Measuring the Unequal Gains from Trade*

Pablo D. Fajgelbaum† — *UCLA and NBER*

Amit K. Khandelwal‡ — *Columbia and NBER*

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Abstract

Individuals that consume different baskets of goods are differentially affected by relative price changes caused by international trade. We develop a methodology to measure the unequal gains from trade across consumers within countries. The approach requires data on aggregate expenditures and parameters estimated from a non-homothetic gravity equation. We find that trade typically favors the poor, who concentrate spending in more traded sectors.

Key words: **International Trade, Inequality, Non-Homothetic Preferences**
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†UCLA Department of Economics, 8283 Bunche Hall, Los Angeles, CA 90095 *email*: pfajgelbaum@econ.ucla.edu

‡Columbia Business School, Uris Hall, 3022 Broadway, New York, NY 10027 *email*: ak2796@columbia.edu

1 Introduction

Understanding the distributional impact of international trade is one of the central tasks pursued by international economists. A vast body of research has examined this question through the effect of trade on the distribution of earnings across workers (e.g., Stolper and Samuelson 1941). A second channel operates through the cost of living. It is well known that the consumption baskets of high- and low-income consumers look very different (e.g., Deaton and Muellbauer 1980b). International trade therefore has a distributional impact whenever it affects the relative price of goods that are consumed at different intensities by rich and poor consumers. For example, a trade-induced increase in the price of food has a stronger negative effect on low-income consumers, who typically have larger food expenditure shares than richer consumers. How important are the distributional effects of international trade through this *expenditure channel*? How do they vary across countries? Do they typically favor high- or low- income consumers?

In this paper we develop a methodology to answer these questions. The approach is based on aggregate statistics and model parameters that can be estimated from readily available bilateral trade and production data. It can therefore be implemented across many countries and over time. A recent literature in international trade, including Arkolakis et al. (2012), Melitz and Redding (2014) and Feenstra and Weinstein (2010), measures the aggregate welfare gains from trade by first estimating model parameters from a gravity equation (typically, the elasticity of imports with respect to trade costs) and then combining these parameters with aggregate statistics to calculate the impact of trade on aggregate real income. We estimate model parameters from a *non-homothetic* gravity equation (the elasticity of imports with respect to both trade costs and income) to calculate the impact of trade on the real income of consumers with different expenditures within the economy.

The premise of our analysis is that consumers at different income levels within an economy may have different expenditure shares in goods from different origins or in different sectors. Studying the distributional implications of trade in this context requires a non-homothetic demand structure with good-specific Engel curves, where the elasticity of the expenditure share with respect to individuals' total expenditures is allowed to vary across goods. The Almost-Ideal Demand System (AIDS) is a natural choice. As first pointed out by Deaton and Muellbauer (1980a), it is a first-order approximation to any demand system; importantly for our purposes, it is flexible enough to satisfy the key requirement of good-specific income elasticities and has convenient aggregation properties that allow us to accommodate within-country inequality.

We start with a demand-side result: in the AIDS, the welfare change through the expenditure channel experienced by consumers at each expenditure level as a result of changes in prices, can be recovered from demand parameters and aggregate statistics. These aggregate statistics include the initial levels and changes in aggregate expenditure shares across commodities, and moments from the distribution of expenditure levels across consumers. The intuition for this result is that, conditioning on moments of the expenditure distribution, changes in aggregate expenditure shares across goods can be mapped to changes in the relative prices of high- versus low-income elastic goods by inverting the aggregate demand. These relative price changes and demand parameters, in turn, suffice to measure the variation in real income of consumers at each expenditure level through changes in the cost of living.

To study the distributional effects of trade through the expenditure channel we embed this demand structure into a standard model of international trade, the multi-sector Armington model. This simple supply side allows us to cleanly highlight the methodological innovation on the demand side.[1] The model allows for cross-country differences in sectoral productivity and bilateral trade costs, and within each sector goods are differentiated by country of origin. We extend this supply-side structure with two features. First, the endowment of the single factor of production varies across consumers, generating within-country inequality. Second, consumer preferences are given by the AIDS, allowing goods from each sector and country of origin to enter with different income elasticity into the demand of individual consumers. As a result, aggregate trade patterns are driven both by standard Ricardian forces (differences in productivities and trade costs across countries and sectors) and by demand forces (cross-country differences in income distribution and differences in the income elasticity of exports by sector and country).

In the model, differences between the income elasticities of exported and imported goods shape the gains from trade-cost reductions of poor relative to rich consumers within each country. We show how to use demand-side parameters and changes in aggregate expenditure shares to measure welfare changes experienced by consumers at different income levels in response to foreign shocks. For example, a tilt in the aggregate import basket towards goods consumed mostly by the rich may reveal a fall in the import prices of these goods, and a relative welfare improvement for high-income consumers. In countries where exports are high-income elastic relative to imports, the gains from trade are relatively biased to poorer consumers because opening to trade decreases the relative price of low-income elastic goods. Non-homotheticity across sectors also shape the unequal gains from trade across consumers because sectors vary in their tradeability (e.g., food versus services) and in the substitutability across goods supplied by different exporters.

To quantify the unequal gains from trade, we need estimates of the elasticity of individual expenditure shares by sector and country of origin with respect to both prices and income. A salient feature of the model is that it delivers a sectoral non-homothetic gravity equation to estimate these key parameters from readily-available data on production and trade flows. The estimation identifies which countries produce high or low income-elastic goods by projecting budget shares within each sector on standard gravity forces (e.g., distance, border and common language) and a summary statistic of the importer's income distribution whose elasticity can vary across exporters.[2] Consistent with the existing empirical literature, such as Hallak and Schott (2011) and Feenstra and Romalis (2014), we find that richer countries export goods with higher income elasticities within sectors. The estimation also identifies the sectors whose goods are relatively more valued by

[1] For example, the model abstracts away from forces that would lead to distributional effects through changes in the earnings distribution, as well as differentiated exporters within sectors, firm heterogeneity, competitive effects, or input-output linkages. Future work could consider embedding the AIDS into models with a richer supply side.

[2] When non-homotheticities are shut down, the gravity equation in our model corresponds to the translog gravity equation estimated by Novy (2012) and Feenstra and Weinstein (2010).

rich consumers by projecting sectoral expenditure shares on a summary statistic of the importer's income distribution. Consistent with Hallak (2010), our results also suggest non-homotheticities not only across origin countries but also across sectors.

Using the estimated parameters, we apply the results from the theory to ask: who are the winners and losers of trade within countries, how large are the distributional effects, and what country characteristics are important to shape these effects? To answer these questions we perform the counterfactual exercise of increasing trade costs so that each country is brought from its current trade shares to autarky, and compute the gains from trade corresponding to each percentile of the income distribution in each country (i.e., the real income that would be lost by each percentile because of a shut down of trade).

We find a pro-poor bias of trade in every country. On average, the real income loss from closing off trade is 63 percent at the 10th percentile of the income distribution and 28 percent for the 90th percentile. This bias in the gains from trade toward poor consumers hinges on the fact that these consumers spend relatively more on sectors that are more traded, while high-income individuals consume relatively more services, which are among the least traded sectors. Additionally, low-income consumers happen to concentrate spending on sectors with a lower elasticity of substitution across source countries. Larger expenditures in more tradeable sectors and a lower rate of substitution between imports and domestic goods lead to larger gains from trade for the poor than the rich. While this pro-poor bias of trade is present in every country, there is heterogeneity in the difference between the gains from trade of poor and rich consumers across countries. In countries with a lower income elasticity of exports, the gains from trade tend to be less favorable for poor consumers because opening to trade causes an increase in the relative price of low-income elastic goods. Similar results appear in counterfactuals involving smaller changes in trade costs than a movement to autarky; for example, a small reduction in the cost of importing in the food or manufacturing sectors also exhibits a pro-poor bias. However, trade-cost reductions affecting only the service sectors (which are relatively high-income elastic) benefits the rich relatively more.

As we mentioned, our approach to measure welfare gains from trade using aggregate statistics is close to a recent literature that studies the aggregate welfare gains from trade summarized by Costinot and Rodriguez-Clare (2014). This literature confronts the challenge that price changes induced by trade costs are not commonly available by inferring them through the model structure from changes in trade shares.[3] These approaches are designed to measure only aggregate gains rather than distributional consequences.[4] In our setting, we exploit properties of a non-homothetic demand system that also allows us to infer changes in prices from trade shares and to trace out the welfare consequences of these price changes across different consumers within countries. We are motivated by the belief that an approach that is able to quantify the (potentially) unequal gains

[3]For example, autarky prices are rarely observed in data but under standard assumptions on preferences the autarky expenditure shares are generally known. The difference between autarky and observed trade shares can then be used to back out the price changes caused by a counterfactual movement to autarky.

[4]Two exceptions are Burstein and Vogel (2012) and Galle et al. (2014), which use aggregate trade data to estimate the effects of trade on the distribution of earnings.

from trade through the expenditure channel for many countries is useful in assessing the implications of trade, particularly because much of the public opposition towards increased openness stems from the belief that welfare changes are unevenly distributed.

Of course, we are not the first to allow for differences in income elasticities across goods in an international trade framework. Theoretical contributions to this literature including Markusen (1986), Flam and Helpman (1987) and Matsuyama (2000) develop models where richer countries specialize in high-income elastic goods through supply-side forces, while Fajgelbaum et al. (2011) study cross-country patterns of specialization that result from home market effects in vertically differentiated products. Recent papers by Hallak (2006), Fieler (2011), Caron et al. (2014) and Feenstra and Romalis (2014) find that richer countries export goods with higher income elasticity.[5] This role of non-homothetic demand and cross-country differences in the income elasticity of exports in explaining trade data is an important motivation for our focus on explaining the unequal gains from trade through the expenditure channel.

These theoretical and empirical studies use a variety of demand structures. To our knowledge, only a few studies have used the AIDS in the international trade literature: Feenstra and Reinsdorf (2000) show how prices and aggregate expenditures relate to the Divisia index in the AIDS and suggest that this demand system could be useful for welfare evaluation in a trade context, Feenstra (2010) works with a symmetric AIDS expenditure function to study the entry of new goods, and Chaudhuri et al. (2006) use the AIDS to determine the welfare consequences in India of enforcing the Agreement on Trade-Related Intellectual Property Rights.[6] Neary (2004) and Feenstra et al. (2009) use the AIDS for making aggregate real income comparisons across countries and over time using data from the International Comparison Project. Aguiar and Bils (2015) estimated an AIDS in the U.S. to measure inequality in total consumption expenditures from consumption patterns.

A few papers study the effect of trade on inequality through the expenditure channel. Porto (2006) studies the effect of price changes implied by a tariff reform on the distribution of welfare using consumer survey data from Argentina, Faber (2013) exploits Mexico's entry into NAFTA to study the effect of input tariff reductions on the price changes of final goods of different quality, and Atkin et al. (2015) studies the effect of foreign retailers on consumer prices in Mexico. While these papers utilize detailed microdata for specific countries in the context of major reforms, our approach provides a framework to quantify the unequal gains from trade across consumers over a large set of countries using aggregate trade and production data. Within our framework we are able to show theoretically how changes in trade costs map to the welfare changes of individuals in each point of the expenditure distribution, how to compute these effects using model parameters and aggregate statistics, and how to estimate the parameters from cross-country trade and production

[5] See also Schott (2004), Hallak and Schott (2011) and Khandelwal (2010) who provide evidence that richer countries export higher-quality goods, which typically have high income elasticity of demand. In this paper we abstract from quality differentiation within sectors, but note that our methodology could be implemented using disaggregated trade data where differences in the income elasticity of demand may be driven by differences in quality.

[6] If good-specific income elasticities are neutralized, the AIDS collapses to the homothetic translog demand system studied in an international trade context by Kee et al. (2008), Feenstra and Weinstein (2010), Arkolakis et al. (2010) and Novy (2012).

data.

There is of course a large literature that examines trade and inequality through the earnings channel. A dominant theme in this literature, as summarized by Goldberg and Pavcnik (2007), has been the poor performance of Stolper-Samuelson effects, which predict that trade increases the relative wages of low-skill workers in countries where these workers are relatively abundant, in rationalizing patterns from low-income countries.[7] We complement these and other studies that focus on the earnings channel by examining the implications of trade through the expenditure channel.

The remainder of the paper is divided into five sections. Section 2 uses standard consumer theory to derive generic expressions for the distribution of welfare changes across consumers, and applies these results to the AIDS. Section 3 embeds these results in a standard trade framework, derives the non-homothetic gravity equation, and provides the expressions to determine the gains from trade across consumers. Section 4 estimates the key elasticities from the gravity equation. Section 5 presents the results of counterfactuals that simulate foreign-trade cost shocks. Section 6 concludes.

2 Consumers

We start by deriving generic expressions for the distribution of welfare changes in response to price changes across consumers that vary in their total expenditures. We only use properties of demand implied by standard demand theory. In Section 3, we link these results to a standard model of trade in general equilibrium.

2.1 Definition of the Expenditure Channel

We study an economy with J goods for final consumption with price vector $\mathbf{p} = \{p_j\}_{j=1}^{J}$ taken as given by $h = 1, .., H$ consumers. Consumer h has indirect utility v_h and total expenditures x_h. We denote the indirect utility function by $v(x_h, \mathbf{p})$. We let $s_{j,h} \equiv s_j(x_h, \mathbf{p})$ be the share of good j in the total expenditures of individual h, and $S_j = \sum_h \left(\frac{x_h}{\sum_{h'} x_{h'}}\right) s_{j,h}$ be the share of good j in aggregate expenditures.

Consider the change in the log of indirect utility of consumer h due to infinitesimal changes in log-prices $\{\widehat{p}_j\}_{j=1}^{J}$ and in the log of the expenditure level $\widehat{x}_h$:[8]

$$\widehat{v}_h = \sum_{j=1}^{J} \frac{\partial \ln v(x_h, \mathbf{p})}{\partial \ln p_j} \widehat{p}_j + \frac{\partial \ln v(x_h, \mathbf{p})}{\partial \ln x_h} \widehat{x}_h. \tag{1}$$

The equivalent variation of consumer h associated with $\{\widehat{p}_j\}_{j=1}^{J}$ and $\widehat{x}_h$ is defined as the change in

[7]Several recent studies, such as Feenstra and Hanson (1996), Helpman et al. (2012), Brambilla et al. (2012), Frias et al. (2012), and Burstein et al. (2013) study different channels through which trade affects the distribution of earnings such as outsourcing, labor market frictions, quality upgrading, or capital-skill complementarity.

[8]Throughout the paper we use $\widehat{z} \equiv d\ln(z)$ to denote the infinitesimal change in the log of variable z.

log expenditures, $\widehat{\omega}_h$, that leads to the indirect utility change $\widehat{v}_h$ at constant prices:

$$\widehat{v}_h = \frac{\partial \ln v\left(x_h, \mathbf{p}\right)}{\partial \ln x_h} \widehat{\omega}_h. \tag{2}$$

Combining (1) and (2) and applying Roy's identity gives a well-known formula for the equivalent variation:[9]

$$\widehat{\omega}_h = \sum_{j=1}^{J} \left(-\widehat{p}_j\right) s_{j,h} + \widehat{x}_h. \tag{3}$$

The first term on the right-hand side of (3) is an expenditure-share weighted average of price changes. It represents what we refer to as the *expenditure effect*. It is the increase in the cost of living caused by a change in prices applied to the the pre-shock expenditure basket. Henceforth, we refer to $\widehat{\omega}_h$ as the welfare change of individual h, acknowledging that by this we mean the equivalent variation, expressed as share of the initial level of expenditures, associated with a change in prices or in the expenditure level of individual h.

To organize our discussion it is useful to rewrite (3) as follows:

$$\widehat{\omega}_h = \widehat{W} + \widehat{\psi}_h + \widehat{x}_h, \tag{4}$$

where

$$\widehat{W} \equiv \sum_{j=1}^{J} \left(-\widehat{p}_j\right) S_j, \tag{5}$$

is the *aggregate expenditure effect*, and

$$\widehat{\psi}_h \equiv \sum_{j=1}^{J} \left(-\widehat{p}_j\right) \left(s_{j,h} - S_j\right) \tag{6}$$

is the *individual expenditure effect* of consumer h.

The term $\widehat{W}$ is the welfare change through the expenditure channel that corresponds to every consumer either in the absence of within-country inequality or under homothetic preferences. It also corresponds to the welfare change through the cost of expenditures for a hypothetical representative consumer. In turn, the term $\widehat{\psi}_h$ captures that consumers may be differentially affected by the same price changes due to differences in the composition of their expenditure basket. It is different from zero for some consumers only if there is variation across consumers in how they allocate expenditure shares across goods. The focus of this paper is to study how international trade impacts the distribution $\left\{\widehat{\psi}_h\right\}_{h=1}^{H}$.

[9] See Theil (1975).

2.2 Almost-Ideal Demand

The Almost-Ideal Demand System (AIDS) introduced by Deaton and Muellbauer (1980a) belongs to the family of Log Price-Independent Generalized Preferences defined by Muellbauer (1975). The latter are defined by the indirect utility function

$$v(x_h, \mathbf{p}) = F\left[\left(\frac{x_h}{a(\mathbf{p})}\right)^{1/b(\mathbf{p})}\right], \tag{7}$$

where $a(\mathbf{p})$ and $b(\mathbf{p})$ are price aggregators and $F[\cdot]$ is a well-behaved increasing function. The AIDS is the special case that satisfies

$$a(\mathbf{p}) = \exp\left(\underline{\alpha} + \sum_{j=1}^{J}\alpha_j \ln p_j + \frac{1}{2}\sum_{j=1}^{J}\sum_{k=1}^{J}\gamma_{jk}\ln p_j \ln p_k\right), \tag{8}$$

$$b(\mathbf{p}) = \exp\left(\sum_{j=1}^{J}\beta_j \ln p_j\right), \tag{9}$$

where the parameters satisfy the restrictions $\sum_{j=1}^{J}\alpha_j = 1$, $\sum_{j=1}^{J}\beta_j = \sum_{j=1}^{J}\gamma_{jk} = 0$, and $\gamma_{jk} = \gamma_{kj}$ for all j, k.[10]

The first price aggregator, $a(\mathbf{p})$, has the form of a homothetic translog price index. It is independent from non-homotheticities and can be interpreted as the cost of a subsistence basket of goods. The second price aggregator, $b(\mathbf{p})$, captures the relative price of high-income elastic goods. For our purposes, a key feature of these preferences is that the larger is the consumer's expenditure level x_h relative to $a(\mathbf{p})$, the larger is the welfare gain from a reduction in the cost of high income-elastic goods, as captured by a reduction in $b(\mathbf{p})$. We refer to a and b as the homothetic and non-homothetic components of preferences, respectively.

Applying Shephard's Lemma to the indirect utility function defined by equations (7) to (9) generates an expenditure share in good j for individual h equal to:

$$s_j(\mathbf{p}, x_h) = \alpha_j + \sum_{k=1}^{J}\gamma_{jk}\ln p_k + \beta_j \ln\left(\frac{x_h}{a(\mathbf{p})}\right) \tag{10}$$

for $j = 1, \ldots, J$. We assume that (10) predicts non-negative expenditure shares for all goods and consumers, so that the non-negativity restriction is not binding. Since expenditure shares add up to one, this guarantees that expenditure shares are also smaller than one. We discuss how to incorporate this restriction in the empirical analysis in Section 4.

These expenditure shares have two features that suit our purposes. First, the elasticity with

[10] These parameter restrictions correspond to the adding up, homogeneity, and symmetry constraints implied by individual rationality, and ensure that the AIDS is a well-defined demand system. No direct-utility representation of the AIDS exists, but this poses no restriction for our purposes. See Deaton and Muellbauer (1980b).

respect to the expenditure level is allowed to be good-specific.[11] Goods for which $\beta_j > 0$ have positive income elasticity, while goods for which $\beta_j < 0$ have negative income elasticity.[12] Second, they admit aggregation: market-level behavior can be represented by the behavior of a representative consumer. The aggregate market share of good j is $S_j = s_j(\mathbf{p}, \widetilde{x})$, where $\widetilde{x}$ is an inequality-adjusted mean of the distribution of expenditures across consumers, $\widetilde{x} = \overline{x}e^{\Sigma}$, where $\overline{x} \equiv \mathbb{E}[x_h]$ is the mean and $\Sigma \equiv \mathbb{E}\left[\frac{x_h}{\overline{x}} \ln\left(\frac{x_h}{\overline{x}}\right)\right]$ is the Theil index of the expenditure distribution.[13] We can write the aggregate shares as

$$S_j = \alpha_j + \sum_{k=1}^{J} \gamma_{jk} \ln p_k + \beta_j y, \tag{11}$$

where $y = \ln(\tilde{x}/a(\mathbf{p}))$. Henceforth, we follow Deaton and Muellbauer (1980a) and refer to y as the adjusted "real" income.

