Foreign and Domestic Trade Costs, Product Variety, and the Standard of Living Across Countries*

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Abstract

We extend the analysis of Arkolakis, Costinot and Rodríguez-Clare (AER, 2012) to allow for differences in domestic trade costs in addition to foreign trade costs. The domestic trade costs are measured by local transportation charges and wholesaling and retailing margins. By allowing for differences in domestic trade costs, as well as in country size, productivity and in fixed costs, we are able to model both the welfare change between two equilibria and the welfare difference between two countries. We find that the extended ACR formula depends on: (a) the share of expenditure on domestic goods (reflecting in part foreign trade costs); (b) domestic trade costs; (c) the extent of product variety available to consumers. We measure the extent to which differences in the cost of living between countries are explained by these terms. We find that domestic trade costs are of comparable importance to foreign trade costs and that differences in product variety are notably more important than both of these.

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1. Introduction

Since at least McCallum (1995), it has been known that the extent of international trade is surprisingly small as compared to intra-national trade.[1] That observation has led researchers to incorporate the costs of international trade in modern models, such as the time spent clearing customs, transport costs, language differences, the difficulty of making contracts across countries, etc. Such foreign trade costs play a key role, for example, in the various models described by Arkolakis, Costinot and Rodríguez-Clare (ACR, 2012), which lead to a gravity equation for international trade.

Less examined are the consequences of the *domestic* costs of doing trade, by which we mean local transportation charges, and wholesaling and retailing margins. While there are a number of notable studies examining such domestic costs,[2] they have not been incorporated into the theoretical foundation of trade theory. It is significant that ACR treated the domestic costs of doing trade as *fixed* in their analysis of the gains from trade, meaning that within- or between-country differences in these costs are not examined. Literature on the determinants of real GDP, however, finds that the cross-country differences in productivity of the wholesale and retail sectors are of primary importance.[3] In this paper, we extend the analysis of ACR to allow for differences in the domestic costs of trade, as well as in country size, productivity and fixed costs, within and between countries. Our goal is to determine the extent to which domestic trade costs, in addition to foreign trade costs, can explain the differences in the cost of living between countries.

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[1] McCallum (1995) found that in 1988 trade between two Canadian provinces was 22 times greater than trade between a province and a US state, after correcting for GDP and distance.

[2] For example, Atkin and Donaldson (2015) show how internal costs of transport prevent consumers in Ethiopia and Nigeria from benefiting from falling international trade barriers. There are many recent studies of how internal trade costs affects the geographic location of production, with a review by Redding and Rossi-Hansberg (2017).

[3] See Timmer, Inklaar, O'Mahony, and van Ark (2010).

We begin in section 2 by re-examining the theory behind ACR while allowing the domestic costs of trade to vary as well as foreign costs, For simplicity, we focus on only one model underlying the ACR framework – that of Melitz (2003) and Chaney (2008) – though we would expect that similar results would hold in other models, too. We re-derive the expression for the welfare change when domestic costs change, and we find that the share of spending on domestic goods is no longer a sufficient statistic for the welfare change. Instead, the welfare change between two equilibria depends on: (a) the share of expenditure on domestic goods (reflecting in part foreign trade costs); (b) domestic trade costs; (c) the extent of product variety available to consumers. Applying this result across countries, we cannot look only to their openness to inform us about their cost of living or welfare, but we must also consider their domestic trade costs and the extent of product variety.

The implications of our model for the gravity equation in trade are examined in section 3. In section 4, we describe the data that we shall use to determine the foreign and domestic trade costs along with product variety. Following Eaton and Kortum (2002) and Simonovska and Waugh (2014a,b), we use cross-country price data from the International Comparisons Project (ICP). For domestically-produced variety, we use the *count of firms* across countries from the ORBIS global dataset, adjusted to incorporate a Pareto distribution of firm size (as in Naldi, 2003). The count of firms (even adjusted for a Pareto distribution of firm size) is a crude measure of product variety, so we supplement it with newly collected data from the Billion Price Project (BPP, see Cavallo, et al., 2018) that provides a *count of barcodes* across countries in the food and the electronics sectors in major retailers.

Using ICP prices, the country of origin for these products is unknown, so Eaton and Kortum (2002) used the (second) largest price difference across countries to infer trade costs, which are used to estimate the gravity equation. Simonovska and Waugh (2014a,b) extend that analysis to make use of the entire distribution of price differences across countries to infer trade costs and estimate the gravity equation. We rely on much the same technique as Simonovska and Waugh, though extending it to multiple sectors.[4] The country of origin is also unknown for the barcode data from BPP, so in ongoing work we are collected such information from the product packages in a sample of countries, and we use that information to infer domestically-produced variety. That technique will provide an alternative measure of domestic variety as compared to the count of firms. In our results in section 5, we find that domestic trade costs are of comparable importance to foreign trade costs in determining the cost of living across countries, but that differences in product variety are notably more important than both of these. Further conclusions are given in section 6, and the proofs of Propositions are in the Appendix.

2. Modeling Domestic Trade Costs

We introduce domestic costs of trade into the model of Melitz (2003) and Chaney (2008). These are modeled as iceberg costs, meaning that $\tau_d \geq 1$ units must be sent from the domestic firms in order for one unit to reach the consumer. Like the foreign trade costs in Melitz and Chaney, these iceberg costs use up resources. That is a plausible description of resources used in domestic transportation and in the wholesale and retail sectors, which we rely on to measure τ_d. We consider two equilibria that can experience a *domestic shock*, by which we mean a change domestic iceberg costs τ_d, or a change in domestic fixed costs or in the population. In addition, the two equilibria can experience a *foreign shock*, defined as changes in iceberg costs of international trade and in the foreign values of local iceberg costs, fixed costs and population.

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[4] Giri, Yi and Yilmazkudayz (2016) also estimate a sectoral gravity equation following Simonovska and Waugh (2014a,b).

This definition of the foreign shock follows ACR, but the domestic shock is new. By introducing it here, we are able to compare equilibria *within or between countries* with differing values of these shock variables.

The rest of the model is familiar from Melitz and Chaney, so our exposition will be brief. We assume a CES utility function with elasticity of substitution $\sigma > 1$. With trade, the CES price index for the home consumer is defined over domestic and foreign goods as:

$$P = \left[M_d \int_{\varphi_d}^{\infty} p_d(\varphi)^{1-\sigma} \frac{g(\varphi)}{[1-G(\varphi_d)]} d\varphi + M_x^* \int_{\varphi_x^*}^{\infty} p_x^*(\varphi)^{1-\sigma} \frac{g(\varphi)}{[1-G(\varphi_x)]} d\varphi \right]^{1/(1-\sigma)}, \qquad (1)$$

where the first integral reflects the consumer prices of the mass M_d of domestic firms with productivity $\varphi \geq \varphi_{\mathrm{d}}$, and the second integral reflects the import prices $p_x^*(\varphi)$ of the mass M_x^* of *foreign* firms with productivity $\varphi \geq \varphi_x^*$. The density of home and foreign productivities is Pareto distributed with $G(\varphi) = 1-(\varphi / A)^{-\theta}$ for $\varphi \geq A,$ and $\theta > (\sigma - 1) > 1$. Note that the mean productivity is $\int_A^{\infty} \varphi g(\varphi) d\varphi = \left(\frac{\theta}{\theta-1}\right) A.$ It follows that the lower-bound for productivity, *A*, is also proportional to the mean productivity.

To obtain the share of expenditure on domestic goods, which we denote by λ_d, we take the ratio of the first term on the right of (1) to the whole term in brackets,

$$\lambda_d = \left[M_d \int_{\varphi_d}^{\infty} p_d(\varphi)^{1-\sigma} \frac{g(\varphi)}{[1-G(\varphi_d)]} d\varphi \right] \Big/ P^{(1-\sigma)}. \qquad (2)$$

This expression can be simplified by solving for domestic prices. The marginal costs of production at home are w/φ, so that with the usual CES markup the consumer price is $p_d(\varphi) = [\sigma / (\sigma - 1)] \, (\tau_d w / \varphi),$ where $\tau_d \geq 1$ are the domestic iceberg costs. Substituting these prices into the numerator of (2), we obtain:

$$M_d \int_{\varphi_d}^{\infty} \left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} \left(\frac{w\tau_d}{\varphi}\right)^{1-\sigma} \frac{g(\varphi)}{[1-G(\varphi_d)]} d\varphi = M_d \left(\frac{\theta}{\theta-\sigma+1}\right)\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} \left(\frac{w\tau_d}{\varphi_d}\right)^{1-\sigma} . \quad (3)$$

Combining the above results, the share of expenditure on domestic goods is:

$$\lambda_d = \left(\frac{\theta}{\theta-\sigma+1}\right)\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} \left(\frac{w\tau_d}{\varphi_d}\right)^{1-\sigma} \frac{M_d}{P^{1-\sigma}} . \quad (4)$$

Now consider two equilibria, with the second equilibrium denoted by a prime. The ratio of CES price indexes is denoted by P'/P, and it measures the change in the cost of living between the two equilibria, i.e. the inverse of the change in welfare. Then the ratio P'/P is readily obtained by re-arranging (4) as:

$$\frac{P'}{P} = \left[\frac{(M_d')^{\frac{1}{1-\sigma}} w'\tau_d' / \varphi_d'}{M_d^{\frac{1}{1-\sigma}} w\tau_d / \varphi_d}\right]\left(\frac{\lambda_d'}{\lambda_d}\right)^{\frac{1}{\sigma-1}} . \quad (5)$$

This expression can be interpreted as an exact price index according to Proposition 1 of Feenstra (1994). Specifically, we treat the domestic goods as the "common" goods over the two equilibria, and we treat all imported products as new or disappearing, with λ_d and λ_d' denoting the share of expenditure on domestic goods in the two equilibria. The first bracketed term on the right of (5) is the ratio of the *CES price index* of domestic goods,[5] where the variety term $M_d^{\frac{1}{1-\sigma}}$ (and likewise in the prime equilibrium) is the welfare effect of any change in the mass of domestic varieties, while $w\tau_d / \varphi_d$ is proportional to the *average price* of these domestic varieties (using equation (3)). The second term on the right of (5) is the ratio of the share

[5] Proposition 1 of Feenstra (1994) measures the price index of the "common" good using a Sato-Vartia price index. It is equivalent to use the ratio of the CES price index of domestic goods, where this CES domestic price index is defined as expression (3) raised to the power $1/(1 - \sigma)$.

of spending on domestic goods, or one minus the share of spending on new imported varieties. This term reflects that potential gain due to new import varieties, which would result in $\lambda_d' < \lambda_d$ and lower the price index in (5), or the welfare loss from disappearing import varieties, which would result in $\lambda_d' > \lambda_d$ and raise the price index.

