Income, Trade Barriers, and International Trade*

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Abstract

This paper argues that when rich countries export, per capita income differences with the trading partner act as trade barriers. I develop and quantify a multi-country general equilibrium model with non-homothetic preferences and heterogenous firms with no fixed trade barriers. In my model, per capita income level is a key determinant of trade patterns. With non-homothetic preferences, countries, depending on their income, potentially demand different sets of varieties as well as different quantities for a given variety. As a result, rich countries have different demand patterns than poor countries, and trade between rich countries is more intense. I compare my model with a benchmark model with homothetic preferences and bilateral fixed trade barriers. For rich countries the estimated variable trade barriers for exporting to other rich countries are lower in the benchmark model than in my model. Conversely, for rich countries the estimated variable trade barriers for exporting to poor countries are higher in the benchmark model than in my model. A quantitative comparison between the two models shows that they predict similar trade patterns even with different estimated inputs for the variable trade barriers, implying that when rich countries export, income differences with the trading partner in my model play a similar role as additional trade barriers in the benchmark model.

The model with non-homothetic preferences generates unit price variation across different import markets conditional on same exporter and variety while the standard models do not.

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1 Introduction

Rich countries export more to other rich countries than they do to poor countries.[1] In 2006, 49 percent of total world exports were from rich countries to other rich countries. On the other hand, rich countries' total exports to poor countries were only 19 percent of total world exports. Given these observations, I ask and answer the following question: Do income differences with the trading partner act as trade barriers when rich countries are exporting? In other words, do income differences play a similar role as geographical distance or other trade barriers? This paper argues that income differences with the trading partner act as trade barriers when rich countries export.

I develop a multi-country general equilibrium model of trade with heterogenous firms, in terms of different efficiency levels. I use non-homothetic preferences, namely quadratic preferences, in contrast to the standard constant elasticity of substitution (C.E.S.) preferences often used in trade literature. Countries are assumed to have different human capital levels, which will generate differences in per capita income in equilibrium. Unlike the C.E.S. case, demand of a variety can drop to zero at a finite price depending on income levels of consumers. Countries, depending on their income, potentially demand different sets of varieties and different quantities of each variety. In equilibrium, rich countries have similar trade patterns among each other, and trade between rich countries is more intense. There are no assumed fixed production costs or bilateral fixed trade costs for countries. However, differences in income across countries endogenously generate bilateral trade patterns, since consumers may not demand some goods that they cannot afford. As Linder (1961) argues, the demand side is a key determinant of trade patterns.

In order to answer the main question of this paper, I compare my model with a benchmark model.[2] The benchmark model has homothetic preferences and bilateral fixed trade barriers for each pair of countries. However, bilateral fixed trade barriers for each pair of countries imply additional degrees of freedom for the benchmark model. In order to make the comparison between the two models, I make two assumptions: First, I assume that all fixed bilateral trade

[1] I use the World Bank definition for high-income countries. I refer to a country as rich if per capita income of that country is greater than or equal to $11,456 and refer to it as poor otherwise. The data is from the IMF. There are 183 countries in the sample. 48 (135) of these countries are rich (poor) according to the definition I use.

[2] The benchmark model, which is a version of Melitz (2003) and Chaney (2008), will be discussed in detail in appendix A2.

barriers are the same for each pair of countries. Second, I assume that importer per capita income is a function of variable trade barriers.[3] In other words, variable trade barriers being a function of per capita income corresponds to the additional dimension of the benchmark model compared to my model.

Estimation results imply that rich countries, on average, face lower trade barriers compared with poor countries when exporting to a rich country. Moreover, estimation results show that poor countries, on average, face higher trade barriers compared with rich countries when exporting to a poor country. Both models predict the above relations between trade barriers and income differences. However, in order to match the observed bilateral trade patterns, rich countries should face lower trade barriers when exporting to other rich countries and should also face higher trade barriers when exporting to poor countries in the benchmark model. Recovered trade barriers from these estimation results imply that rich countries export more to other rich countries than they do to poor countries in the benchmark model. The reason for this is rich countries face less friction when exporting to other rich countries and face more friction when exporting to poor countries in the benchmark model due to different estimated inputs for the variable trade barriers. After recovering trade barriers and human capital levels in both models, I find that the two models generate similar trade patterns: Rich countries export more to other rich countries than they do to poor countries, as we observe in data. The two models, in terms of measurement errors, are very close to each other, which will be discussed in detail in section 4. The non-homothetic model, without the additional dimension–per capita income–in the estimation, can get trade patterns that are similar to the benchmark model. This result leads me to conclude that when rich countries are exporting, income differences with the trading partner in the non-homothetic model endogenously play a similar role as the additional trade barriers in the benchmark model.

In my model, for a given variety, price elasticity of demand is affected by the maximum price level that a consumer can afford, which is influenced by income level. If the maximum price level that a consumer can afford goes up, then price elasticity of demand for that variety decreases. With standard C.E.S. utility, price elasticity of demand depends only on the elasticity

[3]In order to recover the variable trade barriers I assume a functional form for trade barriers following Eaton and Kortum (2002) and Waugh (2007). In addition to the assumed variables in my model (shared border, distance, exporter fixed effect), importer per capita income is also assumed to be a function of variable trade barriers in the benchmark model, which will be discussed in detail in section 3.3.

of substitution parameter, which is constant. In my model, firms have the option to choose different prices for a given variety, hence markups, for different consumers. This mechanism introduces unit price variation across different import markets conditional on exporter and product category.

Recent empirical studies have documented unit price variation across importers conditional on exporter and variety–e.g., Fieler (2008), Hummels and Skiba (2004). Hummels and Skiba (2004) report that unit price variation (free on board) is 0.64 conditional on exporter and product category.[4] Fieler (2008) finds that unit prices systematically increase with importer per capita in 85 percent of commodity categories. All these findings imply "unit price variation" across different import markets conditional on exporter and variety. Standard models of international trade with C.E.S. preferences, both with competitive markets and monopolistically competitive markets, do not predict unit price variation. A familiar result from the trade literature implies that free on board (f.o.b.) prices are invariant to destination either due to competitive markets or constant markup over marginal cost in the case of monopolistically competitive markets. I use the model to explore unit price variation across importing countries conditional on exporter and product category. The model predictions for unit price variation is in the range of $(0.14, 0.42)$, where the data observation reported by Hummels and Skiba (2004) is 0.64. Standard models predict no variation for unit prices across importers conditional on exporter and variety.

My model is related to Melitz (2003), Melitz and Ottaviano (2008), and Ottaviano, Tabuchi and Thisse (2002) with crucial differences.[5] For the demand side, I use quadratic preferences that are similar to the ones used in Ottaviano, Tabuchi and Thisse (2002) with two important differences.[6] First, since the objective of their paper is different than this paper, they allow an outside sector. The outside sector in their model totally eliminates the income effect. However, in this paper I analyze the effects of endogenous income differences across countries on bilateral trade patterns. Hence, I do not allow an outside sector, i.e. quasilinearity, in order to analyze income differences across countries. Second, since the focus of their paper is different, the pref-

[4]Free on board prices exclude the insurance and transportation cost.

[5]My model is also related to Chaney (2008), which is a version of Melitz (2003). Fieler (2008) analyzes bilateral trade patterns with a Ricardian model of international trade with non-homothetic preferences. In Fieler (2008), goods differ in two respects: the income elasticity of demand and the extent of heterogeneity in production technologies.

[6]Melitz and Ottaviano (2008) also uses the same preferences developed by Ottaviano, Tabuchi and Thisse (2002). See Arkolakis (2008) for a further discussion.

erences used in Ottaviano, Tabuchi and Thisse (2002) have an additional term that captures the competition effect. Since this paper is mainly interested in income differences across countries, I set that parameter to be zero. In this sense, I use preferences that are similar to the ones used by Neary (2003). However, Neary (2003) analyzes oligopolistic competition instead of monopolistically competitive markets.

The supply side of the economy is similar to the one introduced by Melitz (2003) with one difference. In my model, non-homothetic preferences endogenously generate zero demand for some varieties, even with a finite price, depending on income levels. Consumers cannot afford goods with prices above some certain level. Hence, if the price of a variety is higher than the maximum level that a consumer can afford, then demand goes to zero for that variety. Moreover, consumers with different income levels have different upper bounds for the maximum level that they can afford. As a consequence, I do not assume any fixed production costs or bilateral fixed trade barriers.