2.3 The Individual Expenditure Effect with Almost-Ideal Demand

From (10) and (11), the difference in the budget shares of good j between a consumer with expenditure level x_h and the representative consumer is

$$s_{j,h} - S_j = \beta_j \ln\left(\frac{x_h}{\widetilde{x}}\right). \tag{12}$$

Consumers who are richer than the representative consumer have larger expenditure shares than the representative consumer in positive-β_j goods and lower shares in negative-β_j goods. Combining (12) with the individual expenditure effect defined in (6) we obtain

$$\widehat{\psi}_h = -\underbrace{\left(\sum_{j=1}^{J} \beta_j \widehat{p}_j\right)}_{=\hat{b}} \times \ln\left(\frac{x_h}{\widetilde{x}}\right), \tag{13}$$

where $\widehat{b}$ is the change in the log of the non-homothetic component $b(\mathbf{p})$. Note that $\widehat{b}/J$ equals the covariance between the good-specific income elasticities and the price changes.[14] A positive (negative) value of $\hat{b}$ reflects an increase in the relative prices of high- (low-) income elastic goods, leading to a relative welfare loss for rich (poor) consumers.

[11] We note that the AIDS restricts these elasticities to be constant, thus ruling out the possibility that demand peaks at intermediate levels of income. Several discrete-choice models of trade with vertically differentiated products, such Flam and Helpman (1987), Matsuyama (2000), or the multi-quality extension in Section VII of Fajgelbaum et al. (2011), feature non-monotonic income elasticities. Banks et al. (1997) and Lewbel and Pendakur (2009) develop extensions of the AIDS that allow for non-constant income elasticities.

[12] Note that γ's and β's are semi-elasticities since they relate expenditure shares to logs of prices and income, but we refer to them as elasticities to save notation. Note also that although we define x_h as the individual expenditure level, we follow standard terminology and refer to β_j as the income elasticity of the expenditure share in good j.

[13] The Theil index is a measure of inequality which takes the minimum $\Sigma = 0$ if the distribution is concentrated at a single point. In the case of a lognormal expenditure distribution with variance σ^2, it is $\Sigma = \frac{1}{2}\sigma^2$.

[14] I.e., $\mathbb{COV}(\{\beta_j\}, \widehat{p}_j) \equiv \frac{1}{J}\sum_j \left(\beta_j - \frac{1}{J}\sum_{j'} \beta_{j'}\right)\left(p_j - \frac{1}{J}\sum_{j'} p_{j'}\right) = \sum_{j=1}^{J} \widehat{p}_j \beta_j$, where the last equality follows from the fact that the elasticities $\{\beta_j\}$ add up to zero.

Collecting terms, the welfare change of consumer h is

$$\widehat{\omega}_h = \widehat{W} - \widehat{b} \times \ln\left(\frac{x_h}{\widetilde{x}}\right) + \widehat{x}_h. \tag{14}$$

Given a distribution of expenditure levels x_h across consumers, this expression generates the distribution of welfare changes in the economy through the expenditure channel.

A useful property of this structure is that the terms $\left\{\widehat{W}, \widehat{b}\right\}$ can be expressed as a function of demand parameters and aggregate statistics. Intuitively, these terms are simply weighted averages of price changes which can be expressed as a function of changes in aggregate expenditure shares and in the change in adjusted real income y after inverting the aggregate demand system in (11).

Let $\left\{\mathbf{S}, \widehat{\mathbf{S}}\right\}$ be vectors with the levels and changes in aggregate expenditure shares, S_j and $\hat{S}_j$. We also collect the parameters α_j and β_j in the vectors $\{\boldsymbol{\alpha}, \boldsymbol{\beta}\}$ and define $\boldsymbol{\Gamma}$ as the matrix with element γ_{jk} in row j, column k. With this notation, the demand system is characterized by the parameters $\{\underline{\alpha}, \boldsymbol{\alpha}, \boldsymbol{\beta}, \boldsymbol{\Gamma}\}$. We choose an arbitrary good n as the numeraire and assume that expenditure levels are expressed in units of this good. Excluding good n from the demand system, the aggregate expenditure shares in (11) are represented by

$$\mathbf{S_{-n}} = \boldsymbol{\alpha_{-n}} + \boldsymbol{\Gamma_{-n}} \ln \mathbf{p_{-n}} + \boldsymbol{\beta_{-n}} y, \tag{15}$$

where $\mathbf{S_{-n}}$ is a vector with all expenditure shares but the numeraire and $\boldsymbol{\Gamma_{-n}}$ denotes that the n^{th} row and the n^{th} column are excluded from $\boldsymbol{\Gamma}$. We write the change in aggregate expenditure shares from (15) as $\mathbf{dS_{-n}} = \boldsymbol{\Gamma_{-n}} \widehat{\mathbf{p}}_{\mathbf{-n}} + \boldsymbol{\beta_{-n}} dy$ and express the vector of relative price changes as

$$\widehat{\mathbf{p}}_{\mathbf{-n}} = \boldsymbol{\Gamma_{-n}^{-1}} \left(\mathbf{dS_{-n}} - \boldsymbol{\beta_{-n}} dy\right). \tag{16}$$

Combining with the definition of the aggregate and the individual expenditure effects from (5) and (6) yields

$$\widehat{W} = -\mathbf{S}'_{\mathbf{-n}} \boldsymbol{\Gamma_{-n}^{-1}} \left(\mathbf{dS_{-n}} - \boldsymbol{\beta_{-n}} dy\right), \tag{17}$$

$$\widehat{b} = -\boldsymbol{\beta'_{-n}} \boldsymbol{\Gamma_{-n}^{-1}} \left(\mathbf{dS_{-n}} - \boldsymbol{\beta_{-n}} dy\right). \tag{18}$$

These expressions show $\widehat{W}$ and $\widehat{b}$ as functions of levels and changes in aggregate shares, the substitution parameters γ_{jk}, the income-elasticity parameters β_j, and the change in adjusted real income, dy. Additionally, using that $dy = \widehat{\widetilde{x}} - \widehat{a}$ and Shephard's Lemma allows us to also express dy as follows:[15]

$$dy = \frac{\widehat{\widetilde{x}} - \left[\mathbf{S_{-n}}' - y\boldsymbol{\beta'_{-n}}\right] \boldsymbol{\Gamma_{-n}^{-1}} \mathbf{dS_{-n}}}{1 - \left[\mathbf{S_{-n}}' - y\boldsymbol{\beta'_{-n}}\right] \boldsymbol{\Gamma_{-n}^{-1}} \boldsymbol{\beta_{-n}}}. \tag{19}$$

Equations (17) to (19) allow us to express the aggregate and individual expenditure effects as

[15] To derive (19) we use that $\widehat{a} \equiv \frac{\partial \ln a}{\partial \ln \mathbf{p'_{-n}}} \widehat{\mathbf{p}}_{\mathbf{-n}} = \left[\mathbf{S_{-n}}' - \mathbf{y}\boldsymbol{\beta'_{-n}}\right] \widehat{\mathbf{p}}_{\mathbf{-n}}$, where the second line follows from Shephard's Lemma. Replacing $\widehat{\mathbf{p}}_{\mathbf{-n}}$ from (16) into this expression, using that $dy = \widehat{\widetilde{x}} - \hat{a}$ and solving for dy yields (19).

function of the level and changes in aggregate expenditure shares, the parameters $\{\beta_j\}, \{\gamma_{jk}\}$, the initial level of adjusted real income, y, and the change in income of the representative consumer, $\widehat{\bar{x}}$. These formulas correspond to infinitesimal welfare changes and can be used to compute a first-order approximation to the exact welfare change corresponding to a discrete set of price changes.[16]

In deriving this result, we have not specified the supply-side of the economy, and we have allowed for arbitrary changes in the distribution of individual expenditure levels, $\{\widehat{x}_h\}$. These demand-side expressions can be embedded in different supply-side structures to study the welfare changes associated with specific counterfactuals. In the next section, we embed them in a model of international trade to compute the welfare effects caused by changes in trade costs as function of observed expenditure shares.

3 International Trade Framework

We embed the results from the previous section in an Armington trade model. Section 3.1 develops a multi-sector Armington model with Almost-Ideal preferences and within-country income heterogeneity in Section . Section 3.2 derives the non-homothetic gravity equation implied by the framework. Section 3.3 presents expressions for the welfare changes across households resulting from foreign shocks.

3.1 Multi-Sector Model

The world economy consists of N countries, indexed by n as importer and i as exporter. Each country specializes in the production of a different variety within each sector $s = 1, .., S$, so that there are $J = N \times S$ varieties, each defined by a sector-origin dyad. These varieties are demanded at different income elasticities. For example, expenditure shares on textiles from India may decrease with individual income, while shares on U.S. textiles may increase with income. We let p_{ni}^s be the price in country n of the goods in sector s imported from country i, and $\mathbf{p}_n$ be the price vector in country n. The iceberg trade cost of exporting from i to n in sector s is τ_{ni}^s. Perfect competition implies that $p_{ni}^s = \tau_{ni}^s p_{ii}^s$.

Labor is the only factor of production. Country n has constant labor productivity Z_n^s in sector s. Assuming that every country has positive production in every sector, the wage per effective unit of labor in country n is $w_n = p_{nn}^s Z_n^s$ for all $s = 1, .., S$, and an individual h in country i with z_h effective units of labor receives income of $x_h = z_h \times w_n$. Each country is characterized by a mean $\bar{z}_n$ and a Theil index Σ_n of its distribution of effective units of labor across the workforce. Therefore, the income distribution has mean $\bar{x}_n = w_n \bar{z}_n$ and Theil index Σ_i. Income equals expenditure at the individual level (and we use these terms interchangeably) and also at the aggregate level due to balanced trade.

[16]In assuming that the changes in prices are small, we have not allowed for the possibility that consumers drop varieties in response to the price changes. When we measure the welfare losses from moving to autarky in the international trade setup we account for this possibility.

We assume Almost-Ideal Demand and reformulate the aggregate expenditure share equation (11) in this context. Let X_{ni}^s be the value of exports from exporter i to importer n in sector s, and let Y_n be the total income of the importer. The share of aggregate expenditures in country n devoted to goods from country i in sector s is

$$S_{ni}^s = \frac{X_{ni}^s}{Y_n} = \alpha_{ni}^s + \sum_{s'=1}^{S} \sum_{i'=1}^{N} \gamma_{ii'}^{ss'} \ln p_{ni'}^{s'} + \beta_i^s y_n, \tag{20}$$

where $a_n = a(\mathbf{p}_n)$ is the homothetic component of the price index (8) in country n and $y_n = \ln(\bar{x}_n/a_n) + \Sigma_n$ is the adjusted real income of the economy. The income elasticity β_i^s is allowed to vary across both sectors and exporters. The richer is the importing country (higher $\bar{x}_n$) or the more unequal it is (higher Σ_n), the larger is its expenditure share in varieties with positive income elasticity, $\beta_i^s > 0$. In turn, the parameter α_{in}^s may vary across exporters, sectors, and importers, and it captures the overall taste in country n for the goods exported by country i in sector s independently from prices or income in the importer. These coefficients must satisfy $\sum_{i=1}^N \sum_{s=1}^S \beta_i^s = 0$ and $\sum_{i=1}^N \sum_{s=1}^S \alpha_{ni}^s = 1$ for all $n = 1, \ldots, N$.

The coefficient $\gamma_{ii'}^{ss'}$ is the semi-elasticity of the expenditure share in good (i, s) with respect to the price of good (i', s'). We assume no cross-substitution between goods in different sectors ($\gamma_{ii'}^{ss'} = 0$ if $i \neq i'$) and, within each sector s, we assume the same elasticity between goods from different sources ($\gamma_{ii'}^{ss}$ is the same for all $i' \neq i$ for each s, but allowed to vary across s). Formally,

$$\gamma_{ii'}^{ss'} = \begin{cases} -\left(1 - \frac{1}{N}\right)\gamma^s & \text{if } s = s' \text{and } i = i', \\ \frac{\gamma^s}{N} & \text{if } s = s' \text{and } i \neq i', \\ 0 & \text{if } s \neq s'. \end{cases} \tag{21}$$

This structure on the elasticities is convenient because it simplifies the algebra, but it is not necessary to reach analytic results.[17] It allows us to cast a demand system that looks similar to a two-tier demand system (across sectors in the upper tier and across origins within each sector in the lower tier) and to relate it to homothetic multi-sector gravity models.[18]

Using (21), the expenditure share in goods from origin country i in sector s can be simplified to

$$S_{ni}^s = \alpha_{ni}^s - \gamma^s \left[\ln(p_{ni}^s) - \frac{1}{N} \sum_{i'=1}^{N} \ln p_{ni'}^s \right] + \beta_i^s y_n. \tag{22}$$

[17] The normalization by N in (21) only serves the purpose of easing the notation in following derivations.

[18] This nesting is a standard approach to the demand structure in multi-sector trade models. For example, see Feenstra and Romalis (2014) or Costinot and Rodriguez-Clare (2014). Imposing symmetry within sectors also allows us to compare results to estimates of gravity equations derived under a translog demand system from the literature (see below).

The corresponding expenditure share for consumer h in goods from country n in sector s is

$$s^s_{ni,h} = \alpha^s_{ni} - \gamma^s \left[\ln \left(p^s_{ni} \right) - \frac{1}{N} \sum_{i'=1}^{N} \ln p^s_{ni'} \right] + \beta^s_i \left(\ln \left(\frac{x_h}{\tilde{x}_n} \right) + y_n \right). \tag{23}$$

Adding up (22) across exporters, the share of sector s in the total expenditures of country n is:

$$S^s_n = \sum_{i=1}^{N} S^s_{ni} = \overline{\alpha}^s_n + \overline{\beta}^s y_n, \tag{24}$$

where

$$\overline{\alpha}^s_n = \sum_{i=1}^{N} \alpha^s_{ni},$$
$$\overline{\beta}^s = \sum_{i=1}^{N} \beta^s_i.$$

In turn, the share of sector s in total expenditures of consumer h is

$$s^s_{n,h} = \sum_{i=1}^{N} s^s_{ni,h} = \overline{\alpha}^s_n + \overline{\beta}^s \left(y_n + \ln \left(\frac{x_h}{\tilde{x}_n} \right) \right). \tag{25}$$

Equations (24) and (25) show that the expenditure shares across sectors have an "extended Cobb-Douglas" form, which allows for non-homotheticities across sectors through $\overline{\beta}^s$ on top of the fixed expenditure share $\overline{\alpha}^s_n$. We refer to $\overline{\beta}^s$ in (24) as the "sectoral betas".[19]

3.2 Non-Homothetic Gravity Equation

The model yields a sectoral non-homothetic gravity equation that depends on aggregate data and the demand parameters. These parameters are the elasticity of substitution γ^s across exporters in sector s and the income elasticity of the goods supplied by each exporter in each sector, $\{\beta^s_n\}$. Combining (22) and the definition of y_n gives

$$\frac{X^s_{ni}}{Y_n} = \alpha^s_{ni} - \gamma^s \ln \left(\frac{\tau^s_{ni} p^s_{ii}}{\bar{\tau}^s_n \bar{p}^s} \right) + \beta^s_i \left[\ln \left(\frac{\bar{x}_n}{a\left(\mathbf{p}_n\right)} \right) + \Sigma_n \right], \tag{26}$$

where

$$\bar{\tau}^s_n = \exp \left(\frac{1}{N} \sum_{i=1}^{N} \ln \left(\tau^s_{ni} \right) \right)$$

[19] If $\overline{\beta}^s = 0$ for all s (so that non-homotheticities across sectors are shut down), sectoral shares by importer are constant at $S^s_n = \overline{\alpha}^s_n$, as it would be the case with Cobb-Douglas demand across sectors.

and

$$\bar{p}^s = \exp\left(\frac{1}{N}\sum_{i=1}^{N}\ln\left(p_{ii}^s\right)\right).$$

Income of each exporter i in sector s equals the sum of sales to every country, $Y_i^s = \sum_{n=1}^{N} X_{ni}^s$. Using this condition and (26) we can solve for $\gamma^s \ln\left(p_{ii}^s/\bar{p}^s\right)$. Replacing this term back into (26), import shares in country n can be expressed in the gravity form:

$$\frac{X_{ni}^s}{Y_n} = A_{ni}^s + \frac{Y_i^s}{Y_W} - \gamma^s T_{ni}^s + \beta_i^s \Omega_n, \tag{27}$$

where $Y_W = \sum_{i=1}^{I} Y_i$ stands for world income, and where

$$A_{ni}^s = \alpha_{ni}^s - \sum_{n'=1}^{N}\left(\frac{Y_{n'}}{Y_W}\right)\alpha_{n'i}^s, \tag{28}$$

$$T_{ni}^s = \ln\left(\frac{\tau_{ni}^s}{\bar{\tau}_n^s}\right) - \sum_{n'=1}^{N}\left(\frac{Y_{n'}}{Y_W}\right)\ln\left(\frac{\tau_{n'i}^s}{\bar{\tau}_{n'}^s}\right), \tag{29}$$

$$\Omega_n = \left[\ln\left(\frac{\bar{x}_n}{a_n}\right) + \Sigma_n\right] - \sum_{n'=1}^{N}\left(\frac{Y_{n'}}{Y_W}\right)\left[\ln\left(\frac{\bar{x}_{n'}}{a_{n'}}\right) + \Sigma_{n'}\right]. \tag{30}$$

The first term in (27), A_{ni}^s, captures cross-country differences in tastes across sectors or exporters; this term vanishes if α_{ni}^s is constant across importers n. The second term, Y_i^s/Y_W, captures relative size of the exporter due to, for example, high productivity relative to other countries. The third term, T_{ni}^s, measures both bilateral trade costs and multilateral resistance (i.e., the cost of exporting to third countries).

The last term in (27), $\beta_i^s \Omega_n$, is the non-homothetic component of the gravity equation. It includes the good-specific Engel curves needed to measure the unequal gains from trade across consumers. This term captures the "mismatch" between the income elasticity of the exporter and the income distribution of the importer. The larger Ω_n is, either because average income or inequality in the importing country n are high relative to the rest of the world, the higher is the share of expenditures devoted to goods in sector s from country i when i sells high income-elastic goods ($\beta_i^s > 0$). If non-homotheticities are shut down, this last terms disappears and the gravity equation in (27) becomes the translog gravity equation.

