Per-Capita Incomes and the Extensive Margin of Bilateral Trade

- DRAFT: COMMENTS VERY WELCOME -

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June 10, 2010

Abstract

Abstract Richer countries simultaneously export and import more varieties. Whereas a standard Ricardian mechanism indeed predicts that richer countries export more varieties, it immediately implies that these countries import less varieties. Remaining in the Ricardian framework I bring forward a demand side explanation, namely that agents adjust their extensive margin of consumption with rising incomes. Incorporating non-homothetic preferences into the Eaton and Kortum (2002)-model formalizes this intuition. I calibrate the new model using aggregate trade volumes and US consumption data and find that the behavior of its extensive margin of bilateral trade is indeed consistent with what we observe in the data. The paper concludes with two counterfactual experiments that highlight the quantitative importance of demand side effects in determining the extensive margin of trade.

1 Introduction

Richer countries export and import broader sets of goods. Figure 1 for example plots the importer per-capita income against the average number of imported varieties and Figure 2 does the same for exporters - in both Figures a clear positive relation is apparent. Indeed, considering the number of different varieties that are traded between two countries - the extensive margin of the bilateral trade flow - and regressing it on the trading partners’ per-capita incomes (controlling for population sizes and the usual gravity

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I thank Ana Cecília Fieler, Gino Gancia, Pedro Mira, Kevin Staub, Marc Melitz, Pol Antràs, and seminar participants at the University of Zurich and Harvard University for very helpful comments. I gratefully acknowledge financial support by the Verein zur Förderung des Akademischen Nachwuchses (FAN) and the Ecoscientia Foundation.
variables) yields an importer income elasticity of 0.53 and 0.86 for the exporter’s per-capita income (see Table 1). These positive elasticities are robust findings that are preserved on different levels of aggregation, in different data sets, and in the cross-section using between-country variation as well as in the time-series using within-country variation\(^1\).

The present paper seeks to explain these findings in the Ricardian framework due to Eaton and Kortum (2002) (henceforward EK). In this framework the probability that some exporting country is the supplier of a particular variety in a given importing market is an endogenous model outcome and a natural measure for the extensive margin of bilateral trade.\(^2\) A technologically advanced country gets on average good productivity draws and is therefore an active supplier for a relatively broad set of varieties. At the same time good productivity draws imply a high factor productivity and thus high per-capita incomes. Consequently, the EK model generates indeed the positive correlation between exporter income and the extensive margin as observed in the data. For the importer income, on the other hand, the model predicts a negative relation, which is due to the fact that technologically advanced countries will find it optimal to produce many varieties locally as they get good productivity draws for these varieties and the local producers do not have to bear transportation costs.

We argue that this counterfactual prediction of the EK model comes from the way the consumer is modeled and show that with a more realistic consumer behavior the correlation between importer income and the extensive margin is indeed positive. In particular we introduce non-homothetic preferences such that richer agents not only consume higher quantities, but also a broader set of varieties. In choosing their optimal consumption bundle agents order the varieties along their prices and decide up to which price it is optimal to consume positive quantities. In such a setup a technologically more advanced country is still more likely to produce a given variety locally; however this negative effect can be dominated by the expanding set of varieties that are consumed in this country such that the number of varieties that are imported is rising with the importing country’s per-capita income.

To see whether the proposed channels are quantitatively relevant we calibrate our model using aggregate trade volumes to pin down technologies and trade costs and the US consumer expenditure survey to fix the preference parameters. Confronting the calibrated model’s extensive margins of bilateral trade with the - untargeted - data we find that our model preforms quite well. This can for example be illustrated by comparing the elasticities cited above to the ones generated by the theoretical models - the standard model and the model with non-homothetic consumer behavior. For the exporter income both models generate similar elasticities of 0.6 (data: 0.86), whereas their predictions with respect to importer income starkly contrast. The standard model’s elasticity is strongly negative with −0.4, whereas our new model’s elasticity is 0.48 (data: 0.53).

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\(^1\)The corresponding evidence is presented in the Appendix.

\(^2\)This has been noted by Debaere and Mostashari (2005) and Dekle, Eaton, and Kortum (2008).
In order to demonstrate the quantitative importance of income effects when investigating the extensive margin of trade we use the calibrated model to perform two counterfactual experiments. First, we consider the effects of continued rises in China’s and India’s per-capita incomes on the global trade structure. We find that these countries’ extensive margins of exports and imports will significantly rise. The standard model model neglecting importer income effects would actually predict that China’s and India’s imports would fall. Second, we assess the effects of global reductions in trade costs. Such reductions make trade in more varieties worthwhile implying on average higher extensive margins of bilateral trade. However, there is an additional channel coming from the demand side - lower transportation costs make labor more productive and therewith increases incomes, which implies that agents will choose to consume a broader set of varieties. The counterfactual experiment shows that the effect of trade cost reductions on the extensive margin of trade is about twice as high when accounting for the income effects due to non-homothetic consumer behavior.

In terms of theory this paper contributes to the literature by incorporating non-homothetic preferences with binding non-negativity constraints into the EK framework and therewith showing that this framework can be used to analyze the extensive margin of bilateral trade. A closely related paper is Matsuyama (2000) proposing a stylized two country model with hierarchic 0/1-preferences in the Dornbusch, Fischer, and Samuelson (1977) structure. Indeed a variation of this framework could be used to understand the key channels of our new model.3 The new model goes further by proposing a multi-country framework that can accommodate large asymmetries and thus is flexible enough for a direct empirical implementation. Fieler (2008) extends the EK model to two industries with different demand elasticities, which then leads to non-homothetic demand behavior in the sense that poor countries relatively concentrate their expenditures in the low-elasticity industry. If this industry has a low variability in the productivity distribution most varieties will be produced locally and thus the model explains the empirical regularity that trade volumes rise disproportionately with incomes. In terms of the extensive margin her model behaves similar to the standard EK model as all agents find it optimal to consume all existing varieties. I.e. the model would predicts a negative correlation between importer income and the extensive margin. Sauré (2009) and Foellmi, Hepenstrick, and Zweimüller (2009) investigate the role of non-homothetic preferences in the imperfectly competitive frameworks due to Krugman (1980) and Melitz (2003). These papers present stylized two country models4, that are very useful to understand the additional effects that emerge when giving up the perfect competition assumption. The varying demand elasticity coming from the non-homothetic consumer behavior endogenizes the optimal markups, which generates feedback effects between the demand and supply side. This in turn implies among other things that the volumes of trade depend on the per-capita incomes and that producers might decide not to supply poor countries (where they

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3 Similarly EK note that the two country case of their model can be understood as a variation of the Dornbusch, Fischer, and Samuelson (1977) framework.

would optimally charge low markups) due to potential threats of reimports. Assuming perfect competition comes for us at the cost of muting these effects, but with the large gain of a multi-country model that can incorporate large asymmetries and thus admits an empirical implementation. Simonovska (2009) incorporates non-homothetic preferences into Chaney (2008) to explain how endogenous markups drive the systematic positive correlation between unit values and incomes that we observe in the data.

In terms of empirics our paper contributes to the literature concerned with the extensive margin by developing a theoretical model that can be directly calibrated. On a more reduced form level, the determinants of the extensive margin have been analyzed among others by Baldwin and Harrigan (2007) who find a positive effect of the GDP per worker in the importing country and Bernasconi (2009) who documents positive elasticities of the importer and the exporter per-capita incomes in the cross section as well as in the time series.

The remainder of this paper is structured as follows: The next section presents the theoretical model and discusses the predicted relation of per-capita incomes and the extensive margin of bilateral trade. Section 3 describes the calibration strategy and the corresponding results. Section 4 uses the calibrated model to perform two counterfactual experiments that highlight the importance of income effects for the extensive margin of trade. Section 5 considers a number of robustness checks. Section 6 concludes. In the Appendix we present the reduced form evidence for the positive correlation between per-capita incomes of the trading partners and the extensive margin of trade, a number of omitted proofs from Section 2, a detailed data description, and details on the calibration procedure.

2 The Model

We consider a static model with $N$ countries. The countries’ population sizes are denoted by $L_n$. Every agent is endowed with one unit of labor, whereas labor is assumed to be perfectly mobile within countries, but immobile across countries. There is one industry producing a variety of diversified consumption goods. The measure of varieties is exogenously given and normalized to one.

2.1 Consumer Behavior and Production Technology

Consumer Behavior. Agents maximize a symmetric additively separable utility function

$$U = \int_{j=0}^{1} v(x(j)) \, dj$$

subject to their budget constraint $E \leq \int_{j=0}^{1} p(j) x(j) \, dj$ and the non-negativity constraints $x(j) \geq 0 \, \forall \, j$. For now we can work with a general subutility function $v(c)$ satisfying $v'(x) > 0$, $v''(x) < 0$, and $v'(0) < \infty$. For the empirical application further below we will assume some specific functional form.
The crucial assumption on the general subutility function $v(c)$ is the finite marginal utility of consuming additional varieties, $v'(0) < \infty$, implying that the non-negativity constraint is potentially binding. The corresponding first order conditions for a variety $j$ are given by

$$
\begin{align*}
    v'(x(j)) &= \lambda \rho(j) \quad \text{for } x(j) \geq 0 \\
    v'(0) &< \lambda \rho(j) \quad \text{for } x(j) = 0
\end{align*}
$$

(1)

where $\lambda$ is the Lagrange multiplier. The respective demand function is depicted in Figure 3. Note that there is a finite price $v'(0)/\lambda$ above which the optimal quantity is zero. As the varieties enter the utility function symmetrically, agents simply order the varieties increasing in the prices and then choose up to which price they still want to consume a positive amount. From the first order conditions (1) we know the price $p(M)$ at which the non-negativity constraint just becomes binding, $p(M) = v'(0)/\lambda$. As the goods spectrum is normalized to one this marginal variety $M$ defines then the extensive margin of consumption and at the same time the share of available varieties that are consumed in positive quantities. If the price distribution is represented by a continuous cdf $G(p)$ - this will be the case in the equilibrium - we can solve for the extensive margin of consumption

$$
M = G(v'(0)/\lambda),
$$

which is represented in Figure 4. Reindexing the varieties such that $p(j) < p(i)$ for $j < i$ implies that for the varieties $j < M$ the first order condition (1) is binding and the Marshallian demand is given by $x(\lambda p) = v'^{-1}(\lambda p)$. Inserting this into the budget constraint and making a change of variable $p = G^{-1}(j)$ yields

$$
E = \int_{p=0}^{v'(0)/\lambda} p x(\lambda p) g(p) \, dp
$$

implicitly defining the marginal utility of income $\lambda$. Knowing $\lambda$ we can solve for the extensive margin of consumption $M$ and the optimal quantities of the varieties $j < M$.

