1): a^h, I will have:

$$\epsilon^h \equiv \frac{d\ln EX_{ij}^h}{d\ln(L_i/L_j)} = a^h + \gamma_1^h \theta^h, \tag{36}$$

and the threshold of "normal" and "inferior country size elasticity" sectors – $\bar{\bar{\eta}}^h$ will shift to the right as shown in figure 7 and will be ***sector-specific***.

The first step here is to obtain the elasticity of trade with respect to relative income – the a^h of (36) – by estimating the log transformation of (21) for each sector. Ideally I would use the pooled data over the entire time span to structurally estimate the specification, and get

Table 6a: Consumption of domestic production and imports – income

	Dependent variable: $\ln(X^h_{jj}/X^h_{ij})$			
	(1)	(2)	(3)	(4)
$\ln y_j$	-2.941***	-4.324***	-2.601***	-3.722***
	(0.225)	(0.793)	(0.237)	(0.801)
$\varepsilon_j^{h'}$			-2.021**	-2.057***
			(0.795)	(0.748)
$\ln y_j \times \varepsilon_j^{h'}$	0.167*	0.132	0.0563	0.0366
	(0.0983)	(0.0922)	(0.107)	(0.100)
M & X GDP	Yes	Yes	Yes	Yes
Comp. Advt.	Yes	Yes	Yes	Yes
Trade costs	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes		
M & X FE		Yes		Yes
Year FE		Yes		Yes
Observations	1,562,287	1,562,287	1,562,287	1,562,287
R-squared	0.540	0.592	0.476	0.533

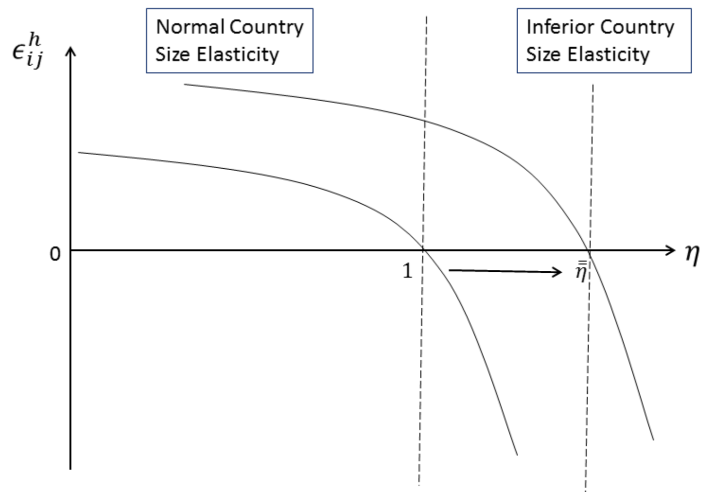
Notes: Robust standard errors are clustered on importer-sector level, and are reported in parentheses. $\varepsilon_j^{h'}$ is the sectoral per-capita income elasticity of (33). GDP of the trading partners are in log forms. *** p<0.01, ** p<0.05, * p<0.1

Table 6b: Consumption of domestic production and imports – country size

	Dependent variable: $\ln(X^h_{jj}/X^h_{ij})$					
	(1) Full sample		(2) HME sample		(3) Sectors 322 & 369	
$\ln L_j$	0.513	3.963***	0.552	3.983***	-1.165*	0.672
	(0.352)	(1.256)	(0.355)	(1.286)	(0.682)	(3.871)
$\kappa^{h'}$	-16.65***	-18.28***	-16.27***	-17.90***	-7.810	-11.26*
	(4.917)	(4.582)	(4.918)	(4.582)	(8.913)	(6.299)
$\ln L_j \times \kappa^{h'}$	0.689**	0.797***	0.673**	0.780***	0.807	0.997**
	(0.300)	(0.282)	(0.301)	(0.283)	(0.563)	(0.402)
M & X GDP	Yes	Yes	Yes	Yes	Yes	Yes
Comp. Advt.	Yes	Yes	Yes	Yes	Yes	Yes
Trade costs	Yes	Yes	Yes	Yes	Yes	Yes
M & X FE		Yes		Yes		Yes
Decade FE		Yes		Yes		Yes
Observations	1,562,287	1,562,287	1,512,413	1,512,413	105,500	105,500
R-squared	0.108	0.264	0.109	0.264	0.151	0.458

Notes: Robust standard errors are clustered on importer-sector level, and are reported in parentheses. $\kappa^{h'}$ is the sectoral country size elasticity of (33). GDP of the trading partners are in log forms. *** p<0.01, ** p<0.05, * p<0.1

Figure 7: ϵ_{ij}^h for $a^h > 1$.



a single $\hat{a}^h$ for each sector. Doing so will require the inclusion of a set of home-foreign-decade fixed effects to capture the time pattern in $(\lambda_i/\lambda_j)^{-\gamma_3^h\theta^h}$, as well as both home fixed effects and foreign fixed effects from the $(D_{ji}^h/D_{ij}^h)^{\theta^h}$ term. However, with such large dimension of fixed effects, the constrained estimation[35] applied to (21) will not have sufficient degrees of freedom and consequently fails to deliver any estimates. Since my ultimate goal is to estimate the relative income and country size elasticities of relative exports the following specification is used:

$$\ln EX_{ij}^h = \varepsilon_{ij}^h \ln\frac{y_i}{y_j} + \epsilon^h \ln\frac{L_i}{L_j} + \theta^h \ln\frac{T_i^h}{T_j^h} + \gamma_2^h\theta^h \ln\frac{\Phi_i^h}{\Phi_j^h} + F^h - H^h + \frac{\theta^h - (\sigma^h - 1)}{\sigma^h - 1}\ln\frac{f_{ji}^h}{f_{ij}^h}, \quad (37)$$

where F^h and H^h are *Foreign* (country j) and *Home* (country i) fixed effects.[36] Note that (37) is equivalent to the linear transformation of (21): the income and country size terms in (21) – $\left(\frac{Y_i}{Y_j}\right)\left(\frac{\lambda_i}{\lambda_j}\right)^{-\gamma_3^h\theta^h}\left(\frac{L_i}{L_j}\right)^{\gamma_1^h\theta^h}\left(\frac{w_i}{w_j}\right)^{-\theta^h}$ – are replaced by $\left(\frac{y_i}{y_j}\right)^{\varepsilon_{ij}^h}\left(\frac{L_i}{L_j}\right)^{\epsilon^h}$. Again, if the elasticity of EX_{ij}^h with respect to (Y_i/Y_j) is not constrained to be unity, but assumed to

[35]Both $(L_i/L_j)^{\gamma_1^h\theta^h}$ and $(Z_i^h/Z_j^h)^{\theta^h}$ will be constrained during estimation.

[36]Note that the relative trade barriers $\theta^h \ln\frac{D_{ji}^h}{D_{ij}^h} = \theta^h \ln\frac{d_{ji}^h {\Phi_i^h}^{\gamma_2^h}}{d_{ij}^h {\Phi_j^h}^{\gamma_2^h}} = \theta^h\left(\ln d_{ji}^h - \ln d_{ij}^h\right) + \gamma_2^h\theta^h\ln\frac{\Phi_i^h}{\Phi_j^h}$. Given the definition of bilateral trade barriers in (26), $\ln d_{ji}^h$ and $\ln d_{ij}^h$ only differ in the home fixed effects term, and then $\theta^h\left(\ln d_{ji}^h - \ln d_{ij}^h\right) = F^h - H^h$.

be some sectoral a^h, I shall have:

$$\begin{aligned}
\varepsilon_{ij}^h &= \frac{d\ln EX_{ij}^h}{d\ln(y_i/y_j)} = \frac{A_{ij}^h}{[2a^h - 2\theta^h - \gamma_3^h\theta^h(\zeta_i + \zeta_j)]}, \\
\epsilon^h &= \frac{d\ln EX_{ij}^h}{d\ln(L_i/L_j)} = a^h + \gamma_1^h\theta^h.
\end{aligned} \tag{38}$$

In (23) and (24), since $a^h = 1$, ε_{ij}^h is always negative and ϵ^h is always positive (for the "normal country size elasticity" sectors). However in (38), if a^h is sufficiently large, ε_{ij}^h can be positive, and if a^h is sufficiently small ϵ^h can be negative. That is to say, how relative exports respond to relative income and relative country size for each sector depends on each a^h. Equation (37) is estimated for each sector, and the estimates of the relative demand elasticities are reported in table 7. There is considerable variation in the estimates across sectors. First for relative per-capita income, 27 out of 28 estimates are significant at 1% level, and among the significant estimates, 8 sectors exhibit positive elasticities, implying a large a^h for each of these sectors. And for the rest 19 sectors, higher relative income decreases relative exports for these sectors in the sample. Second, for relative country size, 16 out of 26 significant estimates are positive, exhibiting the "exporter home-market effect". Moreover, the presence of the home-market effect suggests greater than unity a^h's for the sectors in my sample as shown in figure 7, and therefore, the sectors with positive ϵ^h are identified to be "normal country size elasticity" sectors, and the rest are identified to be "inferior country size elasticity" sectors.

According to (38), and also as stated in propositions 4 and 5, the effect of relative demand on relative trade varies by sectoral elasticities. To investigate this pattern, I regress relative trade from *Home* (i) to *Foreign* (j) on relative per-capita income and country size as well as their interactions with relative sectoral income and country size elasticities controlling for comparative advantage and trade costs. In panels (1) and (2) of table 8, the estimates of relative trade elasticity with respect to relative per-capita income are negative and is significant at 1% level when the full set of controls is included. In panels (3) and (4), I repeat this exercise *excluding* sectors with positive estimates of ε_{ij}^h in table 7 and get negative and significant estimates of the main effect of relative per-capita income. The interaction estimates are also negative as expected though not statistically significant. These average effects across sectors confirm proposition 4: relative exports decreases with relative per-capita income of *Home*, as decreases *less* in sectors that are more elastic with respect to income. Panels (5) and (6) investigate the "exporter home-market effect" with respect to country size. The estimated effects of relative country size are both positive and significant, and moreover, their interactions with market seize elasticity have are significantly negative. These results confirm the theoretical predictions by Proposition 5 that larger *Home* size relative to *Foreign* increases relative exports of *Home* to *Foreign*, and this home-market effect is weakened by sectoral country size elasticity. Finally in columns (7) and (8) I restrict the sample to sectors that exhibit positive estimates of ϵ^h. While both the main effect of relative country size and the interaction term have the expected signs, confirming the presence of the home-market effect, the estimates of the interaction terms become insignificant. This is probably due to the fact that by limiting the sample to sectors exhibiting the home-market effect in the sample, I exclude sectors over which the negative effect of country size elasticity is the strongest.

Table 7: The exporter home-market effect – sectoral effect of relative demand

ISIC code	Description	ε_{ij}^h	Std. error	ϵ^h	Std. error
311	Food products	-1.286***	0.080	-13.499***	0.242
313	Beverages	-0.766***	0.144	-3.473***	0.552
314	Tobacco	1.671***	0.417	6.631***	1.277
321	Textiles	0.624***	0.083	0.170	0.224
322	Wearing apparel, except footwear	-7.482***	0.283	-1.458*	0.763
323	Leather products	-1.923***	0.214	-1.690***	0.612
324	Footwear, except rubber or plastic	-2.463***	0.332	17.891***	0.948
331	Wood products, except furniture	-2.774***	0.209	8.143***	0.622
332	Furniture, except metal	-4.148***	0.265	19.279***	0.800
341	Paper and products	-0.542***	0.088	-0.633**	0.257
342	Printing and publishing	-3.828***	0.155	5.949***	0.519
351	Industrial chemicals	3.678***	0.154	-16.673***	0.456
352	Other chemicals	-0.879***	0.121	1.417***	0.369
353	Petroleum refineries	1.085***	0.213	5.788***	0.656
354	Misc. petroleum and coal products	-4.183***	0.369	-25.611***	1.195
355	Rubber products	2.080***	0.194	-2.193***	0.566
356	Plastic products	-0.112	0.169	10.730***	0.517
361	Pottery, china, earthenware	-3.337***	0.144	0.269	0.467
362	Glass and products	-0.261***	0.132	14.544***	0.452
369	Other non-metallic mineral products	-4.321***	0.160	-6.011***	0.426
371	Iron and steel	-0.545***	0.135	5.432***	0.453
372	Non-ferrous metals	-5.725***	0.152	-8.944***	0.458
381	Fabricated metal products	-1.937***	0.065	10.741***	0.192
382	Machinery, except electrical	2.373***	0.141	21.576***	0.427
383	Machinery, electric	2.342***	0.142	15.201***	0.429
384	Transport equipment	-2.152***	0.122	-10.875***	0.436
385	Professional & scientific equipment	2.575***	0.208	3.447***	0.596
390	Other manufactured products	-3.096***	0.217	7.417***	0.667

Notes: ε_{ij}^h and ϵ^h are relative per-capita income and relative country size elasticities, respectively. Their estimates are obtained by estimating (37) using constrained OLS. *** p<0.01, ** p<0.05, * p<0.1.