3.3 Distributional Impact of a Foreign-Trade Shock

Using the results from Section 2, we derive the welfare impacts of a foreign-trade shock across the expenditure distribution. Without loss of generality we normalize the wage in country n to 1, $w_n = 1$. Consider a foreign shock to this country consisting of an infinitesimal change in foreign productivities, foreign endowments or trade costs between any country pair. From the perspective of an individual consumer h in country n, this shock affects welfare through the price changes

$\{\widehat{p}^s_{ni}\}_{i,s}$ and the income change $\widehat{x}_h$. From (21) and (22), the change in the price of imported relative to own varieties satisfies:

$$\widehat{p}^s_{ni} - \widehat{p}^s_{nn} = -\frac{dS^s_{ni} - dS^s_{nn}}{\gamma^s} + \frac{1}{\gamma^s}\left(\beta^s_i - \beta^s_n\right) dy_n. \tag{31}$$

Because only foreign shocks are present, the change in income $\widehat{x}_h$ is the same for all consumers and equal to the change in the price of domestic commodities, $\widehat{x}_h = \widehat{\widetilde{x}} = \widehat{p}^s_{nn} = 0$ for all h in country N and for all $s = 1, .., S$.[20] Imposing these restrictions, we can re-write (17) as

$$\widehat{W}_n \equiv \widehat{W}_{H,n} + \widehat{W}_{NH,n}, \tag{32}$$

where

$$\widehat{W}_{H,n} = \sum_{s=1}^{S}\sum_{i=1}^{N} \frac{1}{\gamma^s} S^s_{ni}\left(dS^s_{ni} - dS^s_{nn}\right), \tag{33}$$

$$\widehat{W}_{NH,n} = \sum_{s=1}^{S}\sum_{i=1}^{N} \frac{1}{\gamma^s} S^s_{ni}\left(\beta^s_n - \beta^s_i\right) dy_n. \tag{34}$$

Using these restrictions, we can also rewrite the slope of the individual effect in (18) as

$$\widehat{b}_n = \sum_{s=1}^{S}\sum_{i=1}^{N} \frac{\beta^s_i}{\gamma^s}\left(dS^s_{nn} - dS^s_{ni} + \left(\beta^s_i - \beta^s_n\right) dy_n\right), \tag{35}$$

and the change in the adjusted real income from equation (19) as

$$dy_n = \frac{\sum_{s=1}^{S}\sum_{i=1}^{N} \frac{1}{\gamma^s}\left(S^s_{ni} - \beta^s_{ni} y_n\right)\left(dS^s_{ni} - dS^s_{nn}\right)}{1 - \sum_{s=1}^{S}\sum_{i=1}^{N} \frac{1}{\gamma^s}\left(S^s_{ni} - \beta^s_i y_n\right)\left(\beta^s_n - \beta^s_i\right)}. \tag{36}$$

Expressions (32) to (36) provide a closed-form characterization of the welfare effects of a foreign-trade shock that includes three novel margins. First, preferences are non-homothetic with good-specific income elasticities. Second, the formulas accommodate within-country inequality through the Theil index of expenditure distribution Σ_n, which enters through the level of y_n. Third, and key for our purposes, the expressions characterize the welfare change experienced by individuals at each income level, so that the entire distribution of welfare changes across consumers h in country n can be computed from (14) using:

$$\widehat{\omega}_h = \widehat{W}_n - \widehat{b}_n \times \ln\left(\frac{x_h}{\widetilde{x}}\right). \tag{37}$$

The aggregate expenditure effect, $\widehat{W}_n$, includes a homothetic part $\widehat{W}_{H,n}$ independent from the β^s_n's. When non-homotheticities are shut down, this term corresponds to the aggregate gains under

[20] Note that because of the Ricardian supply-side specification there is no change in the relative price across domestic goods or in relative incomes across consumers.

translog demand.[21] The aggregate effect also includes and a non-homothetic part, $\widehat{W}_{NH,n}$, which adjusts for the country's pattern of specialization in high- or low-income elastic goods and for the change in adjusted real income.

The key term for measuring unequal welfare effects is the change in the non-homothetic component $\widehat{b}_n$. As we have established, $\widehat{b}_n < 0$ implies a decrease in the relative price of high income-elastic goods, which favors high-income consumers. To develop an intuition for how observed trade shares and parameters map to $\widehat{b}_n$, consider the single-sector version of the model. Setting $S = 1$ and omitting the s superscript from every variable, equation (35) can be written as

$$\widehat{b}_n = \frac{1}{\gamma}\left(\sigma_\beta^2 dy_n - d\bar{\beta}_n\right), \tag{38}$$

where $\sigma_\beta^2 = \sum_{i=1}^N \beta_i^2$, and where

$$\bar{\beta}_n = \sum_{i=1}^N \beta_i S_{ni}. \tag{39}$$

The parameter σ_β^2 is proportional to the variance of the β_n's and captures the strength of non-homotheticities across goods from different origins. The term $\bar{\beta}_n$ is proportional to the covariance between the S_{ni}'s and the β_i's, and measures the bias in the composition of aggregate expenditure shares of country i towards goods from high-β exporters. The larger is $\bar{\beta}_n$, the relatively more economy n spends in goods that are preferred by high-income consumers. Suppose that $d\bar{\beta}_n > 0$, i.e., a movement of aggregate trade shares towards high-β_i exporters; if $\gamma > 0$ and the aggregate real income of the economy stays constant ($dy_n = 0$), this implies a reduction in the relative price of imports from high-β_i exporters, and a positive welfare impact on consumers who are richer than the representative consumer.[22]

Equations (32) to (36) express changes in individual welfare as the equivalent variation of a consumer that corresponds to an infinitesimal change in prices caused by foreign shocks. To obtain the exact change in real income experienced by an individual with expenditure level x_h in country n between an initial scenario under trade (tr) and a counterfactual scenario (cf) we integrate (37),[23]

$$\omega_{n,h}^{tr\to cf} = \left(\frac{W_n^{cf}}{W_n^{tr}}\right)\left(\frac{x_h}{\tilde{x}_n}\right)^{-\ln\left(b_n^{cf}/b_n^{tr}\right)}, \tag{40}$$

where W_n^{cf}/W_n^{tr} and b_n^{cf}/b_n^{tr} correspond to integrating (32) to (36) between the expenditure shares

[21] Feenstra and Weinstein (2010) measures the aggregate gains from trade in the U.S. under translog preferences in a context with competitive effects, and Arkolakis et al. (2010) study the aggregate gains from trade with competitive effects under homothetic translog demand and Pareto distribution of productivity. The AIDS nests the demand systems in these papers, but we abstract from competitive effects. With a single sector, the translog term in (33) becomes $\widehat{W}_{H,n} = \sum_{i=1}^N \frac{1}{\gamma} S_{ni}\left(dS_{ni} - dS_{nn}\right)$. Under CES preferences with elasticity σ, the equivalent term is $\frac{1}{1-\sigma}\widehat{S}_{nn}$, which depends on just the own trade share. See Arkolakis et al. (2012).

[22] At the same time, keeping prices constant, $dy_n > 0$ would imply a movement of aggregate shares to high-β_i exporters ($d\bar{\beta}_n > 0$). Therefore, conditioning on $d\bar{\beta}_n$, a larger dy_n implies an increase in the relative price of high-income elastic goods.

[23] An expression similar to (40) appears in Feenstra et al. (2009).

in the initial and counterfactual scenarios. If $\omega_{n,h}^{tr\to cf} < 1$, individual h is willing to pay a fraction $1 - \omega_{n,h}^{tr\to cf}$ of her income in the initial trade scenario to avoid the movement to the counterfactual scenario.

In Section 5 we perform the counterfactual experiment of bringing each country to autarky, and also simulate partial changes in the trade costs. In each case, we compute (40) using the changes in expenditure shares that take place between the observed and counterfactual scenarios. For that, we need the income elasticities $\{\beta_n^s\}$ and the substitution parameters $\{\gamma^s\}$. The next section explains the estimation of the gravity equation to obtain these parameters.

4 Estimation of the Gravity Equation

In this section, we estimate the non-homothetic gravity derived in Section 3.[24] Section 4.1 describes the data, and Section 4.2 presents the estimation results.

4.1 Data

To estimate the non-homothetic gravity equation we use data compiled by World Input-Output Database (WIOD). The database records bilateral trade flows and production data by sector for 40 countries (27 European countries and 13 other large countries) across 35 sectors that cover food, manufacturing and services (we take an average of flows between 2005-2007 to smooth out annual shocks). The data record total expenditures by sector and country of origin, as well as final consumption; we use total expenditures as the baseline and report robustness checks that restrict attention to final consumption. We obtain bilateral distance, common language and border information from CEPII's *Gravity* database. Price levels, adjusted for cross-country quality variation, are obtained from Feenstra and Romalis (2014). Income per capita and population are from the Penn World Tables, and we obtain gini coefficients from the World Income Inequality Database (Version 2.0c, 2008) published by the World Institute for Development Research.[25]

The left-hand-side of (27), $\frac{X_{ni}^s}{Y_i}$, can be directly measured using the data from sector s and exporter i's share in country n's expenditures. Similarly, we use country i's sales in sector s to construct $\frac{Y_i^s}{Y_W}$.

The term T_{ni}^s in (27) captures bilateral trade costs between exporter i and importer n in sector s relative to the world. Direct measures of bilateral trade costs across countries are unavailable so we proxy them with bilateral observables. Specifically we assume $\tau_{ni}^s = d_{ni}^{\rho^s} \Pi_j g_{j,ni}^{-\delta_j^s} \tilde{\epsilon}_{ni}^s$, where d_{ni} stands for distance, ρ^s reflects the elasticity between distance and trade costs in sector s, the g's

[24]In principle, one could obtain the parameters from other data sources, such as household surveys, that record consumption variation across households within countries. We have chosen to use cross-country data because it is internally consistent within our framework, and it is a common approach taken in the literature. In Section 5.4, we explore results that use parameters estimated from the U.S. consumption expenditure microdata.

[25]The World Income Inequality Database provides gini coefficients from both expenditure and income data. Ideally, we would use ginis from only the expenditure data, but this is not always available for some countries during certain time periods. We construct a country's average gini using the available data between 2001-2006.

are other gravity variables (common border and common language),[26] and $\tilde{\epsilon}^s_{ni}$ is an unobserved component of the trade cost between i and n in sector s.[27] This allows us to re-write the gravity equation as

$$\frac{X^s_{ni}}{Y_n} = A^s_{ni} + \frac{Y^s_i}{Y_W} - (\gamma^s \rho^s) D_{ni} + \sum_j \left(\gamma^s \delta^s_j\right) G_{j,ni} + \beta^s_i \Omega_n + \epsilon^s_{ni}, \tag{41}$$

where, letting $\bar{d}_n = \frac{1}{N} \sum_{i=1}^N \ln(d_{ni})$,

$$D_{ni} = \ln\left(\frac{d_{ni}}{\bar{d}_n}\right) - \sum_{n'=1}^N \left(\frac{Y_{n'}}{Y_W}\right) \ln\left(\frac{d_{n'i}}{\bar{d}_{n'}}\right). \tag{42}$$

and where $G_{j,ni}$ is defined in the same way as 42 but with $g_{j,ni}$ instead of d_{ni}.[28] As seen from (45), because we do not directly observe trade costs we cannot separately identify γ^s and ρ^s. Following Novy (2012) we set $\rho^s = \rho = 0.177$ for all s.[29]

The term Ω_n in (41) captures importer n's inequality-adjusted real income relative to the world. To construct this variable, we assume that the distribution of efficiency units in each country n is log-normal, $\ln z_h \sim \mathcal{N}\left(\mu_n, \sigma^2_n\right)$. This implies a log-normal distribution of expenditures with Theil index equal to $\sigma^2_n/2$ where $\sigma^2_n = 2\left[\Phi^{-1}\left(\frac{gini_n+1}{2}\right)\right]^2$. We construct $\bar{x}_n$ from total expenditure and total population of country n. We follow Deaton and Muellbauer (1980a), and more recently Atkin (2013), to proxy the homothetic component a_n with a Stone index, for which we use $a_n = \sum_i S_{ni} \ln(p_{nn} d^\rho_{ni})$, where p_{nn} are the quality-adjusted prices estimated by Feenstra and Romalis (2014). The obvious advantage of this approach is that it avoids the estimation of the α^s_{ni}, which enter the gravity specification non-linearly and are not required for our welfare calculations. The measure of real spending per capita divided by the Stone price index, $\bar{x}_i/a_i$, is strongly correlated with countries' real income per capita; this suggests that Ω_i indeed captures the relative difference in real income across countries.

To measure A^s_{ni}, we decompose α^s_{ni} into an exporter effect α_i, a sector-specific effect α^s, and an importer-specific taste for each sector ε^s_n:

$$\alpha^s_{ni} = \alpha_i \left(\alpha^s + \varepsilon^s_n\right). \tag{43}$$

We further impose the restriction $\sum_{i=1}^N \alpha_i = 1$. Under the assumption (43), the sectoral expenditure

[26]Since bilateral distance is measured between the largest cities in each country using population as weights, it is defined when $i = n$; see Mayer and Zignago (2011). Note that we parametrize trade costs such that a positive effect of common language and common border on trade is reflected in $\delta^s_j > 0$.

[27]Waugh (2010) includes exporter effects in the trade-cost specification. The gravity equation (27) would be unchanged in this case because the exporter effect would wash out from T^s_{ni} in (29).

[28]From the structure of trade costs it follows that the error term is $\epsilon^s_{ni} = -\gamma^s \left(\ln\left(\frac{\tilde{\epsilon}^s_{ni}}{\overline{\tilde{\epsilon}^s_n}}\right) - \sum_{n'=1}^N \left(\frac{Y_{n'}}{Y_W}\right) \ln\left(\frac{\tilde{\epsilon}^s_{n'i}}{\overline{\tilde{\epsilon}^s_{n'}}}\right)\right)$ where $\overline{\tilde{\epsilon}^s_n} = \exp\left(\frac{1}{N}\sum_{n'=1}^N \ln\left(\tilde{\epsilon}^s_{n'i}\right)\right)$.

[29]Below we explore the sensitivity of the results to alternative values of this parameter.

shares from the upper-tier equation (24) becomes:

$$S_n^s = \alpha^s + \overline{\beta}^s y_n + \varepsilon_n^s. \tag{44}$$

This equation is an Engel curve that projects expenditure shares on the adjusted real income.[30] Specifically, it regresses sector expenditure shares on sector dummies and the importer's adjusted real income interacted with sector dummies. The interaction coefficients will have the structural interpretation as the sectoral betas $\overline{\beta}^s$.[31] Using (28), (43), and (44) we can write $A_{ni}^s = \alpha_i \left(S_n^s - S_W^s - \overline{\beta}^s \Omega_n \right)$, where S_W^s is the share of sector s in world expenditures. Combining this with the gravity equation in (41), we reach the following estimating equation:

$$\frac{X_{ni}^s}{Y_n} = \frac{Y_i^s}{Y_W} + \alpha_i \left(S_n^s - S_W^s \right) - \left(\gamma^s \rho^s \right) D_{ni} + \sum_j \left(\gamma^s \delta_j^s \right) G_{j,ni} + \left(\beta_i^s - \alpha_i \bar{\beta}^s \right) \Omega_n + \epsilon_{ni}^s, \tag{45}$$

The gravity equation (45) identifies $\left(\beta_i^s - \alpha_i \bar{\beta}^s \right)$ using the variation in Ω_n across importers for each exporter. Using the $\bar{\beta}^s$ estimated from the sectoral Engel curve in (44) and the α_i estimated from (45) we can recover the β_i^s (which is needed to perform the counterfactuals). Since the market shares sum to one for each importer, it is guaranteed that $\sum_i \sum_s \beta_i^s = 0$ in the estimation, as the theory requires. We cluster the estimation at the importer level to allow for correlation in the errors across exporters.

The sectoral gravity equation aggregates to the gravity equation of a single-sector model. Summing (45) across sectors s gives the total expenditure share dedicated to goods from i in the importing country n,

$$\frac{X_{ni}}{Y_n} = \frac{Y_i}{Y_W} - \left(\gamma \rho \right) D_{ni} + \sum_j \left(\gamma \delta_j \right) G_{j,ni} + \beta_i \Omega_n + \epsilon_{ni}, \tag{46}$$

where $\gamma \rho \equiv \sum_{s=1}^S \gamma^s \rho^s$, $\beta_i \equiv \sum_{s=1}^S \beta_i^s$, and $\epsilon_{ni} \equiv \sum_{s=1}^S \epsilon_{ni}^s$. We can readily identify (46) as the gravity equation that would arise in a single-sector model ($S = 1$). Thus, summing our estimates on the gravity terms from (45) will match the gravity coefficients from a single-sector model. Likewise, the sum of the sector-specific income elasticities by exporter $\sum_s \beta_i^s$ estimated from (45) matches the income elasticity β_i estimated from (46).

[30] Note that sectoral shares in value added and efficiency units are allowed to vary independently from expenditure shares depending on the distribution of sectoral productivities Z_n^s and trade patterns. The sectoral productivities are not estimated and are not needed to perform the counterfactuals.

[31] The term ε_i^s captures cross-country differences in tastes across sectors that are not explained by differences in income or inequality levels. As in Costinot et al. (2012) or Caliendo and Parro (2012), this flexibility is needed for the model to match sectoral shares by importer. This approach to measuring taste differences is also in the spirit of Atkin (2013), who attributes regional differences in tastes to variation in demand that is not captured by observables.

4.2 Estimation Results

We begin by estimating the single-sector gravity model in equation (46). This regression aggregates across the sectors in the data, and as illustrated in (46), the baseline multi-sector gravity equation aggregates exactly to this single-sector gravity equation. The results are reported in Table 1. Consistent with the literature, we find that bilateral distance reduces trade flows between countries, which is captured by the statistically significant coefficient on D_{ni}. Under the assumption that $\rho = 0.177$, the estimate implies $\gamma = 0.24$ (=.043/.177).[32] The additional trade costs–common language and a contiguous border term–also have the intuitive signs.

The table also reports estimates of the 40 β_i parameters, one corresponding to each exporter, in the subsequent rows. The exporters with the highest β's are the U.S. and Japan, while Indonesia and India have the lowest β's. This means that U.S. and Japan export goods that are preferred by richer consumers, while the latter export goods that are preferred by poorer consumers. To visualize the β's, we plot them against the per capita income in Figure 1. The relationship is strongly positive and statistically significant. We emphasize that this relationship is *not* imposed by the estimation. Rather, these coefficients reflect that richer countries are more likely to spend on products from richer countries, conditional on trade costs. We also note that the β's are fully flexible, which is why the coefficients are often not statistically significant, but the null hypothesis that all income elasticities are zero is rejected.[33] Moreover, the finding that a subset are statistically significant is sufficient to reject homothetic preferences in the data, and is consistent with the existing literature who finds that richer countries export goods with higher income elasticities.[34]

We next report the results for the multi-sector estimation. As noted earlier, the analysis involves estimating the Engel curve in (44), which projects sectoral expenditure shares on adjusted real income across countries. Table 2 reports the sectoral betas, $\overline{\beta}^s$. Compared to food and manufacturing sectors (listed in column 1A), service sectors (listed in column 1B) tend to be high-income elastic.[35] This pattern can be visualized by plotting countries' expenditure shares in these three broad categories against their income per capita in Figure 2: the Engel curve for services is positively sloped, while it is negatively sloped for food and manufacturing.[36] These sectoral elasticities

[32]This estimate is close to the translog gravity equation estimate of $\gamma = 0.167$ estimated by Novy (2012). Feenstra and Weinstein (2010) report a median γ of 0.19 using a different data, level of aggregation and estimation procedure, so our estimate is in line with the few papers that have run gravity regressions with the translog specification.

[33]If we reduce the number of estimated parameters by imposing a relationship between income elasticities and exporter income, we find a positive and statistically significant relationship between the two variables. Specifically, we can impose that $\beta_i = B_0 + B_1 y_i$, which is similar to how Feenstra and Romalis (2014) allow for non-homotheticities. The theoretical restriction $\sum_i \beta_i = 0$ implies that $B_0 = -B_1 \frac{1}{N} \sum_i y_i$, transforming this linear relationship to $\beta_i = B_1 \left(y_i - \frac{1}{N} \sum_{i'} y_{i'}\right)$ and reducing the number of income elasticity parameters to be estimated from 40 to 1. If we impose this to estimate the gravity equation, we find $B_1 = 0.0057$ (standard error of 0.0026). This estimate is very close to regressing our estimated β_i's reported in Table 1 on $\left(y_i - \frac{1}{N} \sum_{i'} y_{i'}\right)$, which yields a coefficient of 0.008 (standard error of 0.0035).

[34]See Hallak (2006), Khandelwal (2010), Hallak and Schott (2011), and Feenstra and Romalis (2014).

[35]To see this, we aggregate the $\bar{\beta}^s$ into three categories: food includes "Agriculture" and "Food, Beverages and Tobacco", manufacturing includes the remaining sectors listed in column 1A of Table 2, and services is comprised of the 19 sectors in column 1B. The corresponding elasticities for food, manufacturing and services are -0.0343, -0.0410, and 0.0753, respectively. (Again, the sum of these three broad classifications is zero.)