Production. The production technology exhibits constant returns to scale and uses only labor\(^5\) as input. As labor is perfectly mobile within countries, but immobile across countries, there is a country specific wage rate $w_i$. The production technology in country $i$ for variety $j$ is shifted with a country-variety specific productivity $z_i(j)$. Thus the unit costs are $w_i/z_i(j)$. Assuming perfect competition and Samuelsonian iceberg transportation costs\(^6\) ($d_{ni}$ is the amount of goods that need to be shipped in $i$ in order for one unit

\(^5\)This assumption can readily be relaxed and we could allow for multiple input factors. Moreover, some (up to all) inputs can be internationally mobile. For the sake of expositional simplicity we consider only one input factor.

\(^6\)As standard in the literature we assume that the triangle inequality $d_{ni} \leq d_{li} d_{nl}$ holds for all countries $i, l, n$. 

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to arrive in country \( n \) the price at which country \( i \) offers variety \( j \) in country \( n \) is

\[
p_{ni} (j) = \frac{w_i d_{ni}}{z_i (j)}. \tag{2}
\]

**Technological heterogeneity.** Technological heterogeneity is modelled as in EK. We assume that country \( i \)'s productivity for variety \( j \), \( z_i (j) \), is the realization of a Fréchet distributed random variable

\[
\Pr [Z_i (j) \leq z] = \exp \left\{ -T_i z^{-\theta} \right\},
\]

where \( T_i \) is country specific and governs absolute advantage. \( \theta \) is common to all countries and regulates the global variability in efficiency draws and therewith the gains from trade realized through comparative advantages.

Let’s consider a country \( n \) that consumes a measure \( M_n \leq 1 \) of all available varieties. Note that \( M_n \) will be endogenized in the general equilibrium. Given the assumptions made up to now, a number of well known EK results directly follows (the Appendix outlines the formal derivation of these results).

i. The price at which country \( i \) offers a variety \( j \) in country \( n \) is a Fréchet distributed random variable

\[
\Pr [P_{ni} (j) \leq p] = 1 - \exp \left\{ - \left( T_i (w_i d_{ni})^{-\theta} \right) p^\theta \right\}.
\]

ii. The probability that country \( i \) is the cheapest supplier of variety \( j \) in country \( n \) is given by

\[
\pi_{ni} = \frac{T_i (w_i d_{ni})^{-\theta}}{\Phi_n},
\]

where \( \Phi_n = \sum_{i=1}^{N} T_i (w_i d_{ni})^{-\theta} \). \( \pi_{ni} \) is also the measure of varieties for which country \( i \) is the cheapest supplier in country \( n \).

iii. The minimal price on offer for variety \( j \) in country \( n \) itself is again a Fréchet distributed random variable

\[
\Pr \left[ \min \{ P_{ni} \}_{i=1}^{N} \leq p \right] = G_n (p) = 1 - \exp \left\{ -\Phi_n p^\theta \right\}.
\]

\( G_n (p) \) also represents the distribution of the lowest prices across goods in country \( n \).

iv. The measure of varieties produced in \( i \) and actually consumed in \( n \) is given by

\[
m_{ni} = M_n \pi_{ni}.
\]

We shall call \( m_{ni} \) the extensive margin of the trade flow from country \( i \) to country \( n \).
2.2 Equilibrium

In the general equilibrium firms price according to (2) and consumers behave as implied by (1) and satisfy their budget constraint with equality. The equilibrium then pins down the set of country specific wage rates and extensive margins of consumption \( \{w_n, M_n\}_{n=1}^N \). We will show that the equilibrium exists and that it is unique.

The Volume of Bilateral Trade Flows An agent in country \( n \) observes the price distribution \( G_n(p) \) and allocates his expenditures according to (1) over the different varieties. Optimality and non-saturation implies that he spends his total income \( w_n \). Because the productivity draws are iid across different varieties the varieties that origin from a given country \( i \) are evenly distributed over all varieties consumed. But this then implies that the share of expenditures going to country \( i \) is just equal to \( \pi_{ni} \). We show this formally in the Appendix. Denoting country \( n \)'s population size with \( L_n \) then implies that the aggregate volume of the trade flow from \( i \) to \( n \) is

\[
X_{ni} = \pi_{ni} w_n L_n, \tag{3}
\]

i.e. our model delivers exactly the same prediction with respect to volume as does the standard EK model. In particular the result is independent of the preference parameters as long as the draws are iid across varieties.

Separation of Demand and Supply Side An important feature of our model is the fact that due to the competitive environment the equilibrium wage rates are independent of the demand structure. To see this, consider country \( i \)'s balance of payments

\[
\sum_{n \neq i} X_{ni} = \sum_{j \neq i} X_{ij}.
\]

By adding \( X_{ii} \) on both sides the right hand side becomes country \( i \)'s aggregate expenditures, which in equilibrium must be equal to total labor income \( w_i L_i \). Using (3) on the right hand side we then can write

\[
w_i L_i = \sum_{n=1}^N \frac{T_i (w_i d_{ni})^{-\theta}}{\sum_{j=1}^N T_j (w_j d_{nj})^{-\theta}} w_n L_n, \tag{4}
\]

which can also be understood as the labor market clearing condition for country \( i \). In the Appendix we show that for given states of technologies \( \{T_i\}_{i=1}^N \), population sizes \( \{L_i\}_{i=1}^N \), transportation costs \( \{d_{ni}\}_{n=1}^N \), and comparative advantage parameter \( \theta \) there is a unique set of equilibrium wage rates that satisfies simultaneously all countries' labor market clearing conditions (4). In other words the model exhibits a certain separation of the demand and supply side that is a very convenient feature of the model when it comes to calibrating the model. Note that for example monopolistic competition with non-homothetic
preferences would not exhibit this separation, as the optimal markup varies with the demand structure, i.e. we have feedback effects from income on the production decision and via the implied labor productivity back on income.

The Extensive Margin of Bilateral Trade Flows. When it comes to the extensive margin, the demand side matters. An agent in country \( n \) observes the local price distribution \( G_n(p) \) and decides to consume a measure \( M_n = G(v'(0)/\lambda_n) \). The optimal measure varies with the demand structure, e.g. we have feedback effects from income on the production decision and via the implied labor productivity back on income.

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Using property iv. from above we get the equilibrium extensive margin of the trade flow from \( i \) to \( n \)

\[
m_{ni} = \pi_{ni} M_n.
\]

Here, we already see how the extensive margin of the trade flow from \( i \) to \( n \) depends on the technologies and therefore the per-capita incomes in these two countries. A better technology in the exporting country \( i \) implies a higher \( \pi_{ni} \) and a slightly higher \( M_n \) as the price distribution in country \( n \) shifts towards the origin. Better technology and therefore higher per-capita income in the importing country \( n \) implies a higher extensive margin of consumption \( M_n \) and at the same time a lower \( \pi_{ni} \) as the measure of varieties that are produced cheapest in country \( n \) increases. In the estimated model it turns out that the latter effect is dominated by the former, i.e. we get the positive correlation between per-capita income and extensive margin that is in the data.

The Intensive Margin of Trade. Up to now we only considered the extensive margin of trade. Of course there is also an intensive margin of trade, which is defined by \( \text{Volume} = (\text{Intensive Margin}) \times (\text{Extensive Margin}) \). Above we have seen that the aggregate volumes behave as in the homothetic model, whereas the extensive margin changes with income. But this implies that the intensive margin will also depend on income. In particular the standard model would predict that the income elasticity of the intensive margin is one, because consumption reacts only along this margin. In our model the extensive margin of consumption extends with income implying that the intensive margin of consumption’s income elasticity must be smaller than one, albeit still positive. Consequently the elasticity of intensive margin of bilateral trade must also be smaller than in the standard model, which is consistent with the empirical evidence. In the empirical implementation we will use the aggregate volumes and the extensive margin as
moments. Therefore, we will mostly discuss volumes and extensive margins in what follows and abstain from separately mentioning the intensive margin, which is directly determined by the aggregate volumes and the extensive margin.

### 2.3 Discussion

**Non-Homotheticity**  The key mechanism in our new model is the endogenous extensive margin of consumption. Because the marginal utility from consuming an additional variety is finite agents find it optimal to consume only a subset of all available varieties. The agents use the country specific price distributions to order the varieties along their prices and decide up to which price they still consume positive quantities. The bilateral extensive margin of trade between an exporter $i$ and an importer $n$ is then determined by the fraction of country $n$'s extensive margin of consumption that for which country $i$ is the cheapest supplier. Note that in our model varieties are intrinsically symmetric, i.e. for a given quantity the agents get the same utility contribution independent of the index of the variety. A more realistic formulation might be a consumption hierarchy implying that the marginal utility depends not only on the quantity consumed but also on the variety’s index. We abstain from this formulation because we cannot observe this hierarchy in the data and moreover the outcome of such an augmented model behaves observationally equivalent to our model as long as the countries’ productivity draws are iid across the indices. This result is reminiscent to the isomorphism of quality and productivity in the Melitz (2003) and the EK framework of heterogeneous firms.

**Product Cycles and Non-Homotheticity**  The tractability of our model is achieved by perfect competition precluding feedback effects from the demand side onto the supply side. Nevertheless there are several channels trough which such feedback effects may work in reality. A first potential channel is related to the consumption hierarchy discussed above. In a dynamic setting with innovating firms one could imagine firms directing their research efforts towards varieties for which they have a relatively large home market, i.e. firms in the South would primarily try to imitate varieties that already exist and that are already consumed in the South, whereas North firms will seek to innovate and develop new varieties that then are only consumed in the North, which would generate product cycles. Indeed there is evidence that the product mix of a country’s exports changes with its stage of development as documented in Feenstra and Rose (2000).

**Market Structure**  Another potentially relevant feedback mechanism comes with imperfect competition. Because with non-homothetic preferences the demand elasticity varies along the demand curve, the optimal markups of - for example - monopolistically competitive producers would vary. This then implies that the aggregate volumes of trade depend on income as the average markups vary with the country’s per-capita
income (and of course income distribution). Whereas the mechanism of our model would be still present in such a framework, the equilibrium would be much more complicated due to these feedback effects.\footnote{The analytical tractability of perfect competition and non-homothetic demand has also been used in Murata (2009) in a closed economy context.} In our model in contrast the aggregate volumes only depend on the total expenditures of the countries. We will see that this result helps a lot when considering the empirical implementation of our model.