Table 8: The exporter home-market effect – average effects of relative demand

	Dependent variable: $\ln(EX_{ij}/EX_{ji})$							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\ln(y_i/y_j)$	-2.430**	-2.566***	-3.827***	-3.912***				
	(1.008)	(1.018)	(1.279)	(1.307)				
$\ln(y_i/y_j) \times \varepsilon^h$	-0.506	-0.513	-0.00650	-0.0225				
	(0.376)	(0.376)	(0.492)	(0.505)				
$\ln(L_i/L_j)$					7.170***	6.531**	6.977**	13.00***
					(1.567)	(2.769)	(2.439)	(3.006)
$\ln(L_i/L_j) \times \kappa^h$					-3.306**	-3.304**	-2.679	-2.849
					(1.304)	(1.285)	(2.126)	(2.137)
Home & Foreign GDP	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Comp. Advt.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Trade costs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Home & Foreign FE		Yes		Yes		Yes		Yes
Year FE		Yes		Yes		Yes		Yes
Observations	943,514	943,514	667,994	667,994	943,514	943,514	585,964	585,964
R-squared	0.129	0.199	0.140	0.216	0.145	0.286	0.166	0.329

Notes: ε^h and κ^h are sectoral per-capita income and country size elasticities respectively. Since sector fixed effects are included for all specifications, the effects of the demand elasticities are omitted. Robust standard errors are clustered on sector level, and are reported in parentheses. GDP of trading partners are in log forms. *** p<0.01, ** p<0.05, * p<0.1

3.5 Trade volumes and trade patterns

The estimates of demand elasticities from previous section display considerable deviations from unity, and I now examine whether this non-homotheticity with respect to income and country size improves our understanding of some observed stylized facts in trade data. Note that using the estimated demand, production parameters and trade costs from the empirical analysis will back out the observed data precisely since they are directly generated from the structural gravity equation. Therefore, I reconstruct bilateral trade data using the estimated productivity and trade barriers assuming homothetic preferences with respect to per-capita income and/or country size.[37] Then by comparing the observed (with non-homothetic preferences) and constructed data, I can infer the demand non-homotheticity's capability of explaining observed trade patterns. In particular, I'll be looking at bilateral trade between partners of different income levels and the measure of a country's openness to trade. [38]

3.5.1 North-South trade

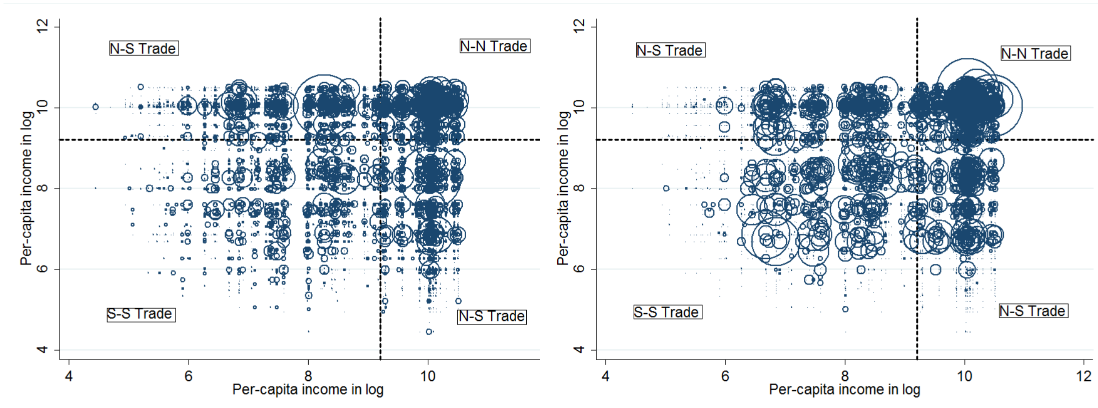
It is a well documented fact that poor countries trade much less than rich countries. In the first exercise, I characterize a country to be either a North country whose GDP per-capita is greater than or equal to \$ 10K, or a South country otherwise. In figure 8, I plot bilateral trade against trading partners' income where the two dashed lines refer to the income thresholds between South and North countries. The size of the bubbles represents the shares of total bilateral trade in the sum of corresponding trading partners' total income, and therefore, bubbles to the northeast of the graph show trade shares among North countries, while bubbles to the southwest of the graph indicate trade shares among South countries. The left panel of figure 8 plots the observed data (where preferences are non-homothetic) for 2000. It is obvious that trade is mostly concentrated among rich countries (in the "N-N Trade" zone), and South countries trade less with North countries and among themselves, especially for the poorest countries to the further southeast of the picture. Trade shares when preferences are assumed to be homothetic (with respect to both income and country size) are shown on the right panel of the same figure. Compare to the data, while rich countries still trade more with each other than with the rest of the world, homothetic demand predicts higher shares of trade among South countries (the "S-S Trade" zone) and North-South countries (the "N-S Trade" zones).

Both Fieler (2011) and Caron et al.(2014) have emphasized how the variation in income elasticities across types of goods helps improve the predictions of trade patterns among countries with different income levels where the former focuses on the channel of within and between industry trade, and the latter looks at the correlation between sectoral skill intensity and income elasticity. My model first confirms the role of income non-homotheticity, since it is straight forward to see from the gravity equation in (10) that bilateral trade is higher if trading partners are both high income countries, especially for income-elastic sec-

[37] The demand elasticities are set to be unity for this case.

[38] For analysis in this subsection, I once again exclude the "inferior" sector ISIC 322 (Wearing apparel, except footwear). In addition, I further exclude sectors that are estimated to display the highest and lower demand elasticities: ISIC 314 (Tobacco) and ISIC 354 (Misc. petroleum and coal products), for two main reasons: first, trade of commodities from these two sectors are often times subject to exceptional regulations and policies that are not captured by current theory, and they are omitted in many empirical studies in trade, and secondly, the estimate of per-capita income elasticity is not significant for sector ISIC 314.

Figure 8: North-South trade.



(L) Data (Non-homothetic) (R) Homothetic preferences

Notes: Data source: Feenstra et al.(2005). This figure plots trade shares of trading partners' total income for year of 2000. The left panel is based on observed data, and the right panel plots reconstructed data assuming homothetic preferences.

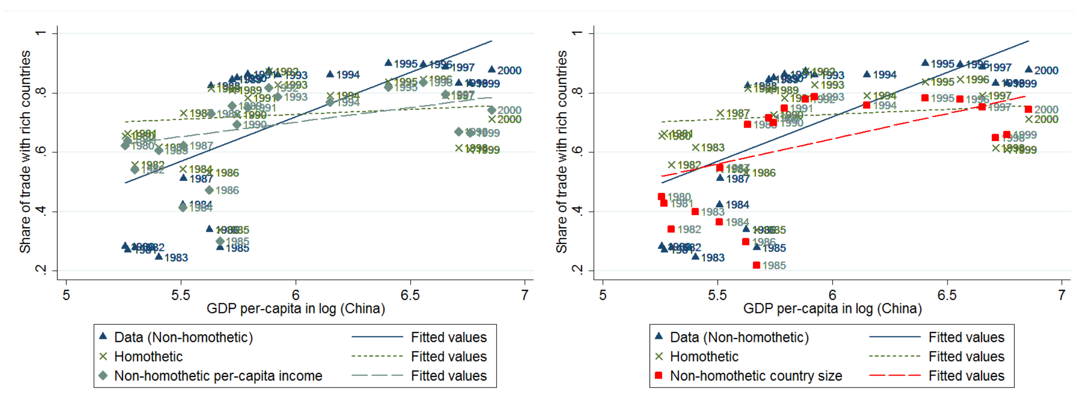
tors. Since rich countries consume and trade more in these sectors, overall trade should be more concentrated among North countries. In addition to previous work, the introduction of the new sectoral margin – country size elasticity, provides another channel to explain the discrepancy between the data and the predictions by homothetic trade models. Following the previous analysis, first note that on the importer/demand side, since the estimates of per-capita income elasticities and country size elasticities are positively correlated, rich countries also tend to consume and import more in sectors with higher country size elasticities. And according to proposition 3, these sectors exhibit weaker "importer home-market effect" which by its nature is against trade. On the exporter/supply side, the "exporter home-market effect" of proposition 5 indicates that large countries are more likely to become net exporters in less elastic sectors with respect to country size, the converse-negative of which implies that rich countries (that are often relatively small in size[39]) export more in sectors with higher country size elasticities and therefore are easier to become net exports in these sectors. Since the home-market effect on both the importer and exporter sides promote trade among rich countries that are in general smaller in size, the non-homotheticity with respect to country size then reinforces the effects of non-homothetic per-capita income in explaining overall trade patterns.

To see this point in data, I compare China's trade with North countries under different demand structures. The solid lines in both panels of figure 9 plot the share of China's bilateral trade with rich countries (per-capita income greater than or equal to $10K) in China's total trade for each year between 1980 and 2000 against China's average individual income. The data show that as China's income increases it trades more with rich countries. The short-dashed line in both graphs represents the same relationship but uses constructed trade data assuming homothetic preferences with respect to both per-capita income and country size.

[39]The correlation between per-capita income and population for countries in the sample is about -0.1.

Compared to the observed data, while the correlation between trade shares with rich countries and income is still positive, it is much weaker, and in particular, homothetic preferences predict higher shares of trade with rich countries when China is relatively poorer, which is more representative of the North-South trade patterns, and lower trade shares when China becomes richer. Then on the left panel, I repeat the same plot with constructed data using estimated per-capita income elasticities and fixing country size elasticities to unity, the fitted value of which is given by the long-dashed line on the graph. Obviously, adding income non-homotheticity improves the predicted trade shares against income: the correlation is more positive than homothetic preferences, and the predicted trade share with rich countries is lower when China is poor back in the 80's. On the right panel, I impose non-homothetic country size instead of income on the data and show the correlation of the constructed data with the long-dashed line. Once again, doing so creates a more positive relationship between trade shares with the North and China's income which is closer to the observed data than the case of homothetic preferences. Moreover, country size non-homotheticity largely corrects the over-predicted trade shares when China is poor. Note that while both non-homothetic income and country size improve the model's capability of predicting North-South trade patterns, imposing solely either one of them at a time does not full recover the observed patterns in the data. This case study on China confirms that income and country size non-homotheticity reinforces the effect of each other in shaping bilateral trade patterns.

Figure 9: North-South trade, cont'd.



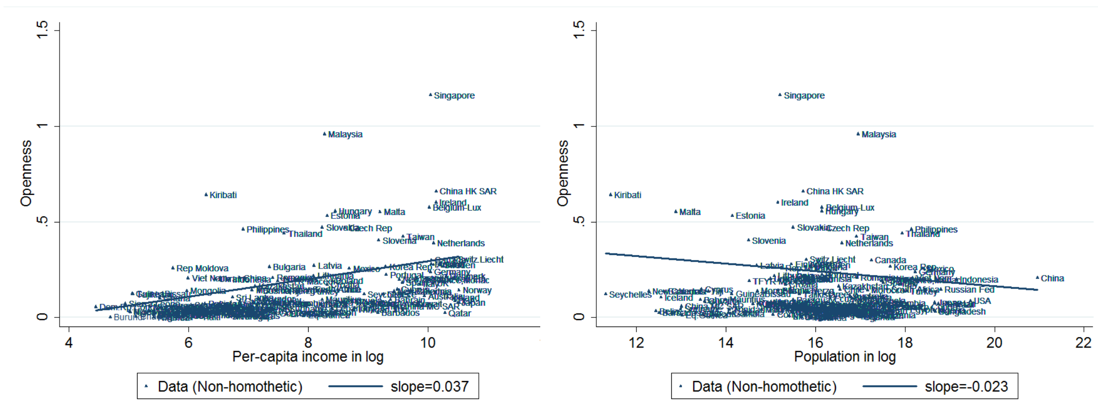
(L) (R)

Notes: Data source: Feenstra et al.(2005). This figure plots China's trade with rich countries from 1980 to 2000.