With CES demand using the consumer price $p_d(\varphi) = [\sigma/(\sigma - 1)]\,(w\tau_d/\varphi)$, and total home expenditure of *X*, the home demand for a firm with productivity φ is:

$$y_d(\varphi) = \frac{X}{P^{1-\sigma}}\left[\frac{w\tau_d\sigma}{\varphi(\sigma-1)}\right]^{-\sigma}. \tag{6}$$

Multiplying by price minus variable cost, $p_d(\varphi) - (w\tau_d/\varphi) = [1/(\sigma - 1)]\,(w\tau_d/\varphi)$, profits in the home market are,

$$\pi_d(\varphi) = \underbrace{\left[\frac{X}{\sigma^{\sigma}}\left(\frac{w\tau_d}{P(\sigma-1)}\right)^{1-\sigma}\right]}_{B_d}\varphi^{\sigma-1} - wf_d\,,$$

where f_d are the fixed costs in the domestic market. It follows that the zero-cutoff-profit (ZCP) condition in the domestic market is,

$$\pi_d(\varphi_d) = B_d\varphi_d^{\sigma-1} - wf_d = 0 \quad \Rightarrow \quad \varphi_d^{\sigma-1} = \frac{wf_d}{B_d} = \frac{wf_d\sigma^{\sigma}}{X}\left(\frac{w\tau_d}{P(\sigma-1)}\right)^{\sigma-1}. \tag{7}$$

We do not describe the rest of the equilibrium conditions here, but they are outlined in the Appendix. An analogous ZCP condition holds for home exporters, too, as well as for domestic sales in the foreign country and for export sales from abroad. We also describe the full employment condition at home, but we do not insist on trade balance, so the model in this section can be thought of as a single sector in a larger economy.[6]

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[6] In specifying the full employment condition, we assume that the fixed costs of entry, domestic production and exporting are all paid using home labor.

We consider two equilibria that can experience both a domestic and a foreign shock, meaning different values of the iceberg costs, fixed costs, and population in both countries. In this way, we can examine the impact on one country from a change in the foreign variables (following ACR), or we can compare the equilibria between two countries that have differing values for the home and foreign shock variables. The equilibrium conditions that we have described above are enough to obtain results on the sources of welfare differences between the two equilibria. We take the ratio of the ZCP productivity in (7) between the two equilibria, and substitute that into (4) to obtain,

$$\left(\frac{X' / w' f_d'}{X / w f_d}\right)^{\frac{1}{\sigma-1}} = \left(\frac{M_d' / \lambda_d'}{M_d / \lambda_d}\right)^{\frac{1}{\sigma-1}}. \tag{8}$$

The expression on the right of (8) is the inverse of the domestic variety and share terms appearing in (5). Expression (8) therefore measures the welfare gain between the two equilibria due to any expansion of import varieties, resulting in $\lambda_d' < \lambda_d$, relative to the welfare loss due to any reduction in domestic varieties, so that $M_d' < M_d$. Comparing two equilibria with the same values of expenditure X relative to fixed costs wf_d, then *there will be no welfare difference due to variety*: equation (8) shows that $M_d' / \lambda_d' = M_d / \lambda_d$ when $X' / w' f_d' = X / w f_d$, which means that there is no difference due to variety in the relative price indexes in (5). That is the case in the one-sector Melitz-Chaney model in ACR (2012), for example, where trade balance ensures that expenditure equals labor income, $X = wL$, and changes in L and f_d are ruled out, so that $X' / w' f_d' = w' L / w' f_d = L / f_d = X / w f_d$. It follows from (8) that $M_d' / \lambda_d' = M_d / \lambda_d$ so there is no welfare difference due to variety. By allowing for domestic shocks, however, we are thus permitting welfare gains from variety across equilibria, either within or between countries.

Expression (8) shows us how to interpret the variety terms appearing in (5), but we still need to solve for ZCP productivity levels appearing there. As mentioned, we assume a Pareto distribution for firm productivity given by $G(\varphi) = 1 - (\varphi / A)^{-\theta}$, $\varphi \geq A$. The mass of operating domestic firms equals $M_d = M_e[1 - G(\varphi_d)] = M_e(\varphi_d / A)^{-\theta}$ where M_e is the mass of entering firms. Then using this in (8), we obtain,

$$\frac{\lambda_d'}{\lambda_d} = \left(\frac{X'/w'f_d'}{X/wf_d}\right)^{-1}\left(\frac{M_e'}{M_e}\right)\left(\frac{\varphi_d'/A'}{\varphi_d/A}\right)^{-\theta} = \left(\frac{X'/w'L'}{X/wL}\right)^{-1}\left(\frac{f_d'/f_e'}{f_d/f_e}\right)\left(\frac{\varphi_d'/A'}{\varphi_d/A}\right)^{-\theta}, \qquad (9)$$

where the final equality uses the fact that the mass of entering firms is inversely proportional to the effective population size, $M_e \propto L / f_e$, as shown in the Appendix, where f_e are the sunk costs of obtaining a productivity draw. The ratio of fixed to sunk costs that appears in (9) is difficult to identify from the data, so we simplify our model by assuming that it is the same across countries. We state this assumption formally by adding a country superscript $i = 1,\ldots,C$:

Assumption 1:

The fixed and sunk costs of producing for the home market are proportional, $f_d / f_e = f_d' / f_e' = f_d^i / f_e^i$ for all countries $i = 1,\ldots,C$.

Assumption 1 ensures that the ratio $(f_d' / f_e')/(f_d / f_e)$ vanishes in (9). We will also consider the following stronger version, which implies Assumption 1:

Assumption 1′:

The fixed and sunk costs of producing for the home market are proportional to the labor force, $f_d / L = f_d' / L' = f_d^i / L^i$ and $f_e / L = f_e' / L' = f_e^i / L^i$ for all countries $i = 1,\ldots,C$.

This stronger version is has been used by Simonovska and Waugh (2014b), for example, in their analysis of the Melitz-Chaney model. It can be viewed as the most extreme case of the fixed market penetration costs discussed by Arkolakis (2010), which he models as L^{α}, $0 \le \alpha \le 1$, and we are using the α=1 case. With the above assumptions, we obtain:

Proposition 1:

(a) Under Assumption 1, the ratio of the real wages between two equilibria is:

$$\left(\frac{w'/P'}{w/P}\right)=\left(\frac{A'}{A}\right)\left(\frac{\lambda'_d}{\lambda_d}\right)^{-\frac{1}{\theta}}\left(\frac{\tau'_d}{\tau_d}\right)^{-1}\left(\frac{M'_d/\lambda'_d}{M_d/\lambda_d}\right)^{\frac{1}{\sigma-1}}\left(\frac{X'/w'L'}{X/wL}\right)^{-\frac{1}{\theta}}. \tag{10}$$

(b) Under Assumption $1'$, this expression is simplified as:

$$\left(\frac{w'/P'}{w/P}\right)=\left(\frac{A'}{A}\right)\left(\frac{\lambda'_d}{\lambda_d}\right)^{-\frac{1}{\theta}}\left(\frac{\tau'_d}{\tau_d}\right)^{-1}\left(\frac{M'_d/\lambda'_d}{M_d/\lambda_d}\right)^{\frac{1}{\sigma-1}-\frac{1}{\theta}}. \tag{11}$$

The first term on the right of (10) is the ratio of overall productivity levels. The second term on the right of (10) is the ratio of the share of expenditure on domestic goods, with a negative exponent: as that share falls, indicating that more varieties are available from abroad, then the gains from trade are higher. This is the “sufficient statistic” identified by ACR for a foreign shock. The third term is the inverse ratio of domestic trade costs, so that a country with higher domestic trade costs will have correspondingly lower welfare. It is surprising that the domestic trade costs do not involve an exponent reflecting the share of expenditure on domestic goods. To explain this, consider two countries where the only difference between them is that one has higher domestic trade costs, $\tau'_d > \tau_d$. That country will have higher domestic prices and therefore lower real wages and welfare, depending on its consumption of the domestic good. But that country will also have lower expenditure on its domestic goods, $\lambda'_d < \lambda_d$, due to the higher prices. So, from (10), the higher domestic trade costs are *offset* by the lower domestic share, meaning that country welfare does not fall in direct proportion to the higher domestic trade costs.

There is one parameterization, however, where the welfare will fall in direct proportion to the domestic trade costs, and that is where the domestic costs of transport and wholesale and retail trade, *apply equally well to domestic and imported goods*. In this case, the iceberg costs faced by foreign exporters would be ρ_x to ship the good abroad, and then τ_d to deliver it to a home consumer, or $\tau_d \rho_x$ in total. Therefore, a higher value of τ_d would *equally impact* both domestic and import prices. It follows that the domestic share λ_d would not be affected, and so in that case it is not surprising that welfare is inversely proportional to domestic trade costs in (10). We will continue with this particular parameterization in the next section.

The fourth term appearing on the right of (10) measures the welfare gain from domestic and import varieties available to consumers, as discussed just after (8), and the final term is an adjustment for trade imbalance. To see why this final term is needed, consider the sources of consumer gains from variety. In the first case, suppose that trade is balanced (so the final term in (10) is unity) and that the labor force of the home and foreign country both double. This will lead to a doubling in the mass of entering firms $M_e \propto L / f_e$ in both countries, but it turns out that there is no change in the ZCP productivities at home or abroad. Along with the doubling in the mass of entering firms there is also a doubling in the mass of available products M_d and M_x^* at home, which lowers the price index in (1) by $2^{1/(1-\sigma)} < 1$. It follows that real wages increase due to the rise in variety, as evaluated by the fourth term on the right of (10) with $(M_d' / M_d)^{1/(\sigma-1)} = 2^{1/(\sigma-1)} > 1$ and $\lambda_d' = \lambda_d$. So applying that exponent $1/(\sigma-1)$ to M_d' / M_d in (10) is appropriate when the new variety is due to *firm entry*.