[36]This is consistent with the literature on structural transformation; see Herrendorf et al. (2014).

are highly correlated with sectoral elasticities estimated using a different non-homothetic framework on different data by Caron et al. (2014); see Appendix Figure A.1 which plots the two sets of elasticities against each other.[37]

The results of the sectoral gravity equation in (45) is reported in Table 3. Columns 1A and 1B report the 35 sector-specific distance coefficients, $\rho\gamma^s$ (where $\rho = .177$ as before). Recall, these these coefficients sum to coefficient on distance from the single-sector model (See Table 1). Likewise, the sector-specific language and border coefficients in columns 2 and 3 of Table 3 sum exactly to the corresponding coefficients in the single-sector estimation.

We suppress the estimates of $\{\beta_n^s\}$ for readability purposes, but recall that $\sum_s \beta_i^s$ equals the exporter income elasticities β_i reported in the single-sector gravity equation. Also note that by construction, $\sum_n \beta_n^s$ equals the sectoral elasticities $\overline{\beta}^s$ displayed in Table 2. To see how β_n^s relate to exporter income per capita, we aggregate these coefficients to three broad classifications–food, manufacturing and services–and report the plot in Figure 3. Analogous to the single-sector estimates in Figure 1, we find that the positive relationship between exporter income per capita and income elasticities holds within sectors as well.

5 The Unequal Gains from Trade

This section conducts counterfactual analyses to measure the distributional consequences of trade. Section 5.1 explains how we numerically implement the expressions from Section 3.3. Section 5.2 shows the results of autarky counterfactuals in the single-sector version of our model. Section 5.3 presents the main results: the autarky counterfactuals in the baseline multi-sector model. Section 5.4 presents a series of robustness checks. In Section 5.5, we conduct counterfactuals of partial changes in foreign trade costs.

5.1 Computing Consumer-Specific Welfare Changes

To measure the unequal distribution of the gains from trade across consumers, we perform the counterfactual experiment of changing trade costs. The main results bring consumers in each country to autarky, and we also simulate partial changes in trade costs. Because we know the changes in expenditure shares that take place between the observed trade shares and the counterfactual scenarios, we can use the results from Section 3.3 to measure the welfare change experienced by consumers at each income level. But before applying these results, a few considerations are in order.

First, we highlight that throughout the analysis we take as given the specialization pattern of countries across goods with different income elasticity. That is, the β_n^s are not allowed to change in counterfactual scenarios. These patterns could change as trade costs change, but we note that

[37] Caron et al. (2014) estimate sectoral income elasticities on GTAP data using constant relative income preferences. We match GTAP sector classifications with WIOD sector classifications to produce the scatter plot.

the direction of the change will depend on what forces determine specialization across goods with different income elasticity.[38]

Second, the restriction to non-negative individual expenditure shares may bind in some instances. Therefore, to compute expression (40) for the welfare change $\omega_{n,h}^{tr\to cf}$ of each consumer h from country n between the initial scenario under trade (tr) and each counterfactual scenario (cf), we must first compute consumer-specific reservation prices. Following Feenstra (2010), this amounts to setting the individual expenditure shares of dropped varieties to zero according to (23), and substituting reservation prices back into the consumed varieties. We then numerically integrate equations (32) to (36) between the aggregate expenditure shares for country n in (22) evaluated at those reservation prices. As this procedure is done for each consumer h separately, we add a subscript h to the terms in (40) to denote that the aggregate expenditure shares used to construct the welfare change of each consumer are consumer-specific:

$$\omega_{n,h}^{tr\to cf} = \left(\frac{W_{n,h}^{cf}}{W_{n,h}^{tr}}\right)\left(\frac{x_h}{\tilde{x}_n}\right)^{-\ln\left(b_{n,h}^{cf}/b_{n,h}^{tr}\right)}. \tag{47}$$

We describe these steps formally in Appendix A.

Finally, we assume, as with the gravity estimation, that the expenditure distribution in country n is lognormal with variance σ_n^2. This allows mapping the observed gini coefficient to the Theil index. Henceforth, we index consumers by their percentile in the income distribution, so that $h \in (0,1)$. Under the log-normal distribution, the expenditure level of a consumer at percentile h in country i is $e^{z_h\sigma_i+\mu_i}$, where z_h denotes the value from a standard normal z-table at percentile h, and $\tilde{x}_i = e^{\sigma_i+\mu_i}$. We can therefore re-write (47) as:

$$\omega_{n,h}^{tr\to cf} = \left(\frac{W_{n,h}^{cf}}{W_{n,h}^{tr}}\right)\left(\frac{b_{n,h}^{cf}}{b_{n,h}^{tr}}\right)^{\sigma_n(1-z_h)}. \tag{48}$$

Consumers at percentile h are willing to pay a fraction $1-\omega_{n,h}^{tr\to cf}$ of their income under trade to avoid the movement from the trade to the counterfactual scenario when $\omega_{n,h}^{tr\to cf} < 1$.

5.2 Single-Sector Analysis

To convey some intuition, we first report results from the single-sector version of the model using the parameters from Table 1. Figure 4 plots the gains from trade by percentile of the income distribution for all the countries in our data (i.e., it plots $1-\omega_{n,h}^{tr\to cf}$ for $\omega_{n,h}^{tr\to cf}$ defined in (48) for all n and $h=\{0.01,..,0.99\}$ when each country is moved to autarky). To facilitate the comparisons across countries, we express the gains from trade of each percentile as difference from the gains

[38] If specialization is demand-driven by home-market effects, as in Fajgelbaum et al. (2011), poor countries would specialize less in low-income elastic goods as trade costs increase. However, if specialization is demand-driven in a neoclassical environment as in Mitra and Trindade (2005), or determined by relative factor endowments, as in Schott (2004) or Caron et al. (2014), the opposite would happen. To our knowledge, no study has established the relative importance of these forces for international specialization patterns in goods with different income elasticity.

of the 50th percentile in each country. The solid red line in the figure shows the average for each percentile across the 40 countries in our sample.

The typical U-shape relationship between the gains from trade and the position in the income distribution implies that poor and rich consumers within each country tend to reap larger benefits from trade compared to middle-income consumers. The reason for these patterns is intuitive in the light of the earlier discussion of equation (38) for the change in the relative price of high-income elastic goods. In a movement to autarky, the change in the relative price of high income-elastic goods experienced by the representative agent of country n is:

$$\ln\left(\frac{b_n^{cf}}{b_n^{tr}}\right) = \frac{1}{\gamma}\left(\sigma_\beta^2\left(y_n^{cf} - y_n^{tr}\right) - \left(\beta_n - \bar{\beta}_n\right)\right). \tag{49}$$

The formula reveals that a key determinant of the bias of trade is the income elasticity of each country's exports relative to each country's imports, captured by $\beta_n - \bar{\beta}_n$.[39] A positive $\beta_n - \bar{\beta}_n$ implies that expenditures move towards higher income elastic goods in a movement to autarky, potentially implying a reduction in their relative price. Therefore, for low-income (high-income) countries which tend to be exporters of low (high) income-elastic goods as shown in Figure 1, trade openness relatively favors rich (poor) individuals.[40] In countries that export products with intermediate income elasticities, middle-income consumers benefit the least from trade because their home country already supplies these goods; at the same time, opening to trade supplies both the rich and poor with products that better match their tastes. This creates a U-shaped pattern of the gains from trade for the typical country in the single-sector model.

5.3 Multi-Sector Analysis

We now present the baseline results from the multi-sector model. We first report the aggregate gains from trade, defined as the gains for the representative agent in each country. Columns 1A and 1B of Table 4 report the real income loss for the representative consumer in each country.[41] We compare these results to a homothetic case by setting $\beta_n^s = 0$ for all n and s in the gravity estimation and re-estimating the remaining parameters; this amounts to estimating a translog multi-sector gravity equation. The translog gravity estimates are reported in Appendix Table A.1; the results reveal that the estimated gravity coefficients hardly change under the constraint that preferences are homothetic (compare Table 3 with Appendix Table A.1). As a result, the aggregate gains under the translog specification, reported in Columns 2A and 2B of Table 4, are very similar to the aggregate gains under the non-homothetic AIDS. This suggests that, in our context, non-

[39] A decomposition of (49) reveals that the second term inside the parenthesis accounts for majority of the variation, 80.7 percent. The first term accounts for only 13.9 percent, and the covariance for the remaining 5.4 percent.

[40] When the economy is in autarky, all foreign goods are dropped and demand for the domestic variety corresponds to a single-good AIDS with unitary income elasticity; see Feenstra (2010). However, the parameter β_n still enters in (49) because it measures the *difference* in relative prices between the actual trade scenario and the autarky prices.

[41] The aggregate gains from trade in the multi-sector setting are higher than the single-sector case. This is consistent with Ossa (2015) and Costinot and Rodriguez-Clare (2014) who show that allowing for sectoral heterogeneity leads to larger measurement of the aggregate gains from trade in CES environments.

homotheticities do not fundamentally change the estimates of the *aggregate* gains from trade.[42] However, as we discuss next, they have a strong impact on the bias of the gains from trade across consumers.

Figure 5 reports the unequal gains from trade with multiple sectors across percentiles using the parameters from Tables 2 and 3. As before, the figure shows the gains from trade for each percentile in each country as a difference from the median percentile of each country. Table 5 reports the absolute gains from trade at the 10th, median, and 90th percentile, as well as for the representative consumer of each country (which is identical to Column 1 of Table 4).

There are two important differences between the results under the single- and under the multi-sector frameworks. First, the relative effects across percentiles are considerably larger. In the single-sector case from Figure 4, the gains from trade (relative to the median) lie within the -5 percent to 10 percent band across most countries and percentiles, while in the multi-sector case the range increases to -40 percent to 60 percent. Second, poor consumers are now predicted to gain more from trade than rich consumers in every country. Every consumer below the median income gains more from trade than every consumer above the median. On average across the countries in our sample, the gains from trade are 63 percent at the 10th percentile of the income distribution and 28 percent at the 90th percentile.

Why do the results for the multi-sector analysis differ from the single-sector analysis? The multi-sector model allows for two key additional margins that influence the pro-poor bias of trade: heterogeneity in the elasticity of substitution $\{\gamma_s\}$ and in the sectoral betas $\{\bar{\beta}^s\}$. By construction, if we restricted the $\{\gamma_s\}$ and $\{\beta_n^s\}$ to be constant across sectors in the multi-sector estimation, we would recover the same unequal gains from trade as in the single-sector estimation, and Figure 5 would look identical to Figure 4. To gauge the importance of each of these margins in shaping the unequal gains, Figure 6 shows the average gains from trade by percentile across all countries for four models: 1) the single-sector model (which is equal to the solid red curve in Figure 4); 2) a multi-sector model with homothetic sectors that imposes $\bar{\beta}^s = 0$ for all s but allows for heterogeneous γ's; 3) a multi-sector model that imposes symmetric γ's ($\gamma_s = \frac{1}{J}\gamma$) but allows for non-homothetic sectors; and 4) the baseline multi-sector model that allows for non-homothetic sectors and sector-specific $\gamma's$ (which is equal to the solid red curve in Figure 5).

We find that including non-homotheticities across sectors (i.e., comparing models 1 versus 3 or models 2 versus 4) is crucial for the strongly pro-poor bias of trade. The reason is that low-income consumers spend relatively more on sectors that are more traded, whereas high-income consumers spend relatively more on services, which are among the least internationally traded sectors. Recall from Figure 2 that the income elasticities of the service sectors are higher than non-service sectors; in addition, the average import share among the service sectors is 6.4 percent compared to 20 percent and 48 percent for food and manufacturing sectors, respectively. We also

[42]We note that this statement relies on defining the aggregate gains as those of the representative consumer. An alternative, which we do not pursue here, would be to define the aggregate gains as the average change in real income, $\frac{1}{H}\sum_h \omega_{n,h}^{tr \to cf} x_h$. This would correspond to the amount of income per capita needed to leave every consumer indifferent between trade and autarky.

find that including heterogeneity in γ_s across sectors (i.e., comparing models 1 versus 2, or models 3 versus 4) slightly biases the gains from trade towards poor consumers. The reason is that low-income consumers concentrate spending on sectors with a lower substitution parameter γ_s. To see this, we construct, for each percentile in each country, an expenditure-share weighted average of the sectoral gammas. Then, we average across all countries and report the results in Appendix Figure A.2. The figure reveals that higher percentiles concentrate spending in sectors where exporters sell more substitutable goods. In sum, larger expenditures in more tradeable sectors and a lower rate of substitution between imports and domestic goods lead to larger gains from trade for the poor than the rich.

While the gains from trade are larger for the poor in every country, we also observe cross-country heterogeneity in the difference between the gains from trade of poor and rich consumers. What determines the strength in the pro-poor bias of trade? As in the single-sector case the answer lies in part in the income elasticity of each country's products vis-à-vis its natural trade partners. In countries that export relatively low income-elastic goods, such as India, the gains from trade are relatively less biased to poor consumers. In these countries, opening to trade increases the relative price of low-income elastic goods (which are exported), or decreases that of high-income elastic goods (which are imported). This can be seen in Figure 7, which plots the difference between the gains from trade of the 90th and 10th percentiles against each country's income elasticity ($\beta_n = \sum_s \beta_n^s$). The difference between the gains from trade of the 90th and 10th percentiles is more negative in countries with higher income elasticity of exports. However, the income elasticity of the goods exported by each country is not sufficient to determine the bias of trade, which also depends on the distribution of expenditures across goods with different income elasticity, as implied by (35).[43]

5.4 Robustness

This subsection examines the robustness of our baseline results to alternative specifications.

5.4.1 Sectoral Income Elasticities $\overline{\beta}^s$

The first set of robustness checks examines the robustness of estimating the $\overline{\beta}^s$ using the Engel curve regression in (44).

An assumption in our framework is that individual preferences are identical across countries.[44] This assumption is standard in models of international trade and in quantitative analyses of these models. A second assumption, that results from the structure of the price elasticities in (21), is that relative prices do not affect sectoral expenditure shares in (44) other than through the homothetic component $a(p)$ (and only so if non-homotheticities are present). As a result, equation (44) for

[43] If the U.S. and India are excluded from the figure, the relationship remains negative but not significant. This suggests that although the income elasticity of a country's products matters, the other terms in (35) also influence the overall bias of trade.

[44] Note that we do allow for some heterogeneity in preferences across countries through the parameter α_{in}^s, which is reflected in the term ε_n^s of the Engel curve (44).

the aggregate shares has an "extended Cobb-Douglas" form consisting of a constant plus a slope with respect to income. This property of the model is also similar to the majority of multi-sector trade models that assume Cobb-Douglas preferences across sectors. Our approach to estimating the Engel curves using cross-country data is consistent with these assumptions. Under these two assumptions, the slopes of Engel curves across consumers within a country are the same as the slopes of the Engel curves that we estimate using aggregate data across countries. This motivates the following two robustness checks.

First, we re-estimate the Engel curve slopes from equation (44) using variation over time by including country-sector fixed effects, rather than just sector fixed effects. This specification controls for time invariant differences in country characteristics, and in principle, may result in very different estimates of the $\overline{\beta}^s$ parameters.[45] However, the $\overline{\beta}^s$ estimated using the specification with country-sector fixed effects are positively correlated with the baseline estimates (the correlation between the estimates is 0.68). Figure 8 compares the welfare gains, averaged across countries, using these alternative sectoral elasticities with the baseline results, resulting in very similar patterns.

As a second robustness check, we estimate the sectoral elasticities relying on consumer-level microdata. This check addresses the concern that variation in consumer expenditures within countries may not be accurately reflected in aggregate expenditures across countries.[46] We use the 2013 U.S. Consumer Expenditure Survey (CE) microdata that records expenditures to estimate the $\overline{\beta}^s$ from the consumer-level version of (44) implied by the model,[47]

$$s^s_{n,h} = \zeta^s_n + \overline{\beta}^s \ln(x_h) + \varepsilon^s_n,$$

where $\zeta^s_n \equiv \alpha^s - \overline{\beta}^s \ln(a_n)$ and h refers to a household in the CE data. To cleanly map the categories in the CE with the sectors in the aggregate data, we classify household expenditures into three broad categories—food, manufacturers and services.[48] We find $\overline{\beta}^{food,CE} = -0.057$ (s.e. = 0.00009), $\overline{\beta}^{mfg,CE} = 0.0375$ (s.e. = 0.0012), and $\overline{\beta}^{service,CE} = 0.0197$ (s.e.=0.001). Compared to baseline Engel curves, the microdata reveal a positive income elasticity for manufactures, and a somewhat flatter (though still positive) income elasticity for services. We then re-estimate the remaining parameters of the model from the gravity equation in (27) imposing these sectoral betas, and recompute the gains from trade using the same aggregate data as in the baseline case.

The results are presented in Figure 8. Consistent with the baseline results, the poorest consumers gain more from trade than the median. The reason is that in both the CE and aggregate

[45] We use an average of bilateral flows between 1995-1997 as the initial year to smooth out annual shocks.

[46] For example, Bee et al. (2012) discusses inconsistencies between aggregation of consumer expenditure surveys and national accounts data in the U.S.

[47] If the CE recorded expenditures by country of origin and/or prices, it would be possible to use these data to estimate obtain estimates of β^s_n and/or γ^s.

[48] We use the 2013 quarterly-level summary expenditure files: fmli132.dta, fmli133.dta, fmli134.dta, and fmli141.dta. We analyze consumption in the current quarter, and construct the categories as follows. Food is the sum of {foodcq alcbevcq, tobacccq}. Manufactured goods is the sum of {apparcq, cartkncq, cartkucq, othvehcq, gasmocq, tvrdiocq, otheqcq, predrqcq, medsupcq, houseqcq, misccq}. Services is the sum of {vehfincq, mainrpcq, vehinscq, vrntlocq, pubtracq, feeadmcq, hlthincq, medsrvcq, sheltcq, utilcq, housopcq, perscacq, readcq, educacq, cashcocq, perinscq}.

data, the Engel curve on food sectors is negative and has low γ^s. The main difference is revealed at the top of the expenditure distribution. In the baseline results, we generally find that the rich gain less than the median-income consumer. But when we estimate the sectoral income elasticities using the the CE data, the average curve bends upward at higher income levels. This is because manufacturing sectors have a higher income elasticity in the CE data and are also more tradeable (relative to services). As a result, using sectoral income elasticities from microdata reveals a slightly different bias of trade relative to the baseline case.

5.4.2 Price Elasticity of Service Sectors and Non-Tradeability

The second set of robustness checks alter the assumptions on the degree of tradeability of some of the service sectors in the data. As discussed earlier, the high elasticity parameters γ^s in service sectors partly affect the bias of the unequal gains. These parameters were obtained by first identifying $\rho^s\gamma^s$ from the semi-elasticity of trade with respect to distance in the gravity equation 45, and then setting $\rho^s = 0.177$ for all sectors. However, one might expect ρ^s to be higher for some service sectors that are essentially non-traded, which would lead us to over-estimate the value of γ^s these sectors.[49]

We perform two robustness checks to address this concern. In a first robustness check, we increase the value of ρ by 25 percent to 0.221 for the 12 service sectors that have, on average across countries, expenditures on imports of less than 10 percent.[50] By increasing ρ for these sectors, we lower their corresponding γ's by 20 percent. In a second robustness check, we treat these 12 service categories as non-tradeable. Appendix B shows that the equations (32) to (36) for the welfare effects of a foreign-trade shock carry over exactly in the presence of non-traded sectors, the only difference being that these sectors must be excluded from the computations.

We re-compute the gains from trade in each of these two cases, and compare the results, averaged across countries, to the baseline result in Figure 9. The three curves are very similar; this reassures us that the main results are not sensitive to the value of ρ in sectors that plausibly have higher price elasticities. The high similarity across these cases is not surprising since the sectors affected by each robustness check features little trade, so that their inclusion in the baseline model does not considerably affect the computations.

5.4.3 Additional Checks

Finally, we present additional robustness checks. As noted earlier, the parameter ρ cannot be separately identified in the data. We therefore re-run the counterfactuals assuming a $\rho = 0.221$, or a 25 percent increase from the baseline value. This implies reducing of the estimate of γ, and as a result, increases the gains from trade according to equation (32). While the welfare estimates

[49] Anderson et al. (2012) show that geographic barriers are a stronger deterrent of trade of some services trade than of goods trade.