### 2.4 Parametrization of $v(x)$

Whereas the effects discussed above emerge for a wide class of subutility functions $v(c)$, we now make some functional form assumptions on $v(c)$ in order to be able quantitatively work with the model. The model is particularly tractable for the subclass of the HARA preferences $v'(x) = (Ax - B)^D$ that satisfy $v'(0) < \infty$. For $B < 0$, $A = -1$, and $D = 1$ we get quadratic preferences\footnote{In the trade context there are two classes of models to mention that also use some form of quadratic preferences. The first class are the general oligopolistic equilibrium models (GOLE) models proposed by Neary (see for example Neary (2009) and Eckel and Neary (2009)) that feature quadratic preferences whose linear demand function make the oligopoly problem particularly tractable. However, typically the authors rule out binding non-negativity constraints as they focus on the oligopolistic interaction rather than the role of per-capita income and this then impedes the effects this paper is about. The second class of models (see for example Melitz and Ottaviano (2008)) uses quadratic preferences nested in a quasi-linear utility function as proposed Ottaviano and Thisse (1999). This framework is usually used to assess the trade related effects on markups. However, the presence of a numéraire good rules out income effects. Moreover binding non-negativity constraints are usually ruled out by assumption. In different economic applications in particular finance this kind of preferences is widely used. Foellmi and Zweimüller (2006) use the preferences also due to the binding non-negativity constraint. Note that the empirical performance of the model is very similar for quadratic preferences.}, for which the model is easy to solve and estimate. The disadvantage is that saturation emerges as $v'(B) = 0$, which introduces an unnecessary complication in the calibration. Another possibility are Stone-Geary preferences with $A = 1$, $B < 0$, and $D = -1$. With these saturation never occurs, i.e. marginal utility remains positive. Another advantage of the Stone-Geary form is that for $B = 0$ the preferences become the standard CES preferences with an elasticity of substitution of $1$. Note that the quantitative behavior of the standard EK model w.r.t. volumes is independent of the elasticity of substitution as noted in Alvarez and Lucas (2006) - using Stone-Geary thus allows us to incorporate the standard model as a special case of of new model. Therefore we will from now onwards work with the following functional form for the subutility\footnote{Note that the empirical performance of the model is very similar for quadratic preferences.}

$$v(x(j)) = \log(\bar{x} + x(j)).$$

The extensive margin of consumption in country $n$ is then given by $M_n = G_n(1/(\bar{x}\lambda_n))$. The Lagrange multiplier is defined by the budget constraint

$$w_n = \frac{M_n}{\lambda_n} - \frac{1}{\bar{x}} \int_{p=0}^{1/(\bar{x}\lambda_n)} pg_n(p) \, dp.$$
In the Appendix we show that we can rewrite the budget constraint using the country specific price
distribution $G_n(p)$ to get an expression implicitly defining the extensive margin of consumption

$$w_n = \bar{x}(\Phi_n)^{-\frac{1}{\theta}} \left( M_n \left( -\log (1 - M_n) \right) \right)^\frac{1}{\theta} - \gamma \left( \frac{1}{\theta} + 1; -\log (1 - M_n) \right).$$ (5)

where $\gamma(z, t) = \int_0^t t^{z-1} e^{-t} dt$ represents the incomplete Gamma function.

3 Empirical Analysis

In this section we calibrate our model and quantitatively assess its performance in explaining the extensive
margin of trade. The theoretical model makes predictions about two key moments of bilateral trade flows
that can be measured in the data - the extensive margin and the volume. For readability we repeat the
respective equations. Volumes are governed by

$$X_{ni} = \pi_{ni} w_n L_n,$$ (6)

and the extensive margin is determined by

$$m_{ni} = M_n \pi_{ni},$$ (7)

where the following equations hold

$$\pi_{ni} = \frac{T_i (w_i d_{ni})^{-\theta}}{\Phi_n},$$

$$w_n = \bar{x}(\Phi_n)^{-\frac{1}{\theta}} \left( M_n \left( -\log (1 - M_n) \right) \right)^\frac{1}{\theta} - \gamma \left( \frac{1}{\theta} + 1; -\log (1 - M_n) \right),$$ (8)

$$\Phi_n = \sum_{i=1}^N T_i (w_i d_{ni})^{-\theta}.$$

We calibrate the country specific technologies and the bilateral trade costs using data on aggregate bilateral
volumes. To pin down the preference parameter $\bar{x}$ we use US consumer expenditure data, whereas $\theta$ is
taken from EK. We then can simulate our new model and compare its predicted extensive margins of
bilateral trade to the data. For the calibration we use data from the year 2000 for 175 countries, i.e. we
have $30'450 = 175 \times 174$ bilateral trade flows. The trade volumes and the extensive margins are taken
from the COMTRADE database, population sizes and per-capita incomes from the World Development
Indicators database, proxies for bilateral trade costs from the CEPII database. All the data are described
in detail in the Appendix.


3.1 Calibration Strategy

The exogenous parameters of our model are the technologies $T_i$, the trade costs $d_{ni}$, the Fréchet parameter $\theta$ representing the elasticity of aggregate volumes with respect to trade costs, and the preference parameter $\bar{x}$ governing the marginal utility in the origin. In what follows we describe the calibration strategy for these parameters.

**Trade Elasticity $\theta$** We take the Fréchet parameter $\theta$ from EK. They provide three estimates for $\theta$. Using price data from the World Bank’s International Comparison Program EK construct proxies for relative prices adjusted by trade costs. Their model predicts a structural relation between these relative price indices and the countries’ relative trade shares. Estimating this relation EK get $\theta = 8.28$. An alternative estimator regresses country fixed effects from a gravity equation on country wages controlling for R&D stock and human capital (years of schooling). The theoretical structure of their model implies that the coefficient associated with wages (in logs) corresponds to $\theta$. The resulting coefficient is lower with $\theta = 3.6$. A third approach instruments the relative price indices used in the first approach with gravity variables (bilateral distance, common border, common language, and membership in the same FTA) and yields an estimate of $\theta = 12.86$. In the calibration we will report the results for all three levels of $\theta$. More recently Simonovska and Waugh (2009) have estimated the trade elasticity using a broader set of countries (129 countries, whereas EK consider only the OECD countries) and report a baseline estimate of $\theta = 7.5$. Moreover they find that the trade elasticity does not seem to systematically vary across countries with different incomes.

**Technologies and Bilateral Trade Costs** As shown above the aggregate volumes of bilateral trade are independent of the specific functional form of preferences. This implies that given a value for $\theta$ we can use the aggregate trade volumes to calibrate all model parameters but the preference parameter $\bar{x}$. One possibility would be to follow EK and derive a log-linear gravity equation that is then estimated by GLS. But because the calibration results will heavily depend on general equilibrium features of the model we prefer to use a more structural approach. In particular we will use the estimation procedure proposed by Fieler (2008). This procedure starts with the observation that the unique set of equilibrium wage rates is defined by

$$w_i L_i = \sum_{n=1}^{N} \frac{T_i (w_i d_{ni})^{-\theta}}{\sum_{j=1}^{N} T_j (w_j d_{nj})^\theta} w_n L_n$$

holding for all countries $i = 1, \ldots, N$. But this also implies that knowing the wage rates $\{w_i\}_{i=1}^{N}$, the population sizes $\{L_i\}_{i=1}^{N}$, $\theta$ and the trade costs matrix $\{d_{ni}\}_{n=1}^{N}$ would allow us to solve for the unique set of absolute advantage parameters $\{T_i\}_{i=1}^{N}$ that are consistent with these wage rates. In the data we directly observe the population sizes. Moreover, following Fieler (2008) we take per-capita income...
as a proxy for wages and model the transportation costs as a function of the usual gravity variables

\[ d_{ni} = 1 + \left( \gamma_0 + \gamma_1 \delta_{ni} + \gamma_2 (\delta_{ni})^2 \right) S_{ni} B_{ni} F_{ni} \]

where \( S_{ni} \) is an indicator taking the value of \( \gamma_L \) if \( n \) and \( i \) share a common language and one otherwise. \( B_{ni} \) and \( F_{ni} \) are similar indicators for common border and membership in the same free-trade agreement.\(^{10}\) Having fixed \( \theta \) at the three values taken from EK we estimate the transportation cost parameters \( \Upsilon = \begin{bmatrix} \gamma_0 & \gamma_1 & \gamma_L & \gamma_B & \gamma_F \end{bmatrix} \) by minimizing the quadratic distance between the model’s trade flows and the ones observed in the data. A detailed description of the procedure can be found in the Appendix.

Given the estimates for \( \Upsilon \) we can compute the implied bilateral trade costs. Combining these with the technology parameters \( \{T_i\}_{i=1}^N \), that are consistent with labor market clearing, we then can derive the corresponding \( \pi_{ni} \) and \( \Phi_n \). The estimates for the trade cost parameters \( \Upsilon \) are reported in Table 2 for the three different values of \( \theta \).

The Preference Parameter \( \bar{x} \) Using the extensive margins of bilateral trade we could estimate the preference parameter \( \bar{x} \) by fitting our model to these data. However, it would be preferable to calibrate \( \bar{x} \) using some other independent moment and then compare how well our model’s extensive margins of trade line up with the data. Thus, we calibrate the preference parameter using consumption data. In particular we use the US Consumer Expenditure Survey\(^{11}\) of the Year 2000. In this database we observe about 7’500 individuals’ expenditures broken down into roughly 600 categories. By counting the categories with positive expenditures we derive a measure for the extensive margin of consumption. Figure 11 plots this measure against annual income (both in logs). We clearly observe the expected positive relation. Indeed the elasticity of the extensive margin of consumption with respect to income is significant and positive at 0.40. To pin down a value for \( \bar{x} \) we plug our estimate for \( \Phi_{US} \) together with the incomes of the CEX individuals into the budget constraint (8) and solve for the implied extensive margins of consumption. We choose \( \bar{x} \) such that we match the income elasticity from the data. The corresponding values are 2.49, 4.42, and 6.40 for \( \theta \) equal to 3.6, 8.28, and 12.86 respectively.

A potential criticism to our approach to estimating \( \bar{x} \) could be the use of US data only. Although the model assumes that preferences are the same in all countries one might prefer an estimate for \( \bar{x} \) that is based on data from multiple countries. To address this we propose an alternative way of estimating \( \bar{x} \) in the robustness section, where we use the multilateral import margin (the number of categories for which

\(^{10}\)Due to the quadratic term it is possible that for high \( \delta_{ni} \) and negative \( \gamma_2 \) the transportation costs are falling in distance. We avoid this by modelling \( \delta_{ni} \) in the following way (if \( \gamma_2 < 0 \))

\[ \delta_{ni} = \begin{cases} \text{dist}_{ni} & \text{dist}_{ni} < -\frac{\gamma_1}{\gamma_2} \\ -\frac{\gamma_1}{\gamma_2} & \text{dist}_{ni} \geq -\frac{\gamma_1}{\gamma_2} \end{cases} \]

\(^{11}\)I thank Susan Joho for providing me with a nicely structured version of the CEX dataset.
we observe positive imports from at least one supplier country) to calibrate \( \bar{\alpha} \). The resulting values are slightly lower; however the quantitative performance remains largely unchanged.