3.5.2 Openness to trade

The positive correlation between the two demand elasticities along with the home-market effect also suggest that the demand non-homotheticity promotes overall trade with the rest of the world of high-income (and relatively small) countries and suppresses total trade by low-income (and relatively large countries) countries, which contributes to explaining the lower observed trade-to-GDP ratios than predicted by homothetic trade models. Defining a country's overall openness to trade as: $(imports + exports)/(2 * GDP)$, figure 10 plots each country's measure of openness against its income on the left panel, and against its population on the right panel both for the year of 2000. As expected, the linear fits exhibit a positive correlation between trade openness and per-capita income (with a slope of 0.037) and a negative correlation between openness and country size (with a slope of -0.023). The comparisons between trade openness generated from non-homothetic observed data and homothetic constructed data are displayed in figures 11a and 11b.

Figure 10: Openness to trade.



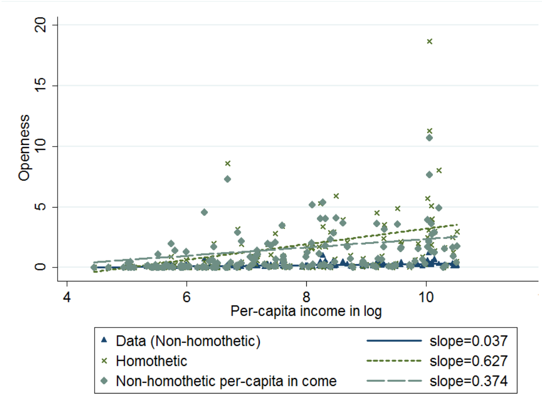
(L) (R)

Notes: Data source: Feenstra et al.(2005). This figure plots each country's total trade (imports+exports) as a share of GDP against the country's income and population in the year of 2000.

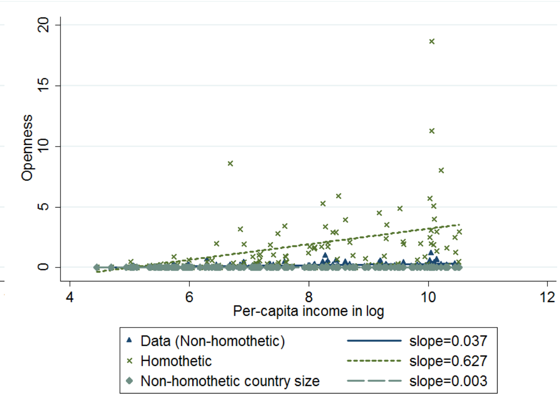
In figure 11a, the short-dashed line in both panels indicated the relationship between trade openness with homothetic preferences and per-capita income of a country. Compare to the pattern of the real data, demand homotheticity predicts first a much stronger relationship (the slope of the fitted line is 0.627) and secondly, it predicts much higher extent of trade openness especially for high-income countries. The theoretical model provides intuitive explanations on these differences. According to the analysis leading up to proposition 2, the difference between a country's imports and consumption of domestic production is weaker in more income-elastic sectors which rich countries consume and trade more under non-homothetic preferences. When preferences are homothetic imports and expenditure on domestically produced good grow at the same rate across all sectors and generate higher trade to income ratios for high-income countries. When non-homothetic income is imposed on the left panel, it predicts a weaker correlation between trade and income per-capita (the slope of the fitted line is 0.374) which is closer to the data. Then on the right panel, I impose non-homothetic country size instead of per-capita income, and it not only generates a weaker relationship between trade shares and income (the slope of the fitted line is 0.003), but also brings down the overly predicted trade openness to the actually observed level which reinforces the effect of income non-homotheticity.

The case for trade openness and country size is more interesting. As shown in figure 11b, homothetic preferences once again predict higher level of trade openness and indicate

Figure 11a: Openness to trade, cont'd.



(L)



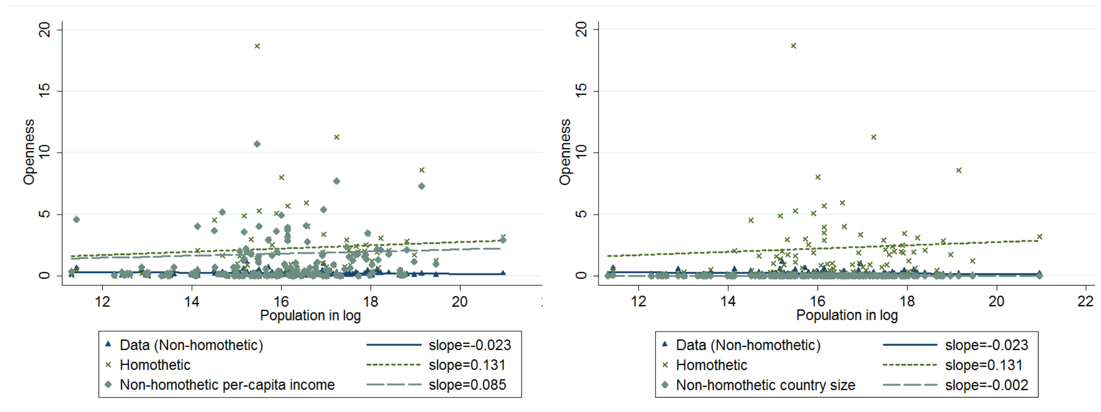
(R)

Notes: Data source: Feenstra et al.(2005). This figure plots each country's total trade (imports+exports) as a share of GDP against the country's income for both observed data and constructed data in the year of 2000.

that larger countries tend to trade more with the rest of the world (the slope of the short-dashed line for homothetic preferences is 0.131), which is the opposite to the observed data patterns. Correcting for non-homothetic per-capita income on the left panel weakens this positive relationship (the slope of the fitted line decreases to 0.085), however the high level of trade openness retains. On the right panel where preferences are non-homothetic with respect to country size, the home-market effect is effective making larger countries consume more domestically produced goods relative to imports in sectors with higher country size elasticities, and the predicted trade shares of GDP well replicate the observed data while the correlation between trade openness and countries size become negative.

In this section, I use a large dataset consisting of data on bilateral trade flows, sectoral production and trade barrier measures to test the home-market effect studied by the theoretical model. The estimation procedure provides a unified framework to estimate the key parameters, such as elasticity of substitution, sectoral measure of productivity dispersion, as well as (average) sectoral per-capita income and country size elasticities, that are of broad interest of international trade studies. I find empirical evidence supporting the presence of both the "importer home-market effect" and the "exporter home-market effect" as predicted by the theory. By comparing the observed trade data and the constructed data using the estimated demand elasticities, I show that non-homothetic per-capita income is an important channel to explain some puzzles in international trade patterns, namely the small trade volumes among poor countries and the lower than expected openness to trade, which confirms the finding by previous studies in non-homothetic preferences. In addition, I show that the home-market effect implied by non-homothetic country size also largely contributes to better understanding of trade puzzles. This margin however is neglected by previous models of perfect competition, and is the main contribution of current work to the literature. The structural nature of the gravity equation derived from the theory allows straightforward ways to investigate the interactions between different determinants of trade patterns, which leads

Figure 11b: Openness to trade, cont'd.



(L) (R)

Notes: Data source: Feenstra et al.(2005). This figure plots each country's total trade (imports+exports) as a share of GDP against the country's population for both observed data and constructed data in the year of 2000.

to the exercise in the next section.

4 Production and Demand in International Trade

As pointed out by Davis and Weinstein (1999), the two broad theories of why countries trade, namely comparative advantage and increasing returns to scale, are often treated as separated shaping factors of trade, and empirical works based on different datasets have been done in attempt to find support for one theory as evidence against the other. By incorporating Ricardian comparative advantage into a trade model of monopolistic competition, the theory of the current paper shows that bilateral trade flows are driven by both forces. In this section, I apply decomposition analysis to bilateral trade data to isolate and examine the contributions of changes in production and demand structures to total trade variation.

4.1 Methodology

The gravity equation derived from the theory indicates that sectoral exports from country i to country j are jointly defined by the production of country i, demand of country j and asymmetric bilateral trade barriers. Therefore it can be expressed by the following general form:

$$X_{ij}^h = Constant \times P_i^h \times D_j^h \times C_{ij}^h,$$

where $P_i^h \equiv Y_i \times \left(T_i^h/w_i\right)^{\theta^h}$ represents the total output and sectoral productivity of the exporter, $D_j^h \equiv y_j^{\varepsilon^h} \times L_j^{\kappa^h}$ is the *elasticity-adjusted* sectoral expenditure by the importer, and $C_{ij}^h \equiv {D_{ij}^h}^{\theta-h} \times f_{ij}^{h^{-\frac{\theta^h-(\sigma^h-1)}{\sigma^h-1}}}$ includes *sector-specific* variable and fixed trade costs. These components can be backed out using the estimates from the empirical section for each country pair at a given point in time.

Since I am interested the effects of production and demand on bilateral trade, I define a *costless trade* variable as:

$$E_{ij}^h \equiv \frac{X_{ij}^h}{Constant \times C_{ij}^h} = P_i^h \times D_j^h,$$

which is bilateral trade net the effect of trade barriers. Therefore, any variations in E_{ij}^h should be driven by changes in production and demand patterns of trading partners. Accordingly, the changes in the *costless trade* between time 0 and time t can be attributed to contributions by its production and demand components with the following decomposition method:

$$\begin{aligned}\Delta E_{ij}^h \equiv E_{ij}^h(t) - E_{ij}^h(0) &= P_i^h(t) \times D_j^h(t) - P_i^h(0) \times D_j^h(0) \\ &= P_i^h(t)D_j^h(t) - P_i^h(0)D_j^h(t) - P_i^h(0)D_j^h(0) + P_i^h(0)D_j^h(t) \\ &= \Delta P_i^h D_j^h(t) + \Delta D_j^h P_i^h(0).\end{aligned} \tag{39}$$

The first term on the right hand side of the last equality of (39) then captures changes in sectoral trade due to changes in the exporter's sectoral productivity (weighted by the importer's sectoral demand pattern at time t), and the second term captures changes in trade due to changes in the importer's sectoral expenditure (weighted by the exporter's productivity at time 0). Note that since the decomposition is applied to changes over a discrete time period, ΔE_{ij}^h can also be expressed as:

$$\Delta E_{ij}^h = \Delta P_i^h D_j^h(0) + \Delta D_j^h P_i^h(t). \tag{40}$$

Expressions (39) and (40) differ in the weights applied to changes in productivities and demand patterns. It is similar to the "index number problem" of the "constant-market-share" analysis as pointed out by Richardson (1971).[40] While Richardson argues that neither of these two identities is explicitly superior to the other, I use the average changes of each component based on both decomposition methods when calculate their contributions to overall trade variation. Explicitly, the contribution of productivity changes to sectoral trade change is:

$$PC_i^h = \frac{\left(\Delta P_i^h D_j^h(t) + \Delta P_i^h D_j^h(0)\right)/2}{\Delta E_{ij}^h}, \tag{41}$$

the contribution of demand pattern changes is:

$$DC_j^h = \frac{\left(\Delta D_i^h P_j^h(t) + \Delta D_i^h P_j^h(0)\right)/2}{\Delta E_{ij}^h}, \tag{42}$$

[40] The "constant-market-share" analysis is a widely used method of decomposing a country's export growth into the effects of changes in a country's export structure and changes in world's imports. See Richardson(1971) for the discussion on the problems and improvements of the application of this approach.

and the aggregate contributions of production and demand changes to total exports growth are:

$$
\begin{aligned}
PC_i &= \frac{\left(\sum_h \Delta P_i^h D_j^h(t) + \sum_h \Delta P_i^h D_j^h(0)\right)/2}{\sum_h \Delta E_{ij}^h}, \\
DC_j &= \frac{\left(\sum_h \Delta D_i^h P_j^h(t) + \sum_h \Delta D_i^h P_j^h(0)\right)/2}{\sum_h \Delta E_{ij}^h}.
\end{aligned}
\tag{43}
$$

4.2 Decomposing U.S. - China trade growth

This decomposition approach can be applied to any country pairs that are trading with each other at both the beginning and the end of the time period. I present the results of a case study on U.S. - China trade, which are the two largest players in international trade market. Trade data of these two countries are not available in the first decade, and therefore I pick the last year in the second decade (1980) and the last year in the fourth decade (2000) as the two reference data points. 1980 is among the early years after the economy reform of China in 1978, and 2000 is the last year before China joint the WTO. Thus a comparison between these two years largely rules out the effect of major trade policy changes that are not captured in the gravity equation.

