Working Paper No. 14-03

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

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October 2014
Revised November 2014

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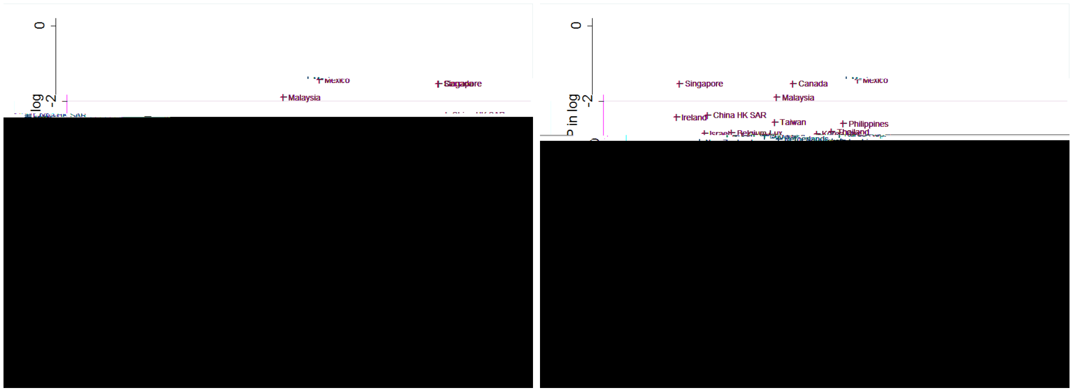
Abstract

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 di erent e ects 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 identi es each industry with two dimensions: per-capita income and country size elasticities with respect to trade, while explicitly controlling for the supply side e ect. Accordingly in the model, the two components of aggregate income { per-capita income and the size of a country { a ect bilateral

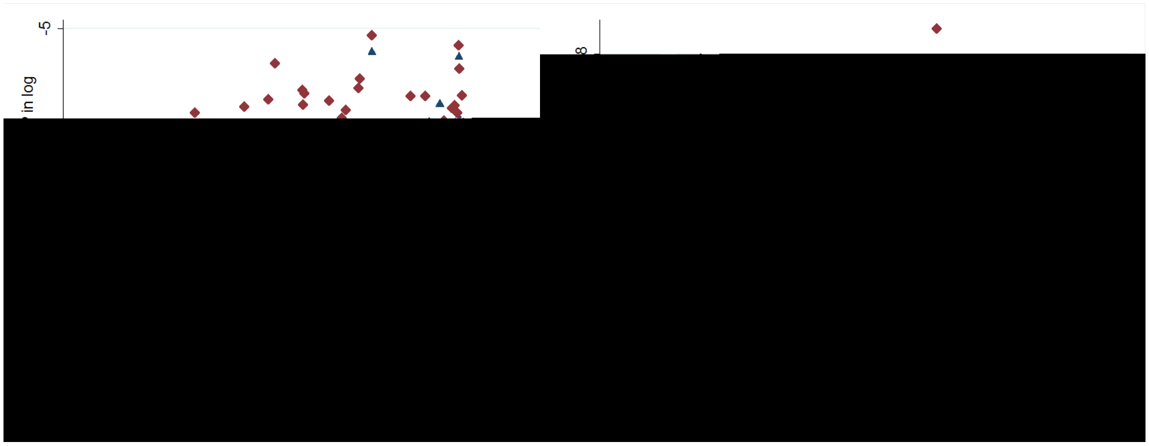
Figure 1: Trade, per-capita income, and country size.



(L) (R)

Notes

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



(L) (R)

Notes: Data source: Feenstra et al.(2005). This gure 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 Classi cation (ISIC) revision 2, for countries that import from the U.S. in the data in the year of 2000.

to the e ect of country size on the level of trade as the importer home-market e ect, and that on relative trade as the exporter home-market e ect. While the analysis focuses on the demand side, I also incorporate Ricardian comparative advantage in the model to control for the supply side e ect. 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 ows.

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 ows. 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 uni ed framework. Applying these estimated parameters to reduced-form analysis con rms the presence of the home-market e ect 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-speci c country size elasticity { o ers an additional channel to explain these trade puzzles, and it reinforces the e ect 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 di erences 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 identi es 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 e ect.

$$U = q^{0\,1} \left(\sum_{h=1}^{H} {}^{h} Q^{h \frac{h\;1}{h}} \right)$$

$$Q^h = \left(\int_0^{h} q^h(!)^{\frac{h\;1}{h}} d! \right)^{\frac{h}{h\;1}};$$

where ^{h} is the endogenous set of varieties (both domestically produced and imported) in sector h. P_h ^{h} is normalized to be 1. The parameter ^{h} is the elasticity of substitution between varieties within sector h and is assumed to be greater than 1. Parameter ^{h} governs the elasticity of substitution between sectors and is normally assumed to be positive. As I will show in the equilibrium, ^{h} and ^{h} will jointly de ne the sectoral per-capita income and country size elasticities, and since they di ers 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 di erent countries have the same preferences, however the non-homotheticity of the utility function will generate di erent 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):

$$X_j^h = {}_j^{\frac{h}{}} L_j \, {}_1^h \, P_j^{h\,1\;h}; \qquad (1)$$

$$x_{ij}^h = X_j^h \left(\frac{p_{ij}^h}{P_j^h} \right)^{1\;h} = {}_j^{\frac{h}{}} L_j \, {}_1^h \, P_j^{h\,1\;h} \left(\frac{p_{ij}^h}{P_j^h} \right)^{1\;h}: \qquad (2)$$

$_j$ is the Lagrangian multiplier associated with the budget constraint of the representative consumer, and it is decreasing in per-capita income. $_1^h$ $[\;(1\;\;)^{\frac{1}{}}\;\;{}^{h}\frac{h\;1}{h}]^{h}$ is a sector-speci c 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 markets is assumed to be perfectly competitive, therefore the sector 0 3.03 0 Td [( )]TJ/F8 05(p)8605n04(ass) the total costs of selling q units of a sector h variety in country j by a rm 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: $p_{ij}^{h} = \frac{h}{h\ \ 1} \frac{w_i d_{ij}^{h}}{z_i^{h}}$.

To incorporate the Ricardian comparative advantage in the model, I rst assume that there are two components of the labor productivity: z_i^{h} T_i^{h} $'^{h}$. T_i^{h} is a country- and sector-speci c 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 rms within a sector; the random productivity shock $'^{h}$, following Helpman, Melitz, and Yeaple (2004) as well as Chaney (2008), is assumed to be drawn from a Pareto distribution over $[1; +1\ )$ with the CDF of: [5]

$$P('^{h} < '\ ) = G^{h}('\ ) = 1 \quad '^{\quad h},$$

where ^{h} is a sector-speci c parameter measuring the dispersion of productivity distribution.[6] I assume that $^{h} > \ ^{h}\ \ 1$ to ensure a well de ned price index. Then there exists a productivity threshold $'^{h}_{ij}$ for a country i sector h rm to pro tably exports to country j. I follow Chaney (2008) assuming that the mass of potential entrants of each di erentiated 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:

$$P_j^{h} = \left(\sum_{i=1}^{N} w_i L_i \int_{'^{h}_{ij}}^{1} \left(\frac{h}{h\ \ 1} \frac{w_i d_{ij}^{h}}{T_i^{h}'}\right)^{1\ \ h} dG^{h}('\ ) \right)^{1}$$