### 3.2 Calibration Results

Given the calibrated values for trade costs, technologies, trade elasticity, and preference parameter we now can simulate the new model and compare its extensive margin to the data. Note that the standard model is a special case of our non-homothetic model (for \( \bar{\alpha} = 0 \)). Moreover the calibrated values for trade cost, technologies, and trade elasticities apply also for the standard model as they are calibrated targeting the aggregate bilateral volumes which are governed in both models, the standard EK and our new model, by the same structural equations. Therefore we can compare the performance of our new model to the standard model’s performance by simply setting \( \bar{\alpha} = 0 \). In what follows we discuss the performance of the calibrated model with respect the empirically observed extensive margin of bilateral trade.

**The Income Elasticities of the Extensive Margin**  A first important moment is the behavior of the extensive margin of bilateral trade for different per-capita incomes of the trading partners. In the theory part we have seen that the extensive margin is unambiguously positively related with per-capita income of the exporter, whereas for the importer income there are two countervailing effects - \( \pi_{ni} \) that is falling in \( n \)'s income and at the same time a rising extensive margin of consumption \( M_n \). Using the data from our simulated model and repeating the regression cited in the introduction we find exporter income elasticities of 0.61 for all three values of \( \theta \) and for both the standard and the new model\(^{12} \). Comparing this to 0.86 in the data confirms our expectations from the theory part; the EK framework yields a positive exporter income elasticity as observed in the data. Quantitatively the estimated elasticity seems to be reasonably close to the data. Turning to the importer income elasticity the calibrated model produces elasticities of 0.42, 0.47, and 0.49 for \( \theta \) equal to 3.6, 8.28, and 12.86 respectively. I.e. the new model indeed generates positive income elasticities as observed in the data. Moreover the elasticities are encouragingly close to the data’s 0.53. The standard model on the other hand neglects non-homothetic consumer behavior and generates strong negative elasticities of \(-0.39\), which is clearly at odds with the data.\(^{13} \)

As noted by Silva and Tenreyro (2006) calculating the elasticities using OLS might bias the results as the information contained in country level zeros is neglected (taking the log of zero yields minus infinity; the corresponding observations are usually dropped). To handle this problem they propose a Poisson pseudo-

\(^{12}\)On a first sight it might surprise that the exporter income elasticities do not differ across the two models and neither across the different values for \( \theta \). The reason for this is that the exporter income elasticity is only driven by \( \partial \pi_{ni} / \partial w_i \), which depends only on technology parameters and trade costs. But these parameters are the same in the standard and the new model. As for \( \theta \) note that the trade costs always are to the power of \( \theta \). Therefore we cannot separately identify \( \theta \) and the level of \( \Gamma \), but the estimated \( \pi_{ni} \) are always the same and thus also the exporter income elasticities.

\(^{13}\)For similar reasons as for the exporter income elasticities the importer income elasticities do not differ across the different \( \theta \) in the standard model. In the new model they differ because \( \theta \) also governs the shape of the price distribution and therefore the agents optimal choice of their extensive margin of consumption.
maximum-likelyhood estimator that does not require dropping the zeros. Running this estimator over the data and the trade patterns generated by the two models we find similar results as above. Quantitatively the exporter income elasticity is now closer to what we observe in the data (0.64 in the data vs. 0.54 for the models), whereas the new model’s importer income is still close to the data. However the model’s elasticity is with 0.44, 0.47, and 0.55 higher than what we observe in the data (0.35). Moreover $\theta = 3.6$ now generates the elasticity closest to the data. The homothetic standard model still delivers a strong negative elasticity of $-0.33$ for all three values of $\theta$.

**The Number of Traded Varieties among Different Country Groups** Another interesting moment is the average number of traded varieties among the richest $x\%$ ($x = 10, 20, 30, 40, 50$) relative to the average among the poorest $x\%$. Both theories - the standard theory and the model augmented with non-homothetic consumer behavior - predict that the ratio lies above one. In the standard model this is because the richest countries have the best technologies and are therefore also competitive in many varieties. In the new model this channel is also active, but additionally we now have the non-homothetic consumer behavior implying that the extensive margin of consumption is higher among the rich countries and therefore the average number of bilaterally traded varieties must be even higher. Table 3 reports the ratios in the data and the models’ ratios. It is apparent that the orders of magnitude of the new model are much closer to what we observe than the standard model’s prediction. In other words the technology channel explains only a small part in the broader trade flows among rich countries, whereas a much larger part can be accounted for through the demand side. This suggests that taking demand side effects into consideration is quantitatively important when thinking about the extensive margin of trade - an issue that we will further investigate with the counterfactual experiments below.

Key to the good performance of our new model its ability to account for non-homothetic consumer behavior. To show how this margin adjusts with income the three panels in Figure 5 plot the calibrated extensive margins of consumption against the per-capita incomes for the different values of $\theta$. For all three different values of $\theta$ the calibrated relation is clearly positive, whereas it becomes more concave with higher $\theta$. Note that there is considerable dispersion coming from the varying degree in the countries remoteness, i.e. the value of $\Phi_n$. In summary we conclude that the calibrated version of our new model captures the behavior of the (non-targeted) extensive margin of trade remarkably well. However, from above deliberations it did not become unambiguously clear which value of the trade elasticity $\theta$ yields the best results. Therefore we will use for the the counterfactual experiments in the next section the standard value of 8.28 from EK, which is also close to the more recent estimate of 7.5 due to Simonovska and Waugh (2009).
4 Counterfactual Experiments

In this section we perform two counterfactual experiments. The objective of these experiments is to highlight that per-capita incomes are quantitatively very important when thinking about the reaction of the extensive margin to some exogenous changes. In each case we start with the economy as calibrated in the previous section (we choose \( \theta = 8.28 \)) and then compare the counterfactual outcome to the initial situation.

4.1 The Rise of China and India

As a first counterfactual experiment we analyze how a continued rise of China and India affects global trade patterns, in particular the extensive margin of trade. In this counterfactual experiment we change China’s and India’s absolute advantage parameters \( T_{CHN} \) and \( T_{IND} \) such that their incomes rise by the same amount as observed between 1985 and 2000, i.e. 250% in China and 170% in India, keeping the absolute advantage parameters of all other countries constant.\(^{14}\)

Technological advances in China and India have the direct effect that these countries will be the cheapest suppliers for a broader set of varieties and therefore have broader extensive margins in their exports. Our model predicts that the average extensive margin of exports rises by 58% for China and 31% for India. The numbers predicted by the standard model are very similar, albeit slightly smaller, which is due to the fact that in the standard model the other countries do not increase their extensive margins of consumption. In our model the rest of the world slightly increases the extensive margin of consumption as the technological improvement in China and India lowers the price distribution in all countries. On average the other countries consume a 0.1% broader set of varieties. For poor countries close to India and China such as Nepal and Buthan we observe the strongest, albeit still small, reactions of around 0.5%. Whereas the extensive margins of rich countries such as the USA and Japan does not react at all. China and India themselves on the other hand strongly increase their extensive margin of consumption by 133% for China and 65% for India. This in turn affects the extensive margins of their import flows, where we estimate average increases of 47% for China and 27% for India. This starkly contrasts with the standard model’s prediction of decreases of −37% and −23% for China and India respectively, which is clearly at odds with the development of China’s and India’s trade flows during the last 15 years. The reason for these contrasting predictions is that in the standard model China and India produce now more varieties locally due to the technological improvement, whereas in the new model this effect is still present, but is dominated by the non-homothetic consumer behavior and the associated increase in the extensive margin of consumption. For the trade flows between China and India our model predicts increases of 200% for

\(^{14}\)Of course it is to expect that over the next year most other countries grow as well, i.e. their \( T_i \) will rise. Note that the level of \( T \) does not matter for the volumina relative to gdp, however it affects the extensive margins of trade and consumption, i.e. we will see a general rise in the extensive margin of trade if the world continues to grow. In order to focus on the effect coming from the relative rise of China and India we keep the other countries states of technology constant.
the flow from China to India and 192% for the flow from India to China. These increases are about twice as high as what is predicted by the standard model (121% and 83% respectively). In both models the extensive margin of trade flows between the rest of the world falls only slightly by around 1% (note that in our model they fall slightly less due to the increase in the extensive margin of consumption in all countries). In summary this counterfactual experiment demonstrates that the rise of China and India strongly affects the extensive margin of trade flows involving these two countries, but much less the other trade flows, i.e. the multilateral effects of technology shocks are small in our model. Moreover it is important to account for non-homothetic consumer behavior as the model would otherwise predict falling extensive margins of imports.

4.2 Changes in Transportation Costs

As a second counterfactual experiment we consider global reductions in transportation costs. Besides increasing the aggregate trade volumes lower trade costs also increase the extensive margin of trade. In the standard model the extensive margin of bilateral trade reacts due to supply side effects - lower transportation costs make trade worthwhile for more varieties, i.e. the extensive margin of trade will expand. In our model we have an additional demand side effect coming from the fact that lower transportation costs increase labor productivity and therewith wages. Because the agents have higher per-capita incomes they will expand their extensive margin of consumption which in turn affects the extensive margin of trade positively. To get a feeling of the quantitative size of this additional effect we take the estimated model and uniformly decrease transportation costs by 10, 25, 50 percent. Besides these gradual reductions we also consider the more extreme cases of autarky$^{15}$ and free trade.

Figures 6 and 7 plot the absolute and the relative changes in the extensive margin of consumption due to a 25% trade costs reduction against the initial per-capita income. Whereas in relative terms the countries with the lowest initial extensive margin of consumption gain most, the relation is positive for the absolute gains. It is interesting to see that there is a considerable heterogeneity in the relation between change and initial per-capita income. This comes from differences in the remoteness of the countries and the associated differences in the effect of trade cost reductions on $\Phi_n$. For the 10%- and 50%-reductions and for free trade we observe qualitatively similar effects. Considering the counterfactual situation of autarky we find that the richest countries would hardly lose any varieties (of course the intensive margin of consumption would greatly suffer), whereas the poor countries lose up to 35% of varieties. Figure 8 plots the relative loss in varieties against actual per-capita income. Again it is interesting to note that

\[ 1 = \tilde{x} (T_n)^{-\frac{\beta}{\theta}} \left( M_n |^{\text{aut}} \left( - \log (1 - M_n |^{\text{aut}}) \right)^{\frac{\gamma}{\theta} + 1} \right) \]

\[ - \gamma \left( - \log (1 - M_n |^{\text{aut}}) \right) - \frac{1}{\theta} \].

$^{15}$Under autarky a country cannot benefit from other countries’ technologies and $\Phi_n$ reduces to $\Phi_n = T_n (w_n)^{-\theta}$. Plugging this into (8) defines us country $n$’s extensive margin of consumption under autarky $M_n |^{\text{aut}}$.
the losses vary considerably for similar incomes, which is because of the degree to which countries benefit from trade is very heterogeneous due to different relative geographic locations. (In the standard model the extensive margin of consumption - trivially - does not react due to the infinite marginal utility associated with consuming additional varieties.)