I quantify the model by choosing country-specific human capital levels and variable trade barriers. In order to estimate the variable trade barriers, I follow Eaton and Kortum (2002) and Waugh (2007). I estimate a structural relationship between observed bilateral trade shares and variable trade barriers representing a gravity equation that has been widely used in empirical trade literature. I assume a functional form for variable trade barriers in order to relate it to observable data. Furthermore, in order to recover the human capital levels, I use additional data: per capita income, population, and the estimation results. Calibration of the benchmark model is very similar to the calibration of my model, with one crucial difference. As discussed before, for the functional form of variable trade barriers, I also assume per capita income as an additional variable, which is assumed to capture the additional dimension for the benchmark model. In other words, in the benchmark model, per capita income is also a function of variable trade barriers in addition to the other variables.

The outline of the rest of the paper is follows: In section 2, I describe the model. Section 3 presents the quantification method. Section 4 discusses income differences and trade barriers. Section 5 discusses the unit price variation and variable markups. Section 6 discusses a potential extension and implication of the non-homothetic model. Section 7 concludes.

2 The Model

I assume that there exist $i, j = 1, 2, ..., N$ countries. i and j denote the source country and the destination country respectively.

2.1 Consumer

Country j has population of measure L_j. Within each country j, consumers are endowed with l_j units of human capital.[7] There is a continuum of differentiated products indexed by $z \in \Omega_j$, where Ω_j is the set of all potential products in country j. All consumers in all countries share the same utility:

$$\int_{z\in\Omega_j} c_j(z)dz - \frac{1}{2}\ \gamma \int_{z\in\Omega_j} (c_j(z))^2\, dz, \tag{1}$$

where γ is positive and $c_j(z)$ denotes the quantity consumed for good z in country j. Parameter γ indexes the degree of product differentiation between varieties. A larger γ implies that varieties are less substitutable with each other.[8] The consumer maximizes the utility function subject to the budget constraint

$$\int_{z\in\Omega_j} p_j(z)c_j(z)dz = w_j l_j, \tag{2}$$

where w_j is the wage in country j and $p_j(z)$ is the price of good z in country j.

The demand for each variety z in country j is

$$c_j(z) = \frac{1 - \lambda_j p_j(z)}{\gamma} \tag{3}$$

whenever $c_j(z) > 0$. λ_j is the Lagrangian multiplier of the budget constraint.[9] The non-negativity constraint for $c_j(z)$ implies that if the price of good z in country j is less than or

[7]This can be interpreted as effective labor being different across countries.

[8]In the limit case, $\gamma = 0$, products are perfect substitutes since consumers only value the consumption level over all products.

[9]$\lambda_j = \frac{1-\gamma\bar{c}_j}{\bar{p}_j}$. See appendix A1 for details.

equal to $\frac{1}{\lambda_j}$, then $c_j(z) > 0$. However, if $p_j(z) > \frac{1}{\lambda_j}$, then $c_j(z) = 0$. Hence, we can define,

$$p_j^{\max} := \frac{1}{\lambda_j}. \tag{4}$$

At $p_j^{\max}$, the demand of a variety is driven to zero, since $p_j^{\max}$ is the maximum level that a consumer can afford in country j. There is no demand for the goods that have higher prices than $p_j^{\max}$.[10] As the marginal utility of income, λ_j, decreases, the maximum price level that a consumer can pay in country j, $p_j^{\max}$, increases.

Market demand for variety z in country j is given by

$$c_j^m(z) = c_j(z)L_j \ \ \forall \ z \in \Omega_j^*, \tag{5}$$

where $c_j^m(z)$ denotes the market demand for variety z in country j, and Ω_j^* denotes the consumed subset of varieties, where $\Omega_j^* \in \Omega_j$.

Also note that for a given good z, price of elasticity of demand (p.e.d.) is given by $\varepsilon_z = [(\frac{p^{\max}}{p(z)} - 1)]^{-1}$, which depends on $p^{\max}$. As the maximum level a consumer can pay in country j increases, p.e.d. for good z decreases. In the case of C.E.S. preferences, p.e.d. is uniquely determined by the level of product differentiation γ.

2.2 Firm

Each good is produced by a single firm. In all countries, all the firms have the same technology, constant returns to scale production function at marginal cost a, where a is the unit labor requirement. Labor is the only factor used in production. Firms are ex-ante only different by their unit labor requirement, a. Firms have to pay a sunk entry cost, e, in order to draw a unit labor requirement realization. I assume that new entrants draw their unit labor requirements from a known distribution $G(a)$ with support on $(0, a_u]$. I also assume that the distribution $G(a)$ and the upper bound for this support, a_u, is the same for all firms and the same in all countries. Firms that can cover their marginal cost stay in the market and start to produce. Remaining firms exit immediately without operating. Surviving firms maximize their profits using the residual demand function. Firms take λ_j as given, which is a monopolistic competition

[10] Marginal utility is bounded for all goods with quadratic preferences, in contrast to the case of C.E.S.

outcome.

The variable trade cost is modeled in the standard "iceberg" formulation. If one unit of any differentiated good is shipped from country i to country j, only a fraction, $\frac{1}{\tau_{ij}}$, of the good arrives. $\tau_{ij} > 1$ for any $i \neq j$, and $\tau_{ii} = 1$.

The profit maximization problem of a firm with unit labor requirement a selling from country i to country j is given by

$$\pi_{ij}(a) = \max_{p_{ij}(a), c_{ij}(a)} p_{ij}(a)\ c_{ij}(a) L_j - \tau_{ij}\ w_i\ a\ c_{ij}(a) L_j \tag{6}$$

s.t.

$$c_{ij}(a) = \frac{1 - \lambda_j p_{ij}(a)}{\gamma}. \tag{7}$$

The F.O.C. of the firm problem implies that

$$c_{ij}^m(a) = \frac{L_j}{\gamma} \left(\lambda_j p_{ij}(a) - \lambda_j \tau_{ij} w_i a \right). \tag{8}$$

The profit maximizing price $p_{ij}(a)$ may be above the price bound $p_j^{\max}$, in which case the firm exits. Let the marginal firm (firm which earns zero profit) selling from country i to country j be a_{ij}^*.[11] The firm, a_{ij}^*, earns zero profit since marginal cost for this firm, $\tau_{ij} w_i a_{ij}^*$, is equal to its price, $p_{ij}(a_{ij}^*)$. The demand level, $c_{ij}(a_{ij}^*)$, is driven to zero for this marginal firm, a_{ij}^*. Setting $c_{ij}^m(a_{ij}^*) = 0$ in (8) we have

$$p_{ij}(a_{ij}^*) = \tau_{ij} w_i a_{ij}^*. \tag{9}$$

We also have that $p_{ij}(a_{ij}^*) = \tau_{ij} w_i a_{ij}^* = p_j^{\max}$, since the marginal firm sets the highest price. There is no demand for the goods which have higher prices than $p_j^{\max}$. Hence, all firms with a lower than or equal to a_{ij}^* (who are selling from country i to country j) remain in the industry, and other firms exit. Therefore, a_{ij}^* is a threshold level for a firm selling from country i to country j. We can express price and quantity in terms of the threshold, a_{ij}^*:

$$p_{ij}(a) = \frac{1}{2} \tau_{ij} w_i \left(a_{ij}^* + a \right), \tag{10}$$

[11] I assume parameters such that $a_u > a_{ij}^*\ \ \forall i, j$.

$$c_{ij}^{m}(a) = \frac{L_j}{2\gamma}\left(\lambda_j \tau_{ij} a_{ij}^{*} w_i - \lambda_j \tau_{ij} w_i a\right). \tag{11}$$

Moreover, since λ_j is defined as $\frac{1}{p_j^{\max}}$, we can write

$$\lambda_j = \frac{1}{\tau_{ij} w_i a_{ij}^{*}}. \tag{12}$$

In contrast to the standard C.E.S. case, f.o.b. prices for a firm selling from country i to j are destination specific. In the case of C.E.S., the f.o.b. price for a firm in country i that is selling to country j is determined by the marginal cost of that firm and constant markup. In contrast to the C.E.S. case, linear demand case gives variable markups. Firms with lower a have the advantage of both setting lower prices and setting higher markups relative to firms with higher costs. Let $m_{ij}(a)$ be markups for a firm with a selling from country i to j where markups are defined as $m_{ij}(a) = p_{ij}(a) - a$. Using equation (10), markups are given by

$$m_{ij}(a) = \frac{1}{2}\left(\tau_{ij} w_i a_{ij}^{*} - \tau_{ij} w_i a\right). \tag{13}$$

In this case, firms selling from country i have the option to set different prices, hence markups, for different destinations. Recall that, in contrast to the C.E.S. case, price elasticity of demand is not constant and varies with $p_j^{\max}$ for a given good.