The current analysis focuses on the 27 sectors that are identified as "normal" in the previous empirical sections and excludes sector ISIC 322. Among these sectors, China exports in 20 sectors to and imports in 21 sectors from the U.S. in 1980, with a total value (imports plus exports) of about 1.5 billion USD. In the year of 2000, China and the U.S. trade with each other in all 27 sectors, and the value of total trade is 116 billion USD, nearly 80-fold of the value back in 1980. The decomposition is applied to both the variation in trade volumes and changes in relative trade. While only the results on aggregate and average trade variation are presented in the following sections, results by sector are available in the on-line appendix.

4.2.1 On the level of bilateral trade

According to the observed date, both the exports by the U.S. and China have experienced large growth over the sample time period. [41] The column $\Delta E_{US,CN}$ of table 9a reports the sign of the changes in the *costless exports* from the U.S. to China, column PC_{US} is the contribution of productivity changes of the U.S. to trade variation, and DC_{CN} is the contribution of changes in Chinese expenditure to trade growth. The results show that, same as observed data, the aggregate *costless exports* from the U.S. to China have increased overtime. About 15% of this increase is due to the increase in the U.S. productivities across sectors, and increase in Chinese expenditure contributes to 85% of the overall trade growth. Similarly in table 9b, the *costless exports* from China to the U.S. also increased between 1980 and 2000. Meanwhile, China has experienced large productivity growth, which contributes to 61% of the overall trade growth, and the rest 39% is attributed to increases in the U.S. demand.

[41] The U.S. exports to China have experienced an average annual growth rate of 16.3% between 1980 and 2000, and exports from China to the U.S. on aggregate grow at an average annual rate of 29.3% between these two data points in time.

Table 9a: Decomposition of trade variation: U.S. to China

$\Delta E_{US,CN}$	PC_{US}	DC_{CN}
+	14.75%	85.25%

Table 9b: Decomposition of trade variation: China to U.S.

$\Delta E_{CN,US}$	PC_{CN}	DC_{US}
+	60.83%	39.17%

I further decompose the contributions of importer demand into its two components – per-capita income and country size, following the same methodology, so that the per-capita income effect (ΔIC_i^h) and the country size effect (ΔLC_i^h) are defined as:

$$\begin{aligned} IC_j^h &= \frac{\left(\Delta I_j^h L_j^h(t) + \Delta I_j^h L_j^h(0)\right)/2}{\Delta D_j^h}, \\ LC_j^h &= \frac{\left(\Delta L_j^h I_j^h(t) + \Delta L_j^h I_j^h(0)\right)/2}{\Delta D_j^h}. \end{aligned} \tag{44}$$

And on aggregate, the contributions of each demand component are:

$$\begin{aligned} IC_j &= \frac{\left(\sum_j \Delta I_j^h L_j^h(t) + \sum_j \Delta I_j^h L_j^h(0)\right)/2}{\sum_j \Delta D_j^h}, \\ LC_j &= \frac{\left(\sum_j \Delta L_j^h I_j^h(t) + \sum_j \Delta L_j^h I_j^h(0)\right)/2}{\sum_j \Delta D_j^h}. \end{aligned} \tag{45}$$

The results are reported in tables 10c and 10d, and two observations follow. 1) While on average the change in China's total income between 1980 and 2000 is able to explain 85% of the growth in China's imports from the U.S. (net the effect of changes in trade barriers over time), 67% of the overall trade variation is accounted by changes in China's per-capita income (column IC_{CN}), and the rest 18% is attributed to changes in Chinese population over time (column LC_{CN}); 2) on aggregate, total income increase of the U.S. explains 39% of the changes in China's exports to the U.S., among which 32% is due to changes in per-capita income (column IC_{US}), and only 7% is due to changes of the U.S. country size (column LC_{US}).

Table 10a: Decomposition of importer demand variation: China

DC_{CN}	IC_{CN}	LC_{CN}
85.25%	67.39%	17.86%

Table 10b: Decomposition of importer demand variation: U.S.

DC_{US}	IC_{US}	LC_{US}
39.18%	31.71%	7.47%

The decomposition results presented in this subsection indicate that, net of trade barriers, trade variation between the U.S. and China is mostly driven by changes in **Chinese** productivity and demand structure. For both countries, the contribution of aggregate demand is mostly dominated by the change in per-capita income instead of country size. This is consistent with the fact that the world has experienced more substantial changes in productivities and national income growth over the last few decades, especially for emerging economies in East Asia, like China.[42] Based on the estimates from previous section, between 1980 and 2000, the average annual fundamental productivity growth rate across sectors for China is well above 10%, while on the demand side, per-capita income of the U.S. grows at a higher average annual rate (5.36%) than population (1.09%), both of which are lower than the productivity growth rate of China.

4.2.2 Relative trade: the home-market effect v.s. comparative advantage

Lastly I apply the same decompose methodology to changes in relative trade patterns between the U.S. and China, and examine the effects of the home-market effect and comparative advantage. [43] The observed bilateral data show that in 2000, the U.S. runs a trade deficit of 75 billion USD, while in 1980 the U.S. enjoys a trade surplus of 430 million USD. If I look at *relative costless trade*, which is defined as $RE_{ij}^h \equiv E_{ij}^h/E_{ji}^h$, it has surprisingly increased on average across sectors. This suggests that, between 1980 and 2000, the observed decrease in U.S. net exports to China is mostly due to large decreases in trade barriers of China against the U.S. (which is equivalent to large increases in trade barriers of the U.S. relative to China.) According to the theory, changes in relative demand patterns and relative sectoral productivities (therefore comparative advantage) jointly determine these changes in this *relative costless trade.*

On the production side, the estimates of sectoral productivities show that the sectoral relative fundamental productivity of the U.S. (T_{US}^h/T_{China}^h) grows at an average annual rate of 5.71% across sectors between 1980 and 2000;[44] on the demand side, over the same time period, relative total income of the U.S. *decreases* at an annual rate of 2.9%, relative per-capita income also *decreases* at almost the same annual rate of 2.7%, and relative population (country size) experiences a slight *decrease* at a rate of 0.17% per year. Thus, if the current model is consistent with the data, most of the increase in relative trade will be explained by the increase in the relative productivity of the U.S.. At the same time, according to proposition 4, the increase in relative per-capita income of China should add to the increase in U.S. relative exports. And following proposition 5, decreasing relative size of the U.S.

[42]See, for example, Zhu (2012), Hsieh and Ossa (2011), Hsieh and Klenow (2009), etc.

[43]In this exercise, U.S. is taken as *Home* , and China is referred to as *Foreign* as in section 2.5.

[44]This also implies that the observed decrease in U.S. exports relative to China between 1980 and 2000 is largely due to the decrease in China's trade barriers against the U.S., instead of catching up in productivities.

on the other hand will offset the effect of relative per-capita income due to the "exporter home-market effect".

The decomposition of relative trade variation is reported in table 11a. Both the contributions of relative sectoral productivity (column RPC) and relative income (column RDC) to the increase in average relative trade are positive as expected, since both *Home's* (the U.S.) sectoral comparative advantage and *Foreign*'s (China) relative demand have increased over time. On average, 89% of the increase in U.S. – China relative trade between 1980 and 2000 is accounted by *the increase in average relative productivities of the U.S.* across sectors, and 11% is due to *the increase in relative total income of China*.

Table 11a: Decomposition of average relative trade variation

ΔRE	RPC	RDC
+	88.51%	11.49%

Then I continue to decompose the effects of RDC into the contributions by relative per-capita income changes RIC, and relative country size changes RLC. The results in table 11b show that the average effect of relative total income is mainly driven by the catching-up of China's per-capita income as it explains 19% of the increase in relative trade on average. Smaller U.S. relative size contributes negatively to the overall sectoral relative trade growth, which is about -8%. This is consistent with the "exporter home-market effect" in relative trade patterns identified by the model. Although the home-market effect in magnitude compared to the contribution of comparative advantage is much smaller, it does not mean that the demand effect is less important than the effect of productivity in shaping trade patterns. This is because over the sample time period, relative country size changes are much smaller than changes in relative productivity between these two countries. One can easily infer from previous analysis that, on average a 1% change in relative productivity explains 15.5% of the variation in relative trade, and 1% change in relative country size contributes to 44.5% of the variation in relative trade. These results imply that the home-market effect is almost 3 times stronger than the effect of comparative advantage in U.S. – China trade!

Table 11b: Decomposition of relative demand variation

RDC^h	RIC^h	RLC^h
11.49%	19.06%	-7.57%

The data decomposition results in this section acknowledge economic significance of both comparative advantage and the home-market effect as important shaping factors of international trade. The methodology can easily be applied to any country-pairs, and it should be noted that the results vary by country-pairs and time period accordingly.

5 Conclusion

With more attention being drawn to demand structure as an important determinant of international trade in recent literature, this paper introduces non-homothetic preferences as well as Ricardian comparative advantage into a monopolist competition trade model with firm level heterogeneity. The theory delivers a structural gravity equation incorporating the different roles of per-capita income and country size in shaping bilateral trade patterns. Higher per-capita income in general always increases imports, and larger country size generates the home-market effect, which can be applied to either the importer or the exporter. On one hand, larger size of the importer shifts total sectoral expenditure towards domestically produced goods relative to imports, and on the other hand, larger country size relative to a trading partner makes a country more likely to become a net exporter. The former is referred to as the "importer home-market effect" and the latter as the "exporter home-market effect". Due to the non-homotheticity of the model, these effects vary by sectoral characteristics, such as per-capita income and country size elasticities.

Empirical analysis is also carried out to identify the home-market effect. In the first step, estimating the structural gravity equation delivers estimates of sectoral per-capita income and country size elasticities, and furthermore it also generates estimates of several key parameters which are not only central to this paper, but also of much broader interest of studies in international economics. In the second step, I apply the estimated demand elasticities to explicitly test the "importer home-market effect" and the "exporter home-market effect" using a large dataset with information on bilateral trade flows, output and measures of trade barriers. The empirical findings strongly support the theoretical hypotheses on the home-market effect.

I then perform a comparison between real trade data and constructed data assuming homothetic preferences to study some observed trade puzzles. Specifically, the results show that income non-homotheticity improves the model's capability to explain small volumes in South-South trade and North-South trade compared to North-North trade and the smaller trade-to-income ratios than predicted by standard trade models. Moreover, the current analysis shows that the additional sectoral margin introduced by this paper: country size elasticity, which does exist in previous models of perfect competition and constant returns to scale, reinforces the effect of non-homothetic per-capita income in explaining these puzzles. I also conduct date decomposition to isolate the effects of demand and productivity changes on bilateral trade variation. A case study on U.S. – China trade is carried out to quantitatively evaluate the contributions by demand and production in explaining trade variation over time. The results show that over the 20 years between 1980 and 2000, changes in productivities and demand structures of China explain more than half of the overall trade variation between these two countries. And when considering relative trade, the home-market effect is almost 3 times stronger than comparative advantage in explaining changes in U.S. exports relative to China.

Lastly, a brief discussion on future research agenda. For the sake of analytical simplicity, labor is assumed to be the only factor of production in the setting of the current model. One can extend the model to allow for trade in intermediate goods and even capture the non-homotheticity on the supply side. This approach should empirically fit the data better, however it does add considerable complexity to the theoretical framework and therefore is not discussed in the current paper.

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Appendix: Derivation of Main Theoretical Results

I provide detailed derivation of the key results of the theoretical model in this appendix.