[50] These sectors are: electricity, gas and water; construction; motor vehicle sales and maintenance; wholesale trade; retail trade; hotels and restaurants; telecommunications; real estate; public administration and defense; education; health; and other personal services.

in levels increase, Figure 10 shows that the relative gains from trade across percentiles are largely unaffected. The figure also reports the results from setting $\rho = 0.133$, a 25 percent decrease in the baseline value, and again the results are qualitatively unchanged. Hence, while ρ affects the level of the gains from trade predicted by the model, it does not affect the distributional bias.[51]

Next, we examine the sensitivity of our analysis by using final rather than total expenditures.[52]As mentioned earlier, the WIOD allow us to separate final expenditures from total expenditures, and we use these data to re-estimate the main results. See Appendix Tables A.2 and A.3 for the parameter estimation results. Figure 11 reports the welfare gains, averaged across countries, against the baseline results, and the results are similar.

The last robustness checks implements a more flexible version of the gravity equation in (45) by replacing Y_n^s/Y_W with exporter-sector pair fixed effects. This specification is more flexible in that it does not rely on the full structure of the model. We report the results of the sectoral gravity equation in Appendix Table A.4 (the Engel-curve estimates of the $\overline{\beta}^s$ are the same as those reported in Table 2), and find a correlation of the income elasticities with the baseline coefficients of 0.90. Figure 11 compares the welfare gains with the baseline results, and once again the message remains unchanged.

5.5 Partial Changes in Trade Costs

The welfare changes implied by the trade-to-autarky counterfactual are special in two ways. First, the magnitude of the shock is larger than what is typically experienced by countries that enact trade reforms. Second, trade reforms often target specific sectors rather than all sectors at the same time; as such, the clear pro-poor bias of trade may not be present when a trade liberalization only affects specific sectors. In this sub-section, we examine the welfare implications of partial reductions in trade costs involving specific sectors.

We consider a 5 percent reduction in the cost of importing in specific sectors: $\Delta \ln \tau_{ni}^s = -5$ percent for all $i \neq n$ and for all s in some subset of all sectors, and $\Delta \ln \tau_{ni}^s = 0$ otherwise. We separately simulate the welfare impact of this shock for each country n at a time treating each country as a small open economy, so that changes in trade costs have a negligible impact on wages in foreign countries. The change in the price of goods in sector s imported from i relative to domestically produced goods is then $\Delta \ln \left(p_{ni}^s/p_{nn}^s\right) = \Delta \ln \tau_{ni}^s$ for all i, s. Feeding these price changes to the aggregate demand system (20) we find the aggregate shares in the final scenario, and then follow the steps in Section 5.1 to measure welfare changes by percentile.

In results available upon request, we compare the welfare change of the representative consumer implied by this shock for manufacturing sectors with the welfare changes implied by a standard

[51]When $\rho = 0.133$, the aggregate gain from trade, averaged across countries, is 25 percent. When $\rho = 0.221$, the average is 37 percent.

[52]We work with total expenditures as the baseline because separating final expenditures requires taking a stand on the end use on products (see Dietzenbacher et al. 2013). The most accurate way to account for intermediate inputs would be to enrich the supply-side structure to account for input-output linkages, but we do not pursue this route here.

multi-sector Armington trade model with Cobb-Douglas preferences across sectors and CES preferences across origins within sectors (e.g, Ossa 2015).[53] The aggregate gains estimates are very similar between the two models (correlation of 0.98). The 5 percent reduction in the cost of all manufacturing imports increases welfare of the representative consumer by between 0.2 percent and 1.3 percent across countries.

Figure 12 displays three panels that report the average welfare change across countries corresponding to the 5 percent trade cost decrease in the food sectors, the manufacturing sectors, and the service sectors. Given the smaller shock to prices, the differences in the gains from trade across percentiles are, of course, smaller than in the case of moving to autarky. A pro-poor bias of trade still results when sectors within food or manufacturing, which are typically negative-income elastic, experience a decline in foreign trade costs. Alternatively, when only the service sectors, which are typically positive-income elastic, experience a decline in the cost of importing, we see an overall U-shaped pattern, with the very rich gaining relatively more.

6 Conclusion

This paper develops a methodology to measure the distribution of welfare changes across heterogeneous consumers through the expenditure channel for many countries over time. The approach has broad applicability as it is based on aggregate statistics and model parameters that can be estimated from readily available bilateral trade and production data. This is possible by using the AIDS demand structure which allows for non-homotheticities and has convenient aggregation properties.

We estimate a non-homothetic gravity equation generated by the model to obtain the key parameters required by the approach, and identify the effect of trade on the distribution of welfare changes through counterfactual changes in trade costs. The estimated parameters suggest large differences in how trade affects individuals along the income distribution in different countries. The multi-sector analysis reveals that the gains from trade are typically biased towards the poor. This is because the poor tend to concentrate expenditures in sectors that are more traded, and because these sectors have lower price elasticities. Heterogeneity in the pro-poor bias of trade is driven, in part, by a country's pattern of specialization relative to its trading partners.

While our goal in this paper is to demonstrate the importance of demand heterogeneity across consumers for the distributional effects of trade, we believe that a promising avenue lies in integrating this approach with a richer supply-side structure to measure jointly the impact of trade through both the expenditure and income channels across consumers. We leave this for future work.

[53] In this case, the indirect utility of the representative consumer in country n is $w_n * \Pi_s^S \left(\sum (p_{ni}^s)^{1-\sigma^s}\right)^{-\alpha_n^s/(1-\sigma^s)}$, where α_n^s is the expenditure share of country n in sector s and $\sigma^s > 1$ is the elasticity of substitution across origins within sector s. The change in real income due to the partial change in trade costs in a subset of sectors $s \in shocked$ is $\prod_{s \in shocked} \left(\frac{S_{nn}^{s,trade}}{\alpha_n^s} + \sum_{i \neq n} \left(e^{(1-\sigma^s)\Delta \ln \tau_{ni}^s} \frac{S_{ni}^{s,trade}}{\alpha_n^s} \right) \right)^{-\alpha_n^s/(1-\sigma^s)} - 1$. The case of going to autarky is nested in this expression when $\Delta \ln \tau_{ni}^s = \infty$ for all s and $i \neq n$. We use the elasticities reported by Ossa (2015) and match them to the WIOD sector classification to compute the welfare gains.

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A Appendix to Section 5

This appendix provides the details to implement the counterfactuals in Section 5.

A.1 Reservation Prices

The restriction to non-negative individual expenditure shares may bind in the counterfactuals. In these cases, we find consumer-specific reservation prices that set the individual shares of dropped varieties to zero, and adjust the remaining individual shares using these reservation prices. Let $N^{s,j}_{n,h}$ be the number of varieties not consumed by percentile h from country n in sector s at prices $\{p^{s,j}_{ni}\}$ under scenario j, $I^{s,j}_{n,h}$ be the set of such varieties, and $\left\{p^{s,j}_{ni,h}\right\}$ be the reservation prices of consumer h. The notation j may correspond to the initial scenario under trade ($j = tr$) or to a counterfactual ($j = cf$).

For each percentile h in country n, we have that $p^{s,j}_{ni,h} = p^{s,j}_{ni}$ for all $i \notin I^{s,j}_{n,h}$ and $s^{s,j}_{ni,h} = 0$ for all $i \in I^{s,j}_{n,h}$. From (23), the reservation prices $p^{s,j}_{ni,h}$ for $i \in I^{s,j}_{n,h}$ and the individual shares $s^{s,j}_{ni,h}$ for $i \notin I^{s,j}_{n,h}$ satisfy:

$$s^{s,j}_{ni,h} = \alpha^s_{ni} - \gamma^s \ln p^{s,j}_{ni} + \frac{\gamma^s}{N}\left(\sum_{i' \notin I^s_{n,h}} \ln\left(p^{s,j}_{ni'}\right) + \sum_{i' \in I^s_{n,h}} \ln\left(p^{s,j}_{ni',h}\right)\right) + \beta^s_i\left(\ln\left(\frac{x_h}{\tilde{x_n}}\right) + y^j_{n,h}\right), \quad i \notin I^{s,j}_{n,h}, \tag{A.1}$$

$$0 = \alpha^s_{ni} - \gamma^s \ln p^{s,j}_{ni,h} + \frac{\gamma^s}{N}\left(\sum_{i' \notin I^s_{n,h}} \ln\left(p^{s,j}_{ni'}\right) + \sum_{i' \in I^s_{n,h}} \ln\left(p^{s,j}_{ni',h}\right)\right) + \beta^s_i\left(\ln\left(\frac{x_h}{\tilde{x_n}}\right) + y^j_{n,h}\right), \quad i \in I^{s,j}_{n,h} \tag{A.2}$$

for $s = 1, .., S$, where $y^j_{n,h} \equiv \ln\left(\tilde{x_n}/a^j_{n,h}\right)$ and $a^j_{n,h} = a\left(\left\{p^{s,j}_{ni,h}\right\}_{i,s}\right)$ is the homothetic component of the price index. Assuming that not every variety in sector s is dropped, (A.2) implies

$$\sum_{i' \in I^{s,j}_{n,h}} \gamma^s \ln p^{s,j}_{ni',h} = \frac{N^{s,j}_{n,h}}{N - N^{s,j}_{n,h}}\gamma^s \sum_{i' \notin I^s_{n,h}} \ln\left(p^{s,j}_{ni'}\right) + \frac{N}{N - N^{s,j}_{n,h}}\left(\sum_{i' \in I^{s,j}_{n,h}} \alpha^s_{ni'} + \sum_{i' \in I^{s,j}_{n,h}} \beta^s_{i'}\left(\ln\left(\frac{x_h}{\tilde{x_n}}\right) + y^j_{n,h}\right)\right). \tag{A.3}$$

Replacing this back into (A.2) gives the reservation prices of the dropped varieties in sector s:

$$\ln p^{s,j}_{ni,h} = \frac{1}{\gamma^s}\left[\alpha^s_{ni} + \frac{1}{N - N^{s,j}_{n,h}} \sum_{i' \in I^{s,j}_{n,h}} \alpha^s_{ni'} + \left(\beta^s_i + \frac{1}{N - N^{s,j}_{n,h}} \sum_{i' \in I^{s,j}_{n,h}} \beta^s_{i'}\right)\left(\ln\left(\frac{x_h}{\tilde{x_n}}\right) + y^j_{n,h}\right)\right] + \frac{1}{N - N^{s,j}_{n,h}} \sum_{i' \notin I^s_{n,h}} \ln\left(p^{s,j}_{ni'}\right), \quad i \in I^{s,j}_{n,h}. \tag{A.4}$$

A.2 Aggregate Expenditure Shares Used in the Counterfactuals

Let $\left\{S^{s,j}_{ni,h}\right\}_{i,s}$ be the expenditure shares that result from evaluating the aggregate-share equation (23) from country n at the reservation prices for consumer h under scenario j, $\left\{p^{s,j}_{ni,h}\right\}_{i,s}$.[54] In the counterfactuals, to measure

[54]We note that these are neither the aggregate shares nor the shares chosen by the representative agent at prices

welfare changes by percentile we integrate equations (32) to (36) between $\left\{S_{ni,h}^{s,tr}\right\}_{i,s}$ and $\left\{S_{ni,h}^{s,cf}\right\}_{i,s}$. To construct $\left\{S_{ni,h}^{s,j}\right\}_{i,s}$ we combine (22), (23), and (A.4) to obtain:

$$S_{ni,h}^{s,j} = \begin{cases} s_{ni,h}^{s,j} - \beta_i^s \ln\left(\frac{x_h}{\tilde{x}_n}\right), & i \notin I_{n,h}^{s,j}, \\ -\beta_i^s \ln\left(\frac{x_h}{\tilde{x}_n}\right), & i \in I_{n,h}^{s,j}. \end{cases} \tag{A.5}$$

Equation (A.5) relies on the individual shares $s_{ni,h}^{s,j}$ for $i \notin I_{n,h}^{s,j}$ defined in (A.1). We next explain how to construct these individual shares in each of the different counterfactual scenarios.

Initial Trade Scenario For the initial trade scenario ($j = tr$) we combine (22) and (A.3) to obtain

$$s_{ni,h}^{s,tr} = \left(S_{ni}^{s,tr} + \frac{1}{N - N_{n,h}^{s,tr}} \sum_{i' \in I_{n,h}^{s,tr}} S_{ni'}^{s,tr}\right) + \left(\beta_i^s + \frac{1}{N - N_{n,h}^{s,tr}} \sum_{i' \in I_{n,h}^{s,tr}} \beta_{i'}^s\right)\left(\ln\left(\frac{x_h}{\tilde{x_n}}\right) + y_{n,h}^{tr} - y_n^{tr}\right), \quad i \notin I_{n,h}^{s,tr}. \tag{A.6}$$

The aggregate shares $S_{ni}^{s,tr}$ are observed. The set $I_{n,h}^{s,tr}$ in (A.6) is determined by iteration: starting from $I_{n,h}^{s,tr} = \emptyset$, we compute $\left\{s_{ni,h}^{s,tr}\right\}_{i \notin I_{n,h}^{s,tr}}$ and if $s_{ni,h}^{s,tr} < 0$ we include n in the set $I_{n,h}^{s,tr}$ of the next iteration; since $y_{n,h}^{tr}$ is not observed, we approximate its value using y_n^{tr}. It can be shown that this procedure is formally equivalent to evenly redistributing the shares of varieties predicted to be negative at the actual prices among the remaining varieties within each sector.[55]

Autarky For the counterfactuals that move consumers to autarky in Sections 5.2 and 5.3, only own-country varieties are consumed; this implies $I_{n,h}^{s,cf} = \{i : i \neq n\}$. Equations (23) and (25) then imply:

$$\begin{aligned} s_{nn,h}^{s,cf} &= \overline{\alpha}_n^s + \overline{\beta}^s\left(\ln\left(\frac{x_h}{\tilde{x_n}}\right) + y_{n,h}^{cf}\right), \\ s_{ni,h}^{s,cf} &= 0, \quad i \neq n. \end{aligned} \tag{A.7}$$

To measure these individual autarky shares we use the values of β_i^s and $\overline{\beta}^s$ estimated in Section (4.2). From (24), we compute $\overline{\alpha}_n^s = S_n^s - \overline{\beta}^s y_n^{tr}$. To compute $y_{n,h}^{cf}$ we initially guess its value, then use (A.5) to compute $\left\{S_{ni,h}^{s,cf}\right\}$, and then integrate dy_n using (36) between $\left\{S_{ni}^{s,tr}\right\}$ and $\left\{S_{ni,h}^{s,cf}\right\}$ starting from the initial condition y_n^{tr}. These steps yield an updated value of $y_{n,h}^{cf}$ that is then used as a guess for the next iteration, and the procedure continues until convergence. This procedure achieves convergence to the same $y_{n,h}^{cf}$ from multiple initial guesses for each percentile-country pair for all but a handful of cases which are excluded from the figures and tables referenced in Section 5.[56]

Partial Changes in Trade Costs For the counterfactuals involving partial changes in foreign-trade costs (Section 5.5) we construct individual shares following steps similar to the initial trade scenario using the aggregate final shares

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$\left\{p_{ni,h}^{s,j}\right\}_{i,s}$. These shares result from evaluating equation (23) at the h-specific reservation prices, and they are not restricted to be between 0 and 1.

[55] We note that these adjustments do not affect the aggregate predictions of the model: the observed aggregate expenditure shares under trade $\left\{S_{ni}^{s,tr}\right\}$ have a correlation of 0.99 with the aggregate expenditure shares $\left\{\sum_h \left(\frac{x_h}{\sum_{h'} x_{h'}}\right) s_{ni,h}^{s,tr}\right\}$ resulting from adding up the expenditures shares of each percentile h at the reservation prices $\left\{p_{ni,h}^{s,tr}\right\}$.

[56] In the baseline multi-sector counterfactual there are 3,960 (=40 countries*99 percentiles) combinations and we do not obtain convergence in 20 of these cases corresponding to extreme percentiles.

$S_{in}^{s,cf} = S_{in}^{s,tr} + \Delta S_{ni}^{s}$. The term ΔS_{ni}^{s} can be computed from (22), which implies

$$\Delta S_{ni}^{s} = -\gamma^{s}\left[\Delta \ln \tau_{ni}^{s} - \frac{1}{N}\sum_{i'=1}^{N} \Delta \ln \tau_{ni'}^{s}\right] + \beta_{i}^{s} \Delta y_{n}. \tag{A.8}$$

We integrate $dy_n = -\sum_s \sum_i \left(S_{ni}^s - \beta_i^s y_n\right) \hat{\tau}_{ni}^s$ (which follows from Shepard's Lemma) and $dS_{ni}^s = -\gamma^s \left[\hat{\tau_{ni}^s} - \frac{1}{N}\sum_{i'=1}^N \hat{\tau_{ni'}^s}\right] +$ $\beta_i^s dy_n$ (which follows from (A.8)) to obtain Δy_n.

B Computing Welfare Changes with a Non-Traded Sector

We derive the welfare results assuming that a subset of sectors are non-traded. Assume that $s = NT$ is a non-traded sector. We show that equations (32) to (36) for the welfare effects of a foreign-trade shock remain the same with the only difference being that the non-traded sector is excluded from the expressions.

In sector $s = NT$, the preferences of country n are only defined over the variety produced by country n. We let β^{NT} be the income elasticity corresponding to the non-traded sector. The adding-up constrain then implies $\gamma^{NT} = 0$, $\beta^{NT} = -\sum_{s \neq NT} \sum_{i=1}^{N} \beta_i^s$, and $\alpha_{nn}^{NT} = \overline{\alpha}_n^{NT} = 1 - \sum_{s \neq NT} \overline{\alpha}_n^s$. Letting S_n^{NT} be the share of expenditures in non-traded goods, the aggregate expenditure shares (22) in country n are now defined as follows:

$$S_{ni}^{s} = \alpha_{ni}^{s} - \gamma^{s}\left[\ln\left(\frac{p_{ni}^{s}}{p_{nn}^{\hat{s}}}\right) - \frac{1}{N}\sum_{i'=1}^{N}\ln\left(\frac{p_{ni'}^{s}}{p_{nn}^{\hat{s}}}\right)\right] + \beta_{i}^{s} y_{n} \text{ for } s \neq NT, \tag{A.9}$$

$$S_{n}^{NT} = \overline{\alpha}_{n}^{NT} + \beta^{NT} y_{n}. \tag{A.10}$$

In changes, equation (A.9) can be written as:

$$\hat{p}_{ni}^{s} - \hat{p}_{nn}^{s} = -\frac{dS_{ni}^{s} - dS_{nn}^{s}}{\gamma^{s}} + \frac{1}{\gamma^{s}}\left(\beta_{i}^{s} - \beta_{n}^{s}\right) dy_{n}. \tag{A.11}$$

Additionally, we have that:

$$\hat{p}_{nn}^{s} = \hat{p}_{nn}^{NT} = \hat{w}_{n}. \tag{A.12}$$

Since $\widehat{x}_h = \hat{w}_n$, the welfare change of consumer h defined in (4) is:

$$\widehat{\omega}_{h} = \widehat{W}_{n} - \hat{b}_{n} \times \ln\left(\frac{x_{h}}{\widetilde{x}}\right) + \hat{w}_{n}. \tag{A.13}$$

where, using (5) and (13), we have

$$\widehat{W}_{n} = \sum_{s \neq NT} \sum_{i} \left(-\widehat{p}_{ni}^{s}\right) S_{ni}^{s} - \widehat{p}_{nn}^{NT} S_{n}^{NT}, \tag{A.14}$$

$$\widehat{b}_{n} = \sum_{s \neq NT} \sum_{i} \widehat{p}_{ni}^{s} \beta_{i}^{s} + \widehat{p}_{nn}^{NT} \beta^{NT}. \tag{A.15}$$

Combining (A.11) to (A.15), and using the normalization of the own wage ($\hat{w}_n = 0$), leads to:

$$\widehat{W}_{n} = \sum_{s \neq NT} \sum_{i} \left(dS_{ni}^{s} - dS_{nn}^{s} + \left(\beta_{n}^{s} - \beta_{i}^{s}\right) dy_{n}\right) \frac{S_{ni}^{s}}{\gamma^{s}},$$

$$\widehat{b}_{n} = \sum_{s \neq NT} \sum_{i} \frac{\beta_{i}^{s}}{\gamma^{s}} \left(dS_{nn}^{s} - dS_{ni}^{s} + \left(\beta_{i}^{s} - \beta_{n}^{s}\right) dy_{n}\right),$$

which correspond to (32) to (35) when all sectors are traded. To characterize welfare changes it remains to solve for

dy. From Shephard's Lemma,

$$\hat{a}_n \equiv \sum_{s\neq NT}\sum_i \frac{\partial \ln a}{\partial \ln p^s_{ni}}\hat{p}^s_{ni} + \frac{\partial \ln a}{\partial \ln p^{NT}_n}\hat{p}^{NT}_n,$$
$$= \sum_{s\neq NT}\sum_i \left(S^s_{ni} - \beta^s_{ni} y_n\right)\hat{p}^s_{ni} + \left(S^{NT}_n - \beta^{NT}_n y_n\right)\hat{p}^{NT}_n.$$

Combining this expression with (A.11) to (A.15), using that $dy_n = \hat{w}_n - \hat{a}_n$ and solving for dy_n yields

$$dy_n = \frac{\sum_{s\neq NT}\sum_i \frac{1}{\gamma^s}\left(S^s_{ni} - \beta^s_{ni} y_n\right)\left(dS^s_{ni} - dS^s_{nn}\right)}{1 - \sum_{s\neq NT}\sum_i \frac{1}{\gamma^s}\left(S^s_{ni} - \beta^s_i y_n\right)\left(\beta^s_n - \beta^s_i\right)},$$

which corresponds to (36) when all sectors are traded.