Moreover, for a firm with given a, sales, $r_{ij}(a) = p_{ij}(a) c_{ij}(a)$, and profits, $\pi_{ij}(a) = r_{ij}(a) - c_{ij}(a)\tau_{ij} w_i a$ can be expressed in terms of thresholds:

$$r_{ij}(a) = \lambda_j \frac{L_j}{4\gamma}\left(\left(\tau_{ij} a_{ij}^{*} w_i\right)^2 - \left(\tau_{ij} a w_i\right)^2\right), \tag{14}$$

$$\pi_{ij}(a) = \lambda_j \frac{L_j}{4\gamma}\left(\tau_{ij}\right)^2 \left(\left(a_{ij}^{*} w_i\right) - \left(w_i a\right)\right)^2. \tag{15}$$

2.3 Market Clearing

The market clearing condition implies that total income of a country i is equal to the total spending of country i:

$$w_i l_i L_i = \sum_{j=1}^{N} T_{ji}. \tag{16}$$

The left hand side (L.H.S.) denotes the total income of country i. L.H.S. can be decomposed in two parts, as $w_i l_i$ is the per capita income and L_i is the measure of population. T_{ji} denotes the country i's spending over the goods from country j. Summing over all countries, including domestic markets, the right hand side denotes the total spending for country i.

Total export sales from country i to country j, T_{ij}, can be expressed as the multiplication of average sales per firms and the measure of the firms selling from country i to country j. Let M_i^E be the number of entrants in country i.[12] However, not all entrants produce in country i. Only a fraction of entrants in country i produce in order to sell in country j. The measure of operating firms from country i to country j is given by $M_{ij} = M_i^E \left(\frac{a_{ij}^*}{a_u}\right)^{\varphi}$. Then, total sales from country i to j are given by

$$T_{ij} = M_i^E \frac{(a_{ij}^*)^{\varphi}}{a_u} \frac{1}{(\varphi+2)(2\gamma)} \frac{L_j}{\lambda_j}. \tag{17}$$

Equations (12), (16), and (17) imply the following market clearing condition:

$$w_i l_i L_i = \sum_{j=1}^{N} M_i^E \left(\frac{a_{ij}^*}{a_u}\right)^{\varphi} \frac{L_j}{2\gamma} w_i \tau_{ij} a_{ij}^* \left(\frac{1}{(\varphi+2)}\right). \tag{18}$$

2.4 Free Entry

Firms pay a sunk cost, e, in order to draw their unit labor requirement, a. After firms pay the sunk entry cost, I assume that they draw their unit labor requirement from a Pareto distribution with support on $(0, a_u]$ which is given by

$$G(a) = \left(\frac{a}{a_u}\right)^{\varphi}, \tag{19}$$

[12] M_i^E can be determined by the free entry condition and labor market clearing condition which is going to be explained in section 2.5.

where $\varphi > 1$ is the shape parameter. Let $G^*(a)$ be the distribution of unit labor requirement conditional on entry. Then, the truncated unit labor requirement distribution will be given by $G^*(a) = \left(\frac{a}{a^*_{ij}}\right)^{\varphi}, a \in (0, a^*_{ij}]$.[13] Free entry implies that, in equilibrium, expected profits, conditional on entry, of a firm must be equal to entry costs, $w_i e$. If the expected profit is lower than the entry cost, then a firm chooses not to enter the industry. As a result, only firms that have higher expected profits (conditional on entry) than the entry cost enter the industry. After equating expected profits (conditional on entry) equal to entry cost,

$$\left(\frac{a^*_{ii}}{a_u}\right)^{\varphi} \sum_{j=1}^{N} \left(\frac{a^*_{ij}}{a^*_{ii}}\right)^{\varphi} \frac{L_j}{2\gamma} a^*_{ij} \tau_{ij} \left[\frac{1}{(\varphi+1)(\varphi+2)}\right] = e. \tag{20}$$

2.5 Number of Entrants

Using the market clearing and free entry condition, we can determine the number of entrants in country i, M_i^E. Replacing equation (20) inside the market clearing condition (18) yields the following:

$$M_i^E = \frac{l_i L_i}{(\varphi+1)e}. \tag{21}$$

Then, the number of operating firms selling from country i to j is

$$M_{ij} = \frac{l_i L_i}{(\varphi+1)e} \left(\frac{a^*_{ij}}{a_u}\right)^{\varphi}. \tag{22}$$

2.6 Market Shares

Let μ_{ij} be the market shares defined as the ratio of total export sales from country i to country j, T_{ij}, to the total spending of country j, $\sum_{v=1}^{N} T_{vj}$:

$$\mu_{ij} := \frac{T_{ij}}{\sum_{v=1}^{N} T_{vj}}. \tag{23}$$

Using the definition of μ_{ij} and equation (17) for total exports from country i to country j, we

[13] The truncated distribution will also be Pareto with shape φ.

can express market shares as

$$\mu_{ij} = \frac{M_i^E \left(a_{ij}^*\right)^{\varphi}}{\sum_{v=1}^{N} M_i^E \left(a_{vj}^*\right)^{\varphi}}. \tag{24}$$

Since $\lambda_j = \frac{1}{a_{ij}^* w_i \tau_{ij}}$, we have

$$\mu_{ij} = \frac{M_i^E \left(w_i \tau_{ij}\right)^{-\varphi}}{\sum_{v=1}^{N} M_v^E \left(w_v \tau_{vj}\right)^{-\varphi}}. \tag{25}$$

Moreover, substituting equation (21) into equation (25) yields the following relation for market shares:

$$\mu_{ij} = \frac{L_i l_i \left(w_i \tau_{ij}\right)^{-\varphi}}{\sum_{v=1}^{N} L_v l_v \left(w_v \tau_{vj}\right)^{-\varphi}}. \tag{26}$$

2.7 Equilibrium

In order to characterize the equilibrium, I impose balanced trade. In other words, country j's total exports must be equal to country j's total imports. Moreover, including each country j's consumption of goods produced at home implies the following condition:

$$\sum_{j=1}^{N} T_{ij} = \sum_{j=1}^{N} T_{ji}. \tag{27}$$

Using the market clearing condition, free entry condition, and balanced trade equation, the equilibrium threshold for the firms in country i selling to country j is characterized by the following equation:

$$a_{ij}^* = \left(\frac{l_j w_j a_u^{\varphi} e(\varphi+1)(\varphi+2)2\gamma}{w_i^{(\varphi+1)} \tau_{ij}^{(\varphi+1)} \sum_{v=1}^{N} \left(L_v l_v w_v^{-\varphi} \tau_{vj}^{-\varphi}\right)} \right)^{\frac{1}{(\varphi+1)}}, \tag{28}$$

where balanced trade imposes restrictions on relative wages:

$$w_i l_i L_i = \sum_{j=1}^{N} \mu_{ij} w_j l_j L_j, \tag{29}$$

where μ_{ij} is the fraction of spending by country j on goods from country i. The equilibrium number of operating firms selling from country i to country j is given by $M_{ij} = \frac{l_i L_i}{(\varphi+1)e} \left(\frac{a_{ij}^*}{a_u}\right)^{\varphi}$.

3 Quantification

In this section, I first describe the data. Then I explain the quantification methodology for the non-homothetic model and the benchmark model respectively.[14]

3.1 Data

I use a sample of 20 countries. I select countries according to the following criteria: I divide 183 countries into two groups, rich and poor, according to the World Bank definition for high-income countries. I refer to countries as rich if they are defined as high income countries according to the World Bank definition and refer them as poor otherwise. A country is a high-income country if per capita income is over $\$11,455$. After dividing the countries into two groups according to their per capita income, I choose ten countries with the highest GDP in each group.[15] In my sample, the rich countries are Australia, Canada, France, Germany, Japan, Italy, Korea, Spain, United States, and United Kingdom. The poor countries in my sample are Brazil, China, India, Indonesia, Iran, Mexico, Poland, Russia, South Africa, and Turkey. These 20 countries represent approximately 81 percent of world GDP. The model year is 2006. Bilateral trade flow data is taken from the IMF-DOTS CD-ROM.[16]

The empirical counterparts for T_{ij}'s and T_{jj}'s are as follows: T_{ij} is the total export sales from country i to country j. T_{jj} represents the gross domestic production for country j minus exports of country j plus imports of country j. Trade shares are defined as the ratio of the T_{ij} to T_{jj}.[17] For my sample, I only have one pair of bilateral trade with zero trade out of 380 observations. I drop this observation and set a sufficiently high trade barrier when computing the bilateral trade patterns.

Per capita GDP data and population data are from the IMF. The distance measures and border data are from the Centre D'Etudes Prospectives Et D'Informations Internationales (http://www.cpeii.fr). Distance measures are in miles and calculated following the great circle

[14] See appendix A2 for a more precise description of the benchmark model and its associated gravity equation.

[15] I repeat all the calibration exercises with different sets of countries. Results do not qualitatively change. Section 4 discusses the case in which I use a lower threshold when dividing countries into two groups according to their per capita income.