A1: The price index in (6) and the productivity threshold in (7)

Since σ^h follow Pareto distribution, I can express the price index of equation (3) as in terms of the productivity threshold $\bar{\varphi}_{ij}^h$ as following:

$$
\begin{aligned}
{P_j^h}^{1-\sigma^h} &= \sum_{i=1}^{N} w_i L_i \times \int_{\bar{\varphi}_{ij}^h}^{\infty} \left(\frac{\sigma^h}{\sigma^h - 1} \frac{w_i d_{ij}^h}{T_i^h \varphi} \right)^{1-\sigma^h} \times \theta^h \times \varphi^{-\theta^h - 1} d\varphi \\
&= \sum_{i=1}^{N} w_i L_i \times \left(\frac{\sigma^h}{\sigma^h - 1} \frac{w_i d_{ij}^h}{T_i^h} \right)^{1-\sigma^h} \times \theta^h \times \int_{\bar{\varphi}_{ij}^h}^{\infty} \varphi^{\sigma^h - \theta^h - 2} d\varphi \\
&= \sum_{i=1}^{N} w_i L_i \times \left(\frac{\sigma^h}{\sigma^h - 1} \frac{w_i d_{ij}^h}{T_i^h} \right)^{1-\sigma^h} \times \frac{\theta^h}{\theta^h - (\sigma^h - 1)} \times \left(\bar{\varphi}_{ij}^h \right)^{\sigma^h - 1 - \theta^h}.
\end{aligned}
\tag{A.1}
$$

Then from (5), I can solve for the expression of $\bar{\varphi}_{ij}^h$ such that:

$$
\left(\bar{\varphi}_{ij}^h \right)^{\sigma^h - 1} = \left(\frac{\sigma^h}{\sigma^h - 1} \frac{w_i d_{ij}^h}{T_i^h} \right) \times \frac{\sigma^h}{\alpha_1^h} \times f_{ij}^h \times \frac{\lambda_j^{\frac{\eta^h}{\alpha}}}{L_j} \times {P_j^h}^{\eta^h - \sigma^h}. \tag{A.2}
$$

Plug (A.2) back to (A.1), I get:

$$
\begin{aligned}
(P_j^h)^{\frac{\theta^h(\eta^h - \sigma^h) - (\sigma^h - 1)(\eta^h - 1)}{\sigma^h - 1}} =& \frac{\theta^h}{\theta^h - (\sigma^h - 1)} \times \left(\frac{\sigma^h}{\alpha_1^h} \right)^{\frac{(\sigma^h - 1) - \theta^h}{\sigma^h - 1}} \times \lambda_j^{-\frac{\eta^h[\theta^h - (\sigma^h - 1)]}{\alpha(\sigma^h - 1)}} L_j^{\frac{\theta^h - (\sigma^h - 1)}{\sigma^h - 1}} \times \\
& \sum_{i=1}^{N} w_i L_i \left(\frac{\sigma^h}{\sigma^h - 1} \frac{w_i d_{ij}^h}{T_i^h} \right)^{-\theta^h} \times (f_{ij}^h)^{-\frac{\theta^h - (\sigma^h - 1)}{\sigma^h - 1}}.
\end{aligned}
\tag{A.3}
$$

Define $\gamma_1^h \equiv \frac{\sigma^h - 1}{\theta^h(\eta^h - \sigma^h) - (\sigma^h - 1)(\eta^h - 1)}$, and substitute $w_i L_i = Y_i/(1+\pi)$ back in (A.3):

$$
\begin{aligned}
{P_j^h}^{\frac{1}{\gamma_1^h}} =& \frac{\theta^h}{\theta^h - (\sigma^h - 1)} \times \left(\frac{\sigma^h}{\alpha_1^h} \right)^{\frac{(\sigma^h - 1) - \theta^h}{\sigma^h - 1}} \times \left(\frac{\sigma^h}{\sigma^h - 1} \right)^{-\theta^h} \times \lambda_j^{-\frac{\eta^h[\theta^h - (\sigma^h - 1)]}{\alpha(\sigma^h - 1)}} L_j^{\frac{\theta^h - (\sigma^h - 1)}{\sigma^h - 1}} \times \\
& \frac{Y}{1+\pi} \times \sum_{i=1}^{N} \frac{Y_i}{Y} \times \left(\frac{w_i d_{ij}^h}{T_i^h} \right)^{-\theta^h} \times (f_{ij}^h)^{-\frac{\theta^h - (\sigma^h - 1)}{\sigma^h - 1}}.
\end{aligned}
\tag{A.4}
$$

Then define $\alpha_2^h \equiv \frac{\theta^h}{\theta^h - (\sigma^h - 1)} \times \left(\frac{\sigma^h}{\sigma^h - 1} \right)^{-\theta^h} \times \left(\frac{\sigma^h}{\alpha_1^h} \right)^{\frac{(\sigma^h - 1) - \theta^h}{\sigma^h - 1}} \times \left(\frac{Y}{1+\pi} \right)$, and $\Phi_j^h \equiv \sum_{i=1}^{N} \left(\frac{Y_i}{Y} \right) \times$

$\left(\frac{w_i d_{ij}^h}{T_i^h}\right)^{-\theta^h} \times f_{ij}^{h\,-\frac{\theta^h-(\sigma^h-1)}{\sigma^h-1}}$. Substituting α_2^h and Φ_j^h back to (A.4) delivers the expression of sectoral price index of (6).

Next, plug $P_j^h = \alpha_2^{h\,\gamma_1^h} \times (\lambda_j^{-\frac{\eta^h}{\alpha}} L_j)^{\frac{\theta^h-(\sigma^h-1)}{(\sigma^h-1)}\gamma_1^h} \times \Phi_j^{h\,\gamma_1^h}$ into (A.2), I get:

$$\bar{\varphi}_{ij}^h = \frac{\sigma^h}{\sigma^h-1} \times \left(\frac{\sigma^h}{\alpha_1^h}\right)^{\frac{1}{\sigma^h-1}} \times \alpha_2^{h\,\frac{\eta^h-\sigma^h}{(\sigma^h-1)}\gamma_1^h} \times \left(\lambda_j^{-\frac{\eta^h}{\alpha}} L_j\right)^{\gamma_1^h} \times \frac{w_i d_{ij}^h}{T_i^h} \times \Phi_j^{h\,\frac{\eta^h-\sigma^h}{(\sigma^h-1)}\gamma_1^h} \times f_{ij}^{h\,\frac{1}{\sigma^h-1}}. \quad \text{(A.5)}$$

Define $\alpha_3^h \equiv \frac{\sigma^h}{\sigma^h-1} \times \left(\frac{\sigma^h}{\alpha_1^h}\right)^{\frac{1}{\sigma^h-1}} \times \alpha_2^{h\,\gamma_2^h}$, $\gamma_2^h = \dfrac{\eta^h-\sigma^h}{\gamma_1^h(\sigma^h-1)} = \frac{\eta^h-\sigma^h}{\theta^h(\eta^h-\sigma^h)-(\sigma^h-1)(\eta^h-1)}$, $\gamma_3^h = \dfrac{\eta^h}{\alpha} \times \gamma_1^h = \frac{\eta^h(\sigma^h-1)}{\alpha[\theta^h(\eta^h-\sigma^h)-(\sigma^h-1)(\eta^h-1)]}$, and substituting them back to (A.5) will generate the solution of the sectoral productivity threshold of (7).

A2: Dividend per share in (9)

From (4), the dividend per share is $\pi = \frac{\sum_{h=1}^H \sum_{j=1}^N \sum_{i=1}^N w_i L_i \left(\int_{\bar{\varphi}_{ij}^h}^\infty \pi_{ij}^h dG^h(\varphi)\right)}{\sum_{i=1}^N w_i L_i}$, and since $\pi_{ij}^h = x_{ij}^h/\sigma^h - f_{ij}^h = \alpha_1^h \alpha_2^{h\,(\sigma^h-\eta^h)\gamma_1^h} \times \lambda_j^{\gamma_3^h(\sigma^h-1)} L_j^{\gamma_1^h(1-\sigma^h)} \times \Phi_j^{h\,(\sigma^h-\eta^h)\gamma_1^h} \times (\frac{\sigma^h}{\sigma^h-1}\frac{w_i d_{ij}^h}{T_i^h \varphi})^{1-\sigma^h}/\sigma^h - f_{ij}^h$, I first have:

$$\int_{\bar{\varphi}_{ij}^h}^\infty \pi_{ij}^h dG^h(\varphi) = \underbrace{\frac{\alpha_1^h \alpha_2^{h\,(\sigma^h-\eta^h)\gamma_1^h}}{\sigma^h} \times \left(\frac{\lambda_j^{\gamma_3^h}}{L_j^{\gamma_1^h}}\right)^{(\sigma^h-1)} \times \Phi_j^{h\,(\sigma^h-\eta^h)\gamma_1^h} \times (\frac{\sigma^h}{\sigma^h-1}\frac{w_i d_{ij}^h}{T_i^h})^{1-\sigma^h} \times \int_{\bar{\varphi}_{ij}^h}^\infty \varphi^{\sigma^h-1} dG^h(\varphi)}_{\text{A}}$$
$$- \underbrace{\int_{\bar{\varphi}_{ij}^h}^\infty f_{ij}^h dG^h(\varphi)}_{\text{B}}.$$

I calculate part A and B separately. Plug in the solution of $\bar{\varphi}_{ij}^h$ to part A:

$$A = \frac{\alpha_1^h \alpha_2^{h\,\frac{\sigma^h-\eta^h}{\gamma_1^h}} \alpha_3^{h\,\sigma^h-1-\theta^h}}{\sigma^h} \times \frac{\theta^h}{\theta^h-(\sigma^h-1)} \times \left(\frac{\sigma^h}{\sigma^h-1}\right)^{1-\sigma^h} \times \left(\frac{\lambda_j^{\gamma_3^h}}{L_j^{\gamma_1^h}}\right)^{\theta^h} \times \left(\frac{w_i d_{ij}^h}{T_i^h}\right)^{-\theta^h} \times \Phi_j^{h\,-\gamma_2^h\theta^h} \times f_{ij}^{h\,\frac{\sigma^h-1-\theta^h}{\sigma^h}}.$$

And for part B:

$$B = \alpha_3^{h\,-\theta^h} \times \left(\frac{\lambda_j^{\gamma_3^h}}{L_j^{\gamma_1^h}}\right)^{\theta^h} \times \left(\frac{w_i d_{ij}^h}{T_i^h}\right)^{-\theta^h} \times \Phi_j^{h\,-\gamma_2^h\theta^h} \times f_{ij}^{h\,\frac{\sigma^h-1-\theta^h}{\sigma^h}}.$$

Then I have:

$$\int_{\bar{\varphi}_{ij}^h}^{\infty} \pi_{ij}^h dG^h(\varphi) = A - B = \alpha_4^h \times \left(\frac{\lambda_j^{\gamma_3^h}}{L_j^{\gamma_1^h}}\right)^{\theta^h} \times \left(\frac{w_i d_{ij}^h}{T_i^h}\right)^{-\theta^h} \times \Phi_j^{h^{-\gamma_2^h \theta^h}} \times f_{ij}^{h^{\frac{\sigma^h - 1 - \theta^h}{\sigma^h}}}, \quad \text{(A.6)}$$

where $\alpha_4^h \equiv \alpha_1^{h^{\frac{\theta^h}{\sigma^h - 1}}} \times \alpha_2^{h^{-\gamma_2^h \theta^h}} \times \left(\frac{\sigma^h}{\sigma^h - 1}\right)^{-\theta^h} \times \sigma^{h^{-\frac{\theta^h}{\sigma^h - 1}}} \times \left[\left(\frac{\sigma^h}{\sigma^h - 1}\right)^{\sigma^h - 1} - 1\right]$. With $w_i L_i = Y_i/(1+\pi)$, it follows that:

$$\begin{aligned}
\sum_{i=1}^{N} w_i L_i \times \int_{\bar{\varphi}_{ij}^h}^{\infty} \pi_{ij}^h dG^h(\varphi) =& \alpha_4^h \times \left(\frac{\lambda_j^{\gamma_3^h}}{L_j^{\gamma_1^h}}\right)^{\theta^h} \times \Phi_j^{h^{-\gamma_2^h \theta^h}} \times \frac{Y}{1+\pi} \sum_{i=1}^{N} \frac{Y_i}{Y} \times \left(\frac{w_i d_{ij}^h}{T_i^h}\right)^{-\theta^h} \times f_{ij}^{h^{\frac{\sigma^h - 1 - \theta^h}{\sigma^h}}} \\
=& \alpha_4^h \times \left(\frac{\lambda_j^{\gamma_3^h}}{L_j^{\gamma_1^h}}\right)^{\theta^h} \times \Phi_j^{h^{-\gamma_2^h \theta^h}} \times \frac{Y}{1+\pi} \times \Phi_j^h \\
=& \alpha_4^h \times \left(\frac{\lambda_j^{\gamma_3^h}}{L_j^{\gamma_1^h}}\right)^{\theta^h} \times \Phi_j^{h^{1-\gamma_2^h \theta^h}} \times \frac{Y}{1+\pi}.
\end{aligned} \quad \text{(A.7)}$$