In contrast, suppose that expenditure at home doubles but there is no change in the labor force. Then the mass of entering firms $M_e \propto L / f_e$ is *constant*, and it is also constant if L and f_e change in direct proportion as under Assumption $1'$. The doubling of expenditure X in (7) can be expected to reduce the ZCP productivity φ_d, which would lead to an increase in the available domestic products $M_d = M_e[1 - G(\varphi_d)]$. But that extra variety will be from *lower-productivity* domestic goods. In expression (11), the increase in home variety, $M_d' / M_d > 1$, is therefore evaluated with a *reduced* exponent $0 < [1/(\sigma - 1)] - (1/\theta) < 1/(\sigma - 1)$.

The upshot of this discussion is that (11) is a more conservative way to evaluate an increase in variety, within or between countries, because it uses the reduced exponent. Equation (10) would give more weight to variety differences across countries, but it could lead to unusual empirical values because of the trade balance term appearing there (which would be highly unbalanced for certain sectors). For these reasons, we shall proceed by using expression (11) from Proposition 1(b) in our empirical work.

3. Sectoral Gravity Equation

In order to implement Proposition 1, we need an estimate of the Pareto parameter θ from a gravity equation, as well as the elasticity of substitution σ. Following Eaton and Kortum (EK, 2002) and Simonovska and Waugh (2014a,b), we obtain θ from a gravity equation that is estimated using cross-country price data from the ICP. While Eaton and Kortum derive and estimate the gravity equation in the context of their EK model, Simonovska and Waugh (2014b) are the first to estimate the Melitz-Chaney model using ICP data. To show their results, we again distinguish countries with the superscript *i*, and assume:

Assumption 2:

The fixed costs of domestic production in country, f_d^i, equals the fixed costs of exporting to country i from any other source country *j*, for *i*, *j* = 1,…,*C*.

This assumption is most natural in the case where the fixed costs are viewed as marketing costs paid in the destination country, which we are assuming are equal for all domestic and foreign firms selling there. With this assumption, we obtain a gravity equation that is somewhat simpler than derived in Chaney (2008) because it does not involve any fixed cost terms:

Proposition 2:

(a) Under Assumptions 1 and 2, the value of exports X^{ij} from country *i* to *j* relative to total expenditure X^j in country j is,

$$\lambda^{ij} \equiv \frac{X^{ij}}{X^j} = \frac{T^i (w^i \tau^{ij})^{-\theta}}{\sum_{k=1}^{C} T^k (w^k \tau^{kj})^{-\theta}} \quad , \tag{12}$$

where $T^i \equiv M_e^i (\mathrm{w}^i)^{1-\frac{\theta}{\sigma-1}}$.

(b) Under Assumptions 1′ and 2, and with the fixed costs of exporting paid in the destination country, then (12) holds with $T^i \equiv M_e^i$ and its denominator is proportional to the price index raised to the power $-\theta$,

$$(P^i)^{-\theta} \propto \sum_{k=1}^{C} M_e^k (\mathrm{w}^k \tau^{ki})^{-\theta} . \tag{13}$$

Simonovska and Waugh (2014b) use conditions equivalent to Assumptions 1′ and 2, so part (b) just reproduces their result; nevertheless, we provide a proof of both parts (a) and (b) in the Appendix. Part (a) shows that the same gravity equation in (12) holds under the weaker Assumption 1 along with Assumption 2. The difference between parts (a) and (b) is in the definition of the parameter T^i, and importantly, in the interpretation of the denominator of (12).

Using the interpretation as the price index shown in (13), Simonovska and Waugh (2014a,b) follow Eaton and Kortum in measuring the denominator by an *country average price* from ICP data. We will follow their approach, but we use more disaggregate data from the ICP than what was available to them, which is explained as follows.

The ICP provides prices at the "basic heading" level, which we denote by *h*; for example, "rice" is a basic heading. There are 62 basic headings for traded products included in the ICP 2005 that Simonovska and Waugh (2014a,b) used, so they took the simple geometric mean of these prices to form the country price index in (13). For the ICP 2011 round we have more detailed data available, which are the "items" denoted by *n* within each basic heading: for example, "basmati rice" is an item. We denote the prices for items *n*, consumed in country *i*, by p_n^i and we distinguished the items $n \in \Omega(s)$ belonging to each broad sector s. The *average log price* for each country and sector is defined by:

$$D_s^i \equiv \tfrac{1}{N_s} \sum\nolimits_{n \in \Omega(s)} \ln p_n^i \, , \tag{14}$$

where N_s is the number of elements in $\Omega(s)$. Based on the results of Proposition 2(b), we can use $\exp D_s^i$ as an estimate of the sectoral price index P_s^i, so that according to (13) in log terms, $-\theta D_s^i$ can be used to replace the denominator of (12) when needed.

Let use turn now to the estimation of the gravity equation. Taking the log ratio $\lambda_{ns}^{ij} / \lambda_{ns}^{ii}$ from (12), for items $n \in \Omega(s)$ in sector *s*, and using $-\theta_s D_s^i$ to replace the log of the denominator of (12), we obtain the canonical form of the gravity equation:

$$\ln\left(\frac{\lambda_{ns}^{ij}}{\lambda_{ns}^{ii}}\right) = -\theta_s \left(\ln \tau_s^{ij} - \ln \tau_s^{ii} + D_s^i - D_s^j\right), \tag{15}$$

where τ_s^{ij} denotes the iceberg costs to ship items n in sector s from country i to j. A limitation of the ICP price data is that the country of origin is not known, however, so trade costs cannot be inferred by the distance between countries or any similar variable. Instead, Eaton and Kortum and Simonovska and Waugh used the largest (or second largest) price difference across countries to infer trade costs. They estimate this cost by,

$$\ln \hat{\tau}_s^{ij} = \max_{n \in \Omega(s)} \left\{ \ln p_n^j - \ln p_n^i \right\}. \tag{16}$$

The idea behind this approach is that only items that are produced in country *i* and sold in *j* would be expected to have $\{\ln p_n^j - \ln p_n^i\} > 0$. Since we do not know the country of origin, we take the maximum over those log differences (which may be positive or negative depending on the direction of trade) to estimate the trade costs.

Equation (16) is intended to measure the *foreign* costs of trade, since these are used in the gravity equation (15). As it stands, however, the estimate in (16) also includes domestic trade costs if these are applied to imported goods. That will be the case in our country data, and so we state it formally as:

Assumption 3:
In sector s, the trade costs of selling from country i to j are $\tau_s^{ij} \equiv \rho_s^{ij} \tau_s^{jj}$, with $\rho_s^{ij} \geq 1$ and $\rho_s^{ii} = 1$.

In this assumption, we use ρ_s^{ij} to measure the *pure foreign* trade costs of shipping from country *i* to *j*, while τ_s^{jj} denotes the *domestic* trade cost of selling either imported or home-produced goods in country *j*.

To illustrate the usefulness of this assumption, suppose that good *n* with productivity φ_n is exported from country $k(n)$, so that using our notation from the previous section, the prices in

i and j of that good are $p_n^i = [\sigma/(\sigma-1)]\ (w^k \tau^{ki}/\varphi_n)$ and $p_n^j = [\sigma/(\sigma-1)]\ (w^k \tau^{kj}/\varphi_n)$. Then using Assumption 3, the inferred iceberg cost becomes:

$$\begin{aligned}\ln \hat{\tau}_s^{ij} &= \max_{n \in \Omega(s)} \left\{ \ln p_n^j - \ln p_n^i \right\} = (\ln \tau_s^{jj} - \ln \tau_s^{ii}) + \max_{k(n), n \in \Omega(s)} \left\{ \ln \rho_s^{kj} - \ln \rho_s^{ki} \right\} \\ &\leq (\ln \tau_s^{jj} - \ln \tau_s^{ii}) + \ln \rho_s^{ij}.\end{aligned} \tag{17}$$

The second line of (17) follows from arbitrage, since the costs of shipping from k to j, ρ_s^{kj}, must be less than the costs of shipping from k to i and then from i to j, which is $\rho_s^{ki}\rho_s^{ij}$. It follows that $\ln \rho_s^{kj} \leq \ln \rho_s^{ki} + \ln \rho_s^{ij} \Leftrightarrow \ln \rho_s^{kj} - \ln \rho_s^{ki} \leq \ln \rho_s^{ij}$, so the inequality in (17) is obtained.

Notice that the fixed effects D_s^i and D_s^i in (15) will absorb the domestic costs $\ln \tau_s^{jj}$ and $\ln \tau_s^{jj}$ that appear in (15) and (17), so that the remaining variation in $\ln \hat{\tau}_s^{ij}$ reflects the *foreign trade costs* $\ln \rho_s^{ij}$ and no modification of the standard gravity equation is needed.[7] Even with these domestic trade costs absorbed under Assumption 3, however, (17) tells us that $\ln \hat{\tau}_s^{ij}$ does not *exactly* reflect the foreign trade costs $\ln \rho_s^{ij}$ because of the *inequality* that appears there. This is the starting point for Simonovska and Waugh (2014a), who show that the method used by EK to estimate the gravity equation results in a consistent but upward biased estimate of θ_s. They propose a simulated method of moment estimator that yields unbiased (and smaller θ_s estimates). Simonovska and Waugh (2014b) extend that analysis to the Melitz-Chaney model. Proposition 2 above tells us that the structure of gravity equation in our model – even with domestic shocks – is much that same as in their analysis. Accordingly, we will follow their method to obtain estimates of θ_s for the various sectors s that we consider.[8]

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[7] This point was recognized by Eaton and Kortum (2002, note 26) and Simonovska and Waugh (2014a).
[8] In this version of the paper we have used the method that Simonovska and Waugh (2014a) apply to the EK model to recover θ_s, but in ongoing work we are extending our analysis to use the method that Simonovska and Waugh (2014b) apply to the Melitz-Chaney model.