[16] DOTS refers to the IMF's "Direction of Trade Statistics."

[17] Note that market shares are defined as $\mu_{ij} := \frac{T_{ij}}{\sum_{v=1}^{N} T_{vj}}$. However, I define trade shares as $\frac{T_{ij}}{T_{jj}}$.

Table 1: Parameter values

	My model	Benchmark
parameter		
γ	5	-
a_u	2	2
f	-	1
σ	-	5
φ	6.67	6.67

formula.[18]

The parameter φ indexes the dispersion of unit labor requirements a and is treated as equal across countries, which is a standard approach in international trade. It is closely related to the parameter θ in Eaton and Kortum (2002). Eaton and Kortum (2002) find a range of $(3.60, 12.86)$ depending on their estimation method for parameter θ.[19] I selected a value of $\varphi = 6.67$, which lies in the middle of their different estimations.[20]

The parameter for the upper bound of the unit labor requirement, a_u, plays no quantitative role other than satisfying the necessary assumptions. For my model, I choose the demand parameter, γ, to be 5. For the benchmark model, I choose the constant elasticity of substitution, σ, to also be 5. Table 1 summarizes the selected parameters.

3.2 Quantification of the Non-homothetic Model

I calibrate the human capital parameters and trade barriers using bilateral trade, per capita income, and population data. First, I estimate the trade barriers by using the bilateral trade data. Second, I calibrate the human capital parameters by using the estimation results, per capita income, and population data. I follow the methodology used in Eaton and Kortum (2002) and Waugh (2007) in order to estimate the trade barriers. The model yields a gravity equation for aggregate bilateral trade flows. In order to derive the gravity equation, I use the equation for T_{ij}, total export sales from country i to j. Then, dividing both sides by country

[18] The great circle formula uses latitudes and longitudes of the capital cities of different countries.

[19] Another related work Del Gatta, Mion and Ottaviano (2006) find that average φ estimated to be close to 2 by using 11 EU countries and 18 manufacturing sectors.

[20] I also repeat the exercises for different values of φ in order to show the robustness of my results.

j's spending on home country goods, T_{jj},

$$\frac{T_{ij}}{T_{jj}} = \frac{L_i l_i w_i^{-\varphi} \tau_{ij}^{-\varphi}}{L_j l_j w_j^{-\varphi}}. \tag{30}$$

Similar to Eaton and Kortum (2002) and Waugh (2007), taking logs implies the following log-linear relationship:

$$\log\left(\frac{T_{ij}}{T_{jj}}\right) = V_i - V_j - \varphi \log \tau_{ij}, \tag{31}$$

where $V_j = \log(L_j) + \log(l_j) - \varphi \log(w_j)$. Following Waugh (2007), I assume the following functional form for variable trade barriers in order to relate them with the observable data:[21]

$$\log(\tau_{ij}) = b_{ij} + d_k + x_i + \delta_{ij}. \tag{32}$$

Here, b_{ij} is the border effect and equals 1 if country i and j share a border and 0 otherwise. $d_k (k = 1, ..., 6)$ is the effect of distance between country i and j lying in the kth intervals. The six distance intervals are in miles: $[0, 375]; [375, 750]; [750, 1500]; [1500, 3000]$; $[3000, 6000]$; $[6000, \text{maximum}]$. Following Waugh (2007) I use exporter fixed effects, x_i $(j = 1, ..., 20)$. x_i captures the additional cost country i faces to export a good to country j. I also assume that the error term δ_{ij} is orthogonal to the other regressors. Equations (31) and (32) provide the basis for the estimation of τ_{ij}'s and V_j's. I use ordinary least squares method for the estimation. In the appendix, table 4 shows the estimation results. Finally, I use the estimation results in order to recover the trade barriers.[22]

3.3 Quantification of the Benchmark Model

The benchmark model has homothetic preferences. On the other hand, in the benchmark model, countries face bilateral fixed trade barriers for each pair of countries in addition to variable trade barriers. Note that with non-homothetic preferences, there are no fixed production cost or bilateral fixed trade barriers. Since there is always positive demand for all produced goods in

[21] Eaton and Kortum (2002) uses importer fixed effect instead of exporter fixed effect. See Waugh (2007) for a detailed discussion.

[22] See appendix A3 for the calibration of human capital levels. In appendix, third column in table (6) presents the calibrated human capital levels.

the benchmark model, bilateral fixed trade barriers are necessary for the existence of some firms not exporting from country i to country j. As discussed earlier, bilateral fixed trade barriers give additional degrees of freedom to the benchmark model. In order to answer the main question of this paper, I make a comparison between the two models. To do so, I make two assumptions for the benchmark model: First, I assume that bilateral fixed trade barriers are the same for each pair of countries. Second, I assume that variable trade barriers are a function of per capita income. The second assumption captures the additional country specific characteristic for the trade barriers in the benchmark model.

Quantification of the benchmark is similar to the quantification of the non-homothetic model with one crucial difference: For the functional form of variable trade barriers, I assume importer per capita income, y_j, as an additional variable. Hence, y_j corresponds to the additional dimension for the benchmark model. For the benchmark model, the assumed functional form for the trade barriers takes the following form:

$$\log(\tau_{ij}) = b_{ij} + d_k + x_i + y_j + \delta_{ij}. \tag{33}$$

y_j captures the effect of importer's per capita income on trade barriers while country i exports to country j. In the appendix, table 5 presents the estimation results for the benchmark case. Using these estimation results, I recover the trade barriers for the benchmark model.[23]

Estimation results of these two models imply that in the benchmark model, countries systematically face lower trade barriers when exporting to rich countries compared to the estimation results of my model. Moreover, countries systematically face relatively higher trade barriers when exporting to poor countries compared to the estimation results of my model. For example, exporter i faces lower trade barriers when exporting to the United States (relatively rich country in the sample) with the recovered trade barriers calculated from (33) compared to those which are calculated from (32). Moreover, exporter i faces higher trade barriers when exporting to Poland (relatively poor country in the sample) with the recovered trade barriers calculated from (33) compared to those which are calculated from (32). Since the above findings are robust across countries in my sample, these results imply lower trade barriers when exporting to rich countries with the recovered trade barriers from the benchmark model compared to my model.

[23]See appendix A4 for the calibration of human capital levels for the benchmark model. In the appendix, the second column in table 6 presents the calibrated human capital levels for the benchmark model.

Moreover, these results imply higher trade barriers when exporting to poor countries with the recovered trade barriers from the benchmark compared to my model.

4 Do income differences act as trade barriers?

This section first presents the relation between income differences and trade barriers. Second, I compare the estimated trade barriers for the two models. Finally, I compare the two models in terms of bilateral trade patterns in order to answer the following question: Do income differences with the trading partner act as trade barriers when rich countries export?

Figure 1 depicts the estimated trade barriers the United States faces when exporting to other countries (in my sample) in the benchmark model. The x-axis shows the income differences between the United States and the trading partner, $y_{US} - y_{tradingpartner}$. Figure 1 implies that the United States, on average, faces lower trade barriers when exporting to other rich countries and faces, on average, higher trade barriers when exporting to poor countries. In other words, when the income difference between the United States and the trading partner goes up, the trade barriers which the United States faces go up. In order to match the observed bilateral trade pattern, trade barriers should be given as in figure 1–large differences between the trade barriers the United States faces when exporting to rich and poor. However, this paper claims that income differences can be some portion of this large difference between the trade barriers the United States faces when exporting to rich and poor.

Figure 2 depicts the relation between income differences with the trading partner and the estimated trade barriers when exporting to a rich country, the United States, in the benchmark model. In figure 2, the x-axis shows the per capita income difference between the United States and the exporting country i, $y_{\text{US}} - y_i$. Figure 2 implies that rich countries, on average, face lower trade barriers than what poor countries face when exporting to United States. This result is robust for all rich countries in the sample.

Figure 3 shows the relation between income differences and the estimated trade barriers when exporting to a poor country, India, in the benchmark model. In figure 3, the x-axis shows the per capita income difference between the exporting country i and India, $y_i - y_{India}$. Figure 3 implies that poor countries, on average, face higher trade barriers than what rich countries face when exporting to India. This result is robust for all poor countries in the sample.