Lastly, substitute (A.7) into the definition of π:

$$\begin{aligned}
\pi =& \frac{\sum_{h=1}^{H} \sum_{j=1}^{N} \sum_{i=1}^{N} w_i L_i \left(\int_{\bar{\varphi}_{ij}^h}^{\infty} \pi_{ij}^h dG^h(\varphi)\right)}{\sum_{i=1}^{N} w_i L_i} \\
=& \frac{\sum_{h=1}^{H} \sum_{j=1}^{N} \alpha_4^h \times \left(\frac{\lambda_j^{\gamma_3^h}}{L_j^{\gamma_1^h}}\right)^{\theta^h} \times \Phi_j^{h^{1-\gamma_2^h \theta^h}} \times \frac{Y}{1+\pi}}{\sum_{i=1}^{N} w_i L_i} \\
=& \frac{\sum_{h=1}^{H} \alpha_4^h \sum_{j=1}^{N} \left(\frac{\lambda_j^{\gamma_3^h}}{L_j^{\gamma_1^h}}\right)^{\theta^h} \times \Phi_j^{h^{1-\gamma_2^h \theta^h}} \times \frac{Y}{1+\pi}}{\sum_{i=1}^{N} \frac{Y_i}{1+\pi}} \\
=& \frac{\sum_{h=1}^{H} \alpha_4^h \sum_{j=1}^{N} \left(\frac{\lambda_j^{\gamma_3^h}}{L_j^{\gamma_1^h}}\right)^{\theta^h} \times \Phi_j^{h^{1-\gamma_2^h \theta^h}} \times \frac{Y}{1+\pi}}{\frac{Y}{1+\pi}} \\
=& \sum_{h=1}^{H} \alpha_4^h \sum_{j=1}^{N} \left(\frac{\lambda_j^{\gamma_3^h}}{L_j^{\gamma_1^h}}\right)^{\theta^h} \times \Phi_j^{h^{1-\gamma_2^h \theta^h}}.
\end{aligned} \quad \text{(A.8)}$$

A3: The gravity equation of bilateral trade in (10)

Again, he demand for each sector h variety produced in country i by country j consumers is given by $x_{ij}^h = \alpha_1^h \alpha_2^{h(\sigma^h-\eta^h)\gamma_1^h} \times \lambda_j^{\gamma_3^h(\sigma^h-1)} L_j^{\gamma_1^h(1-\sigma^h)} \times \Phi_j^{h(\sigma^h-\eta^h)\gamma_1^h} \times \left(\frac{\sigma^h}{\sigma^h-1}\frac{w_i d_{ij}^h}{T_i^h \varphi}\right)^{1-\sigma^h}$, then I have:

$$\begin{aligned}\int_{\bar{\varphi}_{ij}^h}^{\infty} x_{ij}^h(\varphi) dG^h(\varphi) =& \alpha_1^h \alpha_2^{h(\sigma^h-\eta^h)\gamma_1^h} \times \left(\frac{\lambda_j^{\gamma_3^h}}{L_j^{\gamma_1^h}}\right)^{\sigma^h-1} \times \Phi_j^{h(\sigma^h-\eta^h)\gamma_1^h} \times \left(\frac{\sigma^h}{\sigma^h-1}\frac{w_i d_{ij}^h}{T_i^h}\right)^{1-\sigma^h} \times \\ & \frac{\theta^h}{\theta^h-(\sigma^h-1)} \times \left(\bar{\varphi}_{ij}^h\right)^{\sigma^h-1-\theta^h} \\ & \text{(Plug in } \bar{\varphi}_{ij}^h \text{ of (7))} \\ =& \alpha_1^h \alpha_2^{h(\sigma^h-\eta^h)\gamma_1^h} \alpha_3^{h\,\sigma^h-1-\theta^h} \times \frac{\theta^h}{\theta^h-(\sigma^h-1)} \times \left(\frac{\sigma^h}{\sigma^h-1}\right)^{1-\sigma^h} \times \\ & \lambda_j^{\gamma_3^h\theta^h} L_j^{-\gamma_1^h\theta^h} \times \left(\frac{w_i d_{ij}^h}{T_i^h}\right)^{-\theta^h} \times \Phi_j^{h-\gamma_2^h\theta^h} \times f_{ij}^{h\,\frac{\sigma^h-1-\theta^h}{\sigma^h-1}}.\end{aligned} \tag{A.9}$$

It is straight forward to show that, given the definition of α_3^h in the main text, $\alpha_1^h \alpha_2^{h(\sigma^h-\eta^h)\gamma_1^h} \alpha_3^{h\,\sigma^h-1-\theta^h} \times \frac{\theta^h}{\theta^h-(\sigma^h-1)} \times (\frac{\sigma^h}{\sigma^h-1})^{1-\sigma^h} = \alpha_1^h \alpha_2^{h\,1-\gamma_2^h\theta^h} \times \frac{1+\pi}{Y}$, and then the sectoral exports from country i to country j is calculated as:

$$\begin{aligned} X_{ij}^h &= w_i L_i \int_{\bar{\varphi}_{ij}^h}^{\infty} x_{ij}^h(\varphi) dG^h(\varphi) \\ &= \alpha_1^h \alpha_2^{h\,1-\gamma_2^h\theta^h} \times \frac{1+\pi}{Y} \times \frac{Y_i}{1+\pi} \times \lambda_j^{\gamma_3^h\theta^h} L_j^{-\gamma_1^h\theta^h} \times \left(\frac{w_i d_{ij}^h}{T_i^h}\right)^{-\theta^h} \times \Phi_j^{h-\gamma_2^h\theta^h} \times f_{ij}^{h\,\frac{\sigma^h-1-\theta^h}{\sigma^h-1}} \\ &= \alpha_1^h \alpha_2^{h\,1-\gamma_2^h\theta^h} \times \frac{Y_i \times \lambda_j^{\gamma_3^h\theta^h} L_j^{-\gamma_1^h\theta^h}}{Y} \times \left(\frac{T_i^h}{w_i}\right)^{\theta^h} \times \left(d_{ij}^h \times \Phi_j^{h\gamma_2^h}\right)^{-\theta^h} \times f_{ij}^{h-\frac{\theta^h-(\sigma^h-1)}{\sigma^h-1}},\end{aligned} \tag{A.10}$$

which is the gravity equation in (10).

A4: The elasticities of bilateral trade with respect to y_i in (14)

I derive the income elasticity of bilateral trade on the intensive margin and extensive margin, and derivations of the elasticity with respect to sectoral productivity and country size follows analogously.

The intensive margin of bilateral trade with respect to per-capita income of the importing country j is defined as: $w_i L_i \int_{\bar{\varphi}_{ij}^h}^{\infty} \frac{\partial x_{ij}^h(\varphi)}{\partial y_j} dG^h(\varphi)$. Using the expression of demand for each variety $x^h_{ij} = \alpha^h_1 \alpha^{h(\sigma^h-\eta^h)\gamma^h_1}_2 \times \lambda_j^{\gamma^h_3(\sigma^h-1)} L_j^{\gamma^h_1(1-\sigma^h)} \times \Phi_j^{h(\sigma^h-\eta^h)\gamma^h_1} \times (\frac{\sigma^h}{\sigma^h-1}\frac{w_i d^h_{ij}}{T^h_i \varphi})^{1-\sigma^h}$, I have:

$$\frac{\partial x^h_{ij}(\varphi)}{\partial y_j} = \gamma^h_3 \left(\sigma^h - 1\right) \times \frac{x^h_{ij}}{\lambda_j} \times \frac{\partial \lambda_j}{\partial y_j}.$$

It then follows immediately that:

$$\begin{aligned} w_i L_i \int_{\bar{\varphi}^h_{ij}}^{\infty} \frac{\partial x^h_{ij}(\varphi)}{\partial y_j} dG^h(\varphi) &= \gamma^h_3 \left(\sigma^h - 1\right) \times \frac{1}{\lambda_j} \times \frac{\partial \lambda_j}{\partial y_j} \times w_i L_i \int_{\bar{\varphi}^h_{ij}}^{\infty} x^h_{ij} dG^h(\varphi) \\ &= \gamma^h_3 \left(\sigma^h - 1\right) \times \frac{1}{\lambda_j} \times \frac{\partial \lambda_j}{\partial y_j} \times X^h_{ij}. \end{aligned} \tag{A.11}$$

Thus the intensive margin income elasticity of bilateral trade equals:

$$\begin{aligned} w_i L_i \int_{\bar{\varphi}^h_{ij}}^{\infty} \frac{\partial x^h_{ij}(\varphi)}{\partial y_j} dG^h(\varphi) \times \frac{y_j}{X^h_{ij}} &= \gamma^h_3 \left(\sigma^h - 1\right) \times \frac{1}{\lambda_j} \times \frac{\partial \lambda_j}{\partial y_j} \times X^h_{ij} \times \frac{y_j}{X^h_{ij}} \\ &= \gamma^h_3 \left(\sigma^h - 1\right) \frac{\partial \lambda_j}{\partial y_j} \times \frac{y_j}{\lambda_j} \\ &= \gamma^h_3 \left(\sigma^h - 1\right) \times \zeta_j. \end{aligned} \tag{A.12}$$

For the extensive margin $w_i L_i x^h_{ij}(\bar{\varphi}^h_{ij}) G^{h\prime}(\bar{\varphi}^h_{ij}) \frac{\partial \bar{\varphi}^h_{ij}}{\partial y_j}$, first note that

$$\frac{\partial \bar{\varphi}^h_{ij}}{\partial y_j} = -\gamma^h_3 \times \frac{\bar{\varphi}^h_{ij}}{\lambda_j} \times \frac{\partial \lambda_j}{\partial y_j}, \quad \text{and}$$

$$G^{h\prime}(\bar{\varphi}^h_{ij}) = \theta^h \times \left(\bar{\varphi}^h_{ij}\right)^{-\theta^h - 1}.$$

And then

$$\begin{aligned} w_i L_i x^h_{ij}(\bar{\varphi}^h_{ij}) G^{h\prime}(\bar{\varphi}^h_{ij}) \frac{\partial \bar{\varphi}^h_{ij}}{\partial y_j} =& w_i L_i \times \alpha^h_1 \alpha^{h(\sigma^h-\eta^h)\gamma^h_1}_2 \times \lambda_j^{\gamma^h_3(\sigma^h-1)} L_j^{\gamma^h_1(1-\sigma^h)} \times \Phi_j^{h(\sigma^h-\eta^h)\gamma^h_1} \times \\ & (\frac{\sigma^h}{\sigma^h-1}\frac{w_i d^h_{ij}}{T^h_i \bar{\varphi}^h_{ij}})^{1-\sigma^h} \times \theta^h \times \left(\bar{\varphi}^h_{ij}\right)^{-\theta^h-1} \times -\gamma^h_3 \times \frac{\bar{\varphi}^h_{ij}}{\lambda_j} \times \frac{\partial \lambda_j}{\partial y_j} \\ =& w_i L_i \times \alpha^h_1 \alpha^{h(\sigma^h-\eta^h)\gamma^h_1}_2 \times \lambda_j^{\gamma^h_3(\sigma^h-1)} L_j^{\gamma^h_1(1-\sigma^h)} \times \Phi_j^{h(\sigma^h-\eta^h)\gamma^h_1} \times \\ & (\frac{\sigma^h}{\sigma^h-1}\frac{w_i d^h_{ij}}{T^h_i})^{1-\sigma^h} \times \theta^h \times \left(\bar{\varphi}^h_{ij}\right)^{\sigma^h-1-\theta^h} \times -\gamma^h_3 \times \frac{1}{\lambda_j} \times \frac{\partial \lambda_j}{\partial y_j}. \end{aligned}$$