Tables and Figures

Table 1: Gravity Estimates: Single Sector

Variables	(1A)		(1B)
-$Distance_{ni}$	0.043 ***		
	(0.005)		
$Language_{ni}$	0.131 ***		
	(0.021)		
$Border_{ni}$	0.135 ***		
	(0.023)		
Ω_{n} x		Ω_{n} x	
β-USA	0.052 **	β-POL	-0.001
	(0.022)		(0.011)
β-JPN	0.028 ***	β-IDN	-0.023
	(0.008)		(0.032)
β-CHN	0.008	β-AUT	-0.001
	(0.031)		(0.009)
β-DEU	-0.015	β-DNK	0.003
	(0.013)		(0.009)
β-GBR	0.005	β-GRC	0.018 *
	(0.013)		(0.009)
β-FRA	-0.013	β-IRL	-0.009
	(0.011)		(0.013)
β-ITA	0.006	β-FIN	0.013
	(0.006)		(0.010)
β-ESP	-0.004	β-PRT	-0.001
	(0.006)		(0.005)
β-CAN	-0.017	β-CZE	-0.003
	(0.015)		(0.006)
β-KOR	0.006	β-ROM	0.003
	(0.012)		(0.015)
β-IND	-0.048	β-HUN	0.008
	(0.042)		(0.012)
β-BRA	-0.010	β-SVK	0.005
	(0.017)		(0.010)
β-RUS	-0.003	β-LUX	-0.012 *
	(0.022)		(0.007)
β-MEX	-0.029 *	β-SVN	-0.002
	(0.017)		(0.005)
β-AUS	0.011	β-BGR	0.004
	(0.012)		(0.016)
β-NLD	-0.008	β-LTU	0.004
	(0.009)		(0.010)
β-TUR	0.006	β-LVA	0.006
	(0.016)		(0.009)
β-BEL	-0.025 **	β-EST	0.007
	(0.011)		(0.007)
β-TWN	0.017	β-CYP	0.016 **
	(0.011)		(0.008)
β-SWE	0.006	β-MLT	-0.006
	(0.008)		(0.010)
Joint F-test p-value for income elasticities	0.00		
R2	0.47		
Observations	1,600		
Implied γ	0.24		

Notes: Table reports the estimates of the single-sector gravity equation that aggregates the data across the 35 sectors. There are 40 income elasticity parameters β_i. We assume that ρ=0.177, and the implied γ={coefficient on -$Distance_{ni}$}/ρ is noted at the bottom of the table. Standard errors are clustered by importer. Significance * .10; ** .05; *** .01.

Table 2: Engel Curve Estimation: Baseline

Variables	(1A)		(1B)
Agriculture	-0.0218 ***	Electricity, Gas and Water Supply	-0.0033
	(0.002)		(0.002)
Mining	-0.0080 ***	Construction	-0.0053
	(0.002)		(0.003)
Food, Beverages and Tobacco	-0.0125 ***	Sale, Repair of Motor Vehicles	0.0027 ***
	(0.003)		(0.001)
Textiles	-0.0063 ***	Wholesale Trade and Commission Trade	0.0010
	(0.001)		(0.003)
Leather and Footwear	-0.0009 ***	Retail Trade	-0.0020
	(0.000)		(0.002)
Wood Products	-0.0008	Hotels and Restaurants	0.0021
	(0.001)		(0.001)
Printing and Publishing	0.0014 *	Inland Transport	-0.0089 ***
	(0.001)		(0.003)
Coke, Refined Petroleum, Nuclear Fuel	-0.0056 ***	Water Transport	-0.0007
	(0.002)		(0.001)
Chemicals and Chemical Products	-0.0046 ***	Air Transport	0.0007 *
	(0.001)		(0.000)
Rubber and Plastics	-0.0016 *	Other Auxiliary Transport Activities	0.0038 ***
	(0.001)		(0.001)
Other Non-Metallic Minerals	-0.0027 ***	Post and Telecommunications	0.0012
	(0.001)		(0.001)
Basic Metals and Fabricated Metal	-0.0031	Financial Intermediation	0.0280
	(0.004)		(0.018)
Machinery	-0.0028	Real Estate Activities	0.0095 ***
	(0.002)		(0.003)
Electrical and Optical Equipment	-0.0021	Renting of M&Eq	0.0243 ***
	(0.003)		(0.003)
Transport Equipment	-0.0033 *	Public Admin and Defence	0.0038
	(0.002)		(0.003)
Manufacturing, nec	-0.0005	Education	0.0022 **
	(0.001)		(0.001)
		Health and Social Work	0.0128 ***
			(0.003)
		Other Community and Social Services	0.0031
			(0.003)
		Private Households with Employed Persons	0.0003 **
			(0.000)
Sector FEs	yes		
Joint F-test p-value for sectoral elasticities	0.00		
R-squared	0.67		
Observations	1,400		

Notes: Table reports the sectoral income elasticities from the Engel curve equation. It is a regression of importers' sectoral expenditures shares on the adjusted real income interacted with sector dummies. Sectors "Agriculture" and "Food, Beverages and Tobacco" are the food sectors, and the remaining sectors in column 1A are the manufacturing sectors; the service sectors are listed in column 1B. The regression also includes sector fixed effects. Standard errors are clustered by importer. Significance * .10; ** .05; *** .01.

Table 3: Sectoral Gravity Estimates: Baseline

Variables	-Distance (1A)	Language (2A)	Border (3A)		-Distance (1B)	Language (2B)	Border (3B)
Agriculture	0.0011 ***	0.0054 ***	0.0049 ***	Electricity, Gas and Water Supply	0.0012 ***	0.0051 ***	0.0046 ***
	(0.000)	(0.001)	(0.001)		(0.000)	(0.001)	(0.001)
Mining	0.0006 ***	0.0016 ***	0.0022 ***	Construction	0.0038 ***	0.0135 ***	0.0129 ***
	(0.000)	(0.000)	(0.001)		-(0.001)	(0.002)	(0.002)
Food, Beverages and Tobacco	0.0016 ***	0.0061 ***	0.0061 ***	Sale, Repair of Motor Vehicles	0.0005 ***	0.0025 ***	0.0022 ***
	(0.000)	(0.001)	(0.001)		(0.000)	(0.000)	(0.000)
Textiles	0.0004 ***	0.0012 ***	0.0014 ***	Wholesale Trade and Commission Trade	0.0020 ***	0.0082 ***	0.0072 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.001)	(0.001)
Leather and Footwear	0.0001 ***	0.0002 ***	0.0002 ***	Retail Trade	0.0018 ***	0.0060 ***	0.0059 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.001)	(0.001)
Wood Products	0.0002 ***	0.0011 ***	0.0011 ***	Hotels and Restaurants	0.0013 ***	0.0037 ***	0.0037 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.001)	(0.001)
Printing and Publishing	0.0007 ***	0.0020 ***	0.0024 ***	Inland Transport	0.0008 ***	0.0047 ***	0.0045 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.001)	(0.001)
Coke, Refined Petroleum, Nuclear Fuel	0.0008 ***	0.0023 ***	0.0032 ***	Water Transport	0.0001 ***	0.0002 ***	0.0002 **
	(0.000)	(0.001)	(0.001)		(0.000)	(0.000)	(0.000)
Chemicals and Chemical Products	0.0013 ***	0.0016 ***	0.0022 ***	Air Transport	0.0002 ***	0.0004 ***	0.0005 ***
	(0.000)	(0.000)	(0.001)		(0.000)	(0.000)	(0.000)
Rubber and Plastics	0.0005 ***	0.0010 ***	0.0013 ***	Other Auxiliary Transport Activities	0.0004 ***	0.0025 ***	0.0024 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)
Other Non-Metallic Minerals	0.0005 ***	0.0016 ***	0.0016 ***	Post and Telecommunications	0.0010 ***	0.0033 ***	0.0034 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.001)	(0.001)
Basic Metals and Fabricated Metal	0.0018 ***	0.0036 ***	0.0042 ***	Financial Intermediation	0.0031 ***	0.0056 ***	0.0064 ***
	(0.000)	(0.001)	(0.001)		(0.000)	(0.001)	(0.001)
Machinery	0.0009 ***	0.0015 ***	0.0016 ***	Real Estate Activities	0.0031 ***	0.0097 ***	0.0096 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.002)	(0.002)
Electrical and Optical Equipment	0.0014 ***	0.0014 **	0.0017 ***	Renting of M&Eq	0.0027 ***	0.0097 ***	0.0103 ***
	(0.000)	(0.001)	(0.000)		(0.000)	(0.002)	(0.002)
Transport Equipment	0.0011 ***	0.0019 ***	0.0027 ***	Public Admin and Defence	0.0029 ***	0.0073 ***	0.0078 ***
	(0.000)	(0.001)	(0.001)		(0.000)	(0.001)	(0.001)
Manufacturing, nec	0.0003 ***	0.0009 ***	0.0011 ***	Education	0.0011 ***	0.0045 ***	0.0040 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.001)	(0.001)
				Health and Social Work	0.0017 ***	0.0061 ***	0.0064 ***
					(0.000)	(0.001)	(0.001)
				Other Community and Social Services	0.0018 ***	0.0044 ***	0.0048 ***
					(0.000)	(0.001)	(0.001)
				Private Households with Employed Persons	0.0001 **	0.0002 ***	0.0002 ***
					(0.000)	(0.000)	(0.000)
Ω_n x Sector-Exporter Dummies			not displayed				
Joint F-test p-value for income elasticities			0.00				
R-squared			0.40				
Observations			56,000				

Notes: Table reports the estimates of the sectoral gravity equation. The results report sector-specific coefficients on (the negative of) distance, language and border in columns 1, 2 and 3, respectively. The sum of these coefficients exactly sum to the corresponding coefficients in Table 1. The table supresses the sector-exporter interaction coefficients to save space, but recall that the sum of these coefficients across sectors equals sectoral coefficients in Table 2, and the sum of the coefficients for each exporter across sectors equals the country-specific coefficients in Table 1. Standard errors are clustered by importer. Significance * .10; ** .05; *** .01.

Table 4: Aggregate Gains from Trade: AIDS vs Translog

Country	Aggregate Gains (AIDS)	Aggregate Gains (Translog)	Gains at Median (AIDS)	Country Import Share	Country	Aggregate Gains (AIDS)	Aggregate Gains (Translog)	Gains at Median (AIDS)	Country Import Share
	(1A)	(2A)	(3A)	(4A)		(1B)	(2B)	(3B)	(4B)
AUS	9%	8%	24%	8%	IRL	40%	43%	52%	32%
AUT	42%	41%	56%	23%	ITA	13%	12%	31%	10%
BEL	50%	51%	63%	28%	JPN	6%	5%	24%	5%
BGR	46%	45%	58%	25%	KOR	16%	16%	33%	11%
BRA	2%	2%	20%	4%	LTU	67%	64%	77%	27%
CAN	29%	30%	44%	16%	LUX	86%	85%	89%	49%
CHN	6%	7%	16%	7%	LVA	36%	35%	52%	22%
CYP	43%	40%	57%	22%	MEX	24%	24%	40%	14%
CZE	50%	49%	60%	26%	MLT	66%	66%	75%	34%
DEU	26%	26%	40%	17%	NLD	28%	28%	45%	21%
DNK	41%	40%	54%	22%	POL	27%	26%	42%	18%
ESP	17%	16%	34%	12%	PRT	27%	26%	46%	17%
EST	50%	48%	65%	27%	ROM	34%	33%	49%	19%
FIN	28%	26%	46%	17%	RUS	16%	16%	32%	9%
FRA	15%	15%	29%	12%	SVK	67%	64%	74%	30%
GBR	14%	13%	33%	12%	SVN	55%	54%	66%	27%
GRC	26%	24%	44%	15%	SWE	29%	27%	43%	19%
HUN	68%	67%	76%	31%	TUR	11%	11%	29%	10%
IDN	5%	5%	11%	8%	TWN	41%	41%	56%	20%
IND	6%	6%	10%	6%	USA	8%	6%	37%	6%
Average	32%	31%	46%	18%					

Notes: Table reports gains from trade. The first and third columns repors the gains for the representative agent and median consumer, respectively, using the estimated parameters from Tables 2 and 3. The second column computes welfare changes using a translog demand system; these parameters are obtained from re-running the gravity equation imposing β^s_i=0 (see Appendix Table A.1). The fourth column reports the aggregate import share for each country.

Table 5: Unequal Gains From Trade: Baseline

Country	10th percentile	50th Percentile	Aggregate Gains	90th Percentile	Country	10th percentile	50th Percentile	Aggregate Gains	90th Percentile
	(1A)	(2A)	(3A)	(4A)		(1B)	(2B)	(3B)	(4B)
AUS	45%	24%	9%	5%	IRL	67%	52%	40%	38%
AUT	68%	56%	42%	38%	ITA	52%	31%	13%	8%
BEL	75%	63%	50%	46%	JPN	46%	24%	6%	2%
BGR	72%	58%	46%	43%	KOR	53%	33%	16%	12%
BRA	57%	20%	2%	3%	LTU	87%	77%	67%	63%
CAN	60%	44%	29%	25%	LUX	91%	89%	86%	85%
CHN	38%	16%	6%	6%	LVA	70%	52%	36%	32%
CYP	71%	57%	43%	39%	MEX	65%	40%	24%	21%
CZE	71%	60%	50%	47%	MLT	83%	75%	66%	64%
DEU	56%	40%	26%	21%	NLD	61%	45%	28%	24%
DNK	67%	54%	41%	37%	POL	61%	42%	27%	23%
ESP	53%	34%	17%	12%	PRT	67%	46%	27%	22%
EST	79%	65%	50%	46%	ROM	67%	49%	34%	31%
FIN	64%	46%	28%	23%	RUS	56%	32%	16%	14%
FRA	45%	29%	15%	11%	SVK	82%	74%	67%	64%
GBR	54%	33%	14%	10%	SVN	76%	66%	55%	52%
GRC	63%	44%	26%	21%	SWE	59%	43%	29%	25%
HUN	84%	76%	68%	65%	TUR	56%	29%	11%	8%
IDN	24%	11%	5%	4%	TWN	72%	56%	41%	37%
IND	19%	10%	6%	6%	USA	69%	37%	8%	4%
Average	63%	46%	32%	28%					

Notes: Table reports gains from trade for the baseline multi-sector model and uses the parameters reported in Tables 2 and 3. The columns report welfare changes associated at the 10th, 50th, the representative consumer (taken from column 1 of Table 4), and the 90th percentiles.

Figure 1: β_i and GDPPC

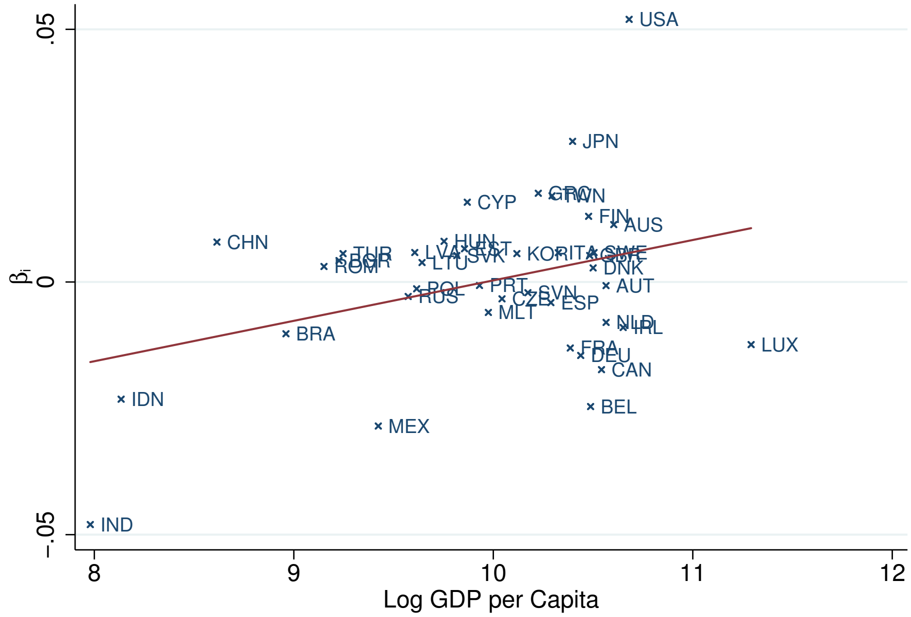


Figure plots exporter income elasticity against its per capita GDP

Figure 2: Engel Curves, by Broad Sector Groups

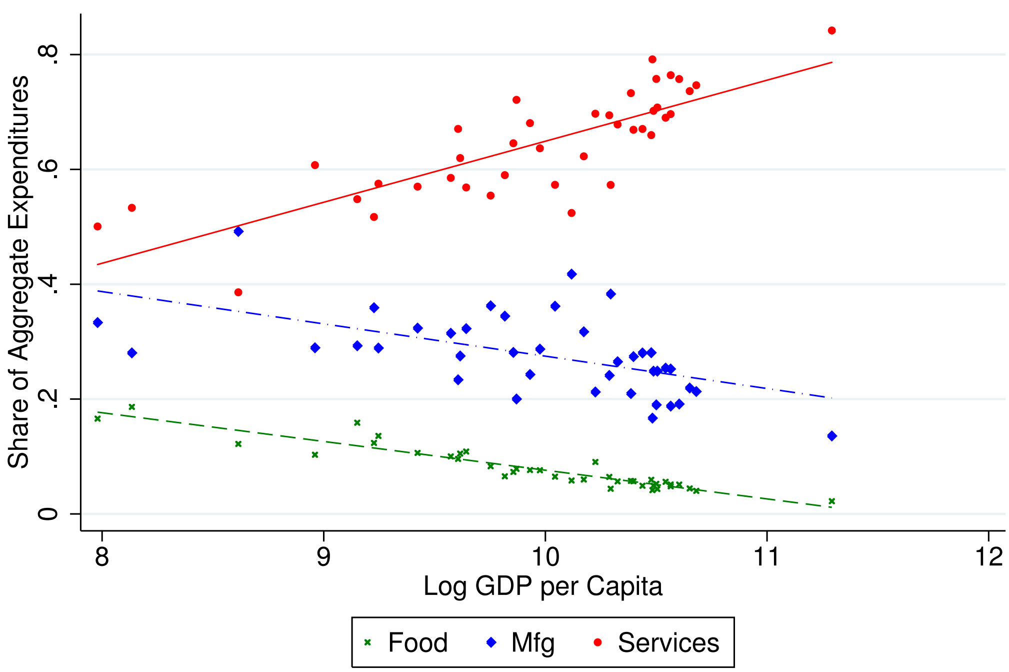


Figure displays Engel curves of expenditure shares in broad sectors against per capita GDP.
See the note in Table 2 for the list of sectors.