Table 2: Differences in trade barriers: Rich countries exporting to Rich countries

Destination	Difference (in percentage)
Australia	-7
Canada	-9
France	-8
Germany	-8
Italy	-6
Japan	-6
Korea	-1
Spain	-4
United Kingdom	-9
United States	-10
Average	-7

Now, I compare the estimated trade barriers of the two models. In the benchmark model, rich countries face lower trade barriers when exporting to other rich countries compared to my model. Moreover, in the benchmark model, rich countries face higher trade barriers when exporting to poor countries compared to my model. As a consequence, recovered trade barriers from the estimation results imply that rich countries export more to other rich countries than they do to poor countries in the benchmark model. These results are the impact of the additional dimension of the benchmark model–per capita income–which is assumed to be a function of variable trade barriers. Table 2 shows the percentage difference between the estimated trade barriers in my model and the estimated trade barriers in the benchmark model when rich countries are exporting to other rich countries. For example, the first row shows that rich countries, on average, face 7 percent lower estimated trade barriers in the benchmark model when exporting to a rich country, Australia, compared to my model. Table 2 also shows that rich countries systematically face lower trade barriers in the benchmark model when exporting to other rich countries. In the benchmark model, rich countries, on average, face 7 percent lower estimated trade barriers when exporting to other rich countries.

Table 3 shows the percentage difference between estimated trade barriers from the two models when rich countries export to poor countries. For example, the first row shows that rich countries, on average, face 5 percent higher estimated trade barriers in the benchmark model when exporting to a poor country, Brazil, compared to my model. Table 3 also implies that

Table 3: Differences in trade barriers: Rich countries exporting to Poor countries

Destination	Difference (in percentage)
Brazil	5
China	7
India	11
Indonesia	7
Iran	8
Mexico	5
Poland	5
Russia	6
South Africa	5
Turkey	5
Average	6

rich countries systematically face higher trade barriers when exporting to poor countries in the benchmark model. In the benchmark model, rich countries, on average, face 6 percent higher estimated trade barriers when exporting to poor countries compared to the estimated trade barriers of my model.

Figure 4 depicts an example for the findings in Table 2 and Table 3 for the case of United States exports. Note that the y-axis shows the ad valorem trade barriers that the United States faces when exporting to country j and the x-axis shows country j's per capita income. On average, in order to match the observed bilateral trade patterns, relatively high trade barriers should be imposed in the benchmark model compared to the non-homothetic model when the United States exports to poor countries. However, on average, in order to match the observed data, relatively low trade barriers should be imposed in the benchmark model compared to the non-homothetic model when the United States exports to the rich countries. Hence, the slope of the trend for the non-homothetic model is smaller than the slope of the trend for the homothetic model. This paper claims that the difference in the slopes of these two trends can be endogenously explained by income differences across countries, which will be discussed later. Moreover, if I use a lower threshold when dividing countries into two groups according to their per capita income, the difference in the slopes of the two trends is even higher.

After recovering the trade barriers, I calibrate human capital levels for both models separately. With the recovered trade barriers and human capitals, I compare the results of the two models in terms of bilateral trade patterns. Figure 5 depicts the data and results of the two models. Both models generate similar bilateral trade patterns in terms of matching data. In the appendix, in figure 5 the distance between the points and the 45 degree line shows the measurement errors for both models.

In order to compare the two models in terms of matching trade shares, $\frac{T_{ij}}{T_{jj}}$, I calculate the measurement errors. First, I calculate the errors for each observation, s, in both models and then take the absolute values of these errors. e_s^{mymodel} and $e_s^{\text{benchmark}}$ denote the errors (after taking absolute values) for each observation, s, respectively for my model and the benchmark model, where e_s^{mymodel}=$|\text{data}_s - \text{prediction}_s|$ in my model and $e_s^{\text{benchmark}}$=$|\text{data}_s - \text{prediction}_s|$ in the benchmark model. Then, I calculate the difference between these two values, $e_s^{\text{mymodel}} - e_s^{\text{benchmark}}$, and divide this value by the corresponding data, data_s. I repeat this for every observation, s, and take the average. Hence, the measurement errors between two models can be calculated as follows:

$$\frac{\sum_{s=1}^{S}\left(\frac{e_s^{\text{mymodel}} - e_s^{\text{benchmark}}}{\text{data}_s}\right)}{S} = 0.012, \tag{34}$$

where S is the total number of observations. A value of 0.012 implies that, on average, the difference between the measurement errors of these two models is 1.2%. Hence, I conclude that non-homothetic preference generate similar trade patterns as the benchmark model: Rich countries export more to other rich countries then they do to poor countries. Due to the low income levels of poor countries, rich countries cannot export to poor consumers as much as they do to rich countries. In other words, poor countries' imports are restricted by their low income.

In order to answer the main question of the paper, I pursue the following steps: First, I show that in the benchmark model, rich countries face lower trade barriers when exporting to other rich countries and also face higher trade barriers when exporting to poor countries compared to my model. Second, I compare two models in terms of bilateral trade patterns. Even with the different inputs for variable trade barriers, the two model generate similar bilateral trade patterns as we observe in data: Rich countries export more to other rich countries than they do to poor countries. These arguments lead me to conclude that when rich countries export, income differences between the trading partner in the non-homothetic model endogenously play a similar role as additional trade barriers in the benchmark model.

5 Unit Price Variation

Recent empirical studies have documented unit price variation across importers conditional on an exporter and a variety–e.g., Fieler (2008), Hummels and Skiba (2004). For example, Hummels and Skiba (2004) look at all the export partner countries for six importers. They report that unit price variation (f.o.b.) is 0.64 conditional on an exporter and a category. Fieler (2008) analyzes years from 1984 through 2000 for approximately 150 countries and finds that unit prices systematically increase with importer per capita income in 85 percent of commodity categories. These findings imply unit price variation across different importers given the same exporter and same variety.

In a standard trade model with monopolistically competitive markets, the pricing rule is equal to marginal cost over constant markup. With standard C.E.S. preferences markups do not depend on cost or demand levels. Hence, conditional on exporter and variety, f.o.b prices are invariant to destination. In other words, for a given variety, an exporter charges the same price to all consumers in all countries. Due to the nature of competitive markets, f.o.b. prices are invariant to destination, similar to monopolistically competitive markets.

In the case of C.E.S., price elasticity of demand, ε, is uniquely determined by the level of product differentiation, which is constant. However, in my model, price elasticity of demand for a given good depends on the maximum level that a consumer can afford, which varies across countries. If the maximum price level that a consumer can afford goes up, then the price elasticity of demand for a given good decreases, as seen in the following equation: $\varepsilon_z = [(\frac{p_{\max}}{p(z)} - 1)]^{-1}$. Given this fact, a firm can set different prices, hence markups, for consumers in different countries.

I use the model to analyze unit price variation across different importers conditional on same exporter and same variety. I follow a similar method with Hummels and Skiba (2004). I define $p_{\bar{i}j}(\bar{a})$ as the mean of the prices which exporter $\bar{i}$ charges for a variety $\bar{a}$ across different importers, where $\bar{i}$ denotes the fixed exporter and $\bar{a}$ denotes the fixed variety. I also define $s_{\bar{i}j}(\bar{a})$ as the standard deviation for the different prices charged across different import markets by a fixed exporter $\bar{i}$ and for a fixed variety $\bar{a}$. For example, for a given exporter, $\bar{i}$ =United States, and for a fixed variety, $\bar{a} = 0.2$, my model predicts that $\frac{s_{\bar{i}j}(\bar{a})}{p_{\bar{i}j}(\bar{a})} = 0.24$. For different exporters and varieties I get similar results which are in the range of $(0.14, 0.42)$. The data observation reported by Hummels and Skiba (2004) is 0.64.[24] The main quantitative models predict zero for this statistic due to either competitive markets or constant markup–in the case of monopolistically competitive markets–whereas my model generates variable markups.

6 Discussion

One of the possible future extensions includes introducing fixed bilateral trade barriers into the framework with non-homothetic preferences. The extended model can potentially generate "zeros" in the bilateral trade matrix. Zeros in the bilateral trade matrix imply no trade between two countries. We observe many "zeros" in the bilateral trade matrix that are not easy to generate with standard models without additional assumptions.[25] However, since the marginal utilities are bounded for all varieties in my model, introducing bilateral fixed trade barriers into my framework can potentially generate no trade between some pairs of countries depending on the calibration of the bilateral fixed trade barriers. Hence, the non-homothetic model can do a better job in terms of matching bilateral trade patterns, including the zeros in the bilateral trade matrix.

Another potential implication from this paper is to analyze the impact of high growth in poor countries. This can be done by calibrating the model in two different points of time. In my model, as poor countries grow, the trade barriers they face fall. As a consequence, the increase in the growth of world trade in the non-homothetic model will be higher than the predicted counterpart in the benchmark model. Furthermore, this argument can play a role in explaining the growth of the trade to GDP ratio.