Recall that the bilateral trade $X^h_{ij} = w_i L_i \int_{\bar{\varphi}^h_{ij}}^{\infty} x^h_{ij}(\varphi) dG^h(\varphi)$, and it can be shown that X^h_{ij} then can be expressed as a function of the productivity threshold $\bar{\varphi}^h_{ij}$ as:

$$
\begin{aligned}
X_{ij}^h = & w_i L_i \times \alpha_1^h \alpha_2^{h(\sigma^h-\eta^h)\gamma_1^h} \times \lambda_j^{\gamma_3^h(\sigma^h-1)} L_j^{\gamma_1^h(1-\sigma^h)} \times \Phi_j^{h(\sigma^h-\eta^h)\gamma_1^h} \times \\
& (\frac{\sigma^h}{\sigma^h-1} \frac{w_i d_{ij}^h}{T_i^h})^{1-\sigma^h} \times \left(\bar{\varphi}_{ij}^h\right)^{\sigma^h-1-\theta^h} \times \frac{\theta^h}{\theta^h-(\sigma^h-1)}.
\end{aligned}
\tag{A.13}
$$

With (A.10), the extensive margin with respect to y_j is essentially:

$$
w_i L_i x_{ij}^h(\bar{\varphi}_{ij}^h) G^{h\prime}(\bar{\varphi}_{ij}^h) \frac{\partial \bar{\varphi}_{ij}^h}{\partial y_j} = X_{ij}^h \times \frac{\theta^h-(\sigma^h-1)}{\theta^h} \times \theta^h \times -\gamma_3^h \times \frac{1}{\lambda_j} \times \frac{\partial \lambda_j}{\partial y_j},
$$

and then the extensive margin income elasticity of bilateral trade equals:

$$
\begin{aligned}
w_i L_i x_{ij}^h(\bar{\varphi}_{ij}^h) G^{h\prime}(\bar{\varphi}_{ij}^h) \frac{\partial \bar{\varphi}_{ij}^h}{\partial y_j} \times \frac{y_j}{X_{ij}^h} = & X_{ij}^h \times \left(\theta^h-(\sigma^h-1)\right) \times -\gamma_3^h \times \frac{1}{\lambda_j} \times \frac{\partial \lambda_j}{\partial y_j} \times \frac{y_j}{X_{ij}^h} \\
= & \gamma_3^h \left(\sigma^h-1-\theta^h\right) \times \zeta_j.
\end{aligned}
\tag{A.14}
$$

The same method is used to derive the elasticity of bilateral trade with respect to sectoral productivity and country size on the intensive margin and the extensive margin in (13) and (16).

A5: $\hat{\eta}^h$ and $\hat{\sigma}^h$ in (32)

From the definitions γ_1^h and γ_2^h in (8), I have $\hat{\gamma}_1^h/\hat{\gamma}_2^h = \dfrac{\hat{\sigma}^h-1}{\hat{\eta}^h-\hat{\sigma}^h}$. Solving for σ^h, I get the following relationship between η^h and σ^h:

$$
\hat{\sigma}^h = \frac{\hat{\gamma}_1^h \hat{\eta}^h + \hat{\gamma}_2^h}{\hat{\gamma}_1^h + \hat{\gamma}_2^h}. \tag{A.15}
$$

Plugging (A.15) back to the expression of γ_1^h, and solving for η^h, I will then get:

$$
\hat{\eta}^h = \frac{\hat{\theta}^h \hat{\gamma}_2^h + 1}{\hat{\gamma}_1^h} + 1, \tag{A.16}
$$

and then from (A.15), I can solve for σ^h as:

$$
\hat{\sigma}^h = \frac{\hat{\theta}^h \hat{\gamma}_2^h - 1}{\hat{\gamma}_1^h + \hat{\gamma}_2^h} + 1. \tag{A.17}
$$

Online Appendix:
Supplementary material for Non-homothetic Gravity

In this web appendix, I provide additional content and results that are relevant but not included in the main text.

A6: Sectoral elasticities and differentiation

Now I investigate the interactions between the within-sector elasticity of substitution σ^h and sectoral per-capita income/country size elasticities. It is straightforward to check that:

$$\frac{-\partial\gamma_3^h}{\partial\sigma^h} = \frac{\theta^h\eta^h(1-\eta^h)}{\alpha[\theta^h(\eta^h-\sigma^h)-(\sigma^h-1)(\eta^h-1)]^2},$$

and therefore the relationship between per-capita income elasticity and elasticity of substitution in my model is non-monotonic: income elasticity increases with σ^h when $\eta^h < 1$ and decreases with σ^h when $\eta^h > 1$. One normally might expect that more differentiated sectors (those with lower σ^h) tends to be more income-elastic (higher -γ_3^h), and the analysis here suggests that this is only true when sectoral income elasticity is higher than a threshold, which is defined in this case as:

$$-\bar{\gamma}_3^h = -\gamma_3^h|_{\eta^h=1} = \frac{1}{\alpha\theta^h}. \tag{A.18}$$

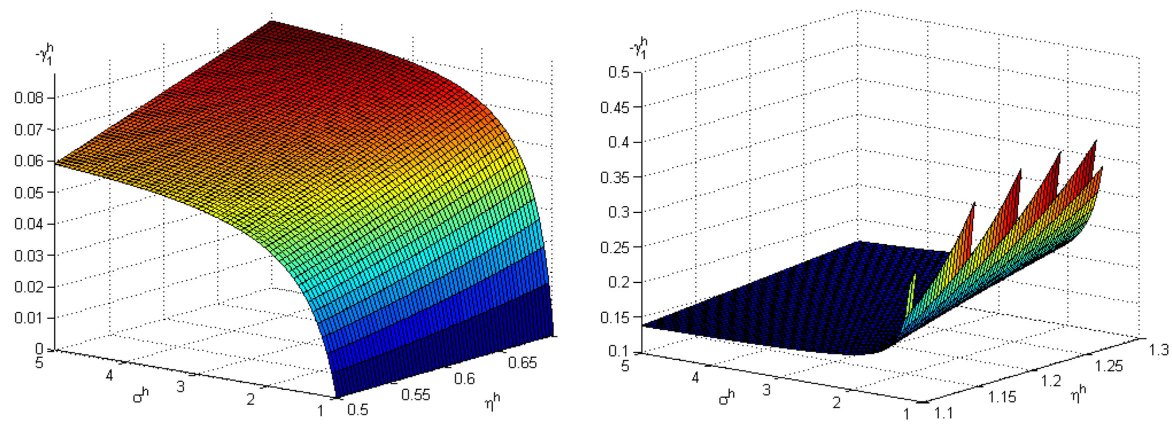
For sectors with $-\gamma_3^h$ that is lower than this threshold, more differentiated sectors tend to be relatively less elastic with respect to per-capita income of consumers.

This exactly same pattern holds for $-\gamma_1^h$, which is graphically shown in figure A.1 with the value of θ^h being set to 8. The left panel plots $-\gamma_1^h$ against σ^h and $\eta^h \in (0.5, 0.7)$, and the right panel for $\eta^h \in (1.1, 1.3)$. And this relationship between $-\gamma_1^h$ and σ^h links the elasticity of substitution with the importer-home market effect. Following the analysis before, for sectors with η^h higher than 1, more differentiated sectors tend to be more elastic with respect to country size, and thus exhibit weaker importer home-market effect. On the other hand, for sectors that are relatively inelastic with respect to country size ($\eta^h < 1$), lower elasticity of substitution is associated with lower country size elasticity, and thus strengthens the importer home-market effect.

A7: Estimating manufacturing TFP of the U.S.

To obtain the estimates of sectoral total factor productivities for the U.S., I rely on the NBER-CES Manufacturing Industry Dataset. The original database contains information on output and factor inputs for 459 SIC87 sectors of the U.S. from 1958 to 2009. I extract data from 1963 to 2000, and match the data up to the 28 ISIC rev.3 manufacturing sectors of

Figure A.1: The change of $-\gamma_1^h$ with respect to σ^h ($\theta^h = 8$).



(L) $\eta^h < 1$ (R) $\eta^h > 1$

my main dataset using a concordance developed by the author.[45] I assume a Cobb-Douglas production function based on 5 factors:

$$\ln Output^h = \ln\Psi^h + \alpha^h_{npw}\ln NPW^h + \alpha^h_{pw}\ln PW^h + \alpha^h_{en}\ln En^h + \alpha^h_{mat}\ln Mat^h + \alpha^h_{cap}\ln Cap^h,$$

where $NPW=$ non-production workers, $PW=$ production workers, $En=$ energy expenditures, $Mat=$ non-energy materials, $Cap=$ capital stock, and $\alpha^h_{npw}+\alpha^h_{pw}+\alpha^h_{en}+\alpha^h_{mat}+\alpha^h_{cap} = 1$ are the shares of expenditures on each factor in total output. Ψ^h denotes the sectoral total factor productivity of the U.S., and will be used as a proxy of T^h_{us} in my model. So I have: $\ln\Psi^h = \ln T^h_{us}$. While the sectoral TFPs are obtained for each year, I report their decade-averages in Table A.1. These estimates are then used together with the importer fixed effects from (28) to extract sectoral productivities of the other countries.

[45] Details on the construction of this concordance are available upon request.

Table A1: Sectoral TFP of the U.S. Ψ^h

ISIC Code	Description	1963-1970 Average	1971-1980 Average	1981-1990 Average	1991-2000 Average
311	Food products	47.323	38.001	92.921	219.925
313	Beverages	815.138	335.714	363.381	573.988
314	Tobacco	516.541	1162.984	26372.230	134713.100
321	Textiles	108.962	144.511	205.658	321.598
322	Wearing apparel, except footwear	153.255	288.199	530.066	698.906
323	Leather products	189.882	269.042	368.413	619.112
324	Footwear, except rubber or plastic	287.997	331.495	372.573	554.252
331	Wood products, except furniture	112.635	140.866	107.496	131.994
332	Furniture, except metal	252.856	331.994	523.502	581.195
341	Paper and products	196.031	217.211	268.947	371.928
342	Printing and publishing	2754.375	3936.364	7229.146	7372.942
351	Industrial chemicals	567.580	440.918	374.023	603.138
352	Other chemicals	1310.130	1126.657	1801.892	2755.442
353	Petroleum refineries	15.991	8.746	7.484	14.714
354	Misc. petroleum and coal products	58.388	29.186	21.329	46.667
355	Rubber products	292.204	394.548	523.365	763.427
356	Plastic products	241.701	327.477	381.320	453.993
361	Pottery, china, earthenware	947.964	1488.149	1930.807	3846.108
362	Glass and products	848.015	1212.344	1369.146	1736.889
369	Other non-metallic mineral products	265.426	236.635	272.095	519.886
371	Iron and steel	179.517	152.438	173.952	300.145
372	Non-ferrous metals	95.895	84.679	105.374	245.770
381	Fabricated metal products	209.128	222.819	294.829	409.463
382	Machinery, except electrical	190.464	311.789	546.408	539.375
383	Machinery, electric	491.611	730.248	1095.067	2146.262
384	Transport equipment	170.100	156.472	176.595	214.895
385	Professional & scientific equipment	817.224	1587.894	2821.249	3138.944
390	Other manufactured products	272.354	365.168	574.416	790.027

Notes: This table reports average sectoral TFPs (output per unit of input-combination) for each decade. U.S. sectoral TFPs are calculated based on a 5-factor Cobb-Douglas production function using the NBER-CES Manufacturing Industry Database.