Figure 3: β by Exporter and Broad Sector Group vs GDPPC

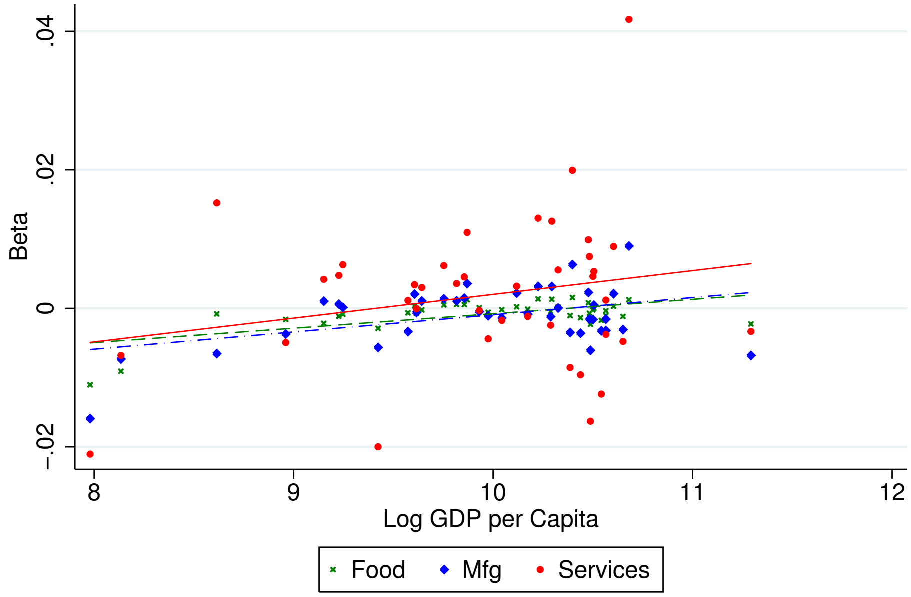
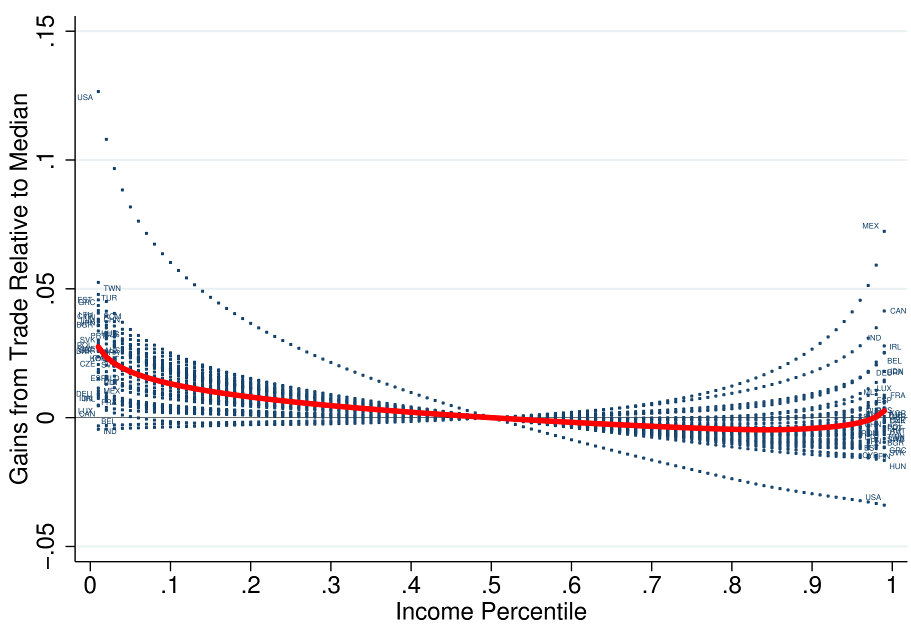


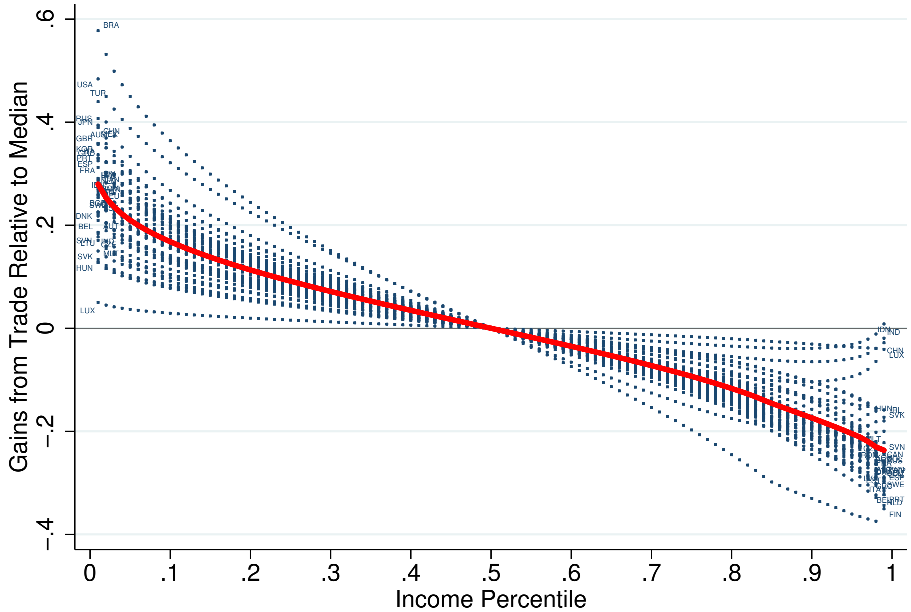
Figure plots income elasticities, summed across broad sectors for each country, against per capita GDP. See the note in Table 2 for the list of sectors.

Figure 4: Distribution of Unequal Gains: Single-Sector Case



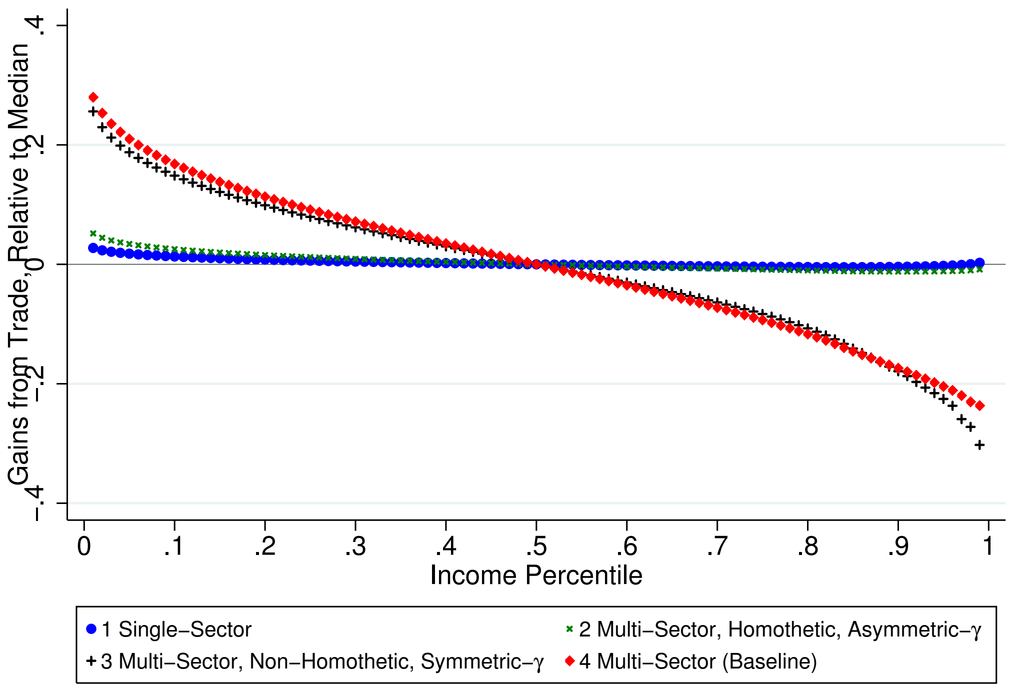
The deviations are relative to the median individual. The red line is the average across countries.

Figure 5: Distribution of Unequal Gains: Baseline Case



The deviations are relative to the median individual. The red line is the average across countries.

Figure 6: Comparison of Distribution of Unequal Gains, Means across Countries



The deviations are relative to the median individual. Figure shows averages across countries, by percentile.

Figure 7: Difference in Gains From Trade Between 90th and 10th Percentiles vs β_i

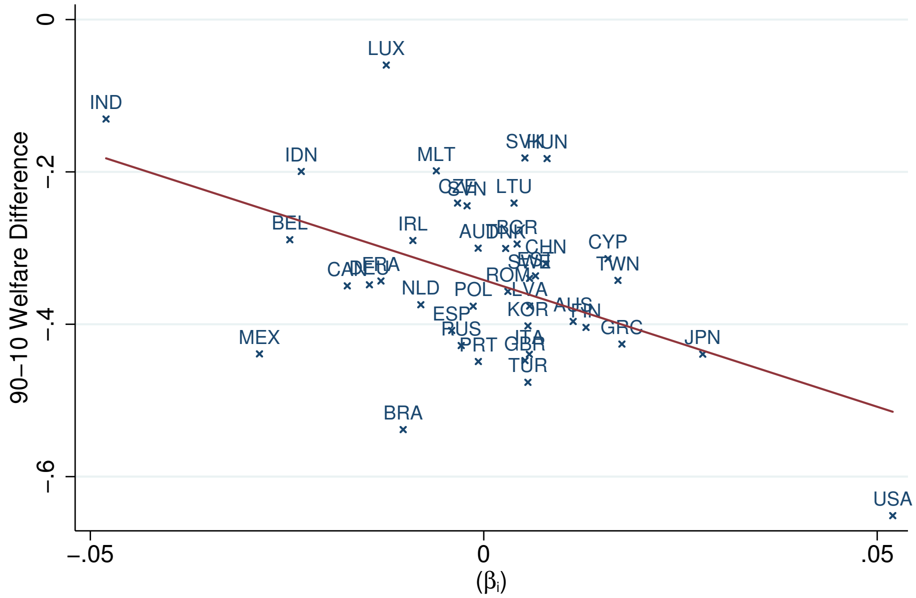
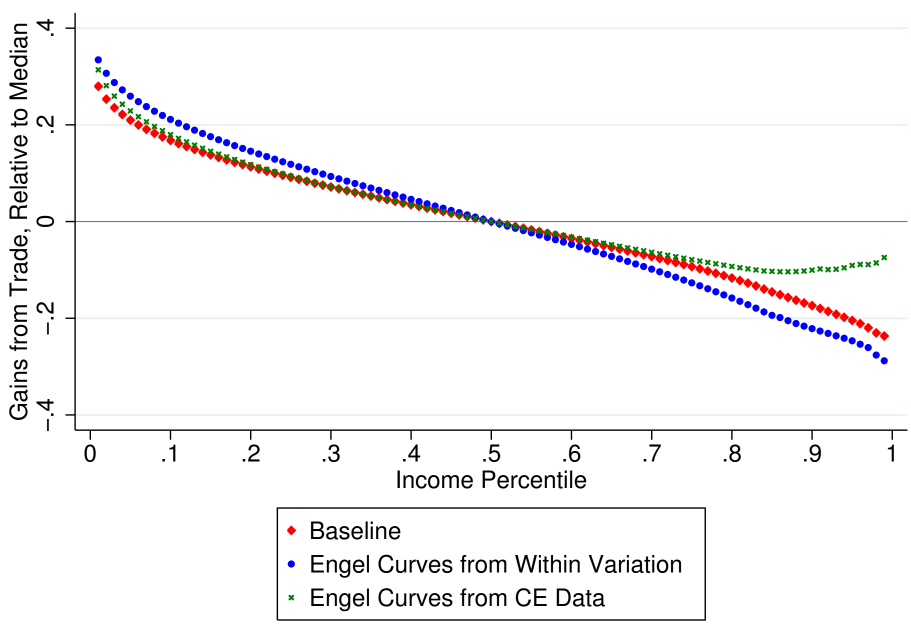


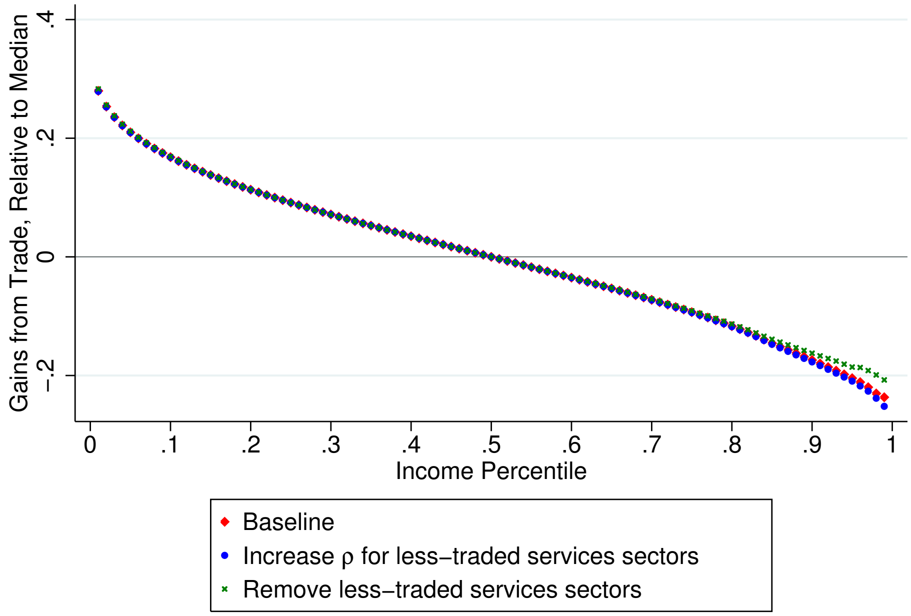
Figure plots the difference in gains from trade between 90th and 10th percentiles against the country's income elasticity

Figure 8: Varying Sectoral Income Elasticities



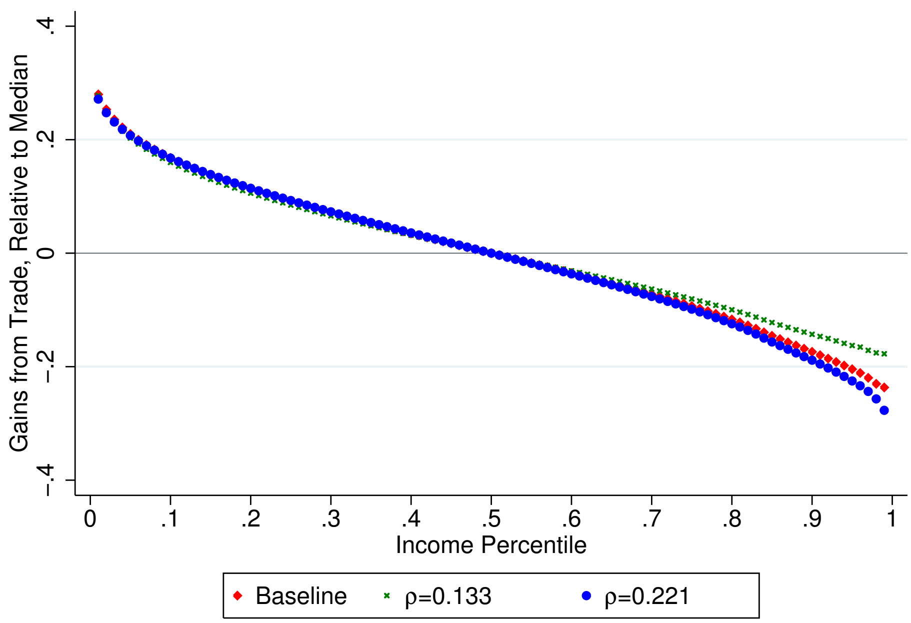
The deviations are relative to the median individual. Figure shows averages across countries, by percentile.

Figure 9: Varying Price Elasticity for Less-Traded Services



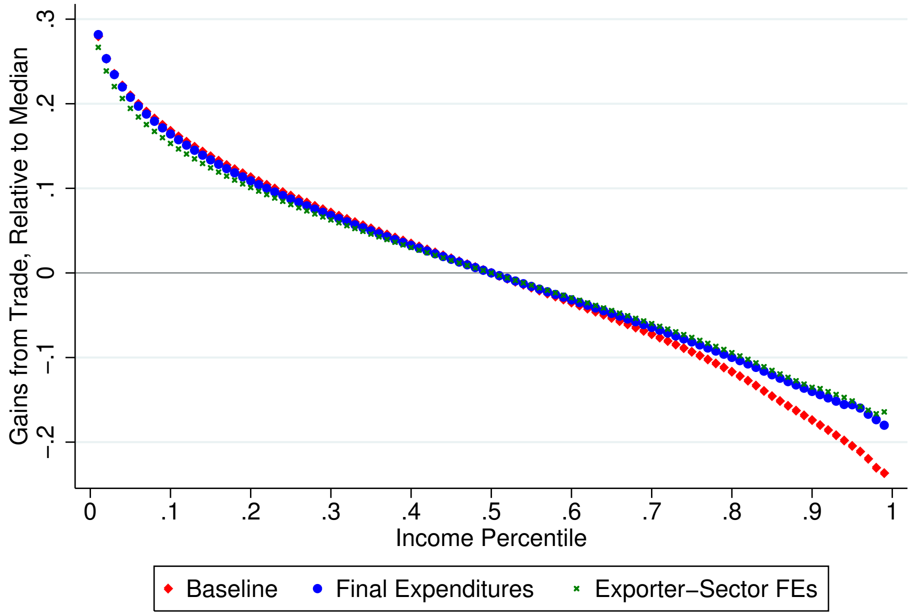
The deviations are relative to the median individual. Figure shows averages across countries, by percentile.

Figure 10: Varying the Value of ρ



The deviations are relative to the median individual. Figure shows averages across countries, by percentile.

Figure 11: Comparing the Baseline to Final Expenditures or Exporter-Sector Fixed Effects



The deviations are relative to the median individual. Figure shows averages across countries, by percentile.

Figure 12: 5% Reduction in Foreign Prices

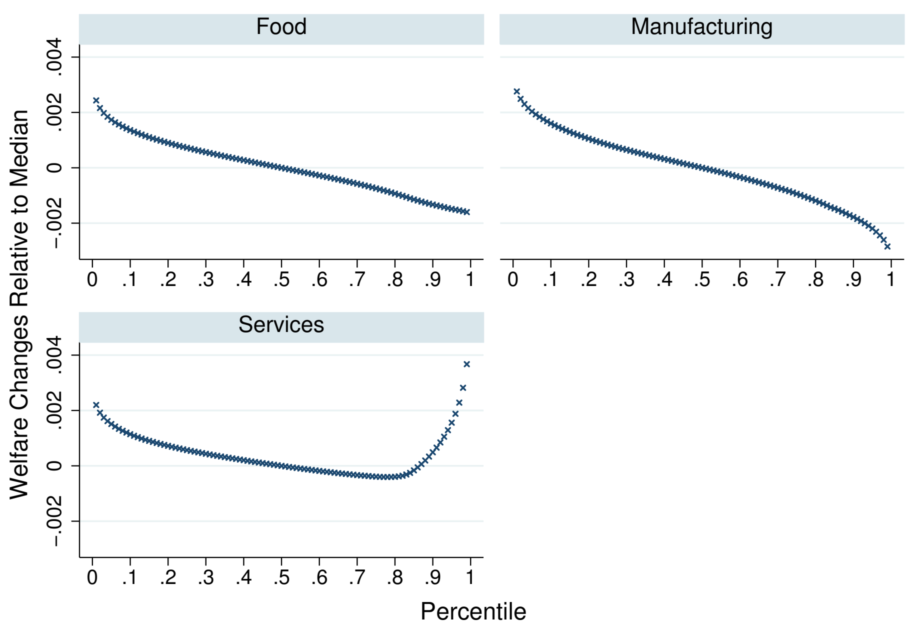


Figure displays the relative welfare gains of 5% decline in foreign trade costs for food, manufacturing, services, and all sectors.