4. Estimates of the Gravity Equation

To estimate θ_s for the different sectors based on sectoral gravity equations (15) requires, first, data on trade flows by sector and, in particular, trade flows of *consumption goods* as assumed in our model. Trade data are taken from the World Input-Output Database (WIOD, Timmer et al. 2015, 2016), which provides trade flows not only by product but also by type-of-use, so that we can distinguish trade flows of consumption goods. Traded products are categorized by industry and we allocate these products to the corresponding consumption sectors. The 2016 release of WIOD covers 43 countries, including all 28 countries in the European Union and 15 other major countries around the world, including the United States, China, India and Indonesia.

The second piece of information consists of the prices needed to implement the trade cost estimator in equation (16). The 2011 round of the International Comparison Program (ICP) is based on detailed surveys of prices of consumption and investment products, both traded and non-traded (World Bank, 2014). We restrict ourselves to the list of (potentially) traded goods for household consumption, of which there are 490. These products span seven sectors of consumption, defined at the two-digit level of the classification of individual consumption by purpose (COICOP), with the number of products varying between 23 (other goods, COICOP 12) and 205 (food, beverages and tobacco, COICOP 01 and 02). In these sectors, the share of expenditure on traded products varies between 25 percent (other goods) and 100 percent (food, beverages and tobacco); see Table 1, below. Four sectors of consumption are omitted because the products in those sectors are either all non-traded (education, hotels and restaurants) or contain so few traded products that the gravity equation estimation is not feasible (housing and utilities, communication). In ICP, not every product is priced in every country, as some products may be atypical of that country's consumption bundle. Of the maximum of 490 consumption products, coverage varies between 213 and 326 products.

Table 1 shows the consumption sectors we include in our analysis. Consumption of traded products represents half of overall household consumption, on average for our set of 43 countries. As discussed above, the share of traded products varies by sector, as does the (maximum) number of products covered in the ICP data. The subsequent column shows the estimates of θ_s, based on the method of Simonovska and Waugh (2014a) and the corresponding 90 percent confidence interval.

Table 1, Consumption sectors, estimated trade elasticity θ_s and elasticity of substitution σ_s

Sector	Code	Traded share (%)	# Products	θ_s	90% C.I.	σ_s
Total traded consumption		47	490	3.56	[3.49–3.61]	
Food, beverages & tobacco	01-02	100	205	4.33	[4.21–4.45]	4.2
Clothing & footwear	03	97	47	4.89	[4.71–5.11]	3.5
Furnishing, household equipment	05	88	69	4.30	[4.19–4.47]	2.5
Health	06	46	52	4.24	[4.19–4.60]	2.5
Transport	07	59	31	7.65	[7.18–8.01]	4.4
Recreation and culture	09	51	59	4.68	[4.53–4.87]	2.2
Other goods	12	25	23	5.19	[4.93–5.50]	2.5

Notes: Code is the COICOP code for the sector, traded share is the share of total sectoral expenditure on traded products, averaged over the 43 countries, # Products is the total number of products in each sector, θ_s is the estimates of the trade elasticity from equation (15), estimated using the Simulated Method of Moments estimator of Simonovska and Waugh (2014a); the 90-percent confidence interval (90% C.I.) is based on a bootstrap, see Simonovska and Waugh (2014a). The final column, σ_s, is the median elasticity of substitution with each sector. These are based on the estimates by Broda and Weinstein (2006) at the HS10 level of detail using the concordance from HS10 to End Use from Feenstra and Jensen (2012). The transport σ_s is based on SITC 5-digit data as the median based on HS10 data is influenced by various large estimates, leading to a σ_s based on HS10 data of 7.8.

Simonovska and Waugh (2014a), using their preferred estimation method and dataset, found θ=4.16 for manufacturing. One important difference with their setup is that our price data are for individual product items, while Simonovska and Waugh (2014a) use relative price estimates for "basic heading" product categories, which span multiple individual product items.

If we estimate a single θ, pooled over all consumption sectors, based on *basic heading* price data rather than product items, we find θ =4.58. As Table 1 shows, moving to pooled estimation over *individual product items* leads to a lower value of 3.56. This lower estimate reflects the greater variability in prices of individual items compared to more aggregate basic heading categories, corresponding to higher implied trade costs and thus, for given trade flows, a lower elasticity.

Turning to the sectoral results, we find higher estimates of θ_s in every sector than for consumption as a whole. This reflects lower variation in prices at the sectoral level than for consumption as a whole, and the fact that every sector has a higher θ_s implies that there are systematic price differences *between* sectors. This observation fits with the Balassa-Samuelson hypothesis, in which differential productivity improvements across sectors lead to differential prices. For most sectors, θ_s is between 4 and 5, a similar magnitude as found in Simonovska and Waugh (2014a,b). The most notable exception is the transport sector, which covers transport equipment and fuel, with θ_s =7.65.

The final column shows the elasticity of substitution σ_s, which is the other key parameter in equation (10). These elasticities are based on Broda and Weinstein (2006), who estimate σ for traded products at the HS-10 level of product detail. We use a concordance from HS-10 to BEA's End Use classification (Feenstra and Jensen, 2012) to allocate the trade-based σ to each consumption sector and the median within each sector is taken as the σ_s shown in the table. Comparing the θ_s and σ_s columns shows that the condition $\theta_s > \sigma_s - 1$ holds for all sectors.

5. The Cost of Living

We shall use Proposition 1(b) to compare the cost of living across countries. To achieve that, we invert (10) to obtain the cost of living between countries *i* and *j*:

$$\left(\frac{P^i}{P^j}\right) = \left(\frac{w^i / A^i}{w^j / A^j}\right)\left(\frac{\lambda_d^i}{\lambda_d^j}\right)^{\frac{1}{\theta}}\left(\frac{\tau_d^i}{\tau_d^j}\right)\left(\frac{M_d^i / \lambda_d^i}{M_d^j / \lambda_d^j}\right)^{\frac{1}{\theta}-\frac{1}{\sigma-1}}. \qquad (20)$$

We can compare this theoretical cost-of-living index across countries to the *price level of consumption*, which we denote by PL_c^i in country *i*. The price level of consumption is measured in the Penn World Table (PWT) as reflecting the observed prices of consumption goods in each country, converted to US$ using the nominal exchange rate and measured relative to the US prices of the same goods. By construction, then, PL_c^i in country i in measured relative to the United State as country j (i.e. $PL_c^{US} \equiv 1$). Many countries in the world have $PL_c^i < 1$, reflecting low prices, but a handful of European countries (especially the Scandinavian countries) have $PL_c^i > 1$, indicating that they have higher US$ prices that the United States.

Several adjustments to (20) are needed to bridge the gap between our stylized model and the data we shall apply to it. First, while our model has only labor, there are many factors of production in reality. This feature is readily incorporated by consideration of the terms w^i / A^i and likewise for country j (i.e. the United States). Let w^i denote a weighted average of factor prices used in production. The term A^i is the lower bound to productivity in (7), and as such it also reflects the mean productivity in country *i* (as discussed just below equation (1)). Suppose we measure country productivity using a dual approach, which would equal the ratio of the weighted average of factor prices to the aggregate output price. Then the ratio w^i / A^i would equal the output price level, which we denote by PL_y^i, which is again taken from PWT.[9]

[9] In contrast to the price level of consumption, the price level of output price level of output reflects the prices of *produced goods* in each country, relative to the US In particular, export prices are included in the price level of output, whereas import prices are included in the price level of consumption.

Second, we shall apply formula (20) at the sectoral level, and within each sector we want to distinguish potentially traded goods *T* from those that are non-traded, denoted with *N*. The transportation sector, for example, includes taxi rides which are a non-traded service. Such services typically do not have domestic trade costs, so that (20) applies only to the potentially traded portion of each sector, which we can measure in practice by the manufacturing portion. The domestic shares λ_{ds}^{i}, in particular are measured for manufactured goods in each sector *s*. Denoting the traded (non-traded) good expenditure in each sector by X_s^{Ti} (X_s^{Ni}), we suppose that there are CES preferences over these portions of expenditure and across sectors. We let W_s^{Ti} equal the Sato-Vartia weight of traded goods in sector s relative to the US.[10] Then (20) is re-written as the cost of living in sector *s* and country *i*, CoL^i, relative to the US as country j:

$$CoL^i = \left(PL_y^i\right)^{W^{Ti}} \prod_{s=1}^{S} \left(\frac{\lambda_s^{ii}}{\lambda_s^{jj}}\right)^{\frac{W_s^{Ti}}{\theta_s}} \left(\frac{\tau_s^{ii}}{\tau_s^{jj}}\right)^{W_s^{Ti}} \left(\frac{M_s^i / \lambda_s^{ii}}{M_s^j / \lambda_s^{jj}}\right)^{\frac{W_s^{Ti}}{\theta_s} - \frac{W_s^{Ti}}{\sigma_s - 1}} \left(PL_{cs}^{Ni}\right)^{W_s^{Ni}} , \qquad (21)$$

where the first term on the right of (21) is the price level of output in each country, obtained from PWT, and it is weighted by the overall share of traded goods in the economy, $W^{Ti} \equiv \sum_{s=1}^{S} W_s^{Ti}$. In the second term we have replaced the share of expenditure on home goods λ_d^i used in (20) with the sectoral notation λ_s^{ii}; in the third term we have likewise replaced the domestic trade costs τ_d^i from (20) with the notation τ_s^{ii}, consistent with Assumption 3; and in the fourth term M_s^i / λ_s^{ii} still denotes the number of home-produced varieties relative to the home expenditure share in country *i* and sector *s*. Those three variables and their sector-specific exponents are

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[10] See the Appendix for the definition of these Sato-Vartia weights for the general nested CES case.

the terms identified in Proposition 1 as determined the relative price of traded goods, and they are weighted by the *traded share* in expenditure W_s^{Ti} relative to the United States. The final term in (21) reflects the price level of *non-traded consumption* goods for each sector, PL_{cs}^{Ni}, which are aggregated across sectors using the *non-traded shares,* W_s^{Ni}. By construction, the cost of living in (21) applies to the entire basket of consumption in each country (i.e. traded and non-traded products), so it can be used to deflate consumption expenditures in each country to obtain a measure of consumer welfare.