2.2 The equilibrium

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

The productivity threshold is de ned by the zero cuto pro t condition: $^{h}_{ij}(\varphi^{h}_{ij}) = 0$. So I have:

$$_{j}\ \frac{^{h}}{}L_{j}\ \ \frac{^{h}_{1}}{^{h}}\ \ P^{h}_{j}\ ^{h\ \ h}\ \ \frac{^{h}}{^{h}\ \ 1}\ \left(\frac{w_{i}d^{h}_{ij}}{T^{h}_{i}\varphi^{h}_{ij}}\right)^{1\ \ h} = f^{h}_{ij}: \quad (5)$$

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

$$P^{h}_{j} = \ ^{h}_{2}\ ^{h}_{1}\ \ _{j}\ \frac{^{h}}{}L_{j}\ ^{\frac{^{h}(^{h}\ \ 1)}{(^{h}\ \ 1)}\ ^{h}_{1}}\ \ ^{h}_{j}\ ^{h}_{1}; \quad (6)$$

$$\varphi^{h}_{ij} = \ ^{h}_{3}\ \ _{j}\ ^{h}_{3}L_{j}\ ^{h}_{1}\ \frac{w_{i}d^{h}_{ij}}{T^{h}_{i}}\ \ ^{h}_{j}\ ^{h}_{2}\ \ f^{h}_{ij}\ ^{\frac{1}{^{h}\ \ 1}}; \quad (7)$$

where $^{h}_{2}\ \ \frac{^{h}}{^{h}\ (^{h}\ \ 1)}\ \ \frac{^{h}}{^{h}\ \ 1}\ ^{h}\ \ \frac{^{h}}{^{h}_{1}}\ ^{\frac{(^{h}\ \ 1)}{^{h}\ \ 1}\ ^{h}}\ \ \frac{Y}{1+}$, and $^{h}_{3}\ \ \frac{^{h}}{^{h}\ \ 1}\ \ \frac{^{h}}{^{h}_{1}}\ ^{\frac{1}{^{h}\ \ 1}}\ ^{h}_{2}\ ^{h}_{2}$ are sector-speci c constants. $^{h}_{j}\ \ \sum_{i=1}^{N}\frac{Y_{i}}{Y}\ \frac{w_{i}d^{h}_{ij}}{T^{h}_{i}}\ ^{h}\ \ f^{h}_{ij}\ ^{\frac{^{h}(^{h}\ \ 1)}{^{h}\ \ 1}}$, 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 re ects the measure of the \multilateral resistance" in Anderson (1979) and Anderson and van Wincoop (2003). Y here refers to the world income. And lastly:

$$\begin{aligned} ^{h}_{1}\ &\ \frac{^{h}\ \ 1}{^{h}(^{h}\ \ ^{h})\ \ (^{h}\ \ 1)(^{h}\ \ 1)}; \\ ^{h}_{2}\ &\ \frac{^{h}\ \ ^{h}}{^{h}(^{h}\ \ ^{h})\ \ (^{h}\ \ 1)(^{h}\ \ 1)}; \\ ^{h}_{3}\ &\ \frac{^{h}(^{h}\ \ 1)}{[\ ^{h}(^{h}\ \ ^{h})\ \ (^{h}\ \ 1)(^{h}\ \ 1)]}: \end{aligned} \quad (8)$$

The sector-speci c 's of (8) are functions of the productivity distribution parameter ^{h} and the parameters governing between- and within-sector elasticities of substitution: ^{h} and ^{h}. How the price index and labor productivity threshold vary with total income and $^{h}_{j}$ depend on the behavior of these parameters. The estimates from the empirical section show that $^{h}_{2}$ 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.

and it follows that the income elasticity is given by:

$$\frac{d\ln X_j^h}{d\ln y_j} = {}^h_3 \; {}^h \quad \frac{d \;\, _j}{dy_j} \quad \frac{X_j^h}{_j} \quad \frac{y_j}{X_j^h} \qquad (12)$$

$$= {}^h_3 \; {}^h \qquad _j\,;$$

where $_j = d\ln \;_j = d\ln y_j < 0$ is the elasticity of the Lagrangian multiplier with respect to per-capita income of country j. In this framework, ^{h}, ^{h} and ^{h} jointly de ne the sectoral income elasticity,[11] and the elasticity of demand with respect to country size ${}^h_1 \; {}^h$.

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 di erentiated sector h relative to the homogeneous sector: $(T_i^h = w_i)^{\;h}$, which controls for the supply side e ect 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 ($_j{}^{h}_{3}\,{}^{h} L_j{}^{h}_{1}\,{}^{h}$) a ect bilateral trade ows asymmetrically, the impacts of two elements of the importer's aggregate demand { per-capita income ($_j$) and country size (L_j) { are also di erentiated and vary by sectoral characteristics.

It is worth mentioning that in the model, since ${}^h_3 = \frac{^h}{} \;\; {}^h_1$ 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 con rmed 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 e ects of production and demand structure on bilateral trade ows.[12]

Di erentiating 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 e ects of T_i^h, y_j and L_j into their e ects on the volumes of exports by each exporter

[11] It is important to discuss the di erence 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 $_j^h$ to some exponent. From (1) the sectoral income elasticity will simply be: $\frac{d\ln X_j^h}{d\ln y_j} = \frac{^h}{} \;\; _j$, and ^{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 ^{h} alone no longer measures the level of income elasticity. In addition, in the EK model, elasticity of substitution ^{h} plays no signi cant role, as it does not enter the expression of bilateral trade. Fieler (2011) thus assumes $^h = \;^h$. 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, ^{h} a ects bilateral trade, so I need to treat ^{h} and ^{h} di erently.

[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 pro t fund: $y_i = w_i(1 + \;)$.

and allowing new entrants to export on the extensive margin; the elasticity of substitution magni es this e ect of productivity on the intensive margin and dampens the e ect on the extensive margin.[15]

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

$$ {}^{h}_{j} \quad \frac{d\ln X^{h}_{ij}}{d\ln y_j} = \underbrace{{}^{h}_{3} \quad {}^{h} \quad 1 \quad {}_{j}}_{\text{the intensive margin elasticity}} \quad \underbrace{{}^{h}_{3} \quad {}^{h} \quad 1 \quad {}^{h} \quad {}_{j}}_{\text{the extensive margin elasticity}} = {}^{h}_{3} \; {}^{h} \quad {}_{j} : \qquad (14) $$

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 (^{h}), within-sector elasticity of substitution (^{h}), as well as productivity dispersion (^{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 $_j$ depends on the sign of $_3$ since $_j$ is negative. Given any , $_3 = \frac{(\quad 1)}{[\ (\quad) \quad (\quad 1)(\quad 1)]}$ is a function of and . Figure 4 plots $_3$ against and for two di erent values of which are commonly used in related literature:[16] the left panel for = 4, and the right panel for = 8. Two main observations follow: (1) The surface of $_3$ consists of two separate parts, the rst part starts from a low and a high (e.g. when = 0 and = 2), and $_3$ increases as increases and decreases; the second part starts with a high and a low , and $_3$ decreases as decreases and increases; the non-monotonicity of $_3$ creates a gap between these two parts. (2) Compare the left panel

I will focus my analysis on normal goods hereafter assuming $< \frac{(\quad 1)}{(\quad 1)}$. 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 ($_3^h$(^{h} 1) $_j$ >

$$X^h_{jj} = {}^h_5 \frac{Y_j \; {}_j^{\,h}{}_3^{\,h} L_j {}^{h}_{1}{}^{h}}{Y} \left(\frac{T^h_j}{w_j} \right)^{h} {}^h_j \; {}^h_2{}^h \; f^h_{jj} \; \frac{h \; (\; h \; 1)}{h \; 1} : \quad (17)$$

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

$$\frac{dX^h_{jj}}{dE_j} = \underbrace{\left(\int_{'^h_{ij}}^{1} \frac{@x^h_{jj}(')w_j L_j)}{@E_j} dG^h(') \right)}_{\text{the intensive margin}} \underbrace{\left(w_j L_j x^h_{jj}(' ^h_{jj}) G^{h0}(' ^h_{jj}) \frac{@ ^h_{jj}}{@E_j} \right)}_{\text{the extensive margin}} ; \quad (18)$$

where $E_j \; 2 \; f \; y_j ; L_j \; g$.