In terms of the extensive margin of multilateral imports our model predicts increases of 77%, 206%, 399%, and 471% (for 10%-, 25%-, 50%-reduction, and free trade). The standard model neglecting the expanding set of consumed varieties would predict increases of about half this size. Turing finally to the extensive margin of bilateral trade flows we observe very heterogenous reactions. Whereas the multilateral import margin clearly increases with falling trade costs, extensive margins of bilateral trade may fall17. Table 4 summarizes the changes in the extensive margins of bilateral trade. Generally the standard model underpredicts the increases in the extensive margin as it does not account for the extending extensive margin of consumption. The standard model would for example predict that 14.2% of all dyads have a contracting extensive margin when trade costs fall by 10%, whereas allowing for non-homothetic consumer behavior shows that only roughly halve that number will actually experience a fall in the number of traded varieties.

To summarize, this counterfactual experiment shows that if one considers a set of countries with large differences in technologies and therefore per-capita incomes, one needs to account for the adjustments on the extensive margin of consumption when thinking about the reaction of the number of traded varieties to changes in transportation costs. Due to the CRS technology our model cannot be used to speak about firms, however similar effects would be present in models with determined firm sizes (and thus numbers). Above experiment thus suggests that if one is using such models to make predictions about how the number of firms reacts to trade liberalizations it will be crucial to account for income effects as otherwise the number of exiting firms will be seriously overestimated.

5 Robustness

5.1 Trade Costs and Per-Capita Income

The available direct evidence on trade costs suggests that trade costs vary systematically with the per-capita income of the trading partners. Anderson and van Wincoop (2004) estimate the ad-valorem tax equivalent for the average trade barrier among rich countries to be 170 percent and significantly higher for poor countries18. Potential explanations are high contracting costs, endogenous transportation in-

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16 For aggregate trade volumes both models predict increases of 101%, 429%, 1431%, and 1745%.
17 Consider for example two very isolated countries with low bilateral trade costs, but extremely high costs for trading with the outside world. Lowering trade costs globally would imply that these countries would start to import much more varieties from the rest of the world, but therefore they will source less varieties from each other, i.e. the extensive margins of their bilateral trade flows are falling.
18 They find for example that for several important goods categories trade costs are larger by a factor of two or even more.
fraction of projectionist policies in industries in which developing countries are specialized. If trade costs indeed correlate negatively with per-capita incomes this can be an alternative explanation for the pattern in the extensive margin that we observe in the data - because costs to ship to a poor country are high we will see this country importing less varieties and produce more varieties locally. Similarly this country exports less varieties because its high trade costs are a disadvantage relative to other countries with lower trade costs (and higher per-capita incomes). Such income dependent trade costs also can rationalize the facts that the trade rises more than proportionally with per-capita incomes and the presence of asymmetric trade volumes (see e.g. Waugh (2009)). To check if trade costs varying with income already account for the movements of the extensive margin of trade we recalibrate the technology parameters and the trade costs by modelling trade costs as being a function of the per-capita incomes of the trading partners (in addition to distance, common border, common language, and membership in the same free trade agreement). This increases the explanatory power with respect to volumes by around 10% as we now can capture the asymmetries in the trade flows and the increasing trade shares of rich countries. To check if we can explain the variation of the extensive margin we repeat the reduced form regression from the introduction and find that the importer income elasticity becomes less negative, however that the sign is still wrong (−0.23). Thus we conclude that augmenting the modelling of trade costs improves the fit in terms of aggregate trade volumes, but the model still fails to even qualitatively capture the behavior of the extensive margin.

5.2 An Alternative Approach to Calibrating $\bar{x}$

Above we calibrated $\bar{x}$ by matching the income elasticity of the extensive margin of consumption in the CEX data. The advantage of this approach is that we can use individual data and directly observe the extensive margin of consumption. The drawback is that such detailed consumer expenditure surveys are only available for a few rich countries. Whereas our model assumes that preferences are homogenous across countries some readers might prefer a calibration strategy that uses data from more countries - in particular with different income levels. In this section we propose an alternative calibration strategy that factors in this concern. In particular we choose $\bar{x}$ such that the correlation of income and the multilateral import margin, i.e. the number of varieties for which we observe positive imports from at least one source country, is matched. Figure 12 plots per-capita incomes against the multilateral import margin - the positive relation is apparent. We target the correlation between the log of a country’s per-capita income and the multilateral import margin, which is $(1 - \pi_{nn}) M_n$ in our model. To make the margins

19 In particular we model trade costs as

$$d_{ni} = 1 + (\gamma_0 + \gamma_1 \delta_{ni} + \gamma_2 \delta^2_{ni} + \gamma_3 w_i + \gamma_4 w^2_i + \gamma_5 w_n + \gamma_6 w^2_n) S_{ni} B_{ni} F_{ni}.$$  

20 We choose the lin-log specification as the fit in the data is best for this specification - the $R^2$ is 0.32 compared with 0.19 for level-level and 0.17 for log-log.
generated by the model comparable to the data we normalize the multilateral import margins by the maximally observed multilateral import margins. The resulting values for $\bar{x}$ are slightly lower than the ones we get using the CEX data - in particular we get 0.53, 1.95, and 2.99 for $\theta$ equal to 3.6, 8.28, and 12.86 respectively. Correspondingly the model’s elasticities are slightly lower with 0.29, 0.38, and 0.39 for the log-log OLS specification (data: 0.53) and 0.30, 0.38, and 0.38 for the PPML estimator (data: 0.35).

5.3 Inequality

Up to now we did not consider within-country inequality. Whereas most of the global inequality is indeed driven by between country variations in per-capita incomes, it is nevertheless interesting to see if and how our results change if we allowed for within country inequality. Taking our model literally implies that if every country features at least one very rich agent all countries will have an extensive margin of consumption that is equal to one. Theoretically, the main reason for this being not the case is the presence of fixed market entry costs (beachhead costs). Incorporating these into our model would require some non-competitive elements that yield markups that can be used to cover these fixed beachhead costs. Moreover the COMTRADE data are censored and we do not observe trade flows smaller than $10^5$ U$.

One possibility to proceed would be to rewrite the model incorporating beachhead costs and to introduce an artificial censoring in the model data that corresponds to the $10^5$ U$ in the data. However, this would require exact data on the top incomes in all countries, which is not available. Therefore we choose a shortcut and simply consider the fifth quintile of the income distribution as the highest income and abstain from explicitly modelling beachhead costs and censoring. We get the corresponding incomes from the UNU-WIDER (2008) World Income Inequality Database, Dollar and Kraay (2002), and Milanovic (2004) (details in the Appendix). Data on the top quintiles are available for 129 countries. Remember that the aggregate volumes are independent of the preference specification, i.e. they behave homothetic. Therefore we simply can use the calibration strategy from above and apply it to the smaller sample of countries. The values for $\bar{x}$ that are calibrated using the CEX data remains unchanged. For the extensive margin of consumption (and therefore also the extensive margin of bilateral trade) the relevant budget constraint is now the one corresponding to the fifth quintile of the income distribution. To see the effect of accounting for within country inequality consider the change in the model’s elasticity of the extensive margin of bilateral trade with respect to importer per-capita income. For $\theta = 8.28$ the elasticity is 0.43 for the representative agent model and 0.31 for the model accounting for within country inequality - for the 129 countries of the sample the elasticity is 0.56. For $\theta = 12.86$ we have 0.61 for representative agents vs. 0.66 accounting for within country inequality and for $\theta = 3.6$ we get 0.53 vs. 0.44. We conclude that within country inequality indeed alters the predictions of the model, however the change is not very big.

\[^{21}\]It also might be interesting to assess how fare this this artificial censoring approach goes in explaining the presence of country level zeros.
and the elasticities for both models - representative and heterogeneous agents - lie still quite close to the
elasticity in the data. In particular it is important to note that the qualitative behavior of the model
remains completely unaltered.

6 Conclusions

This paper started with the observation that the EK framework features a very natural measure for the
extensive margin of bilateral trade, namely the probability that a country $i$ is the cheapest supplier for a
given variety in a destination market $n$. Whereas the correlation of exporter income with the extensive
margin is positive as in the data, the standard model’s correlation with the importer income is negative.
This paper argued that this is due to the negligence of income effects on the consumption structure.
We showed that when introducing non-homothetic preferences the extended model’s correlation between
importer per-capita income and the extensive margin of bilateral trade can indeed be positive. The key
mechanism is a finite marginal utility from consuming additional varieties combined with the heterogeneous
prices, which endogenizes the measure of varieties which are consumed in positive quantities. In such a
setup there is still a tendency for a negative correlation between importer income and extensive margin,
as a technologically advanced country is more likely to produce a given variety locally. However this effect
is dominated by the extensive margin of consumption that is rising with the importing country’s per-
capita income. We empirically implemented our model by calibrating it to aggregate bilateral trade flows
and the US consumer expenditure survey. We found that our model reproduces remarkably well the key
features of the - untargeted - extensive margin of trade. To demonstrate that it is indeed quantitatively
important to account for demand side effects when modelling the extensive margin of trade we performed
two counterfactual experiments related to the rise of China and India and global reductions in trade costs.
Having understood how the extensive margin of trade can be consistently modeled in the EK framework
raises a number of follow-up questions. In particular it would be desirable to extend the model such that
non-trading countries can emerge as an equilibrium outcome. Such non-trading country pairs ("zeros") are
very prevalent in the data and Bernasconi (2009) finds that the emergence of zeros in the trade matrix is
strongly correlated with per-capita incomes. Another interesting question is how the demand side interacts
with innovation incentives - such an extension would need a dynamic model with imperfect competition
and producers that can direct their research efforts. The presence of an endogenous extensive margin of
consumption implies that producers may have an incentive to concentrate their research effort on varieties
for which they have a home market, i.e. rich country producers invent new or higher quality products,
whereas poor country producers specialize more on imitating products that are already produced and
which are consumed in positive quantities in their home markets.
References


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7 Appendix

7.1 Per-Capita Income and the Extensive Margin - Reduced Form Evidence

The central mechanism in our model is a demand for variety that is expanding with income. Jackson (1984) used the Consumer Expenditure Survey provided by the Bureau of Labor Statistics to empirically investigate the ‘Engel curve for Variety’ and finds strong evidence for this kind of consumer behavior. Falkinger and Zweimüller (1996) use cross-country data from the United Nations’ International Comparison Program for 57 countries. They find a strong impact of countries’ per-capita incomes on the number of consumed varieties.