It is instructive to compare the cost of living that we construct in (21), CoL^i, to the price level of consumption from PWT, PL_c^i, which measures the difference in consumption prices across countries. That PWT price level makes no adjustments for the factors entering our extended-ACR formula, i.e. PL_c^i does not adjust for productivity or variety differences across countries or domestic trade costs. So we should view CoL^i as a more accurate measure of the "true" cost of living for consumers. To the extent that it differs systematically from PL_c^i, then that would indicate that the simple price level from PWT is an inadequate measure of the cost of living, so that the implied real consumption from PWT would be an inadequate measure of the standard of living.

We implement equation (21) as follows. The output price level PL_y^i is drawn from PWT 9.0 and the nontraded consumption prices PL_{cs}^{Ni} and the expenditure data needed to compute the Sato-Vartia weights are from ICP2011. The share of consumption expenditure on domestic products, λ_s^{ii}, is computed based on WIOD, as are the trade flows for the gravity equation estimation. The domestic trade costs for most countries are based on data in the input-output tables underlying WIOD, and τ_s^{ii} is measured as consumption expenditure in sector s (excluding taxes on products, such as sales, excise or value-added taxes) divided by the basic-prices value of those expenditures, so τ_s^{ii} incorporates margins paid to wholesale and retail trade firms as well as domestic transportation. For a smaller group of countries[11] we use data from surveys of wholesale and retail trade to approximate the same concept.

Our main measure of the number of domestic varieties M_{ds}^i is based on an estimate of the *number of domestic firms* active in each sector, N_{ds}^i. In the Melitz-Chaney, the sales of firms follows a Pareto distribution and the inverse of the shape parameter equals $\eta_s \equiv (\sigma_s - 1)/\theta_s < 1$ (see di Giovanni, Levchenko, Rancière, 2011, equation (2)). It follows that the *number* of firms is not directly comparable across countries as, for instance, larger markets support a larger number of very large firms. Naldi (2003) shows how to transform a firm count with a specific Pareto parameter into the corresponding Herfindahl index, HI_{ds}^i. Taking the inverse of that index we obtain the number of representative, *equally-sized* firms, as in our theory:

$$M_{ds}^i \equiv \frac{1}{HI_{ds}^i} = \frac{\zeta(N_{ds}^i, 2\eta_s)}{\zeta(N_{ds}^i, \eta_s)^2}, \tag{22}$$

where ζ is the truncated zeta function, given by:

$$\zeta(N, \eta) = \sum_{i=1}^{N} i^{-\eta} . \tag{23}$$

Tus, our measure of equally-size domestic firms M_{ds}^i varies according to the number of firms in country i and sector s, N_{ds}^i, and the inverse of the Pareto parameter of firm sales in that

[11] China, Croatia, Japan, Korea, Mexico, Norway, Switzerland and the United States.

sector, η_s. This measure still assumes that the number of *products* is proportional to the number of representative *firms* and that, across countries, the same fraction of firms in a given sector supply to consumers rather than to other firms or to the government.

The source for these data is Bureau van Dijk's ORBIS global dataset, which, in turn, is based on business registers in different countries. We eliminate duplicate names and drop firms with zero employees to eliminate shell companies. As a verification exercise, we also collected data on the number of firms from national enterprise statistics, primarily from the OECD Structural Business Statistics and Eurostat Enterprise Statistics, supplemented by national reports. For most countries, the correspondence between the two sources is close; the correlation of the log number of firms between both sources is 0.75, rising to 0.90 when excluding India and Indonesia. Both of those countries have very large numbers of informal firms, which would skew upwards their variety count.

In Figure 1, we compare our new measure of the cost of living from equation (21) to the price level of consumption. The left-hand side plots the log of both variables with a 45-degree line, the right-hand side plots the log difference between the two measures. Note that the measures of the cost of living and the consumption price level compare each country to the United States, so the United States is at point (0,0) in both panels. The figure shows that differences between the two measures can be substantial, peaking at over 40 percent higher cost of living in Malta (MLT) and Luxembourg (LUX) and showing more than 20 percent higher cost of living in a further six countries; see the Appendix Table A1 for the list of countries (with ISO codes) and detailed results. On the other end, we find that cost of living is lower than implied by the consumption price level for 10 countries, with China showing a cost of living 19 percent below the level implied by the consumption price level.

Figure 1. The relative cost of living versus the consumption price level in 2011

Notes: The left-hand figure plots log CoL^i versus log PL_c^i for the 43 countries in our analysis, with log CoL^i as defined in equation (21) and log PL_c^i from PWT 9.0 (Feenstra et al., 2015), normalized to USA=1. The right-hand figure plots log CoL^i/PL_c^i versus log PL_c^i.

To further examine the relationship between CoL^i and PL_c^i, we perform a decomposition analysis similar to Eaton, Kortum and Kramarz (2004). We initially run the regression:

$$\ln CoL^i = \alpha_0 + \beta_0 \ln PL_c^i + \varepsilon_0^i, i = 1, \ldots, C. \tag{24}$$

This corresponds to a line of best fit for the left-hand side of Figure 1. Next, we define Z_k^i for k =1,…,5, as the five terms on the right of (21), so that in logs:

$$\ln Z_1^i = W^{Ti} \ln PL_y^i \ , \tag{25}$$

$$\ln Z_2^i = \sum_{s=1}^{S} \frac{W_s^{Ti}}{\theta_s} \ln(\lambda_s^{ii} / \lambda_s^{jj}) \ , \tag{26}$$

$$\ln Z_3^i = \sum_{s=1}^{S} W_s^{Ti} \ln(\tau_s^{ii} / \tau_s^{jj}) \ , \tag{27}$$

$$\ln Z_4^i = \sum_{s=1}^{S} W_s^{Ti} \left[\frac{1}{\theta_s} - \frac{1}{(\sigma_s - 1)} \right] \ln\left(\frac{M_s^i / \lambda_s^{ii}}{M_s^j / \lambda_s^{jj}} \right), \tag{28}$$

$$\ln Z_5^i = \sum_{s=1}^{S} W_s^{Ni} \ln\left(PL_{cs}^{Ni} \right). \tag{29}$$

Then we also run:

$$\ln Z_k^i = \alpha_k + \beta_k \ln PL_c^i + \varepsilon_k^i, \quad k = 1,\ldots,5. \tag{30}$$

Because $\ln CoL_c^i = \sum_{k=1}^{5} \ln Z_k^i$, it will follow that the OLS estimates satisfy:

$$\alpha_0 = \sum_{k=1}^{5} \alpha_k \text{ and } \beta_0 = \sum_{k=1}^{5} \beta_k . \tag{31}$$

The individual β_k parameters will show how the various factors used to calculated the cost of living in each country, CoL^i, are related to the consumption price level PL_c^i used in PWT. The results are shown in Table 2.

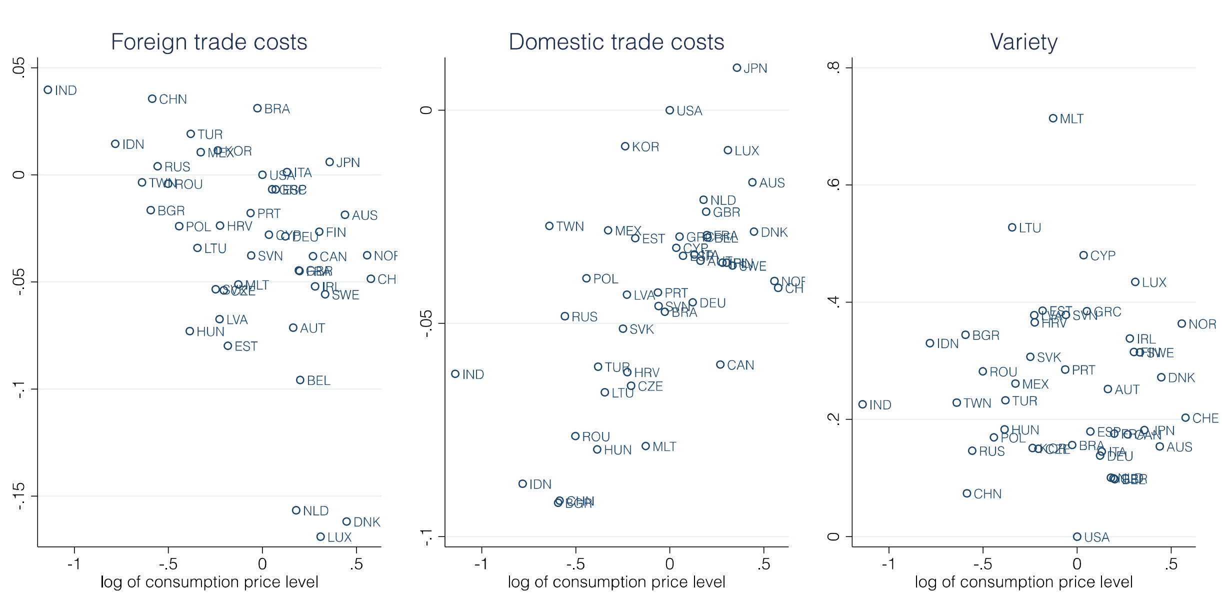
The top line in Table 2 shows that $\beta_0 = 1.12$, indicating that the "true" cost of living increases more rapidly than the consumption price level. Much of this is due to differences in observed prices – of the output price level for traded products and for non-traded prices. Of the three remaining terms, the impact of foreign trade costs decreases significantly with the consumption price level, the impact of domestic trade costs significantly increases, while there is no significant relationship between the impact of variety and the consumption price level.

Table 2. Cost-of-living components regressed on the consumption price level

	Coefficient (s.e.) on the consumption price level	
Cost of living	1.12	(0.04)
Output price level	0.42	(0.02)
Foreign trade costs	-0.06	(0.02)
Domestic trade costs	0.04	(0.01)
Variety	-0.02	(0.04)
Non-traded prices	0.74	(0.03)

Note: The first line shows β_0 from equation (24) and the corresponding robust standard error in parentheses. The subsequent lines show β_k from equations (25)-(29).