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

$$ {}^{h0}_j \; \frac{d\ln X^h_{jj}}{d\ln y_j} = \underbrace{{}^h_3 \; {}^h \; 1 \; {}_j + 2 \; {}^h}_{\substack{\text{the intensive margin}\\ \text{elasticity}}} \; \underbrace{[{}^h_3 \; {}^h \; 1 \; {}^h \; {}_j + {}^h \; ({}^h \; 1)]}_{\substack{\text{the extensive margin}\\ \text{elasticity}}} \quad (19)$$

$$= {}^h_3 \; {}^h \; {}_j + 1 \; {}^h :$$

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 $^h > \; ^h \; 1$. This is because although higher income leads to higher revenue of sales to firms, it also increases the costs of production which forces the productivity threshold of entering domestic market to rise. This logic also applies to the

$$^{h0} \quad \frac{d\ln X_{jj}^{h}}{d\ln L_j} = \underbrace{{}_{1}^{h} \quad {}^{h} \quad 1 + 1}_{\text{the intensive margin elasticity}} \; \underbrace{\left[{}_{1}^{h} \quad {}^{h} \quad 1 \quad {}^{h} \right]}_{\text{the extensive margin elasticity}} = 1 \quad {}_{1}^{h}\,{}^{h} : \qquad (20)$$

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, $^{h0} > {}^{h}$: 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

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 di erent roles in shaping bilateral trade patterns. In particular, country size generates \the importer home-market e ect": 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 e ect 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 de ne 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:

$$EX_{ij}^h = \underbrace{\frac{Y_i}{Y_j} \quad \frac{i}{j}^{\,h_3 \; h} \quad \frac{L_i}{L_j}^{\,h_1 \; h}}_{\text{the demand system}} \underbrace{\left(\frac{Z_i^h}{Z_j^h}\right)^{h}}_{\text{comparative advantage}} \underbrace{\left(\frac{D_{ji}^h}{D_{ij}^h}\right)^{h}}_{\text{variable trade costs}} \underbrace{\left(\frac{f_{ji}^h}{f_{ij}^h}\right)^{\frac{h\;(h\;1)}{h\;1}}}_{\text{xed trade costs}}; \qquad (21)$$

where Z^h

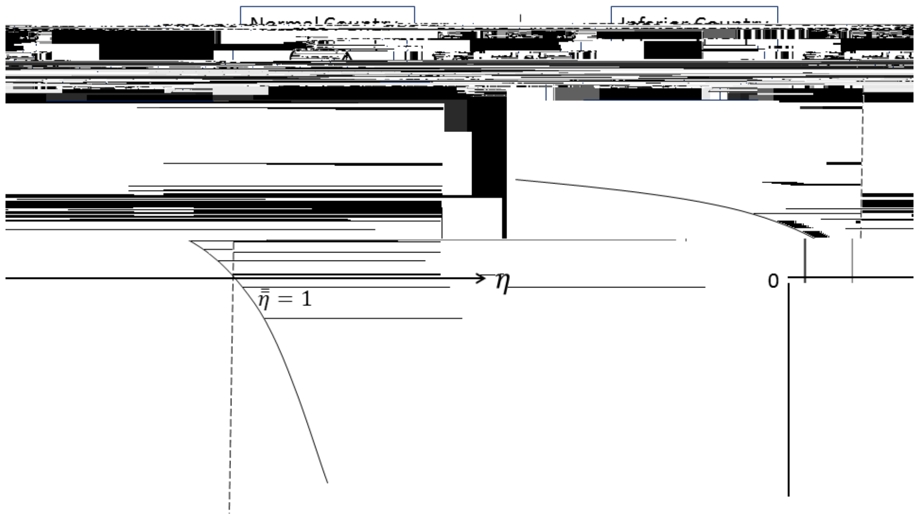
$$\frac{d\ln EX_{ij}^{h}}{d\ln(y_i = y_j)} = \frac{d\ln EX_{ij}^{h}}{d\ln y_i \quad d\ln y_j} = 1 = \left(\frac{d\ln y_i}{d\ln EX_{ij}^{h}} \quad \frac{d\ln y_j}{d\ln EX_{ij}^{h}} \right) :$$

It then follows that:

$$"_{ij}^{h} \quad \frac{d\ln EX_{ij}^{h}}{d\ln(y_i = y_j)} = \frac{A_{ij}^{h}}{[2 \quad 2^{h} \quad {}_3^{h}\ {}^{h}({}_i + {}_j)]} < 0: \tag{23}$$

where $A_{ij}^{h} = (1 \quad {}^{h} \quad {}_3^{h}\ {}^{h} \quad {}_i)(1 \quad {}^{h} \quad {}_3^{h}\ {}^{h} \quad {}_j) > 0$. This means that relative trade decreases with relative income of Home and increases with that of Foreign. In addition, relative trade is a ected also by income elasticity di erently 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 ${}_i = {}_j > 1$, and EX_{ij}^{h} is increasing in ${}_3^{h}$: 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, ${}_i = {}_j < 1$, and EX_{ij}^{h} is decreasing in ${}_3^{h}$: relative trade is higher in income inelastic sectors as Foreign consumes more in these sectors. Another

Figure 6: $^{h}_{ij}$ for any given ^{h} and ^{h}.



the relative country size dominates the demand side e ect: domestic production increases disproportionally to the increase of demand as relative size of Home increases. This in fact captures the home-market e ect on the exporter side (Home) following the Krugman's (1980) idea. However, while the supply side e ect is constant across sectors (with unitary elasticity), the demand side e ect is increasing in magnitude with ^{h}, and therefore with sectoral country size elasticity. Following the terminology used before, this e ect will be phrased as the \exporter home-market e ect", and furthermore, it is weaker in more elastic sectors with respect to country size, and it disappears after ^{h} passes the threshold ^{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 e ect"): Other things equal, relative exports increases with relative size of Home in \normal country size elasticity" sectors. And this \exporter home-market e ect" 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 ^{h} and country size elasticity, lower ^{h} decreases country size elasticity, implying that smaller sectoral elasticity of substitution magni es the home-market e ect. This is consistent with the ndings by Hanson and Xiang (2004), where they argue both theoretically and empirically that the home-market e ect is stronger in more di erentiated sectors.