Translated in a trade context such a consumer behavior implies that richer countries import a broader set of varieties, which is confirmed by Saure’s (2009) finding of a strong positive relation between changes in per-capita incomes and changes in the number of imported varieties (defined on a SITC4 level). This relation also holds in the cross-section as can be seen from Figure 1 plotting for the year 2000 per-capita incomes against the average extensive margin (measured as the number of HS6 categories with positive volumes) of imports of these countries. This graph and the following evidence are based on the COMTRADE data and covariates taken from the WDI and CEPII databases. The data is described in detail the Appendix Section 7.6. Whereas afore mentioned findings provide evidence for non-homothetic consumer behavior, our model goes further by making predictions about the influence of per-capita incomes of trading partners for the extensive margin of bilateral trade.

Figure 2 shows that also the exporter income correlates positive with the extensive margin by plotting per-capita incomes against the average extensive margin of exports. In order to check if the positive correlations also hold when considering country pairs we randomly select 44 countries and plot in Figure 9 for every country the extensive margin of its exports against the per-capita incomes of the importing countries. In Figure 10 the subplots represent importing countries. The scales are in logs and the red line represents the best linear fit. Again we see a clear positive relation between per-capita income and the extensive margin of trade - in this case bilateral trade.

Indeed, when regressing the extensive margin of bilateral trade on the trading partners per-capita incomes, their population sizes, and measures for bilateral trade costs (distance, common border, common official language, and membership in the same free trade agreement) we find the positive income elasticities cited in the introduction. Note also that the coefficient of per-capita income is significantly larger than the coefficient associated with population size implying that rising per-capita income and simultaneously lowering population size such that aggregate GDP remains constant increases the extensive margin of both imports and exports. This suggests that there is a separate role for the decomposition of aggregate GDP.

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22Our sample consists of 175 countries. For expositional clarity we split the sample in 4 subsamples and chose the one containing the USA. Very similar pattern prevail in the other 3 subsamples as can be seen from the regressions performed further below.
into per-capita income and population size in explaining the extensive margin of trade. As above regression is in a log-log specification we had to drop country pairs with zero-trade flows (and therefore an extensive margin of zero). In order to check whether our results are driven by an selection bias we therefore run the Poisson pseudo-maximum likelihood estimator proposed by Silva and Tenreyro (2006). The resulting coefficients are presented in columns 2 of Table 1. Again we find significantly positive coefficients for the both per-capita incomes. Moreover these coefficients are again significantly different from the coefficients associated with population sizes. Instead of only considering the cross-section of the year 2000 Table 5 is based on a panel for the years 1995 – 2005. There are 173 countries in the sample for which all information is available. Regressing the extensive margin on per-capita incomes, population sizes, trade cost proxies, and importer-, exporter-, and time fixed effects yields again significant positive elasticities for the trading partners per-capita incomes. Moreover these elasticities are significantly different from the elasticities associated with per-capita incomes.

The COMTRADE data is aggregated on the HS6 level, which corresponds to around 5’000 goods categories. In order to check if our results also hold in more disaggregated data we use the US import and export data provided by Feenstra, Romalis, and Schott (2002), which are aggregated on the HS10 level implying that we have now more than 10’000 different product categories. The disadvantage of this data set is that we do not observe the full world trade matrix, but only the trade flows from and to the US. Nevertheless, we can use this data as a robustness check for above results. Table 6 presents the cross sectional results for the year 2000. Again we find significant positive coefficients for both exporter and importer incomes. The time series results for 1972 – 2006 are presented in Table 7. We included country- and time-fixed effects, which is why the coefficients of the time invariant trade cost proxies cannot be identified. The coefficients of the per-capita incomes are still significantly positive; however we cannot reject the null hypothesis that the coefficient of population is the same as the income coefficient. A potential reason for this is the small variation in the population growth rates, which leads to large confidence bounds.

All the results discussed above are robust to different measures of the extensive margin such as the weighted measure proposed by Feenstra (1994) and adapted for the cross-section in Hummels and Klenow (2005) or the differently weighted measure discussed in the data description. In summary, considering above results shows that there is a robust and positive correlation between the extensive margin of bilateral trade flows and the per-capita incomes of the trading partners. This regularity holds in the cross-section as well as over time, whereas the time-series for the HS10 level the evidence is somewhat weaker due to relatively low variability in the growth rates of per-capita income and population.

### 7.2 Some Properties due to Fréchet Distributed Productivity Draws

In the following we outline the proofs for the properties i. - iv. stated in the main text.
Property i. \( \Pr [P_{ni} (j) \leq p] = 1 - \exp \left\{-p^\theta T_i (w_i d_{ni})^{-\theta}\right\} \)

Proof. The price on offer in country \( n \) for a variety \( j \) produced in \( i \) is a transformation of the random variable \( Z_i (j) \), \( P_{ni} (j) = w_i d_{ni} / Z_i (j) \). Therefore we can write \( \Pr [P_{ni} (j) \leq p] = \Pr [w_i d_{ni} / Z_i (j) \leq p] = \Pr [w_i d_{ni} / p \leq Z_i (j)] = 1 - \Pr [w_i d_{ni} / p > Z_i (j)] \). But the last probability is just the probability that the productivity draw in \( i \) for variety \( j \) is below some \( z = w_i d_{ni} / p \). In the main text we assumed that this probability is Fréchet distributed with the parameters \( T_i \) and \( \theta \). Combining completes the proof. For later use we define \( G_{ni} (p) = \Pr [P_{ni} (j) \leq p] \)

Property ii. \( \Pr [P_{ni} (j) \leq \min \{P_{ns}; s \neq k\}] = T_i (w_i d_{ni})^{-\theta} / \left( \sum_{i=1}^{N} T_i (w_i d_{ni})^{-\theta} \right) \).

Proof. The probability \( \pi_{ni} (j) \) that country \( i \) supplies country \( n \) with variety \( j \) is the probability that the realization of the random variable \( Z_i (j) \) leads to a price \( P_{ni} (j) \) that is lower than the realizations of all other countries. To start note that the probability that all countries \( s \neq i \) have a price higher than \( p \) is

\[
\Pr [p \leq \min \{P_{ns} (j)\}_{s \neq i}] = \prod_{s \neq i} \Pr [P_{ns} (j) > p].
\]

From i. we know the individual factors of the product. Inserting them yields

\[
\Pr [p \leq \min \{P_{ns} (j)\}_{s \neq i}] = \exp \left\{-p^\theta \sum_{s \neq i} T_s (w_s d_{ns})^{-\theta}\right\}.
\]

Heuristically, the probability \( \pi_{ni} (j) \) is now the weighted sum over all prices \( p \), where as weights we use the probability that country \( i \) supplies \( j \) at a price below \( p \). As we have a continuous price space the appropriate expression is the integral over the prices where we use the pdf of the prices offered by \( i \) in \( n \) for variety \( j \) as weight

\[
\pi_{ni} (j) = \int_{p=0}^{\infty} \Pr [p \leq \min \{P_{ns} (j)\}_{s \neq k}] g_{ni} (p) \, dp.
\]

By taking the first derivative of the cdf from i. we get \( g_{ni} (p) = \theta p^{\theta-1} T_i (w_i d_{ni})^{-\theta} \exp \left\{-p^\theta T_i (w_i d_{ni})^{-\theta}\right\} \).

Inserting this we can write

\[
\pi_{ni} (j) = T_i (w_i d_{ni})^{-\theta} \int_{p=0}^{\infty} \theta p^{\theta-1} \exp \left\{-p^\theta \sum_{s=1}^{N} T_s (w_s d_{ns})^{-\theta}\right\} \, dp.
\]

Solving the integral then completes the first part of the proof. As the draws are iid and we have a continuum of varieties this is also the measure of varieties produced in \( i \) and sold in \( n \).
**Property iii.** $\Pr \left[ \min \{ P_{ni}(j) \}_{i=1}^{N} < p \right] = 1 - \exp \left\{ -p^\theta \sum_{i=1}^{N} T_i(w_i d_{ni})^{-\theta} \right\}$

**Proof.** This cdf represents the probability the lowest price is below $p$ or equally one minus the probability that all prices on offer are higher than $p$. As the prices are iid distributed this is just the product of the individual probabilities

$$\Pr \left[ \min \{ P_{ni}(j) \}_{i=1}^{N} < p \right] = 1 - \prod_{i=1}^{N} \Pr \left[ P_{ni}(j) > p \right].$$

Substituting in the expression for the individual probabilities derived above completes the first part of the proof. As the prices are iid across varieties this is also the distribution across varieties. ■

**Property iv.** $m_{ni} = M_n \pi_{ni}$

**Proof.** We assume that $M_n \leq 1$ and we order the varieties such that the varieties with $j > M_n$ are not demanded in positive quantities. Note that the event that country $i$ is the supplier of variety $j$ in country $n$ is the realization of a Bernoulli random variable with $f(1) = \pi_{ni}$ and $f(0) = 1 - \pi_{ni}$ for $j < M_n$ and $f(0) = 1$ for $j > M_n$ as these varieties are not consumed at all. The Bernoulli variable is iid across the different varieties $j < M_n$. Therefore the measure $m_{ni}$ of varieties supplied from $i$ to $n$ is the expectation over the Bernoulli random variable given that $j < M_n$, which is the expression stated in the main text. ■

### 7.3 Derivation of the expenditure share going to a given country

Let $H_{ni}(p)$ denote the distribution of prices of country $i$ producers in country $n$ that are at the same time the lowest on offer in country $n$. The expenditures of a country $n$ agent going to country $k$, $E_{ni}$, then is

$$E_{ni} = \int_{p=0}^{p(M_n)} p \left( \frac{1}{\lambda p - \bar{x}} \right) h_{ni}(p) dp.$$ 

Now note that $H_{ni}(p)$ is given by

$$H_{ni}(p) = \int_{q=0}^{p} \prod_{s \neq i} (1 - G_{ns}(q)) \frac{\partial G_{ni}(q)}{\partial q} dq.$$ 

Inserting for $G_{ni}(p)$ and its derivative we find that $H_{ni}(p) = \pi_{ni} G_n(p)$ and thus $h_{ni}(p)/\pi_{ni} = g_n(p)$.

Now note that total expenditures of an country $n$ agent in equilibrium are

$$E_n = \int_{p=0}^{p(M_n)} p \left( \frac{1}{\lambda p - \bar{x}} \right) g_n(p) dp = \frac{1}{\pi_{ni}} \int_{p=0}^{p(M_n)} p \left( \frac{1}{\lambda p - \bar{x}} \right) h_{ni}(p) dp.$$ 

But this then directly implies that the share of a country $n$ agent’s expenditures going to country $i$ is given by $E_{ni}/E_n = \pi_{ni}$.

28
7.4 Unique solution to (4)

Claim 1 There is a unique set of wage rates for which (4) holds for all countries \(i = 1, \ldots, N\).