Appendix Tables and Figures

Table A.1: Multi-Sector Translog Gravity Equation

Variables	-Distance (1A)	Language (2A)	Border (3A)		-Distance (1B)	Language (2B)	Border (3B)
Agriculture	0.0013 ***	0.0049 ***	0.0051 ***	Electricity, Gas and Water Supply	0.0013 ***	0.0050 ***	0.0046 ***
	(0.000)	(0.001)	(0.001)		(0.000)	(0.001)	(0.001)
Mining	0.0006 ***	0.0016 ***	0.0023 ***	Construction	0.0039 ***	0.0131 ***	0.0128 ***
	(0.000)	(0.000)	(0.001)		-(0.001)	(0.002)	(0.002)
Food, Beverages and Tobacco	0.0017 ***	0.0059 ***	0.0061 ***	Sale, Repair of Motor Vehicles	0.0005 ***	0.0024 ***	0.0021 ***
	(0.000)	(0.001)	(0.001)		(0.000)	(0.000)	(0.000)
Textiles	0.0004 ***	0.0011 ***	0.0014 ***	Wholesale Trade and Commission Trade	0.0020 ***	0.0081 ***	0.0071 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.001)	(0.001)
Leather and Footwear	0.0001 ***	0.0002 ***	0.0002 ***	Retail Trade	0.0018 ***	0.0059 ***	0.0060 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.001)	(0.001)
Wood Products	0.0002 ***	0.0011 ***	0.0011 ***	Hotels and Restaurants	0.0013 ***	0.0037 ***	0.0037 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.001)	(0.001)
Printing and Publishing	0.0006 ***	0.0020 ***	0.0024 ***	Inland Transport	0.0009 ***	0.0044 ***	0.0045 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.001)	(0.001)
Coke, Refined Petroleum, Nuclear Fuel	0.0008 ***	0.0021 ***	0.0033 ***	Water Transport	0.0001 ***	0.0002 ***	0.0002 ***
	(0.000)	(0.001)	(0.001)		(0.000)	(0.000)	(0.000)
Chemicals and Chemical Products	0.0013 ***	0.0016 ***	0.0023 ***	Air Transport	0.0002 ***	0.0004 ***	0.0005 ***
	(0.000)	(0.000)	(0.001)		(0.000)	(0.000)	(0.000)
Rubber and Plastics	0.0005 ***	0.0010 ***	0.0013 ***	Other Auxiliary Transport Activities	0.0004 ***	0.0024 ***	0.0023 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)
Other Non-Metallic Minerals	0.0005 ***	0.0015 ***	0.0016 ***	Post and Telecommunications	0.0010 ***	0.0033 ***	0.0033 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.001)	(0.001)
Basic Metals and Fabricated Metal	0.0017 ***	0.0034 ***	0.0045 ***	Financial Intermediation	0.0031 ***	0.0056 ***	0.0064 ***
	(0.000)	(0.001)	(0.001)		-(0.001)	(0.001)	(0.001)
Machinery	0.0008 ***	0.0014 ***	0.0017 ***	Real Estate Activities	0.0029 ***	0.0097 ***	0.0095 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.002)	(0.002)
Electrical and Optical Equipment	0.0014 ***	0.0013 ***	0.0018 ***	Renting of M&Eq	0.0026 ***	0.0097 ***	0.0102 ***
	(0.000)	(0.001)	(0.000)		(0.000)	(0.002)	(0.002)
Transport Equipment	0.0011 ***	0.0018 ***	0.0028 ***	Public Admin and Defence	0.0027 ***	0.0074 ***	0.0078 ***
	(0.000)	(0.001)	(0.001)		(0.000)	(0.001)	(0.001)
Manufacturing, nec	0.0003 ***	0.0009 ***	0.0011 ***	Education	0.0012 ***	0.0044 ***	0.0039 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.001)	(0.001)
				Health and Social Work	0.0016 ***	0.0061 ***	0.0063 ***
					(0.000)	(0.001)	(0.001)
				Other Community and Social Services	0.0017 ***	0.0045 ***	0.0047 ***
					(0.000)	(0.001)	(0.001)
				Private Households with Employed Person	0.0001 ***	0.0002 ***	0.0002 ***
					(0.000)	(0.000)	(0.000)
R-squared				0.38			
Observations				56,000			

Notes: Table reports the estimates of the multi-sector translog gravity equation, which shuts of non-homotheticities. The results report sector-specific coefficients on (the negative of) distance, language and border in columns 1, 2 and 3, respectively. Standard errors are clustered by importer. Significance * .10; ** .05; *** .01.

Table A.2: Engel Curve Estimates: Final Expenditures

Variables	(1A)			(1B)	
Agriculture	-0.0219	***	Electricity, Gas and Water Supply	0.0005	
	(0.003)			(0.001)	
Mining	-0.0005		Construction	-0.0169	**
	(0.000)			(0.008)	
Food, Beverages and Tobacco	-0.0169	***	Sale, Repair of Motor Vehicles	0.0037	***
	(0.004)			(0.001)	
Textiles	-0.0045	***	Wholesale Trade and Commission Trade	0.0009	
	(0.001)			(0.003)	
Leather and Footwear	-0.0009	***	Retail Trade	0.0012	
	(0.000)			(0.002)	
Wood Products	0.0002		Hotels and Restaurants	0.0056	**
	(0.000)			(0.002)	
Printing and Publishing	0.0021	***	Inland Transport	-0.0083	***
	(0.000)			(0.003)	
Coke, Refined Petroleum, Nuclear Fuel	-0.0004		Water Transport	-0.0010	
	(0.001)			(0.001)	
Chemicals and Chemical Products	-0.0013		Air Transport	0.0005	
	(0.001)			(0.000)	
Rubber and Plastics	-0.0003		Other Auxiliary Transport Activities	0.0017	**
	(0.000)			(0.001)	
Other Non-Metallic Minerals	-0.0001		Post and Telecommunications	0.0003	
	(0.000)			(0.001)	
Basic Metals and Fabricated Metal	-0.0004		Financial Intermediation	0.0061	***
	(0.001)			(0.002)	
Machinery	-0.0051	*	Real Estate Activities	0.0160	***
	(0.003)			(0.004)	
Electrical and Optical Equipment	-0.0040	***	Renting of M&Eq	0.0039	**
	(0.001)			(0.002)	
Transport Equipment	-0.0031		Public Admin and Defence	0.0082	**
	(0.002)			(0.003)	
Manufacturing, nec	0.0004		Education	0.0044	***
	(0.001)			(0.002)	
			Health and Social Work	0.0246	***
				(0.004)	
			Other Community and Social Services	0.0046	
				(0.003)	
			Private Households with Employed Persons	0.0008	***
				(0.000)	
Sector FEs	yes				
Joint F-test p-value for sectoral elasticities	0.00				
R-squared	0.84				
Observations	1,400				

Notes: Table reports the sectoral income elasticities from the Engel curve equation using data on final expenditures. It is a regression of importers' sectoral expenditures shares on the adjusted real income interacted with sector dummies. The regression also includes sector fixed effects. Standard errors are clustered by importer. Significance * .10; ** .05; *** .01.

Table A.3: Sectoral Gravity Estimates: Final Expenditures

Variables	-Distance (1A)	Language (2A)	Border (3A)		-Distance (1B)	Language (2B)	Border (3B)
Agriculture	0.0009 ***	0.0044 ***	0.0037 ***	Electricity, Gas and Water Supply	0.0007 ***	0.0032 ***	0.0030 ***
	(0.000)	(0.001)	(0.001)		(0.000)	(0.001)	(0.000)
Mining	0.0001 ***	0.0004 **	0.0005 ***	Construction	0.0065 ***	0.0190 ***	0.0182 ***
	(0.000)	(0.000)	(0.000)		-(0.001)	(0.003)	(0.004)
Food, Beverages and Tobacco	0.0020 ***	0.0071 ***	0.0077 ***	Sale, Repair of Motor Vehicles	0.0005 ***	0.0023 ***	0.0022 ***
	(0.000)	(0.001)	(0.001)		(0.000)	(0.000)	(0.000)
Textiles	0.0003 ***	0.0011 ***	0.0015 ***	Wholesale Trade and Commission Trade	0.0021 ***	0.0070 ***	0.0062 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.001)	(0.001)
Leather and Footwear	0.0001 ***	0.0002 ***	0.0003 ***	Retail Trade	0.0023 ***	0.0060 ***	0.0059 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.001)	(0.001)
Wood Products	0.0001 ***	0.0003 ***	0.0003 ***	Hotels and Restaurants	0.0019 ***	0.0056 ***	0.0060 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.001)	(0.001)
Printing and Publishing	0.0003 ***	0.0009 ***	0.0013 ***	Inland Transport	0.0007 ***	0.0036 ***	0.0031 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.001)	(0.001)
Coke, Refined Petroleum, Nuclear Fuel	0.0004 ***	0.0014 ***	0.0023 ***	Water Transport	0.0000 ***	0.0002 ***	0.0002 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)
Chemicals and Chemical Products	0.0004 ***	0.0010 ***	0.0014 ***	Air Transport	0.0002 ***	0.0004 ***	0.0004 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)
Rubber and Plastics	0.0001 ***	0.0003 ***	0.0004 ***	Other Auxiliary Transport Activities	0.0003 ***	0.0014 ***	0.0014 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)
Other Non-Metallic Minerals	0.0001 **	0.0004 ***	0.0004 ***	Post and Telecommunications	0.0009 ***	0.0024 ***	0.0025 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)
Basic Metals and Fabricated Metal	0.0004 ***	0.0013 ***	0.0011 ***	Financial Intermediation	0.0018 ***	0.0049 ***	0.0051 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.001)	(0.001)
Machinery	0.0009 ***	0.0013 ***	0.0017 ***	Real Estate Activities	0.0042 ***	0.0132 ***	0.0130 ***
	(0.000)	(0.000)	(0.000)		-(0.001)	(0.002)	(0.002)
Electrical and Optical Equipment	0.0008 ***	0.0013 ***	0.0016 ***	Renting of M&Eq	0.0010 ***	0.0041 ***	0.0040 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.001)	(0.001)
Transport Equipment	0.0010 ***	0.0018 ***	0.0031 ***	Public Admin and Defence	0.0055 ***	0.0141 ***	0.0137 ***
	(0.000)	(0.001)	(0.001)		-(0.001)	(0.003)	(0.003)
Manufacturing, nec	0.0004 ***	0.0008 ***	0.0013 ***	Education	0.0023 ***	0.0079 ***	0.0075 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.001)	(0.001)
				Health and Social Work	0.0034 ***	0.0116 ***	0.0116 ***
					-(0.001)	(0.002)	(0.002)
				Other Community and Social Services	0.0025 ***	0.0056 ***	0.0061 ***
					-(0.001)	(0.001)	(0.001)
				Private Households with Employed Persons	0.0001 **	0.0004 ***	0.0003 ***
					(0.000)	(0.000)	(0.000)
Ω_i x Sector-Exporter Dummies			not displayed				
Joint F-test p-value for income elasticities			0.00				
R-squared			0.41				
Observations			56,000				

Notes: Table reports the estimates of the sectoral gravity equation using data on final expenditures. The results report sector-specific coefficients on (the negative of) distance, language and border in columns 1, 2 and 3, respectively. The table supresses the sector-exporter interaction coefficients to save space, but recall that the sum of these coefficients across sectors equals sectoral coefficients in Table A.2. Standard errors are clustered by importer. Significance * .10; ** .05; *** .01.

Table A.4: Sectoral Gravity Estimates: Exporter-Sector Fixed Effects

Variables	-Distance (1A)	Language (2A)	Border (3A)		-Distance (1B)	Language (2B)	Border (3B)
Agriculture	0.0015 ***	0.0065 ***	0.0044 ***	Electricity, Gas and Water Supply	0.0017 ***	0.0062 ***	0.0041 ***
	(0.000)	(0.001)	(0.001)		(0.000)	(0.001)	(0.001)
Mining	0.0007 ***	0.0020 ***	0.0019 ***	Construction	0.0050 ***	0.0163 ***	0.0112 ***
	(0.000)	(0.001)	(0.001)		-(0.001)	(0.003)	(0.003)
Food, Beverages and Tobacco	0.0020 ***	0.0073 ***	0.0054 ***	Sale, Repair of Motor Vehicles	0.0007 ***	0.0029 ***	0.0019 ***
	(0.000)	(0.001)	(0.001)		(0.000)	(0.001)	(0.000)
Textiles	0.0004 ***	0.0015 ***	0.0012 ***	Wholesale Trade and Commission Trade	0.0027 ***	0.0097 ***	0.0062 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.002)	(0.001)
Leather and Footwear	0.0001 ***	0.0002 ***	0.0002 ***	Retail Trade	0.0023 ***	0.0071 ***	0.0049 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.001)	(0.001)
Wood Products	0.0003 ***	0.0013 ***	0.0010 ***	Hotels and Restaurants	0.0016 ***	0.0044 ***	0.0031 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.001)	(0.001)
Printing and Publishing	0.0008 ***	0.0024 ***	0.0021 ***	Inland Transport	0.0011 ***	0.0055 ***	0.0041 ***
	(0.000)	(0.001)	(0.000)		(0.000)	(0.001)	(0.001)
Coke, Refined Petroleum, Nuclear Fuel	0.0010 ***	0.0028 ***	0.0027 ***	Water Transport	0.0001 ***	0.0003 ***	0.0002 **
	(0.000)	(0.001)	(0.001)		(0.000)	(0.000)	(0.000)
Chemicals and Chemical Products	0.0014 ***	0.0023 ***	0.0017 ***	Air Transport	0.0003 ***	0.0005 ***	0.0004 ***
	(0.000)	(0.001)	(0.001)		(0.000)	(0.000)	(0.000)
Rubber and Plastics	0.0005 ***	0.0013 ***	0.0011 ***	Other Auxiliary Transport Activities	0.0006 ***	0.0029 ***	0.0022 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.001)	(0.000)
Other Non-Metallic Minerals	0.0006 ***	0.0019 ***	0.0014 ***	Post and Telecommunications	0.0013 ***	0.0040 ***	0.0029 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.001)	(0.001)
Basic Metals and Fabricated Metal	0.0021 ***	0.0046 ***	0.0037 ***	Financial Intermediation	0.0035 ***	0.0072 ***	0.0049 ***
	(0.000)	(0.001)	(0.001)		-(0.001)	(0.002)	(0.002)
Machinery	0.0009 ***	0.0018 ***	0.0014 ***	Real Estate Activities	0.0038 ***	0.0115 ***	0.0080 ***
	(0.000)	(0.000)	(0.000)		-(0.001)	(0.002)	(0.002)
Electrical and Optical Equipment	0.0016 ***	0.0019 ***	0.0011 **	Renting of M&Eq	0.0031 ***	0.0118 ***	0.0087 ***
	(0.000)	(0.001)	(0.000)		-(0.001)	(0.003)	(0.002)
Transport Equipment	0.0012 ***	0.0024 ***	0.0021 ***	Public Admin and Defence	0.0033 ***	0.0088 ***	0.0063 ***
	(0.000)	(0.001)	(0.001)		-(0.001)	(0.002)	(0.002)
Manufacturing, nec	0.0003 ***	0.0010 ***	0.0009 ***	Education	0.0017 ***	0.0054 ***	0.0036 ***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.001)	(0.001)
				Health and Social Work	0.0021 ***	0.0073 ***	0.0055 ***
					(0.000)	(0.002)	(0.001)
				Other Community and Social Services	0.0023 ***	0.0055 ***	0.0040 ***
					-(0.001)	(0.001)	(0.001)
				Private Households with Employed Persons	0.0001 **	0.0002 ***	0.0001 **
					(0.000)	(0.000)	(0.000)
Ω_i x Sector-Exporter Dummies			not displayed				
Joint F-test p-value for income elasticities			0.00				
R-squared			0.45				
Observations			56,000				

Notes: Table reports the estimates of the sectoral gravity equation that includes sector-exporter pair fixed effects. The results report sector-specific coefficients on (the negative of) distance, language and border in columns 1, 2 and 3, respectively. The table supresses the sector-exporter linteraction and level coefficients to save space, but recall that the sum of the interaction coefficients across sectors equals sectoral coefficients in Table 2, and the sum of the coefficients for each exporter across sectors equals the country-specific coefficients in Table 1. Standard errors are clustered by importer. Significance * .10; ** .05; *** .01.

Figure A.1: $\bar{\beta}^s$ versus Sectoral Income Elasticities from Caron et al. (2014)

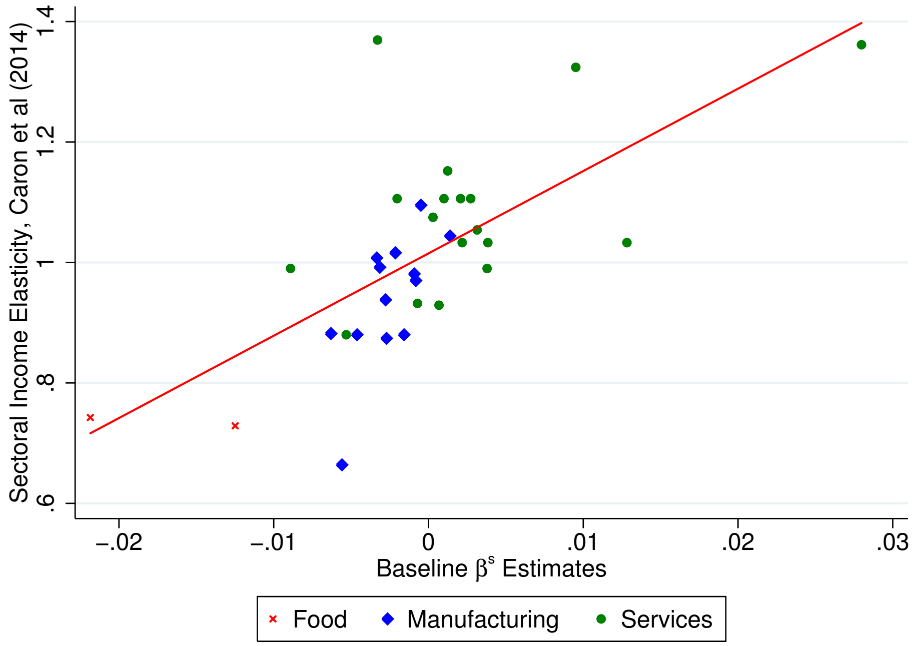
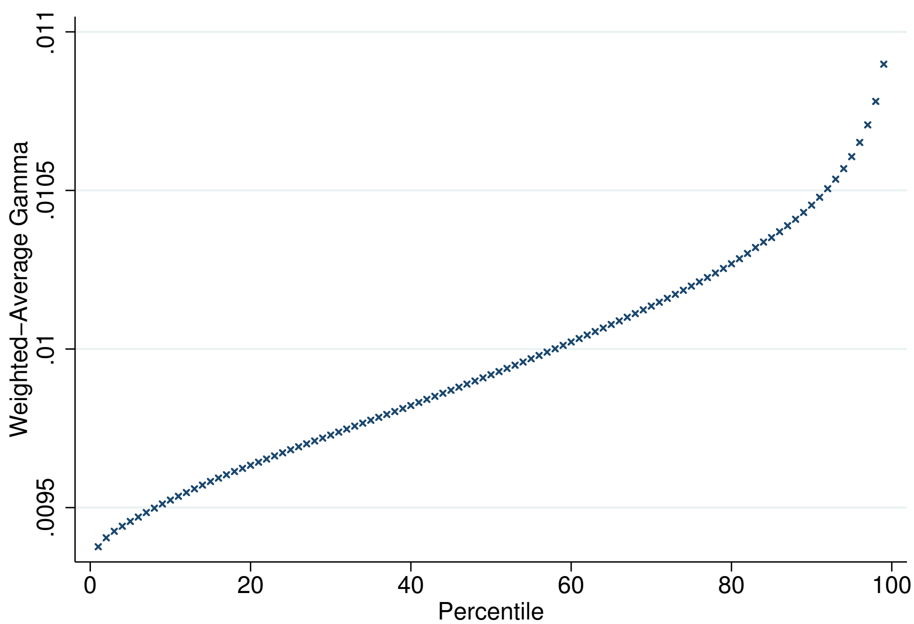


Figure A.2: Average γ, by Percentile



Weighted−average gamma calculated for baseline case

The figure reports $\gamma_h^{av} = \frac{1}{N}\sum_{i=1}^{N}\sum_{s'=1}^{S} s_{n,h}^{s',adj} * \gamma^{s'}$, where $s_{n,h}^{s',adj}$ is the expenditure share of percentile h in country n on goods in sector s'.