A nal 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 e ects of relative demand and relative 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:

$$f_{ij}^h = \exp\left(F_j^h + {}_i^h\right); \quad {}_i^h \quad N(0; {}_h^2)$$

$$f_{jj}^h = \exp\left(F_j + {}^h\right); \quad {}^h \quad N(0; {}_j^2):$$

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 ${}_i^h$ which is normally distributed with mean zero and a sector-specific variance ${}_h^2$. Similarly, the fixed cost of country j firm entering sector h domestically is a country-specific mean F_j plus a sector-specific shock ^{h}, and it follows a normal distribution of mean 0 and a country-specific variance ${}_j^2$. 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

Consequently, I am able to get the estimates of ^{h}, ^{h}, and ^{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 ^h_j for each decade as they are expected to evolve over time by nature. The within sector productivity distribution parameter ^{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 rst estimate (28) using OLS with exporter and importer xed e ects.[31] Table 1 reports the estimates of ^{h} for each sector. All estimates are signi cant at 1% level. Several papers in the literature have attempted to estimate

Table 1a: Estimated sectoral productivity dispersion

ISIC code	Description	$\hat{}_h$	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 re neries	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 & scienti c equipment	2.218***	0.112
390	Other manufactured products	2.537***	0.132

Notes: OLS estimates of $_h$ 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 $\hat{}_h$

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

this sector, and therefore, sector \Wearing apparel, except footwear" is identi ed 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 $\hat{\lambda}_2$'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 the estimation process, the outcomes largely satisfy these constraints which does justi cation to the structural validity of the model. It is worth noting that ^{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 ^{h}

Table 3a: The calculated ^h and ^h

ISIC code	Description	^h	^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 re neries	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 & scienti c equipment	1.213	1.495
390	Other manufactured products	2.169	2.792

Notes: Sectoral values of ^h and ^h are calculated using estimates of $^h_1$, $^h_2$ and ^{h} according to the equations in (32).

Table 3b: Summary stats of ^h and ^h

	Observations	Min	Mean	Max	Std. dev.
^h	27	1.213	6.784	52.418	9.624
^h	27	1.495	6.289	36.635	6.603

Table 4a: Per-capita income elasticities

ISIC code	Description	^{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 re neries	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 & scienti c 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 (^{h}) are obtained by estimating equation (31) for each sector, with ln $_j$ being replaced by per-capita income of the importer { country j.

Table 4b: Market size elasticities

ISIC code	Description	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 re neries	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

385etallic0.904

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 re neries	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 & scienti c 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 coe cients 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 $_L$ captures the average \importer home-market e ect" when positive.

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)
$"^{h^0}_j$			-2.021**	-2.057***
			(0.795)	(0.748)
$\ln y_j \quad "^{h^0}_j$	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 "nddv-4389 errors-4389 red-4387(clst)eed ortser-seorhle

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)

Figure 1.

a single a^h for each sector. Doing so wi clusion of a set of home-foreign-decade xed e ects to capture the time pattern ^{h}, as well as both home xed e ects and foreign xed e ects from the (D^h_{ji} = owever, with such large dimension of xed e ects, the constrained estimation 21) will not have su cient degrees of freedom and consequently fails to delive s. Since my ultimate goal is to estimate the relative income and country size ela ative exports the following speci cation is used:

$$\ln EX^h_{ij} = "^h_{ij} \ln \frac{y_i}{y_j} + {}^h \ln \frac{L_i}{L_j} + {}^h \ln \frac{T^h_i}{T^h_j} \quad F^h \quad H^h + \frac{h \quad (\; h \quad 1)}{h \quad 1} \ln \frac{f^h_{ji}}{f^h_{ij}} ; \quad (37)$$

where F^h and H^h are Foreign (country j) and Home (country i) xed e ects.[36] Note that (37) is equivalent to the linear transformation of (21): the income and country size terms in (21) { $\frac{Y_i}{}$

be some sectoral a^h, I shall have:

$$
\begin{aligned}
"^h_{ij} &= \frac{d\ln EX^h_{ij}}{d\ln(y_i = y_j)} = \frac{A^h_{ij}}{[2a^h \quad 2 \; ^h \quad ^h_3 \; ^h(\; _i + \; _j)]}; \\
^h &= \frac{d\ln EX^h_{ij}}{d\ln(L_i = L_j)} = a^h + \; ^h_1 \; ^h:
\end{aligned}
\tag{38}
$$

In (23) and (24), since $a^h = 1$, $"^h_{ij}$ is always negative and ^{h} is always positive (for the \normal country size elasticity" sectors). However in (38), if a^h is su ciently large, $"^h_{ij}$ can be positive, and if a^h is su ciently small ^{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 signi cant at 1% level, and among the signi cant 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 signi cant estimates are positive, exhibiting the \exporter home-market e ect". Moreover, the presence of the home-market e ect suggests greater than unity a^h's for the sectors in my sample as shown in gure 7, and therefore, the sectors with positive ^{h}

Table 7: The exporter home-market e ect { sectoral e ect of relative demand

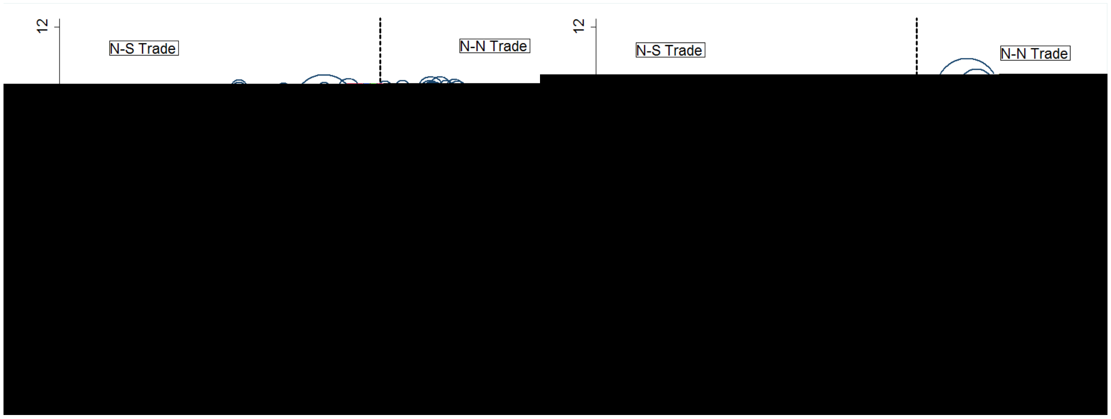
Table 8: The exporter home-market e ect { average e ects of relative demand

	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)				
$\ln(y_i = y_j)$ "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)
$\ln(L_i = L_j)$ h					-3.306**	-3.304**	-2.679	-2.849
					(1.304)	(1.285)	(2.126)	(2.137)

3.5 Trade volumes and trade patterns

The estimates of demand elasticities from previous section display considerable deviations

Figure 8: North-South trade.



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

Notes: Data source: Feenstra et al.(2005). This gure 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.