Proof. This proof is inspired by Alvarez and Lucas (2006). First we write (4) as an excess demand

\[
Z_i \left\{ w_i \right\}_{i=1}^N = \frac{1}{w_i} \sum_{n=1}^N \frac{T_i (w_i d_{ni})}{\sum_{j=1}^N T_j (w_j d_{nj})}^\theta w_n L_n - L_i,
\]

where \(L_i\) represents the supply of labor from country \(i\) and the first term on the left hand side is the global demand for labor from country \(i\). For notational ease we define \(w = (w_1, \ldots, w_N)\).

We first show that this excess demand satisfies the five properties from Proposition 17.B.2 of Mas-Colell, Whinston, and Green (1995).

i. \(Z(w)\) is continuous.
Trivial.

ii. \(Z(w)\) is homogeneous of degree zero.
Trivial.

iii. \(\sum_{n=1}^N w_n Z_n(w) = 0\) for all \(w\).
Follows if all agent’s budget constraints hold with equality, which is the case given non-saturation.

iv. There is an \(s > 0\) such that \(Z_n(w) > -s\) for all \(n\) and \(w\).
As the first part of the excess demand is always non-negative we have \(s = \max \left\{ L_i \right\}_{i=1}^N\).

v. If \((w)^n \to w\), where \(p \neq 0\) and \(p_l = 0\) for some \(l\), then \(\max \{ Z_1((w)^n), \ldots, Z_N((w)^n) \} \to \infty\).
Follows from noting that \(Z_i(w) \to \infty\) for \(w_k \to 0\).

Second, note that because these five properties hold, the existence of a solution to (4) is established with Proposition 17.C.1 from Mas-Colell, Whinston, and Green (1995).

Finally, note that

\[
\frac{\partial Z_i(w)}{\partial w_j} = \frac{1}{w_i} \left( \sum_{n=1}^N \frac{T_i (w_i d_{ni})}{\sum_{j=1}^N T_j (w_j d_{nj})}^\theta w_n L_n + \theta \sum_{n=1}^N \frac{T_i (w_i d_{ni})}{\sum_{j=1}^N T_j (w_j d_{nj})}^\theta \left( \frac{T_j (w_j d_{nj})}{\sum_{j=1}^N T_j (w_j d_{nj})} \right)^{\theta-1} w_n L_n \right) > 0 \ \forall j \neq i,
\]

i.e. the gross substitution property holds. But using Proposition 17.F.3 from Mas-Colell, Whinston, and Green (1995) this implies together with the existence proof from above that there is a unique solution \(\left\{ w_i \right\}_{i=1}^N\) that ensures that (4) holds for all countries \(i = 1, \ldots, N\).
7.5 Derivation of equation (5)

We take a country $n$ agent’s budget restriction and replace the Lagrange multiplier using

$$\lambda_n = \frac{1}{\bar{x} p(M_n)}$$

as implied by optimal consumption (1) to get

$$w_n = \bar{x} \left( p(M_n) M_n - \int_{p=0}^{p(M_n)} p g(p) dp \right).$$

If we then insert the pdf of the Fréchet distribution we have

$$w_n = \bar{x} \left( M_n \left( -\log \left( 1 - M_n \right) \right)^{\frac{1}{\theta}} - \int_{p=0}^{p(M_n)} p \Phi_n p(\theta-1) e^{-\Phi_n p} dp \right).$$

Making the change of variable $t = \Phi_n p^\theta$ (therefore $dt = \Phi_n \theta p^{\theta-1} dp$, $p = (t/\Phi_n)^{1/\theta}$, $\bar{t} = \Phi_n p(M)^\theta$) we can write

$$w_n = \bar{x} \left( M_n \left( -\log \left( 1 - M_n \right) \right)^{\frac{1}{\theta}} - \int_{p=0}^{\Phi_n p(M)^\theta} \bar{t}^{\frac{1}{\theta}} e^{-\bar{t}} d\bar{t} \right).$$

Note that the integrals are incomplete Gamma functions, i.e.

$$w_n = \bar{x} \left( M_n \left( -\log \left( 1 - M_n \right) \right)^{\frac{1}{\theta}} - \gamma \left( \frac{1}{\theta} + 1; \Phi_n p(M)^\theta \right) \right).$$

Finally using the Fréchet distribution we can substitute for $\Phi_n p(M)^\theta = -\log \left( 1 - M_n \right)$ to get equation (5).

7.6 Data Description

We use the data for 175 countries, which are reported in Table 8. This gives rise to $154 \times 175 = 30450$ bilateral trade relations. In the following we describe the corresponding data.

COMTRADE To derive the aggregate value ($X_{ni}$) and the extensive margin ($m_{ni}$) of bilateral trade flows we use the COMTRADE data of the year 2000 as provided by CEPII (Gaulier and Zignago (2008)). This data set provides the dollar values of the bilateral trade flows between 239 economic entities (mostly countries) on the HS6 level of aggregation ($X_{ni}(j)$), which corresponds to 5’111 goods categories. Summing over all HS6 categories we get the aggregate value of a bilateral trade flow from exporting country $i$ to the importing country $n$,

$$X_{ni} = \sum_{j=1}^{5111} X_{ni}(j).$$

We measure the extensive margin of the trade flow from $i$ to $n$ by counting the number of categories with positive trade flows,

$$m_{ni} = \sum_{j=1}^{5111} I [X_{ni}(j) > 0],$$

where
\( I \{ \cdot \} = 1 \) if \( X_{ni}(j) > 0 \) and zero otherwise. An alternative measure would be to weight the categories with their relative importance in world trade and define the extensive margin of bilateral trade as 
\[
m_{ni} = \sum_{j=1}^{J} I \{ X_{ni}(j) > 0 \} X(j)/X,
\]
where \( X(j)/X \) is the share of category \( j \) in global trade.\(^{23}\) In the context of the EK model the weighted measure is correct if the productivity draws are iid across HS6 categories such that within each category we have the same price distribution, whereas the simple counting measure is correct if the productivity draws are grouped together into the HS6 categories. The reality will lie somewhere between these two polar cases. However as the coefficient of correlation between these two polar measures for the extensive margin of trade is 0.95 we are confident that this measurement problem is not too serious. In fact the results presented in the main text do hardly change when using the weighted measure instead of the unweighted measure.

**US Imports and Exports** We use the US import and export data as provided by Feenstra, Romalis, and Schott (2002). This data set provides a panel for the US imports and exports between 1972 – 2006. The level of aggregation is HS10, i.e. we have more than 10’000 product categories. For 161 economic entities (mostly countries) we have the complete data (yearly trade flows, population sizes, per-capita GDP, trade cost proxies). The extensive margins are constructed in the same way as in the COMTRADE data set.

**Per-Capita Incomes and Population Sizes** The per-capita incomes and the population sizes are taken from the Worldbank’s World Development Indicator. The per-capita incomes are measured in current (year 2000) US-dollars. Following EK we deliberately abstain from using purchasing power adjusted incomes as deviations from PPP arise endogenously in the EK framework. For the panel regression we use the same data for the different years - note that changes in the value of the US dollar are captured in the time fixed effects.

**Distance Proxies** All transportation cost proxies but the FTA indicator are taken from the database provided by CEPII. The bilateral distance is measured as the distance between two countries’ most populous cities. The common language indicator takes the value one if two countries have the same official language and common border takes the value one if two countries share a common land border. Membership in the same free trade agreement is one if two countries are member in the same FTA, whereas we only consider the best known FTAs (NAFTA, EU and EEA, EFTA, ASEAN).

**Quintiles** The main data source is the UNU WIDER (2008) world income inequality database. We complement this database with additional information from Dollar and Kraay (2002) and Milanovic (2004).

\(^{23}\)This measure is inspired by Feenstra (1994) who derives a related measure using a CES expenditure system. Because our consumer behaviour is non-homothetic the particular functional form does not apply in our case and we choose the more ad-hoc measure proposed.
One problem is that the income concept varies widely across different countries. In particular quintiles may refer to income or expenditures. Following Dollar and Kray (2002) running the following dummy regression

\[ q_{5i} = a_0 + a_1 D_{i}^{regio} + a_2 D_{i}^{inc} + \varepsilon_i \]

for all quintiles. \( D_{i}^{regio} \) are regional dummies (Eastern Asia and Pacific, Eastern Europe and Central Asia, Mid East and North Africa, Latin America and the Caribbean, South Asia, Sub Sahara, Base Category: Developed World) and \( D_{i}^{inc} \) is a dummy taking the value one if the quintile refers to income. It turns out that \( a_2 \) is not significant, which is why we decide not to adjust the quintiles. Second there are more observations on Gini coefficients than on top quintiles. To have as large as possible a data set we regress top quintiles on Ginis and use the resulting coefficients to construct estimates for the to quintiles. In the final data set we then have 129 countries 117 of which have observed top quintiles. For the remaining 12 countries we estimated the quintiles based on the observe Gini coefficient.

**CEX Data** I use the Consumer Expenditure Survey (CEX) conducted by the Bureau of Labor Statistics (BLS) as provided by the ICPSR web site. The data set is a rolling panel and agents are tracked over one year. The relevant information for us is the average income during this year and the number of Universal Classification Code (UCC) categories with positive consumption in at least one month, which we use to measure the extensive margin of consumption. We consider all agents for which at least one month of the period of their survey participation falls into the year 2000 and whose survey is complete. This leaves us with 7400 observations.

### 7.7 Details on the Calibration Procedure for Technologies and Trade Costs

As discussed in the paper we need to estimate a parameter vector \( \hat{\Upsilon} \) that links observed trade cost proxies to the unobserved trade costs. For a given \( \Upsilon \) we can solve for the technologies that ensure labor market clearing. Using the implied trade costs together with the corresponding technologies together and the data on per-capita incomes and population sizes we can solve for the implied aggregate values of bilateral trade flows \( X_{ni}(\Upsilon) \). We define our point estimate for the parameter vector \( \hat{\Upsilon} \) as

\[ \hat{\Upsilon} = \arg \min_{\Upsilon} L^{vol} \left( \{X_{ni}, X_{ni}(\Upsilon)\}_{i,n \neq i} \right), \]

where \( X_{ni} \) are the aggregate bilateral trade flows in 2000 and \( X_{ni}(\Upsilon) \) are the flows predicted by the model. \( L(\cdot) \) is a quadratic loss function

\[ L^{vol} \left( \{X_{ni}, \tilde{X}_{ni}(\Upsilon)\}_{i,n \neq i} \right) = \left( \sum_{i=1}^{N} \sum_{n \neq i} \omega_{ni} (X_{ni} - \tilde{X}_{ni}(\Upsilon))^2 \right) / \left( \sum_{i=1}^{N} \sum_{n \neq i} \omega_{ni}(X_{ni})^2 \right) \]
with $\omega_{ni}$ a weight to be specified. It is well known from the gravity literature that trade flows are roughly proportional to the product of the trading partners’ GDPs. Therefore we choose as weights

$$\omega_{ni} = (w_i L_i w_n L_n)^{-2}.$$  

Note that we normalized the loss function by the uncentered second moment such that the loss function tells us how much of the total variation in the data cannot be explained with the model.