Figure 2. The impact of foreign and domestic trade costs and variety on the cost of living



Notes: The figure shows $\ln Z_2^i$, $\ln Z_3^i$ and $\ln Z_4^i$ from equations (26)-(28) for foreign trade costs, domestic trade costs and variety, plotted against the consumption price level $\ln PL_c^i$.

Figure 2 plots the terms for foreign trade costs in (26) (measured by the domestic expenditure share), domestic trade costs in (27), and variety in (28) measured against the log of the consumption price level. The first panel, for foreign trade costs, shows that the small open economies of the Netherlands (NLD), Denmark (DMK) and Luxembourg (LUX) have a notably lower cost of living due to low foreign trade costs, with all other countries showing effects between -10 percent and +5 percent. Except for Japan and Italy, all countries with higher consumption price levels than the United States at (0,0) have lower cost of living than the US due to foreign trade costs. Moreover, in the second panel all countries except for Japan have lower cost of living due to smaller domestic trade costs, with the largest impact in countries with the lowest consumption price levels. The impact of differences in variety shows no systematic relationship with the consumption price level, in the third panel. But the absolute effect on the cost of living tends to be large and variety differences *increase* the cost of living, indicating *lower* variety relative to the United States in all countries. This increase is most pronounced in Malta (MLT), Lithuania (LTU), Cyprus (CYP) and Luxembourg (LTU), at over +40 percent.

As a second method to measure the contribution of the components of the cost of living, we take the *difference* between the "true" cost of living in (21) and the price of consumption from PWT, $\Delta CoL^i \equiv CoL^i - \ln PL_c^i$. Further, define the term:

$$\begin{aligned}\Delta P^i &\equiv \ln Z_1^i + \ln Z_5^i - \ln PL_c^i \\ &= W^{Ti} \ln PL_y^i + \sum_{s=1}^{S} W_s^{Ni} \ln\left(PL_{cs}^{Ni}\right) - \ln PL_c^i,\end{aligned} \tag{32}$$

which is the difference between the components of equation (21) due to weighted PWT output and nontraded prices as compared to the price level of consumption. Likewise, we define $\Delta \ln Z_k^i \equiv \ln Z_k^i - \ln PL_c^i$, k =2,3,4, and we run the regressions:

$$\Delta P^i = \delta_1 + \gamma_1 \Delta CoL^i \tag{33}$$

$$\Delta \ln Z_k^i = \delta_k + \gamma_k \Delta CoL^i \;,\;\; k = 2,3,4. \tag{34}$$

These regressions are the counterparts to those shown in equation (30), but here the aim is to account for the cross-country variation in the *difference* between the relative cost of living and the consumption price level. Table 3 presents the results.

Table 3. Difference between the cost of living and the consumption price level

	Coefficient on difference $\Delta CoL^i \equiv CoL^i - \ln PL_c^i$	
Price differences	0.29	(0.12)
Foreign trade costs	-0.09	(0.06)
Domestic trade costs	0.03	(0.03)
Variety	0.76	(0.11)

Note: Each line in the table corresponds to a γ_k from equation (33) and (34), with $k = 1, \ldots, 4$. Robust standard errors are in parentheses.

By construction, the regression coefficients shown in Table 3 sum to unity, so we can interpret them as the portion of the variation in the cost-of-living difference with respect to the consumption price index, $\Delta CoL^i \equiv CoL^i - \ln PL_c^i$, that is explained by the dependent variable in each regression. The weighted prices of output and nontradables, differenced with respect to the consumption prices index as in (32), has a positive and significant regression coefficient of 0.29 as shown in the first row of Table 3. In other words, about 30% of the cost-of living difference is explained by those prices differences ΔP^i. The foreign and domestic trade cost terms defined in (26) and (27) account for much smaller (and insignificant) amounts of the cost-of-living difference, as shown in the second and third rows. The dominant explanation for the cost-of-living difference is the variety term, with a regression coefficient of 0.76 in the final row of Table 3. So variety differences across countries explain about 75% of the "true" cost-of-living index as compared to the consumption price index.

Another way to see the importance of variety is to compare the second panel of Figure 1, where we graph $\Delta CoL^i \equiv CoL^i - \ln PL_c^i$, with the third panel of Figure 2, where we graph the variety term $\ln Z_4^i$ as defined in (28). There is a strong visual connection between the cost-of-living difference with respect to the consumption price index and the variety index, with countries like Lithuania (LTU), Malta (MLT), Luxembourg (LUX) and Cyprus (CYP) having at least a 30 percent higher cost of living in Figure 1, second panel, and also having lower variety that increases the cost of living by at least 40 percent in Figure 2, third panel.

6. Conclusions

[To be completed]

Appendix

Proof of Proposition 1:

The final equality in (9) uses $M_e \propto L / f_e$. To prove this condition and then prove Proposition 1, we complete the description of the model.

Denoting the iceberg costs of exporting from home by τ_x, export demand for the home firm with productivity φ is analogous to (6),

$$y_x(\varphi) = \frac{X^*}{P^{*1-\sigma}} \left[\frac{w\tau_x\sigma}{\varphi(\sigma-1)} \right]^{-\sigma}. \tag{A1}$$

Multiplying by price minus variable cost, $p_x(\varphi) - (w\tau_x / \varphi) = [1/(\sigma - 1)]\ (w\tau_x / \varphi)$, profits in the export market are,

$$\pi_x(\varphi) = \underbrace{\left[\frac{X^*}{\sigma^\sigma} \left(\frac{w\tau_x}{P^*(\sigma-1)} \right)^{1-\sigma} \right]}_{B_x^*} \varphi^{\sigma-1} - wf_x,$$

where f_x are the fixed costs for exporting. It follows that the zero-cutoff-profit condition in the export market is as follows, as we shall make use of later:

$$\pi_x(\varphi_x) = B_x^* \varphi_x^{\sigma-1} - wf_x = 0 \quad \Rightarrow \quad \varphi_x^{\sigma-1} = \frac{wf_x}{B_x} = \frac{wf_x\sigma^\sigma}{X^*} \left(\frac{w\tau_x}{P^*(\sigma-1)} \right)^{\sigma-1}. \tag{A2}$$

Total employment at home for domestic and export sales equals:

$$L = M_e f_e + M_d \int_{\varphi_d}^{\infty} \left[\frac{\tau_d y_d(\varphi)}{\varphi} + f_d \right] \frac{g(\varphi)}{[1-G(\varphi_d)]} d\varphi + M_x \int_{\varphi_x}^{\infty} \left[\frac{\tau_x y_x(\varphi)}{\varphi} + f_x \right] \frac{g(\varphi)}{[1-G(\varphi_x)]} d\varphi. \tag{A3}$$

Notice that we have multiplied the quantity delivered to home and foreign consumers by their respective iceberg costs, τ_d and τ_x, to obtain the quantity produced by the firm. Multiply the entire expression by wages *w*, and then multiply and divide the production terms by $\sigma / (\sigma - 1)$

to obtain prices $p_d(\varphi)=(\tau_d/\varphi)[\sigma/(\sigma-1)]$ and $p_x(\varphi)=(\tau_x/\varphi)[\sigma/(\sigma-1)]$, so that:

$$\begin{aligned} wL &= w\left(M_e f_e + M_d f_d + M_x f_x\right)+\left(\frac{\sigma-1}{\sigma}\right)\left[M_d\int_{\varphi_d}^{\infty}\frac{p_d(\varphi)y_d(\varphi)g(\varphi)}{[1-G(\varphi_d)]}d\varphi + M_x\int_{\varphi_x}^{\infty}\frac{p_x(\varphi)y_x(\varphi)g(\varphi)}{[1-G(\varphi_x)]}d\varphi\right] \\ &= w\left(M_e f_e + M_d f_d + M_x f_x\right)+\left(\frac{\sigma-1}{\sigma}\right)wL, \end{aligned}$$

where the bracketed term on the first line is the total revenue earned by firms, and with zero expected profits that will equal the payment to labor, *wL*. It follows immediately that $L=\sigma\left(M_e f_e + M_d f_d + M_x f_x\right)$. Then the full employment condition (A3) is simplified as

$$\left(\frac{\sigma-1}{\sigma}\right)L = M_d\int_{\varphi_d}^{\infty}\left[\frac{\tau_d y_d(\varphi)}{\varphi}\right]\frac{g(\varphi)}{[1-G(\varphi_d)]}d\varphi + M_x\int_{\varphi_x}^{\infty}\left[\frac{\tau_x y_x(\varphi)}{\varphi}\right]\frac{g(\varphi)}{[1-G(\varphi_x)]}d\varphi. \qquad \text{(A4)}$$

The CES demand with prices $p_d(\varphi)=(\tau_d/\varphi)[\sigma/(\sigma-1)]$ implies that $y_d(\varphi)=(\varphi/\varphi_d)^{\sigma}y_d(\varphi_d)$.

Using the Pareto distribution for productivity, the first integral in (A4) is then:

$$\begin{aligned} \int_{\varphi_d}^{\infty}\left[\frac{\tau_d y_d(\varphi)}{\varphi}\right]\frac{g(\varphi)}{[1-G(\varphi_d)]}d\varphi &= \int_{\varphi_d}^{\infty}\frac{\tau_d y_d(\varphi_d)}{\varphi}\left(\frac{\varphi}{\varphi_d}\right)^{\sigma}\frac{g(\varphi)}{[1-G(\varphi_d)]}d\varphi \\ &= \frac{\tau_d y_d(\varphi_d)}{\varphi_d}\int_{\phi_d}^{\infty}\left(\frac{\varphi}{\varphi_d}\right)^{\sigma-1}\frac{\theta\varphi^{-\theta-1}}{(\varphi_d)^{-\theta}}d\varphi \\ &= \frac{\tau_d y_d(\varphi_d)}{\varphi_d}\frac{\theta}{(\sigma-\theta-1)}\left(\frac{\varphi}{\varphi_d}\right)^{\sigma-\theta-1}\Bigg|_{\varphi_d}^{\infty} \\ &= f_d\,\frac{(\sigma-1)\theta}{(\theta-\sigma+1)}, \end{aligned}$$

where the last line uses $\tau_d y_d(\varphi_d)/\varphi_d=(\sigma-1)f_d$, as seen from (6) and (7). Likewise using (A1) and (A2) we have $\tau_x y_x(\varphi_x)/\varphi_x=(\sigma-1)f_x$, and so the second integral in (A4) is evaluated as:

$$\int_{\varphi_x}^{\infty}\left[\frac{\tau_x y_x(\varphi)}{\varphi}\right]\frac{g(\varphi)}{[1-G(\varphi_x)]}d\varphi = f_x\,\frac{(\sigma-1)\theta}{(\theta-\sigma+1)}.$$

Substituting these back into (A4) we arrive at:

$$L = \frac{\sigma\theta}{(\theta - \sigma + 1)}\left(M_d f_d + M_x f_x\right).$$

Using $L = \sigma\left(M_e f_e + M_d f_d + M_x f_x\right)$ we obtain $M_e = L(\sigma - 1)/\sigma\theta f_e$, so that $M_e \propto L/f_e$.