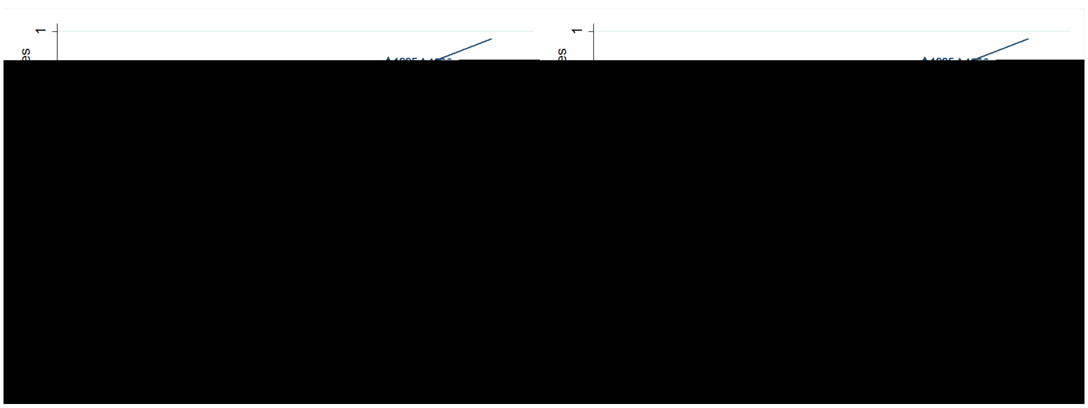
tors. Since rich countries consume and trade more in these sectors, overall trade should be more concentrated among North countries. In addition to previous work, the introduction of the new sectoral margin { country size elasticity, provides another channel to explain the discrepancy between the data and the predictions by homothetic trade models. Following the previous analysis, rst 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 e ect" which by its nature is against trade. On the exporter/supply side, the \exporter home-market e ect" 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 e ect 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 e ects 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 di erent demand structures. The solid lines in both panels of gure 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 xing country size elasticities to unity, the tted 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 con rms that income and country size non-homotheticity reinforces the e ect of each other in shaping bilateral trade patterns.

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



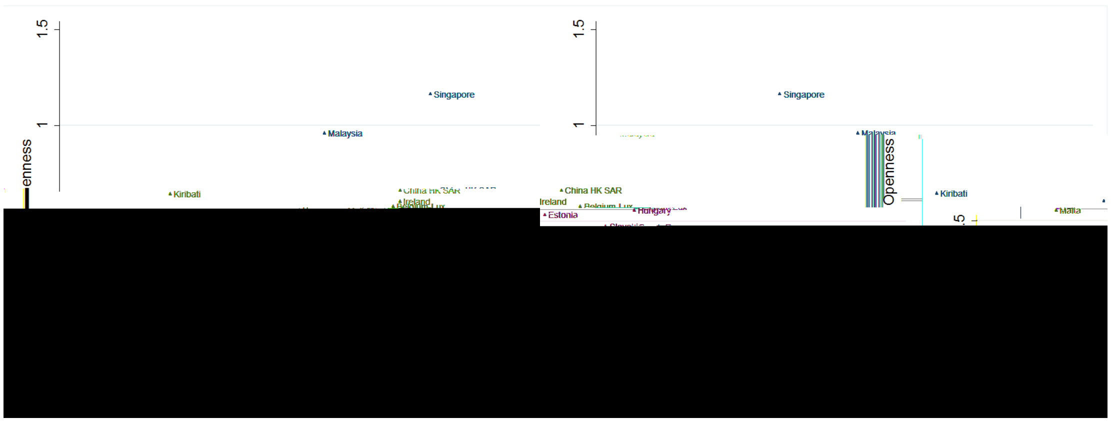
(L) (R)

Notes: Data source: Feenstra et al.(2005). This gure 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 e ect 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 a country's overall openness to trade as: (imports + exports)=(2 GDP), gure 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 ts 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 gures 11a and 11b.

Figure 10: Openness to trade.



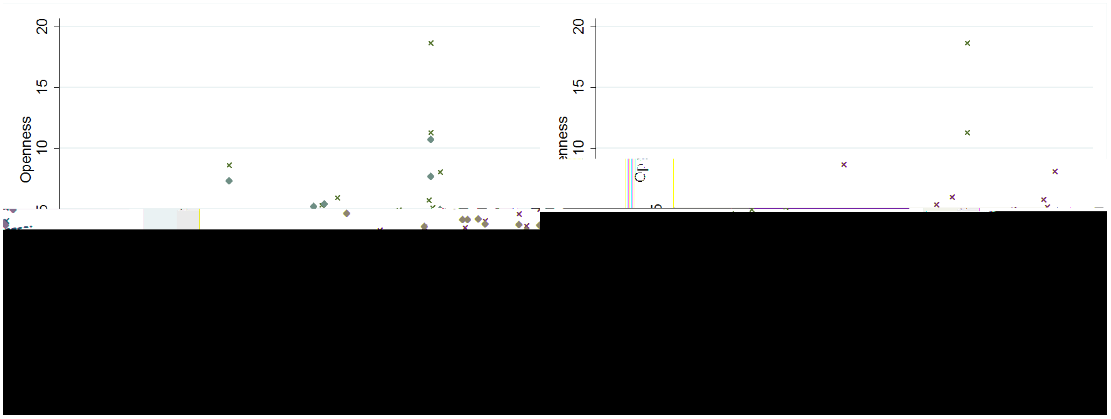
(L) (R)

Notes: Data source: Feenstra et al.(2005). This gure 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 gure 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 rst a much stronger relationship (the slope of the tted 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 di erences. According to the analysis leading up to proposition 2, the di erence 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 tted 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 tted line is 0.003), but also brings down the overly predicted trade openness to the actually observed level which reinforces the e ect of income non-homotheticity.

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

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



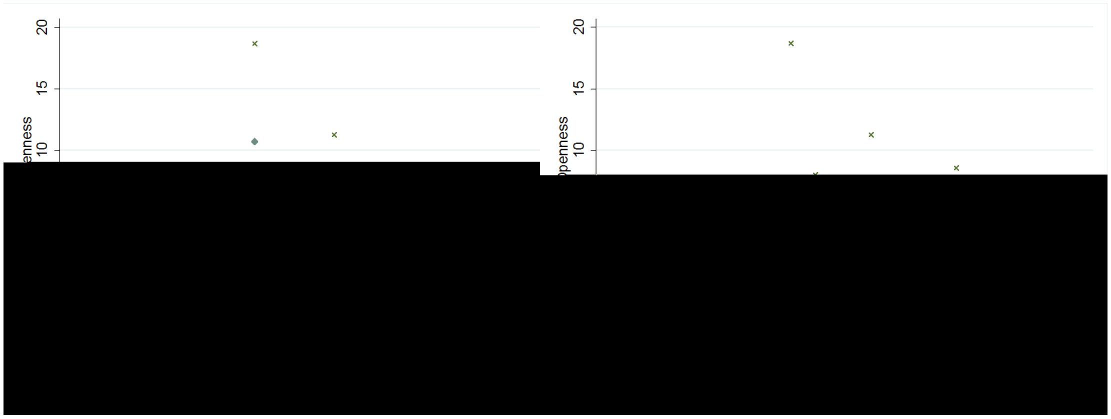
(L) (R)

Notes: Data source: Feenstra et al.(2005). This gure 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 tted 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 e ect is e ective 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 ows, sectoral production and trade barrier measures to test the home-market e ect studied by the theoretical model. The estimation procedure provides a uni ed 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 nd empirical evidence supporting the presence of both the \importer home-market e ect" and the \exporter home-market e ect" 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 con- rms the nding by previous studies in non-homothetic preferences. In addition, I show that the home-market e ect 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 di erent determinants of trade patterns, which leads

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



[redacted]

(L) (R)