7 Conclusion

In this paper, I develop a multi-country general equilibrium model of trade with monopolistically competitive markets. First, I argued that the demand side, per capita income, is a key determinant of bilateral trade patterns. Similar income levels of rich countries imply similar

[24]This is the reported value for all exporters. See Hummels and Skiba (2004) for details.
[25]See Helpman, Melitz, and Rubenstein (2007) for a further discussion.

demand patterns among rich countries, and this makes trade more intense among them. Second, I argued that when rich countries are exporting income differences with the trading partner act as trade barriers. When the income differences between the rich exporter and the trading partner go up, then this will act as even higher trade barriers, which cause even lower exports to poor countries. Moreover, the model with non-homothetic preferences and variable markups yields unit price variation f.o.b. across different import markets conditional on same exporter and same variety.

The model presented in this paper is highly tractable, relatively simple in terms of taking the model to the data, and shows the importance of per capita income and trade barriers to understanding the bilateral trade patterns. Furthermore, understanding the role of income differences as trade barriers is also important to understanding the direction of trade.

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APPENDIX

A1.

In order to derive the marginal utility of income, λ_j, first let Ω_j be the set of all potential goods in country j and Ω_j^* be the set of consumed varieties in country j, where $\Omega_j^* \in \Omega_j$. Let M_j be the measure of this subset Ω_j^*. Also define average prices as:

$$\bar{p}_j := \left(\frac{1}{M_j}\right) \int_{z\in\Omega_j^*} p_j(z)dz, \tag{35}$$

and average consumption as:

$$\bar{c}_j := \left(\frac{1}{M_j}\right) \int_{z\in\Omega_j^*} c_j(z)dz. \tag{36}$$

Then, integrating equation (3), $c_j(z) = \frac{1-\lambda_j p_j(z)}{\gamma}$ over all $z \in \Omega_j^*$ and simple algebra yields:

$$\lambda_j = \frac{1-\gamma\bar{c}_j}{\bar{p}_j}. \tag{37}$$

A2.

The benchmark model is a version of Melitz (2003) and Chaney (2008). For the demand side, the difference is that the benchmark model has homothetic (Constant Elasticity of Substitution) preferences. With C.E.S. preferences, consumers have positive demand for all varieties produced in the economy. For the supply side, firms in country i have to pay bilateral fixed trade barriers f_{ij}'s in order to enter the market in country j in addition to variable trade barriers τ_{ij}. Hence, some firms from country i that cannot cover the fixed bilateral trade barriers cannot enter the market j. In contrast, with the non-homothetic preferences, demand for a good can go to zero at a finite price, so there is no need to assume bilateral fixed trade barriers. The demand side endogenously determines the firms that are entering from market i to market j.
Preferences in homothetic model are given by:

$$\int_{z\in\Omega_j} \left(c_j(z)^{\frac{(\sigma-1)}{\sigma}} dz\right)^{\frac{\sigma}{(\sigma-1)}}, \tag{38}$$

where the $\sigma > 1$ is the constant elasticity of substitution parameter.

For the supply side, the maximization problem for a firm selling from country i to country

j with unit labor requirement a is given by (note that firms take demand, $c_{ij}(a)$, as given):

$$\pi_{ij}(a) = \max_{p_{ij}(a)} p_{ij}(a)\ c_{ij}(a) L_j - \tau_{ij}\ w_i\ a\ c_{ij}(a) L_j - w_i f_{ij}, \tag{39}$$

where the last term shows the cost of fixed bilateral trade barriers for a firm selling from country i to country j.

A3.

In order to calibrate the human capital levels for my model, I pursue the following steps. Total income for country j is given by $Y_j = w_j l_j L_j$. First, taking logs implies the following:

$$\log(Y_j) = \log(w_j) + \log(l_j) + \log(L_j). \tag{40}$$

Then, substituting (40) into following equation:

$$V_j = \log(L_j) + \log(l_j) - \varphi \log(w_j), \tag{41}$$

and solving for l_j yields,

$$\log(l_j) = \frac{V_j + \varphi \log(Y_j)}{(1+\varphi)} - \log(L_j). \tag{42}$$

Since V_j's are known from the estimation and Y_j's and L_j's are observable, we can recover human capital levels l_j's. In table 6, the third column presents the calibrated human capital levels.

A4.

Trade shares, $\frac{T_{ij}}{T_{jj}}$, for the benchmark model can be expressed as:

$$\frac{T_{ij}}{T_{jj}} = \frac{L_i l_i w_i^{-\varphi} \tau_{ij}^{-\varphi} f_{ij}^{\frac{\sigma-1-\varphi}{\sigma-1}}}{L_j l_j w_j^{-\varphi} f_{jj}^{\frac{\sigma-1-\varphi}{\sigma-1}}}, \tag{43}$$

where $\varphi > \sigma - 1$. In order to compare the model, I assume f_{ij}=f $\forall$ i, j. However, the additional dimension of the benchmark model is captured by variable trade barriers, τ_{ij}. Importer per capita income y_j is assumed to be an additional variable in the functional form for variable trade barriers besides shared border, distance, and fixed exporter effect:

$$\log(\tau_{ij}) = b_{ij} + d_k + x_i + y_j + \delta_{ij}. \tag{44}$$

In order to recover human capital parameters, $\hat{l}_j$, in the benchmark model, I pursue the similar steps given for my model. The only difference shows up for $\hat{V}_j$, since the estimation results differ. Hence, we can calculate $\hat{l}_j$ using the following equation:

$$\log(\hat{l}_j) = \frac{\hat{V}_j + \varphi \log(Y_j)}{(1+\varphi)} - \log(L_j). \tag{45}$$

Since we know $\hat{V}_j$'s from the estimation results and Y_j's and L_j's are observable, we can recover $\hat{l}_j$s. In table 6, the second column presents the calibrated human capital levels for the benchmark model.

Table 4: Recovering Trade Barriers

Variable		est.	s.e.
Distance [0,375)	$-\varphi\ d_1$	-4.01	(0.28)
Distance [375,750)	$-\varphi\ d_2$	-4.13	(0.29)
Distance [750,1500)	$-\varphi\ d_3$	-4.69	(0.20)
Distance [1500,3000)	$-\varphi\ d_4$	-4.87	(0.21)
Distance [3000,6000)	$-\varphi\ d_5$	-6.01	(0.08)
Distance [6000,maximum]	$-\varphi\ d_6$	-6.60	(0.12)
Shared Border	$-\varphi\ b$	1.30	(0.34)
Australia	$-\varphi\ x_1$	0.15	(0.26)
Brazil	$-\varphi\ x_2$	0.34	(0.18)
Canada	$-\varphi\ x_3$	-0.01	(0.12)
China	$-\varphi\ x_4$	1.86	(0.18)
France	$-\varphi\ x_5$	0.52	(0.13)
Germany	$-\varphi\ x_6$	1.58	(0.17)
India	$-\varphi\ x_7$	-0.19	(0.18)
Indonesia	$-\varphi\ x_8$	0.02	(0.13)
Iran	$-\varphi\ x_9$	-2.28	(0.50)
Italy	$-\varphi\ x_{10}$	0.53	(0.14)
Japan	$-\varphi\ x_{11}$	1.55	(0.18)
Korea	$-\varphi\ x_{12}$	0.88	(0.18)
Mexico	$-\varphi\ x_{13}$	-2.09	(0.94)
Poland	$-\varphi\ x_{14}$	-1.84	(0.20)
Russia	$-\varphi\ x_{15}$	-0.70	(0.18)
South Africa	$-\varphi\ x_{16}$	-0.81	(0.16)
Spain	$-\varphi\ x_{17}$	-0.37	(0.15)
Turkey	$-\varphi\ x_{18}$	-1.59	(0.24)
United Kingdom	$-\varphi\ x_{19}$	0.52	(0.17)
United States	$-\varphi\ x_{20}$	1.93	(0.22)

Table 5: Recovering Trade Barriers (Benchmark Model)

Variable		est.	s.e.
Distance [0,375)	$-\varphi\ d_1$	-4.31	(0.33)
Distance [375,750)	$-\varphi\ d_2$	-4.41	(0.34)
Distance [750,1500)	$-\varphi\ d_3$	-5.02	(0.26)
Distance [1500,3000)	$-\varphi\ d_4$	-5.19	(0.27)
Distance [3000,6000)	$-\varphi\ d_5$	-6.33	(0.22)
Distance [6000,maximum]	$-\varphi\ d_6$	-6.90	(0.19)
Shared Border	$-\varphi\ b$	1.30	(0.34)
Importer per capita income	$-\varphi\ y$	0.02	(0.01)
Australia	$-\varphi\ x_1$	0.15	(0.26)
Brazil	$-\varphi\ x_2$	0.34	(0.18)
Canada	$-\varphi\ x_3$	-0.01	(0.12)
China	$-\varphi\ x_4$	1.86	(0.18)
France	$-\varphi\ x_5$	0.52	(0.13)
Germany	$-\varphi\ x_6$	1.58	(0.17)
India	$-\varphi\ x_7$	-0.19	(0.18)
Indonesia	$-\varphi\ x_8$	0.02	(0.13)
Iran	$-\varphi\ x_9$	-2.28	(0.50)
Italy	$-\varphi\ x_{10}$	0.53	(0.14)
Japan	$-\varphi\ x_{11}$	1.55	(0.18)
Korea	$-\varphi\ x_{12}$	0.88	(0.18)
Mexico	$-\varphi\ x_{13}$	-2.09	(0.94)
Poland	$-\varphi\ x_{14}$	-1.84	(0.20)
Russia	$-\varphi\ x_{15}$	-0.70	(0.18)
South Africa	$-\varphi\ x_{16}$	-0.81	(0.16)
Spain	$-\varphi\ x_{17}$	-0.37	(0.15)
Turkey	$-\varphi\ x_{18}$	-1.59	(0.24)
United Kingdom	$-\varphi\ x_{19}$	0.52	(0.17)
United States	$-\varphi\ x_{20}$	1.93	(0.22)