Now completing the proof of Proposition 1, from (5) we have:

$$\frac{w'/P'}{w/P} = \left(\frac{M'_d/\lambda'_d}{M_d/\lambda_d}\right)^{\frac{1}{\sigma-1}}\left(\frac{\tau'_d}{\tau_d}\right)^{-1}\left(\frac{\varphi'_d}{\varphi_d}\right). \tag{A5}$$

The final ratio on the right of (A5) is solved using (9) as,

$$\frac{\varphi'_d}{\varphi_d} = \frac{A'}{A}\left(\frac{\lambda'_d}{\lambda_d}\right)^{-1/\theta}\left(\frac{X'/w'L'}{X/wL}\right)^{-1/\theta}, \tag{A6}$$

where $f'_d / f'_e = f_d / f_e$ from Assumption 1. Substituting (A6) into (A5), we obtain (10).

Under Assumption $1'$, the final term in (10) becomes:

$$\left(\frac{X'/w'L'}{X/wL}\right)^{-1/\theta} = \left(\frac{X'/w'f'_d}{X/wf_d}\right)^{-1/\theta} = \left(\frac{M'_d/\lambda'_d}{M_d/\lambda_d}\right)^{-1/\theta}, \tag{A7}$$

where the final equality is from (8). Substituting this into (A6) and (A5), we obtain (11). QED

Proof of Proposition 2:

The mass of profitable domestic firms is $M_d = M_e[1 - G(\varphi_d)]$ and the mass of profitable exporters is $M_x = M_e[1 - G(\varphi_x)]$. Substituting these into the CES price index (1), we can rewrite it by instead integrating over the unconditional distribution $g(\varphi)$ and letting the mass of entrants M_e appear in front of those integrals. We use that rewritten expression as the numerator and denominator of the domestic share in (2). We will generalize our earlier exposition to allow for multiple countries, so that M_e^i are the entrants in country i and φ^{ij} is the zero-cutoff-profit

(ZCP) value of productivity for selling to country j. We also allow the wages w^i to differ across countries. Then the value of exports X^{ij} from country i to j relative to total consumption X^j in county j is written analogously to (2) as:

$$\frac{X^{ij}}{X^j} = \frac{M_e^i \int_{\varphi^{ij}}^{\infty} p^{ij}(\varphi)^{1-\sigma} g(\varphi) d\varphi}{\sum_{k=1}^{C} M_e^k \int_{\varphi^{kj}}^{\infty} p^{kj}(\varphi)^{1-\sigma} g(\varphi) d\varphi} = \frac{M_e^i \int_{\varphi^{ij}}^{\infty} (w^i \tau^{ij} / \varphi)^{1-\sigma} g(\varphi) d\varphi}{\sum_{k=1}^{C} M_e^k \int_{\varphi^{kj}}^{\infty} (w^k \tau^{kj} / \varphi)^{1-\sigma} g(\varphi) d\varphi}, \qquad \text{(A8)}$$

where the second equality follows by using the prices $p^{ij}(\varphi) = [\sigma / (\sigma - 1)](w^i \tau^{ij} / \varphi)$. Notice that the iceberg trade costs τ^{ij} can be moved outside the integrals in the above expression.

The ZCP condition for productivity for home sales is (7), which is written more generally for country i exporting to j as,

$$(\varphi^{ij})^{\sigma-1} = \frac{w^i f^j \sigma^\sigma}{X^j} \left(\frac{w^i \tau^{ij}}{P^j(\sigma - 1)} \right)^{\sigma-1}. \qquad \text{(A9)}$$

From Assumption 2, the fixed cost of exporting to country j is the same as the fixed cost for domestic sales, $f_x^j = f_d^j$, so we denote them both as simply f^j in (A9). We make use of the Pareto distribution to evaluate the integral in the numerator of (A8):

$$\begin{aligned} \int_{\varphi^{ij}}^{\infty} (w^i \tau^{ij} / \varphi)^{1-\sigma} g(\varphi) d\varphi &= (w^i \tau^{ij})^{1-\sigma} \theta \int_{\varphi^{ij}}^{\infty} \varphi^{\sigma-\theta-2} \, \mathrm{d}\varphi \\ &= \frac{(w^i \tau^{ij})^{1-\sigma} \theta}{\sigma - \theta - 1} \varphi^{\sigma-\theta-1} \Big|_{\varphi^{ij}}^{\infty} \\ &= \frac{(w^i \tau^{ij})^{1-\sigma} \theta}{\theta - \sigma + 1} (\varphi^{ij})^{\sigma-\theta-1}. \end{aligned}$$

Combining this result with (A8) and (A9) it follows that,

$$\frac{X^{ij}}{X^j} = \frac{M_e^i (w^i \tau^{ij})^{-\theta} \left(w^i f^j \right)^{1-\frac{\theta}{\sigma-1}}}{\sum_{k=1}^{C} M_e^k (w^k \tau^{kj})^{-\theta} \left(w^k f^j \right)^{1-\frac{\theta}{\sigma-1}}}. \qquad \text{(A10)}$$

Notice that f^j cancels from this expression, so we obtain (12) with $T^i \equiv M_e^i (w^i)^{1-\frac{\theta}{\sigma-1}}$.

When the fixed costs are paid in the destination country, then (A10) is rewritten as,

$$\frac{X^{ij}}{X^j} = \frac{M_e^i (w^i \tau^{ij})^{-\theta} \left(w^j f^j\right)^{1-\frac{\theta}{\sigma-1}}}{\sum_{k=1}^{C} M_e^k (w^k \tau^{kj})^{-\theta} \left(w^j f^j\right)^{1-\frac{\theta}{\sigma-1}}}. \tag{A11}$$

Now the term $w^j f^j$ cancels from this expression, so we obtain (12) with $T^i \equiv M_e^i$. To solve for the price index, we make use of the results from section 2. In (4) we showed the domestic share of expenditure, but it is not a gravity equation because it involves the ZCP productivity φ_d. Using the solution to that productivity from (7), along with $M_d = M_e[1-G(\varphi_d)] = M_e \varphi_d^{-\theta}$ for the Pareto distribution, we obtain the domestic share:

$$\lambda_d \propto \left(\frac{f_d}{L}\right)^{1-\frac{\theta}{\sigma-1}} \left(\frac{w\tau_d}{P_d}\right)^{-\theta} M_e, \tag{A12}$$

where the factor of proportionality depends on θ and σ and so it is constant across countries. Assumption 1′ means that (f_d / L) is also constant across countries, so we rewrite (A12) in the more general notation for countries i =1,…,C:

$$\lambda^{ii} \propto \left(\frac{w^i \tau^{ii}}{P^i}\right)^{-\theta} M_e^i \;\Rightarrow\; (P^i)^{-\theta} \propto \left(\frac{M_e^i}{\lambda^{ii}}\right) (w^i \tau^{ii})^{-\theta}. \tag{A13}$$

With fixed costs paid in the destination country, (A10) is rewritten as (A11), and since $w^j f^j$ cancels from that expression then $\lambda^{ii} \equiv X^{ii} / X^i$ is,

$$\lambda^{ii} = \frac{M_e^i (\mathrm{w}^i \tau^{ii})^{-\theta}}{\sum_{k=1}^{C} M_e^k (\mathrm{w}^k \tau^{ki})^{-\theta}}.$$

Substituting this into (A13), we obtain (13).   QED

Sato-Vartia weights:

We consider the general case of a nested CES function, where the expenditure between traded and non-traded components of expenditure in each sector are related by a CES function, the traded goods are aggregated across countries with another CES function, and then the expenditure over the various sectors is also aggregated using a third CES function.

At the lowest level, the non-traded services included in the price index $\mathrm{P}_{\mathrm{s}}^{\mathrm{Ni}}$ are purchase entirely from domestic sources (e.g. taxi rides within the transportation sector), while the traded goods price index P_s^{Ti} is composed over the prices of goods that can be purchased from home, P_s^{Tii}, and those that are purchased from abroad, P_s^{Tji}, $j \neq i$:

$$P_s^{Ti} = \left[\sum_{j=1}^{C} (P_s^{Tji})^{1-\sigma} \right]^{1/(1-\sigma)}, \ \sigma > 1 .$$

This price index is comparable to what appears in (1) in our model, though in (1) we also allow for a mass of products from each country. Above that level, the price index $\mathrm{P}_{\mathrm{s}}^{\mathrm{i}}$ for country i and sector s is given by:

$$P_s^i = \left[(P_s^{Ti})^{1-\gamma} + (P_s^{Ni})^{1-\gamma} \right]^{1/(1-\gamma)}, \ \gamma > 1. \tag{A14}$$

Finally, we aggregate across sectors using a third CES function,

$$P^i = \left[\sum_{s=1}^{S} (P_s^i)^{1-\eta} \right]^{1/(1-\eta)}, \ \eta > 0. \tag{A15}$$