Notes: Data source: Feenstra et al.(2005). This gure 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 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 e ects of production and demand on bilateral trade, I de ne a costless tradevariable as:

$$E_{ij}^h \quad \frac{X_{ij}^h}{\text{Constant} \quad C_{ij}^h} = P_i^h \quad D_j^h;$$

which is bilateral trade net the e ect 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 thecostless tradebetween time 0 and timet can be attributed to contributions by its production and demand components with the following decomposition method:

$$\begin{aligned} E_{ij}^h \quad E_{ij}^h(t) \quad E_{ij}^h(0) &= P_i^h(t) \quad D_j^h(t) \quad P_i^h(0) \quad D_j^h(0) \\ &= P_i^h(t)D_j^h(t) \quad P_i^h(0)D_j^h(t) \quad P_i^h(0)D_j^h(0) + P_i^h(0)D_j^h(t) \qquad (39) \\ &= \quad P_i^h D_j^h(t) + \quad D_j^h P_i^h(0): \end{aligned}$$

The rst 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, E_{ij}^h can also be expressed as:

$$E_{ij}^h = \quad P_i^h D_j^h(0) + \quad D_j^h P_i^h(t): \qquad (40)$$

Expressions (39) and (40) di er 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:

$$PC_i^h = \frac{P_i^h D_j^h(t) + \quad P_i^h D_j^h(0) \quad =2}{E_{ij}^h}; \qquad (41)$$

the contribution of demand pattern changes is:

$$DC_j^h = \frac{D_i^h P_j^h(t) + \quad D_i^h P_j^h(0) \quad =2}{E_{ij}^h}; \qquad (42)$$

[40] The \constant-market-share" analysis is a widely used method of decomposing a country's export growth into the e ects 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:

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

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 $E_{US;CN}$ 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

$E_{US;CN}$	PC_{US}	DC_{CN}
+	14.75%	85.25%

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

$E_{CN;US}$	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 e ect (IC_j^h) and the country size e ect (LC_j^h) are de ned as:

$$IC_j^h = \frac{ I_j^h L_j^h(t) + I_j^h L_j^h(0) =2}{D_j^h};$$
$$LC_j^h = \frac{ L_j^h I_j^h(t) + L_j^h I_j^h(0) =2}{D_j^h}: \qquad (44)$$

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

$$IC_j = \frac{\sum_j I_j^h L_j^h(t) + \sum_j I_j^h L_j^h(0) =2}{\sum_j D_j^h};$$
$$LC_j = \frac{\sum_j L_j^h I_j^h(t) + \sum_j L_j^h I_j^h(0) =2}{\sum_j D_j^h}: \qquad (45)$$

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 e ect 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 $RE^h_{ij} \quad E^h_{ij}=E^h_{ji}$, 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. ($T^h_{US}=T^h_{China}$) 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.

on the other hand will o set the e ect of relative per-capita income due to the \exporter home-market e ect".

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

RE	RPC	RDC
+	88.51%	11.49%

Then I continue to decompose the e ects 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 e ect 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 e ect" in relative trade patterns identi ed by the model. Although the home-market e ect in magnitude compared to the contribution of comparative advantage is much smaller, it does not mean that the demand e ect is less important than the e ect 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 e ect is almost 3 times stronger than the e ect 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 signi cance of both comparative advantage and the home-market e ect 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 non-homotheticity on the supply side. This approach should empirically t 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 ^{h} follow Pareto distribution, I can express the price index of equation (3) as in terms of the productivity threshold $'^{h}_{ij}$ as following:

$$
\begin{aligned}
P_j^{h\,1\quad h} &= \sum_{i=1}^{N} w_i L_i \int_{'^{h}_{ij}}^{1} \left(\frac{h}{h\quad 1} \frac{w_i d_{ij}^h}{T_i^h\,'} \right)^{1\quad h} h\,' \quad ^{h\quad 1} d' \\
&= \sum_{i=1}^{N} w_i L_i \left(\frac{h}{h\quad 1} \frac{w_i d_{ij}^h}{T_i^h} \right)^{1\quad h} h \int_{'^{h}_{ij}}^{1} '\quad ^{h\quad h\quad 2} d' \qquad \text{(A.1)} \\
&= \sum_{i=1}^{N} w_i L_i \left(\frac{h}{h\quad 1} \frac{w_i d_{ij}^h}{T_i^h} \right)^{1\quad h} \frac{h}{h\quad (\ h\quad 1)} \; '^{h}_{ij} \quad ^{h\quad 1\quad h} :
\end{aligned}
$$

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

$$
'^{h}_{ij} \quad ^{h\quad 1} = \left(\frac{h}{h\quad 1} \frac{w_i d_{ij}^h}{T_i^h} \right) \frac{h}{h\ 1} \; f_{ij}^h \; \frac{\overline{h}\, j}{L_j} \; P_j^{h\quad h} : \qquad \text{(A.2)}
$$

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

$$
(P_j^h)^{\frac{h(\ h\quad h)\quad (\ h\quad 1)(\ h\quad 1)}{h\quad 1}} = \frac{h}{h\quad (\ h\quad 1)} \left(\frac{h}{h\ 1} \right)^{\frac{(\ h\quad 1)\quad h}{h\quad 1}} \; j^{\frac{h[\ h\quad (\ h\quad 1)]}{(\ h\quad 1)}} \; L_j^{\frac{h\quad (\ h\quad 1)}{h\quad 1}}
$$

$$
\sum_{i=1}^{N} w_i L_i \; \frac{h}{h\quad 1} \; w_i d_{ij}^h
$$

$\frac{w_i d_{ij}^h}{T_i^h}$ ^{h} f_{ij}^{h} $\frac{h(h-1)}{h-1}$. Substituting $_2^h$ and $_j^h$ back to (A.4) delivers the expression of sectoral price index of (6).

Next, plug $P_j^h = {}_2^h {}^h_1 \; ({}_j \; \frac{h}{}L_j)^{\frac{h(h-1)}{(h-1)}} {}^h_1 \; {}_j^h {}^h_1$ into (A.2), I get:

$$'^h_{ij} = \frac{h}{h-1} \; \frac{h}{^h_1}^{\frac{1}{h-1}} \; {}^h_2{}^{\frac{h\;h}{(h-1)}}{}^h_1 \; {}_j \frac{h}{}L_j \; {}^h_1 \; \frac{w_i d_{ij}^h}{T_i^h} \; {}_j^h{}^{\frac{h\;h}{(h-1)}}{}^h_1 \; f_{ij}^{h\,\frac{1}{h-1}}: \quad (A.5)$$