Table 6: Calibrated Human Capital Levels

	Benchmark	My model
Countries	$\log(l_j)$	$\log(l_j)$
Australia	8.78	8.74
Brazil	6.80	6.82
Canada	8.75	8.71
China	5.76	5.79
France	8.56	8.52
Germany	8.57	8.53
India	4.87	4.91
Indonesia	5.77	5.81
Iran	6.45	6.48
Italy	8.47	8.45
Japan	8.42	8.39
Korea	8.14	8.14
Mexico	7.23	7.25
Poland	7.42	7.38
Russia	6.96	7.05
South Africa	6.98	7.01
Spain	8.41	8.40
Turkey	7.22	7.24
United Kingdom	8.67	8.63
United States	8.52	8.47

Figure 1. Trade Barriers Imposed on US Exports

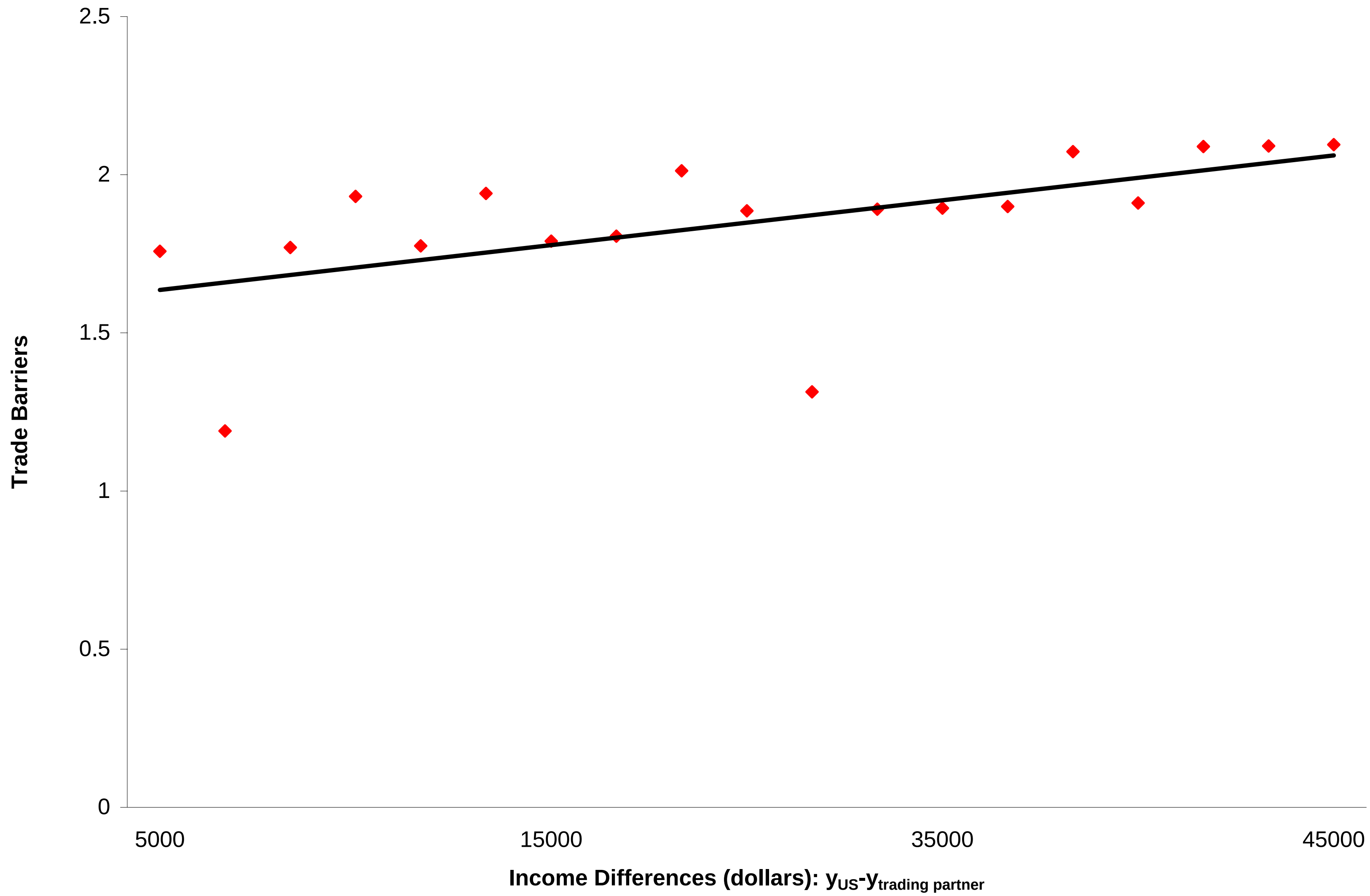

Figure 2. Trade Barriers: Exporting to U.S.