A8: Decomposing U.S. – China trade

This section reports the decomposition of U.S – China trade results by sector. I first show the results on trade volumes in tables A2 and A3, which correspond to the results on tables 9a and 9b in the main text. There are several points that worth mentioning to help better understand the results. First, while exports of all sample sectors have increased over the 20 years, the *costless exports* ΔE_{ij}^h can be negative, indicating that the observed exports growth is purely driven by the *decrease* in bilateral trade barriers of those sectors, and trade net the effects of trade barriers has shrunk over the sample time period: for example, the column $\Delta E_{US,CN}^h$ of table A2 reports the sign of the changes in the *costless exports* from the U.S. to China, and among the 21 sectors, $E_{US,CN}^h$ have decrease in 2 sectors – ISIC 342 (printing and publishing) and ISIC 382 (machinery, except electrical). Second, since sectoral productivity can either increase or decrease over time, the contribution of changes in productivity to trade variance (e.g. column PC_{US}^h) can be either positive or negative. Last but not the least, since aggregate income of both China and U.S. have increase between 1980 and 2000, and the estimated sectoral per-capita income and market-size elasticities are all positive for these sample sectors, ΔP_i^h is positive for all sectors. Therefore, the contribution of demand pattern changes to bilateral trade variance can be negative only for the sectors with negative ΔE_{ij}^hs, such as sectors ISIC 342 and ISIC 382. Thus, the decomposition results of table A2 show that sectoral productivities of the U.S. have decreased in 8 out of the 19 sectors with positive *costless exports* changes,[46] and these negative effects are compensated by increases in sectoral expenditure by China. As for sectors ISIC 342 and ISIC 382, positive contributions of PC_{US}^h and negative contributions of DC_{CN}^h indicate decreases of U.S. productivities and increases of Chinese demand in these two sectors. In aggregate, as in table 9a, the *costless exports* from the U.S. to China have increased across sectors between 1980 and 2000, and about 15% of this increase is due to the increase in the U.S. productivities across sectors, and increase in Chinese expenditure contributes to 85% of the overall trade growth. Table A3 reports the results of the decomposition of Chinese exports to the U.S.. Interestingly, the *costless exports* EX_{CN}^h have decreased in 12 out of the 20 available sample sectors, implying decreasing Chinese productivity in those sectors. Meanwhile, China has experienced large productivity growth in the other 7 sectors, [47] making the overall productivity across sectors to increase over time, contributing to 61% of the cross-sector trade growth, and the rest 39% of the increase in exports is attributed to increases in the U.S. demand.

The decomposition of importer demand contributions by sector are shown in tables A4 and A5.

Lastly tables A6 and A7 report the results on decomposing relative trade variation be-

[46] These are sectors ISIC 313, ISIC 321, ISIC 331, ISIC 332, ISIC 356, ISIC 362, ISIC 381, and ISIC 384.

[47] They are ISIC 311, ISIC 321, ISIC 323, ISIC 341, ISIC 342, ISIC 353, and ISIC 383.

Table A2: Decomposition of trade variation: U.S. to China

ISIC code	Description	$\Delta E^h_{US,CN}$	PC^h_{US}	DC^h_{CN}
311	Food products	+	55.92%	44.08%
313	Beverages	+	-68.19%	168.19%
321	Textiles	+	-19.75%	119.75%
323	Leather products	+	20.39%	79.61%
331	Wood products, except furniture	+	-208.13%	308.13%
332	Furniture, except metal	+	-280.09%	380.09%
341	Paper and products	+	14.93%	85.07%
342	Printing and publishing	-	561.78%	-461.78%
352	Other chemicals	+	1.10%	98.90%
353	Petroleum refineries	+	36.33%	63.67%
354	Misc. petroleum and coal products	+	29.76%	70.24%
355	Rubber products	+	13.37%	86.63%
356	Plastic products	+	-306.08%	406.08%
362	Glass and products	+	-77.09%	177.09%
371	Iron and steel	+	28.38%	71.62%
372	Non-ferrous metals	+	45.00%	55.00%
381	Fabricated metal products	+	-136.99%	236.99%
382	Machinery, except electrical	-	2006.23%	-1906.23%
383	Machinery, electric	+	41.30%	58.70%
384	Transport equipment	+	-621.05%	721.05%
390	Other manufactured products	+	19.60%	80.40%
	Aggregate	+	**14.75%**	**85.25%**

Notes: This table reports the decomposition of exports growth from the U.S. to China between 1980 and 2000. Column $\Delta E^h_{US,CN}$ indicates the sign of changes in the *costless trade* as defined in (39) and (40). PC^h_{US} is the contribution of changes in U.S. productivity to $\Delta E^h_{US,CN}$, and DC^h_{CN} is the contribution of changes in Chinese demand pattern to $\Delta E^h_{US,CN}$.

Table A3: Decomposition of trade variation: China to U.S.

ISIC code	Description	$\Delta E^h_{CN,US}$	PC^h_{CN}	DC^h_{US}
311	Food products	+	61.85%	38.15%
313	Beverages	-	918.50%	-818.50%
321	Textiles	+	45.00%	55.00%
323	Leather products	+	52.68%	47.32%
324	Footwear, except rubber or plastic	-	1642.38%	-1542.38%
331	Wood products, except furniture	+	-22.12%	122.12%
332	Furniture, except metal	-	1349.17%	-1249.17%
341	Paper and products	+	64.45%	35.55%
342	Printing and publishing	+	61.00%	39.00%
352	Other chemicals	-	584.60%	-484.60%
353	Petroleum refineries	+	54.10%	45.90%
354	Misc. petroleum and coal products	-	5404.10%	-5304.10%
356	Plastic products	-	649.14%	-549.14%
361	Pottery, china, earthenware	-	543.37%	-443.37%
362	Glass and products	-	489.35%	-389.35%
372	Non-ferrous metals	-	1004.82%	-904.82%
381	Fabricated metal products	-	666.44%	-566.44%
382	Machinery, except electrical	-	600.28%	-500.28%
383	Machinery, electric	+	55.26%	44.74%
390	Other manufactured products	-	1967.55%	-1867.55%
	Aggregate	+	**60.83%**	**39.17%**

Notes: This table reports the decomposition of exports growth from the China to the U.S. between 1980 and 2000. Column $\Delta E^h_{CN,US}$ indicates the sign of changes in the *costless trade* as defined in (39) and (40). PC^h_{CN} is the contribution of changes in Chinese productivity to $\Delta E^h_{CN,US}$, and DC^h_{US} is the contribution of changes in the demand pattern of the U.S. to $\Delta E^h_{CN,US}$.

Table A4: Decomposition of importer demand variation: China

ISIC code	Description	DC^{h}_{CN}	IC^{h}_{CN}	LC^{h}_{CN}
311	Food products	44.08%	38.04%	6.04%
313	Beverages	168.19%	150.89%	17.30%
321	Textiles	119.75%	103.50%	16.25%
323	Leather products	79.61%	71.88%	7.73%
331	Wood products, except furniture	308.13%	274.89%	33.25%
332	Furniture, except metal	380.09%	315.66%	64.43%
341	Paper and products	85.07%	74.79%	10.29%
342	Printing and publishing	-461.78%	-395.36%	-66.42%
352	Other chemicals	98.90%	82.82%	16.08%
353	Petroleum refineries	63.67%	56.04%	7.63%
354	Misc. petroleum and coal products	70.24%	55.53%	14.71%
355	Rubber products	86.63%	73.70%	12.93%
356	Plastic products	406.08%	362.42%	43.66%
362	Glass and products	177.09%	157.55%	19.54%
371	Iron and steel	71.62%	62.26%	9.36%
372	Non-ferrous metals	55.00%	46.92%	8.08%
381	Fabricated metal products	236.99%	205.78%	31.21%
382	Machinery, except electrical	-1906.23%	-1663.53%	-242.70%
383	Machinery, electric	58.70%	51.22%	7.49%
384	Transport equipment	721.05%	606.08%	114.97%
390	Other manufactured products	80.40%	69.50%	10.90%
	Aggregate	**85.25%**	**67.39%**	**17.86%**

Notes: This table reports the decomposition of demand pattern variation of China between 1980 and 2000. DC^{h}_{CN} is the contribution of changes in Chinese demand pattern to overall variation in the *costless trade*. IC^{h}_{CN} is the contribution of changes in per-capita income of China and LC^{h}_{CN} is the contribution of changes in Chinese market-size.

Table A5: Decomposition of importer demand variation: U.S.

ISIC code	Description	DC^h_{US}	IC^h_{US}	LC^h_{US}
311	Food products	38.15%	32.23%	5.92%
313	Beverages	-818.50%	-734.84%	-83.65%
321	Textiles	55.00%	47.25%	7.74%
323	Leather products	47.32%	42.93%	4.39%
324	Footwear, except rubber or plastic	-1542.38%	-1398.07%	-144.32%
331	Wood products, except furniture	122.12%	107.26%	14.86%
332	Furniture, except metal	-1249.17%	-1048.07%	-201.10%
341	Paper and products	35.55%	30.49%	5.05%
342	Printing and publishing	39.00%	32.71%	6.29%
352	Other chemicals	-484.60%	-404.29%	-80.31%
353	Petroleum refineries	45.90%	40.42%	5.47%
354	Misc. petroleum and coal products	-5304.10%	-4293.08%	-1011.02%
356	Plastic products	-549.14%	-490.44%	-58.70%
361	Pottery, china, earthenware	-443.37%	-404.64%	-38.73%
362	Glass and products	-389.35%	-345.10%	-44.24%
372	Non-ferrous metals	-904.82%	-769.23%	-135.59%
381	Fabricated metal products	-566.44%	-491.51%	-74.94%
382	Machinery, except electrical	-500.28%	-436.11%	-64.17%
383	Machinery, electric	44.74%	38.61%	6.13%
390	Other manufactured products	-1867.55%	-1632.70%	-234.85%
	Aggregate	**39.18%**	**31.71%**	**7.47%**

Notes: This table reports the decomposition of demand pattern variation of the U.S. between 1980 and 2000. DC^h_{US} is the contribution of changes in demand pattern of the U.S. to overall variation in the *costless trade*. IC^h_{US} is the contribution of changes in per-capita income of the U.S. and LC^h_{US} is the contribution of changes in market-size of the U.S..

tween the U.S. and China. They correspond to tables 11a and 11b in the main text.

Table A6: Decomposition of relative trade variation

ISIC code	Description	ΔRE^h	RPC^h	RDC^h
311	Food products	+	37.07%	62.93%
313	Beverages	+	67.92%	32.08%
321	Textiles	-	34.62%	65.38%
323	Leather products	-	147.03%	-47.03%
331	Wood products, except furniture	-	562.49%	-462.49%
332	Furniture, except metal	+	59.81%	40.19%
341	Paper and products	-	105.36%	-5.36%
342	Printing and publishing	-	258.50%	-158.50%
352	Other chemicals	+	100.38%	-0.38%
353	Petroleum refineries	-	69.44%	30.56%
354	Misc. petroleum and coal products	+	53.67%	46.33%
356	Plastic products	+	527.69%	-427.69%
362	Glass and products	+	88.86%	11.14%
372	Non-ferrous metals	+	50.17%	49.83%
381	Fabricated metal products	+	85.40%	14.60%
382	Machinery, except electrical	+	461.24%	-361.24%
383	Machinery, electric	-	-432.88%	532.88%
390	Other manufactured products	+	100.38%	-0.38%
	Average	+	**88.51%**	**11.49%**

Notes: This table reports the decomposition of the variation in exports by the U.S. relative to exports by China between 1980 and 2000. Column ΔRE^h indicates the sign of changes in the *costless relative trade*. RPC^h is the contribution of changes in relative productivity toΔRE^h, and RDC^h is the contribution of changes in relative demand patterns to ΔRE^h.

Table A7: Decomposition of relative demand variation

ISIC code	Description	RDC^h	RIC^h	RLC^h
311	Food products	62.93%	81.83%	-18.90%
313	Beverages	32.08%	36.28%	-4.20%
321	Textiles	65.38%	39.78%	25.60%
323	Leather products	-47.03%	-68.41%	21.38%
331	Wood products, except furniture	-462.49%	-473.19%	10.70%
332	Furniture, except metal	40.19%	43.80%	-3.62%
341	Paper and products	-5.36%	-7.72%	2.37%
342	Printing and publishing	-158.50%	-158.44%	-0.06%
352	Other chemicals	-0.38%	4.58%	-4.96%
353	Petroleum refineries	30.56%	22.60%	7.96%
354	Misc. petroleum and coal products	46.33%	48.50%	-2.17%
356	Plastic products	-427.69%	-345.27%	-82.41%
362	Glass and products	11.14%	16.33%	-5.19%
372	Non-ferrous metals	49.83%	50.73%	-0.90%
381	Fabricated metal products	14.60%	23.79%	-9.19%
382	Machinery, except electrical	-361.24%	-276.62%	-84.62%
383	Machinery, electric	532.88%	413.49%	119.38%
390	Other manufactured products	-0.38%	7.07%	-7.46%
	Average	**11.49%**	**19.06%**	**-7.57%**

Notes: This table reports the decomposition of relative demand pattern variation of between the U.S. and China over 1980 to 2000. RDC^h is the contribution of changes in relative demand patterns to overall variation in the *relative costless trade*. RIC^h_{US} is the contribution of changes in relative per-capita income between the U.S. and China, and RLC^h_{US} is the contribution of changes in relative market-size between these two countries.