De ne $^h_3$ $\frac{h}{h-1}$ $\frac{h}{^h_1}^{\frac{1}{h-1}}$ ${}^h_2{}^{h}_2$, $^h_2 = \frac{h\;h}{^h_1(h-1)} = \frac{h\;h}{h(h\;h)(h-1)(h-1)}$, $^h_3 = \frac{h}{}$ $^h_1 = \frac{h(h-1)}{[h(h\;h)(h-1)(h-1)]}$, 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 $= \frac{\sum_{h=1}^{H}\sum_{j=1}^{N}\sum_{i=1}^{N} w_i L_i \int_{'^h_{ij}}^{1} {}^h_{ij}\, dG^h(')}{\sum_{i=1}^{N} w_i L_i}$, and since $^h_{ij} = x^h_{ij} = {}^h \; f^h_{ij} = {}^h_1 \, {}^h_2{}^{(h\;h)}{}^h_1 \; {}_j \, {}^h_3{}^{(h-1)} L_j \, {}^h_1{}^{(1\;h)} \; {}^h_j{}^{(h\;h)}{}^h_1 \; (\frac{h}{h-1}\frac{w_i d^h_{ij}}{T_i^h\,'})^{1\;h} = {}^h \; f^h_{ij}$, I rst have:

$$\int_{'^h_{ij}}^{1} {}^h_{ij}\, dG^h(') = \underbrace{\frac{^h_1\,{}^h_2{}^{(h\;h)}{}^h_1}{h} \left(\frac{{}_j\,{}^h_3}{L_j\,{}^h_1} \right)^{1\,(h-1)} {}^h_j{}^{(h\;h)}{}^h_1 \left(\frac{h}{h-1}\frac{w_i d^h_{ij}}{T_i^h}\right)^{1\;h} \int_{'^h_{ij}}^{1} '^{\,h\;1} dG^h(')}_{A} \underbrace{\int_{'^h_{ij}}^{1} f^h_{ij}\, dG^h(')}_{B}:$$

I calculate part A and B separately. Plug in the solution of $'^h_{ij}$ to part A:

$$A = \frac{^h_1\,{}^h_2{}^{\frac{h\;h}{^h_1}}\,{}^h_3{}^{h\;1\;h}}{h} \; \frac{h}{h\,(h-1)} \; \frac{h}{h-1}{}^{1\;h} \left(\frac{{}_j\,{}^h_3}{L_j\,{}^h_1} \right)^{1\;h} \left(\frac{w_i d^h_{ij}}{T^h_i} \right)^{h} {}^h_j \; {}^h_2{}^h \; f^h_{ij}{}^{\frac{h\;1\;h}{h}}:$$

And for part B:

$$B = {}^h_3{}^h \left(\frac{{}_j\,{}^h_3}{L_j\,{}^h_1} \right)^{1\;h} \left(\frac{w_i d^h_{ij}}{T^h_i} \right)^{h} {}^h_j \; {}^h_2{}^h \; f^h_{ij}{}^{\frac{h\;1\;h}{h}}:$$

Then I have:

$$\int_{' \, {}^h_{ij}}^{1} {}^h_{ij} \, dG^h(' \,) = A \quad B = {}^h_4 \left(\frac{{}^h_3 \, j}{L_j \, {}^h_1} \right)^{1 \quad h} \left(\frac{w_i d^h_{ij}}{T^h_i} \right)^{h} {}^h_j \; {}^h_2 \; {}^h \; f^h_{ij} \frac{h \;\; 1 \;\; h}{h} ; \tag{A.6}$$

where ${}^h_4 \quad {}^h_1 \frac{h}{h \;\; 1} \quad {}^h_2 \; {}^h_2 \; {}^h \quad \frac{h}{h \;\; 1} \quad {}^h \quad h \; \frac{h}{h \;\; 1} \quad \frac{h}{h \;\; 1} \quad {}^h \; 1 \quad 1$. With $w_i L_i =$ $Y_i=(1 + \quad)$, it follows that:

$$\sum_{i=1}^{N} w_i L_i \int_{' \, {}^h_{ij}}^{1} {}^h_{ij} \, dG^h(' \,) = {}^h_4 \left(\frac{{}^h_3 \, j}{L_j \, {}^h_1} \right)^{1 \quad h} {}^h_j \; {}^h_2 \; {}^h \; \frac{Y}{1+} \sum_{i=1}^{N} \frac{Y_i}{Y} \left(\frac{w_i d^h_{ij}}{T^h_i} \right)^{h} f^h_{ij} \frac{h \;\; 1 \;\; h}{h}$$

$$= {}^h_4 \left(\frac{{}^h_3 \, j}{L_j \, {}^h_1} \right)^{1 \quad h} {}^h_j \; {}^h_2 \; {}^h \; \frac{Y}{1+} \quad {}^h_j$$

$$= {}^h_4 \left(\frac{{}^h_3 \, j}{L_j \, {}^h_1} \right)^{1 \quad h} {}^{h \, 1}_j \; {}^h_2 \; {}^h \; \frac{Y}{1+} : \tag{A.7}$$

Lastly, substitute (A.7) into the de nition of :

$$= \frac{\sum_{h=1}^{H} \sum_{j=1}^{N} \sum_{i=1}^{N} w_i L_i \int_{' \, {}^h_{ij}}^{1} {}^h_{ij} \, dG^h(' \,)}{\sum_{i=1}^{N} w_i L_i}$$

$$= \frac{\sum_{h=1}^{H} \sum_{j=1}^{N} {}^h_4 \left(\frac{{}^h_3 \, j}{L_j \, {}^h_1} \right)^{h} {}^{h \, 1}_j \; {}^h_2 \; {}^h \; \frac{Y}{1+}}{\sum_{i=1}^{N} w_i L_i}$$

$$= \frac{\sum_{h=1}^{H} {}^h_4 \sum_{j=1}^{N} \left(\frac{{}^h_3 \, j}{L_j \, {}^h_1} \right)^{h} {}^{h \, 1}_j \; {}^h_2 \; {}^h \; \frac{Y}{1+}}{\sum_{i=1}^{N} \frac{Y_i}{1+}} \tag{A.8}$$

$$= \frac{\sum_{h=1}^{H} {}^h_4 \sum_{j=1}^{N} \left(\frac{{}^h_3 \, j}{L_j \, {}^h_1} \right)^{h} {}^{h \, 1}_j \; {}^h_2 \; {}^h \; \frac{Y}{1+}}{\frac{Y}{1+}}$$

$$= \sum_{h=1}^{H} {}^h_4 \sum_{j=1}^{N} \left(\frac{{}^h_3 \, j}{L_j \, {}^h_1} \right)^{1 \quad h} {}^{h \, 1}_j \; {}^h_2 \; {}^h :$$

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 $x_{ij}^{h} = {}_{1}^{h}\ {}_{2}^{h(\ h\ \ h)\ \frac{h}{1}}\ {}_{j}^{\frac{h}{3}(\ h\ \ 1)} L_{j}^{\frac{h}{1}(1\ \ h)}\ {}_{j}^{h(\ h\ \ h)\ \frac{h}{1}} \left(\frac{h}{h\ \ 1} \frac{w_i d_{ij}^{h}}{T_i^{h} '} \right)^{1\ \ h}$,

then I have:

$$\int_{'_{ij}^{h}}^{1} x_{ij}^{h}(')\,dG^{h}(') = {}_{1}^{h}\ {}_{2}^{h(\ h\ \ h)\ \frac{h}{1}} \left(\frac{{}_{j}^{\frac{h}{3}}}{L_{j}^{\frac{h}{1}}} \right)^{\ h\ \ 1} {}_{j}^{h(\ h\ \ h)}(') =$$

variety $x_{ij}^h = {}^h_1 \; {}^h_2{}^{(\; h \quad h) \; h}_{\;\;\;\;\;\;\;\;\;\;\;\;\;\;1} \quad {}_j{}^{h}_3{}^{(\; h \quad 1)} L_j{}^{h}_1{}^{(1 \quad h)} \quad {}_j^h{}^{(\; h \quad h) \; h}_{\;\;\;\;\;\;\;\;\;\;\;\;\;\;1} \quad \left(\frac{h}{h \; 1}\frac{w_i d_{ij}^h}{T_i^h \, '}\right)^{1 \quad h}$, I have:

$$\frac{@x_{ij}^h(')}{@y_j} = {}^h_3 \quad h \quad 1 \quad \frac{x_{ij}^h}{j} \quad \frac{@ \, j}{@y_j}:$$