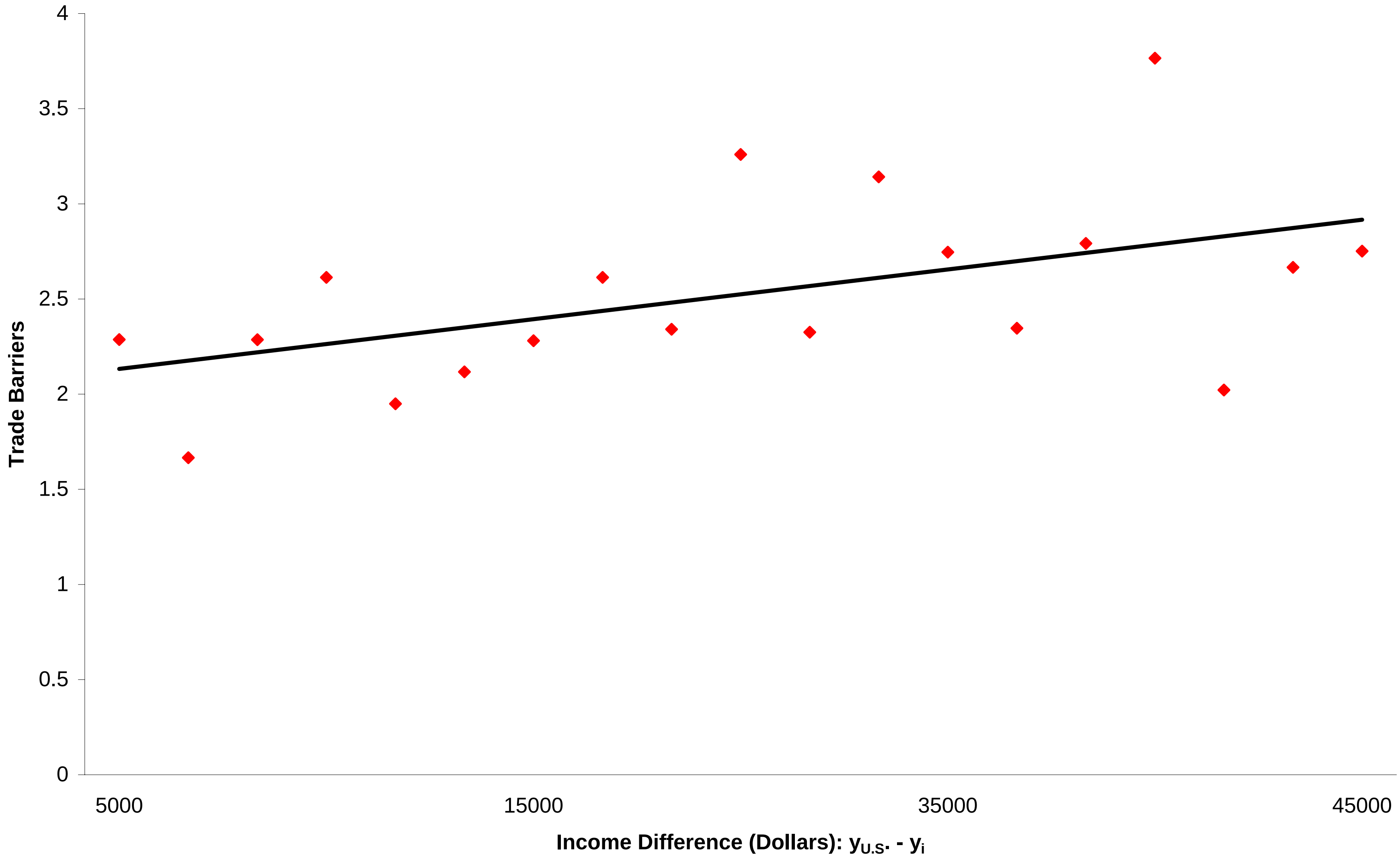

Figure 3. Trade Barriers: Exporting to India

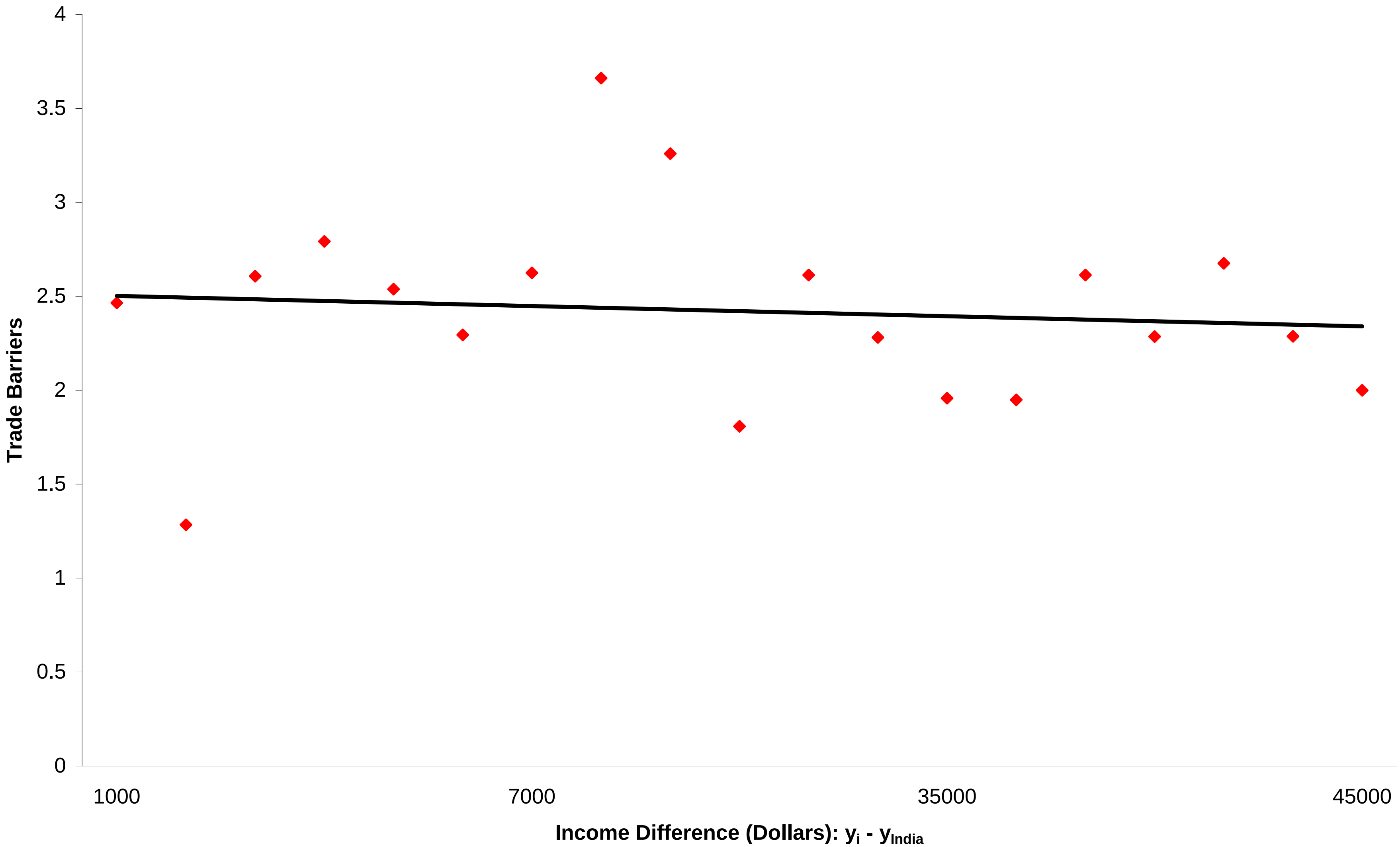

Figure 4. Different trade barriers should imposed in two models (when US exports)

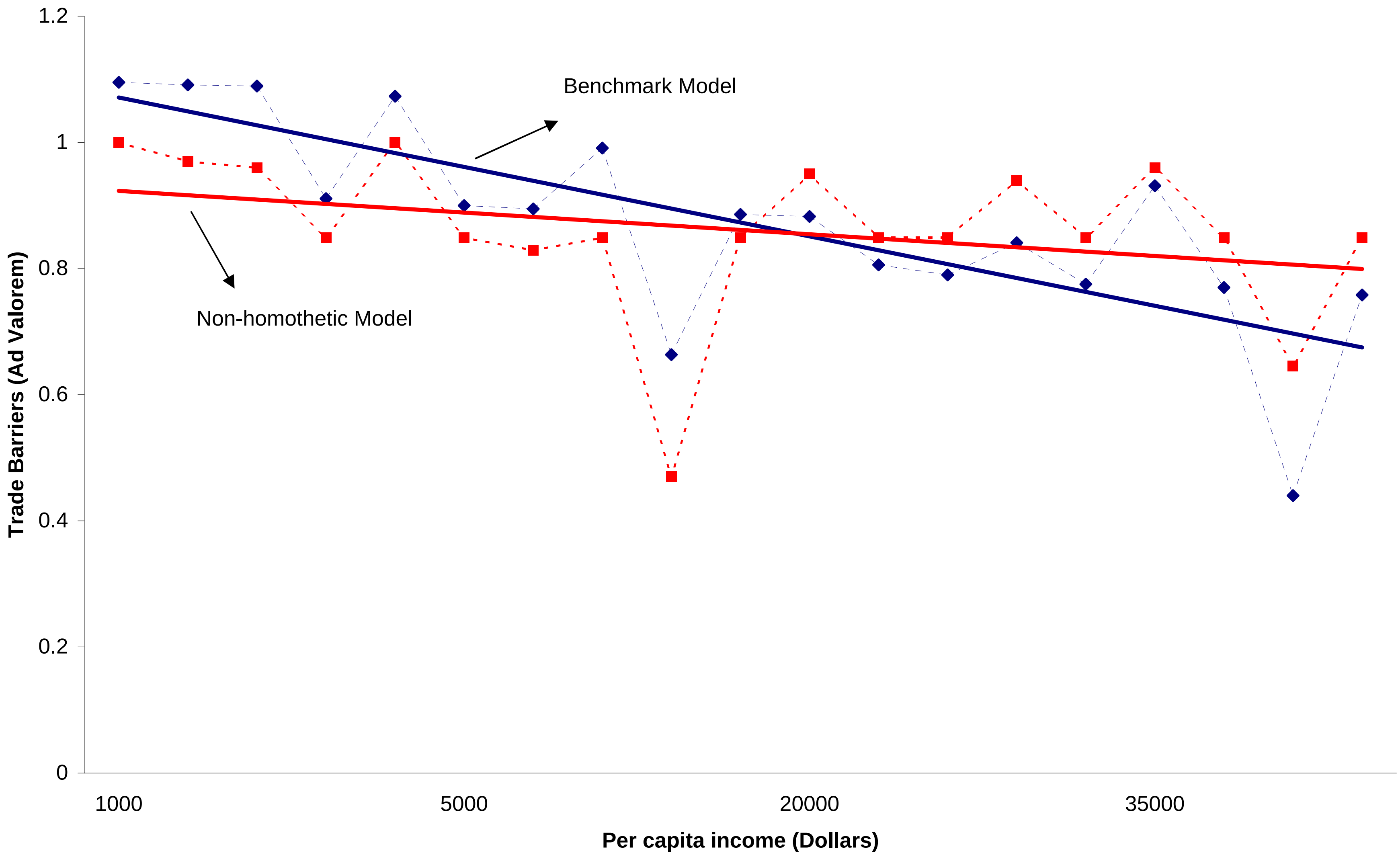

Figure 5. Trade Shares