Choose country *j* (i.e. the United States) as the base country. Then the sectoral prices index in country *i* relative to *j* can be measured by the Sato-Vartia price index:

$$\frac{P_s^i}{P_s^j} = \left(\frac{P_s^{Ti}}{P_s^{Tj}} \right)^{\omega_s^{Ti}} \left(\frac{P_s^{Ni}}{P_s^{Nj}} \right)^{\omega_s^{Ni}}, \tag{A16}$$

where the Sato-Vartia weights, $\omega_s^{Ti}+\omega_s^{Ni}=1$, are defined over the expenditure shares on traded and non-traded services. Since we have already used the variable *X* to denote expenditures and *s* to denote sectors, we will use *x* to denote expenditure shares. So $x_s^{Ti} \equiv X_s^{Ti} / X_s^{i}$ is the share of expenditure on traded goods relative to total expenditure, $X_s^{i} \equiv (X_s^{Ti}+X_s^{Ni})$, in country *i* and sector *s*. Then the Sato-Vartia weights used in (A16) are;

$$\omega_s^{Ti} \equiv \frac{(x_s^{Ti}-x_s^{Tj})}{(\ln x_s^{Ti}-\ln x_s^{Tj})} \Bigg/ \left[\frac{(x_s^{Ti}-x_s^{Tj})}{(\ln x_s^{Ti}-\ln x_s^{Tj})}+\frac{(x_s^{Ni}-x_s^{Nj})}{(\ln x_s^{Ni}-\ln x_s^{Nj})}\right],\ \omega_s^{Ni}=1-\omega_s^{Ti}. \qquad \text{(A17)}$$

Analogously, the overall price index in country i relative to that for in country j is constructed as the Sato Vartia index defined over sectors:

$$\frac{P^i}{P^j}=\sum_{s=1}^{S}\left(\frac{P_s^i}{P_s^j}\right)^{\omega_s^i}, \qquad \text{(A18)}$$

where the Sato-Vartia weights are defined over the expenditure shares $x_s^i \equiv X_s^i / X^i$:

$$\omega_s^{i} \equiv \frac{(x_s^{i}-x_s^{j})}{(\ln x_s^{i}-\ln x_s^{j})} \Bigg/ \left[\sum_{r=1}^{S}\frac{(x_r^{i}-x_r^{j})}{(\ln x_r^{i}-\ln x_r^{j})}\right]. \qquad \text{(A19)}$$

Equation (21) aggregates over traded goods and non-traded services and over sectors. Substituting (A16) into (A18), that country-level relative price is:

$$\frac{P^i}{P^j}=\sum_{s=1}^{S}\left(\frac{P_s^{Ti}}{P_s^{Tj}}\right)^{\omega_s^{Ti}\omega_s^i}\left(\frac{P_s^{Ni}}{P_s^{Nj}}\right)^{\omega_s^{Ni}\omega_s^i}. \qquad \text{(A20)}$$

It follows that the relevant weights that appear in (21) are $W_s^{Ti} \equiv \omega_s^{Ti}\omega_s^i$ and $W_s^{Ni} \equiv \omega_s^{Ni}\omega_s^i$. The latter weights are applied in (21) to the price levels for non-traded services in each sector that are constructed from ICP data.

Appendix Table A 1

Country	ISO-code	PLc	CoL	log(CoL/PLc)	Due to: prices	foreign trade costs	domestic trade costs	varieties
India	IND	0.32	0.34	0.06	1.59	0.04	-0.06	0.23
Indonesia	IDN	0.46	0.45	-0.01	0.94	0.01	-0.09	0.33
Taiwan	TWN	0.53	0.55	0.04	0.86	0.00	-0.03	0.23
Bulgaria	BGR	0.55	0.56	0.01	-0.23	-0.02	-0.09	0.34
China	CHN	0.56	0.46	-0.19	0.44	0.04	-0.09	0.07
Russia	RUS	0.57	0.54	-0.07	0.80	0.00	-0.05	0.15
Romania	ROU	0.61	0.63	0.04	1.04	0.00	-0.08	0.28
Poland	POL	0.64	0.63	-0.03	-0.36	-0.02	-0.04	0.17
Hungary	HUN	0.68	0.62	-0.10	0.36	-0.07	-0.08	0.18
Turkey	TUR	0.68	0.68	0.00	0.11	0.02	-0.06	0.23
Lithuania	LTU	0.71	0.96	0.30	0.43	-0.03	-0.07	0.53
Mexico	MEX	0.72	0.84	0.15	0.76	0.01	-0.03	0.26
Slovakia	SVK	0.78	0.87	0.11	0.29	-0.05	-0.05	0.31
Korea	KOR	0.79	0.75	-0.04	-0.04	0.01	-0.01	0.15
Latvia	LVA	0.80	0.89	0.11	0.53	-0.07	-0.04	0.38
Croatia	HRV	0.80	0.93	0.15	0.42	-0.02	-0.06	0.37
Czech Republic	CZE	0.81	0.79	-0.03	0.41	-0.05	-0.06	0.15
Estonia	EST	0.83	1.00	0.18	0.17	-0.08	-0.03	0.39
Malta	MLT	0.88	1.46	0.50	-0.23	-0.05	-0.08	0.71
Portugal	PRT	0.94	1.13	0.18	-0.45	-0.02	-0.04	0.29
Slovenia	SVN	0.94	1.21	0.25	-0.99	-0.04	-0.05	0.38
Brazil	BRA	0.97	1.00	0.02	-1.25	0.03	-0.05	0.16
United States	USA	1.00	1.00	0.00	0.19	0.00	0.00	0.00
Cyprus	CYP	1.04	1.49	0.36	0.07	-0.03	-0.03	0.48
Greece	GRC	1.05	1.40	0.28	0.26	-0.01	-0.03	0.38
Spain	ESP	1.07	1.20	0.11	-0.51	-0.01	-0.03	0.18
Germany	DEU	1.13	1.16	0.02	-0.59	-0.03	-0.05	0.14
Italy	ITA	1.14	1.24	0.08	0.42	0.00	-0.03	0.15
Austria	AUT	1.18	1.35	0.14	-0.55	-0.07	-0.04	0.25
Netherlands	NLD	1.20	1.13	-0.06	-0.60	-0.16	-0.02	0.10
United Kingdom	GBR	1.21	1.27	0.05	-0.40	-0.04	-0.02	0.10
France	FRA	1.22	1.34	0.10	0.00	-0.04	-0.03	0.18
Belgium	BEL	1.22	1.21	-0.01	0.21	-0.10	-0.03	0.10
Canada	CAN	1.31	1.37	0.05	-0.84	-0.04	-0.06	0.17
Ireland	IRL	1.32	1.56	0.16	-0.39	-0.05	-0.04	0.34

Finland	FIN	1.35	1.75	0.26	-0.96	-0.03	-0.04	0.32
Luxmebourg	LUX	1.36	2.23	0.49	-1.04	-0.17	-0.01	0.43
Sweden	SWE	1.40	1.76	0.23	-0.68	-0.06	-0.04	0.31
Japan	JPN	1.43	1.67	0.15	-0.46	0.01	0.01	0.18
Australia	AUS	1.55	1.76	0.12	-0.09	-0.02	-0.02	0.15
Denmark	DNK	1.56	1.67	0.06	-1.02	-0.16	-0.03	0.27
Norway	NOR	1.74	2.01	0.14	-1.35	-0.04	-0.04	0.36
Switzerland	CHE	1.78	1.91	0.07	-0.58	-0.05	-0.04	0.20

References

Arkolakis, Costas. 2010. “Market Penetration Costs and the New Consumers Margin in International Trade,“ *Journal of Political Economy*, 118(8): 1151 – 1199

Arkolakis, Costas, Arnaud Costinot and Andrés Rodríguez-Clare. 2012. “New Trade Models, Same Old Gains?“ *American Economic Review* 102(1): 94-130.

Atkin, David and Dave Donaldson. 2015. “Who's Getting Globalized? The Size and Implications of Intra-national Trade Costs,” NBER Working Paper No. 21439.

Chaney, Thomas. 2008. “Distorted Gravity: the Intensive and Extensive Margins of International Trade.” *American Economic Review* 98(4): September, 1707-1721.

di Giovanni, Julian, Levchenko, Andrei A. and Rancière, Romain, 2011. “Power Laws in Firm Size and Openness to Trade: Measurement and Implications,” *Journal of International Economics*, 85(1): September, 42-52.

Eaton, Jonathan and Samuel Kortum. 2002. “Technology, Geography and Trade.” *Econometrica,* 70(7): September, 1741-1780.

Eaton, Jonathan, Samuel Kortum and Francis Kramarz. 2004. “Dissecting Trade: Firms, Industries, and Export Destinations.” *American Economic Review,* 94(2): 150-154.

Giri, Rahul, Kei-Mu Yi, and Hakan Yilmazkudayz. 2016. “Gains from Trade: Does Sectoral Heterogeneity Matter?” IMF, University of Houston and University of Florida.

McCallum, John. 1995. “National Borders Matter.” *American Economic Review* 85: 615-623.

Melitz, Marc. 2003. “The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity.” *Econometrica*, 71(6): November, 1695-1725.

Naldi, M. 2003. “Concentration Indices and Zipf’s Law.” *Economics Letters,* 78: 329-334.

Redding, Stephen J. and Esteban Rossi-Hansberg. 2017. “Quantitative Spatial Economics.” *Annual Review of Economics*, 9(1), 21-58.

Simonovska, Ina and Michael E. Waugh. 2014a. “The Elasticity of Trade: Estimates and Evidence.” *Journal of International Economics,* 92: 34-50.

Simonovska, Ina and Michael E. Waugh. 2014b. “Trade Models, Trade Elasticities, and the Gains from Trade.” NBER Working Paper 20495.

Timmer, Marcel P., Robert Inklaar, Mary O’Mahony, and Bart van Ark. 2010. *Economic Growth in Europe*. Cambridge: Cambridge University Press.

Timmer, M. P., Dietzenbacher, E., Los, B., Stehrer, R. and de Vries, G. J. 2015. "An Illustrated User Guide to the World Input–Output Database: The Case of Global Automotive Production", *Review of International Economics*, 23: 575–605.

Timmer, M. P., Los, B., Stehrer, R. and de Vries, G. J. 2016. "An Anatomy of the Global Trade Slowdown based on the WIOD 2016 Release", *GGDC research memorandum* number 162, University of Groningen.

World Bank. 2014. *Purchasing Power Parities and the Real Size of World Economies. A Comprehensive report of the 2011 International Comparison Program.* World Bank: Washington: DC.