It then follows immediately that:

$$\begin{aligned} w_i L_i \int_{'^h_{ij}}^{1} \frac{@x_{ij}^h(')}{@y_j} dG^h(') &= {}^h_3 \quad h \quad 1 \quad \frac{1}{j} \quad \frac{@ \, j}{@y_j} \quad w_i L_i \int_{'^h_{ij}}^{1} x_{ij}^h \, dG^h(') \\ &= {}^h_3 \quad h \quad 1 \quad \frac{1}{j} \quad \frac{@ \, j}{@y_j} \quad X_{ij}^h : \end{aligned} \tag{A.11}$$

Thus the intensive margin income elasticity of bilateral trade equals:

$$\begin{aligned} w_i L_i \int_{'^h_{ij}}^{1} \frac{@x_{ij}^h(')}{@y_j} dG^h(') \quad \frac{y_j}{X_{ij}^h} &= {}^h_3 \quad h \quad 1 \quad \frac{1}{j} \quad \frac{@ \, j}{@y_j} \quad X_{ij}^h \quad \frac{y_j}{X_{ij}^h} \\ &= {}^h_3 \quad h \quad 1 \quad \frac{@ \, j}{@y_j} \quad \frac{y_j}{j} \\ &= {}^h_3 \quad h \quad 1 \quad {}_j : \end{aligned} \tag{A.12}$$

For the extensive margin $w_i L_i x_{ij}^h(' \; {}^h_{ij}) G^{h\,0}(' \; {}^h_{ij}) \frac{@ \; {}^h_{ij}}{@y_j}$, rst note that

$$\frac{@ \; {}^h_{ij}}{@y_j} = \quad {}^h_3 \quad \frac{'^h_{ij}}{j} \quad \frac{@ \, j}{@y_j}; \quad \text{and}$$

$$G^{h\,0}(' \; {}^h_{ij}) = \; h \quad '^h_{ij} \quad {}^{h \quad 1}:$$

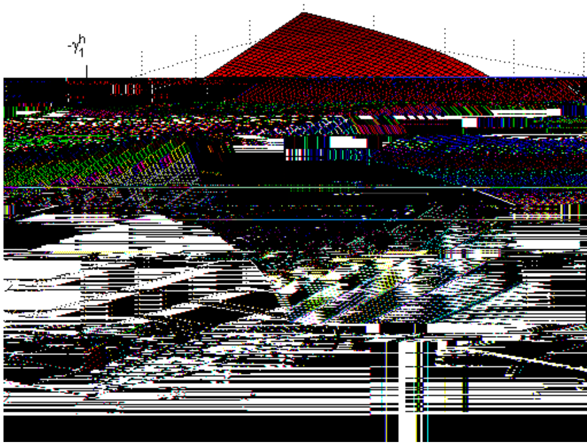
And then

$$\begin{aligned} w_i L_i x_{ij}^h(' \; {}^h_{ij}) G^{h\,0}(' \; {}^h_{ij}) \frac{@ \; {}^h_{ij}}{@y_j} &= w_i L_i \quad {}^h_1 \; {}^h_2{}^{(\; h \quad h) \; h}_{\;\;\;\;\;\;\;\;\;\;\;\;\;\;1} \quad {}_j{}^{h}_3{}^{(\; h \quad 1)} L_j{}^{h}_1{}^{(1 \quad h)} \quad {}_j^h{}^{(\; h \quad h) \; h}_{\;\;\;\;\;\;\;\;\;\;\;\;\;\;1} \\ & \quad \left(\frac{h}{h \quad 1}\frac{w_i d_{ij}^h}{T_i^h \, ' \; {}^h_{ij}}\right)^{1 \quad h} \quad h \quad '^h_{ij} \quad {}^{h \quad 1} \quad {}^h_3 \quad \frac{'^h_{ij}}{j} \quad \frac{@ \, j}{@y_j} \\ &= w_i L_i \quad {}^h_1 \; {}^h_2{}^{(\; h \quad h) \; h}_{\;\;\;\;\;\;\;\;\;\;\;\;\;\;1} \quad {}_j{}^{h}_3{}^{(\; h \quad 1)} L_j{}^{h}_1{}^{(1 \quad h)} \quad {}_j^h{}^{(\; h \quad h) \; h}_{\;\;\;\;\;\;\;\;\;\;\;\;\;\;1} \\ & \quad \left(\frac{h}{h \quad 1}\frac{w_i d_{ij}^h}{T_i^h}\right)^{1 \quad h} \quad h \quad '^h_{ij} \quad {}^{h \quad 1 \quad h} \quad {}^h_3 \quad \frac{1}{j} \quad \frac{@ \, j}{@y_j}: \end{aligned}$$

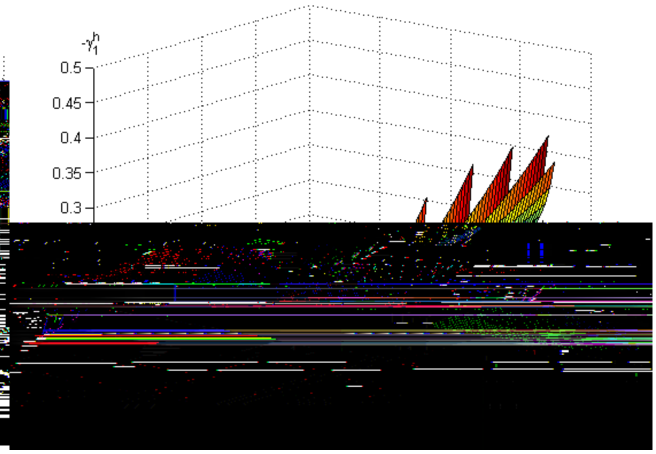
Recall that the bilateral trade $X_{ij}^h = w_i L_i \int_{'^h_{ij}}^{1} x_{ij}^h(') dG^h(')$, and it can be shown that X_{ij}^h then can be expressed as a function of the productivity threshold ${}^h_{ij}$ as:

$$X_{ij}^{h} = w_i L_i \quad {}^{h}_{1}$$

Figure A.1: The change of $^h_1$ with respect to ^{h} ($^h = 8$).



(L) $^h < 1$



(R) $^h > 1$

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

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

where NPW = non-production workers, PW = production workers, En = energy expenditures, Mat = non-energy materials, Cap = capital stock, and ${}^h_{npw} + {}^h_{pw} + {}^h_{en} + {}^h_{mat} + {}^h_{cap} = 1$
+

Table A1: Sectoral TFP of the U.S. [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	331.994131.994		

A8: Decomposing U.S. { China trade

This section reports the decomposition of U.S { China trade results by sector. I rst 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

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

ISIC code	Description	$E^h_{US;CN}$	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 re neries	+	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 $E^h_{US;CN}$ indicates the sign of changes in the costless trade as de ned in (39) and (40). PC^h_{US} is the contribution of changes in U.S. productivity to $E^h_{US;CN}$, and DC^h_{CN} is the contribution of changes in Chinese demand pattern to $E^h_{US;CN}$.

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

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 re neries	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%

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 re neries	45.9%		

Table A7: Decomposition of relative demand variation

ISIC code	Description	RDC^h	RIC^h	RAaC