We chose the following algorithm for the numerical implementation of our estimation procedure$^{24}$:

1. Start with an initial guess $\Upsilon^0$

2. Solve for the implied $\{T_i\}_{i=1}^N$ and use them to compute the corresponding $\{\pi_{ni}\}_{n=1}^N$  

3. We then plug them into (6) to get the implied trade flows $\{X_{ni}(\Upsilon)\}_{n=1}^N$

4. Evaluate the loss function $L\left(\{X_{ni}, X_{ni}(\Upsilon^0)\}_{i,n\neq i}\right)$

5. Adjust the guess using the complex method of numerical optimization and repeat steps 2-5 until a local minimum is found

6. Repeat steps 1-5 for different initial guesses to ensure finding a global minimum

The value of the loss function that corresponds to our point estimate of $\Upsilon$ is 0.71, i.e. the model can explain 0.29 of the variation in the data that goes beyond variation which is simply due to gravity.

$^{24}$The corresponding FORTRAN routine is available upon request from the author.
Table 1: Dependent Variable - bilateral extensive margin (HS6)

<table>
<thead>
<tr>
<th></th>
<th>log-log OLS</th>
<th>PPML</th>
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<tbody>
<tr>
<td>i_pc_gdp</td>
<td>0.540***</td>
<td>0.350***</td>
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<tr>
<td>e_pc_gdp</td>
<td>0.866***</td>
<td>0.632***</td>
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<td>e_pop</td>
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<td>0.392***</td>
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<tr>
<td>N</td>
<td>18815</td>
<td>30450</td>
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<td>$R^2$</td>
<td>0.338</td>
<td>0.465</td>
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</table>

*** denotes significance at the 1%-level. Standard errors are robust.

Table 2: Estimated trade cost parameters

<table>
<thead>
<tr>
<th>$\theta = 3.6$</th>
<th>$\theta = 8.28$</th>
<th>$\theta = 12.86$</th>
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<tr>
<td>Loss</td>
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<td>0.71</td>
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<td>$\gamma_0$</td>
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<td>0.65</td>
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<td>$\gamma_1$</td>
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<td>$\gamma_2$</td>
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<td>−0.05</td>
</tr>
<tr>
<td>$\gamma_B$</td>
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<td>1.21</td>
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<tr>
<td>$\gamma_L$</td>
<td>0.77</td>
<td>0.80</td>
</tr>
<tr>
<td>$\gamma_F$</td>
<td>0.96</td>
<td>0.99</td>
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</table>
Table 3: Average extensive margin among the richest $x\%$ relative to average among poorest $x\%$

<table>
<thead>
<tr>
<th>$x%$</th>
<th>data</th>
<th>$\theta = 3.6$</th>
<th>$\theta = 8.28$</th>
<th>$\theta = 12.86$</th>
<th>$\theta = 3.6$</th>
<th>$\theta = 8.28$</th>
<th>$\theta = 12.86$</th>
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<tbody>
<tr>
<td>10</td>
<td>413</td>
<td>300</td>
<td>352</td>
<td>399</td>
<td>5</td>
<td>5</td>
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<tr>
<td>20</td>
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<td>35</td>
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<td>22</td>
<td>2</td>
<td>2</td>
<td>2</td>
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</table>

Table 4: Summary of the reaction (in %) of the extensive margin of bilateral trade to changes in trade costs

<table>
<thead>
<tr>
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<th>10%-reduction</th>
<th>25%-reduction</th>
<th>50%-reduction</th>
<th>free trade</th>
</tr>
</thead>
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<td></td>
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<td>EK</td>
<td>new model</td>
<td>EK</td>
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<td>top5%</td>
<td>1.09</td>
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<td>4.08</td>
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<td>-0.38</td>
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<tr>
<td>mean</td>
<td>0.49</td>
<td>0.41</td>
<td>1.21</td>
<td>0.91</td>
</tr>
<tr>
<td>median</td>
<td>0.48</td>
<td>0.40</td>
<td>0.79</td>
<td>0.46</td>
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<tr>
<td>% negative</td>
<td>0.08</td>
<td>0.14</td>
<td>0.20</td>
<td>0.31</td>
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Table 5: Dependent Variable - extensive margin of US imports and exports (HS6), years 1995-2005

<table>
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<td>i_pc_gdp</td>
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</tr>
<tr>
<td>e_pc_gdp</td>
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<tr>
<td>i_pop</td>
<td>0.15**</td>
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<td>e_pop</td>
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<td>language</td>
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<td>$R^2$</td>
<td>0.81</td>
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*** and ** denote significance at the 1%- and the 5%-level respectively. Standard errors are robust.

Table 6: Dependent Variable - extensive margin of US imports and exports (HS10), year 2000

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<td>pc_gdp</td>
<td>0.82***</td>
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<td>pop</td>
<td>0.66***</td>
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<td>distance</td>
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<tr>
<td>border</td>
<td>-0.46</td>
<td>-1.54***</td>
</tr>
<tr>
<td>language</td>
<td>0.42***</td>
<td>0.60</td>
</tr>
<tr>
<td>const</td>
<td>-5.27***</td>
<td>3.55**</td>
</tr>
<tr>
<td>N</td>
<td>155</td>
<td>156</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.77</td>
<td>0.65</td>
</tr>
</tbody>
</table>

*** and ** denote significance at the 1%- and the 5%-level respectively. Standard errors are robust.

We consider only major FTAs, i.e. in the case of the USA the NAFTA. Therefore the variable FTA is dropped as it colinear with the border dummy.
Table 7: Dependent Variable - extensive margin of US imports and exports (HS10), 1972 - 2006

<table>
<thead>
<tr>
<th></th>
<th>Imports</th>
<th>Exports</th>
</tr>
</thead>
<tbody>
<tr>
<td>pc_gdp</td>
<td>0.21**</td>
<td>0.43***</td>
</tr>
<tr>
<td>pop</td>
<td>0.48*</td>
<td>-0.09</td>
</tr>
<tr>
<td>country FE</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>time FE</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>N</td>
<td>4667</td>
<td>4686</td>
</tr>
</tbody>
</table>

***, **, and * denote significance at the 1%-r, the 5% and the 10%-level respectively.
Standard errors are robust.

Table 8: Countries in the Sample

<p>| Albania          | Congo | Honduras | Mauritius | Sierra Leone |
| Algeria          | Congo, DR | Hong Kong | Mexico | Singapore |
| Angola           | Costa Rica | Hungary | Micronesia | Slovakia |
| Antigua and Barbuda | Croatia | Iceland | Moldova | Slovenia |
| Argentina        | Cyprus | India | Mongolia | Solomon Islands |
| Armenia          | Czech Republic | Indonesia | Morocco | South Africa |
| Australia        | Côte d’Ivoire | Iran | Mozambique | Spain |
| Austria          | Denmark | Ireland | Nepal | Sri Lanka |
| Azerbaijan       | Djibouti | Israel | Netherlands | Sudan |
| Bahamas          | Dominica | Italy | New Caledonia | Suriname |
| Bahrain          | Dominican Republic | Jamaica | New Zealand | Sweden |
| Bangladesh       | East Timor | Japan | Nicaragua | Switzerland |
| Barbados         | Ecuador | Jordan | Niger | Syria |
| Belarus          | Egypt | Kazakhstan | Nigeria | Tajikistan |
| Belgium and Luxembourg | El Salvador | Kenya | Norway | Tanzania |
| Belize           | Equatorial Guinea | Kiribati | Oman | Thailand |
| Benin            | Eritrea | Korea | Pakistan | Togo |
| Bhutan           | Estonia | Kuwait | Panama | Tonga |
| Bolivia          | Ethiopia | Kyrgyzstan | Papua New Guinea | Trinidad and Tobago |
| Bosnia and Herzegovina | Fiji | Laos | Paraguay | Tunisia |
| Brazil           | Finland | Latvia | Peru | Turkey |</p>
<table>
<thead>
<tr>
<th>Brunei Darussalam</th>
<th>France</th>
<th>Lebanon</th>
<th>Philippines</th>
<th>Turkmenistan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulgaria</td>
<td>French Polynesia</td>
<td>Liberia</td>
<td>Poland</td>
<td>Uganda</td>
</tr>
<tr>
<td>Burkina Faso</td>
<td>Gabon</td>
<td>Libya</td>
<td>Portugal</td>
<td>Ukraine</td>
</tr>
<tr>
<td>Burundi</td>
<td>Gambia</td>
<td>Lithuania</td>
<td>Qatar</td>
<td>United Arab Emirates</td>
</tr>
<tr>
<td>Cambodia</td>
<td>Georgia</td>
<td>Macau</td>
<td>Romania</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>Cameroon</td>
<td>Germany</td>
<td>Macedonia</td>
<td>Russian Federation</td>
<td>USA</td>
</tr>
<tr>
<td>Canada</td>
<td>Ghana</td>
<td>Madagascar</td>
<td>Rwanda</td>
<td>Uruguay</td>
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<tr>
<td>Cape Verde</td>
<td>Greece</td>
<td>Malawi</td>
<td>Saint Kitts</td>
<td>Uzbekistan</td>
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<tr>
<td>Central African Republic</td>
<td>Grenada</td>
<td>Malaysia</td>
<td>Saint Lucia</td>
<td>Vanuatu</td>
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<td>Chad</td>
<td>Guatemala</td>
<td>Maldives</td>
<td>Saint Vincent</td>
<td>Venezuela</td>
</tr>
<tr>
<td>Chile</td>
<td>Guinea</td>
<td>Mali</td>
<td>Samoa</td>
<td>Viet Nam</td>
</tr>
<tr>
<td>China</td>
<td>Guinea-Bissau</td>
<td>Malta</td>
<td>Saudi Arabia</td>
<td>Yemen</td>
</tr>
<tr>
<td>Colombia</td>
<td>Guyana</td>
<td>Marshall Islands</td>
<td>Senegal</td>
<td>Zambia</td>
</tr>
<tr>
<td>Comoros</td>
<td>Haiti</td>
<td>Mauritania</td>
<td>Seychelles</td>
<td>Zimbabwe</td>
</tr>
</tbody>
</table>
Figure 1: Per-capita incomes vs. the average extensive margin of imports (both in logs).
Figure 2: Per-capita incomes vs. average extensive margin of exports (both in logs).
Figure 3: A microeconomic demand function with bounded marginal utility in the origin.
Figure 4: The extensive margin of consumption $M_n$ as a function of the price distribution $G_n(p)$, marginal utility of income $\lambda_n$, and the marginal utility from new varieties $v'(0)$.
Figure 5: The estimated extensive margin of consumption ($M_n$) against per-capita income for the different values of $\theta$. 

\[ \theta = 3.6 \]

\[ \theta = 8.28 \]

\[ \theta = 12.86 \]