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Abstract: Observed trade flows provide one metric to gauge the degree of international goods market segmentation. Deviations from the law of one price provide another. New survey data on retail prices for a broad cross section of goods across 13 EU countries, compiled by Crucini, Telmer and Zachariadis (2005), show that (i) the average dispersion of law of one price deviations across all goods is 28 percent and (ii) the range of that dispersion across goods is large, varying from 2 percent to 83 percent. Quantitative multi-country Ricardian models, *a la* Eaton and Kortum, use data on bilateral trade volumes to estimate international trade barriers or *trade costs*. This paper investigates whether the degree of international goods market segmentation implied by these models can account for observed cross-country dispersion in prices. When heterogeneous and asymmetric trade costs are carefully calibrated to match observed bilateral trade volumes, the model can account for 85 percent of the average dispersion of law of one price deviations found in the data. However, it generates only 21 percent of the good by good variation in price dispersion. The model is augmented to permit heterogeneity in local costs of distribution - across goods and countries - and is calibrated to match data on distribution margins. While the augmented model can reproduce 96.5 percent of the average dispersion of law of one price deviations, it can match only 32 percent of the variation in that dispersion. Heterogeneity in trade costs, and in local distribution costs, cannot account for observed heterogeneity in the dispersion of law of one price deviations.

JEL Codes: F11, F15

Keywords: Trade, international trade costs, distribution costs, law of one price, price dispersion

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1 Introduction

The law of one price (LOOP) states that once the price of a traded good is expressed in a common currency, the good should sell for the same price in different countries. The intuition is that, in perfectly integrated international markets, free trade in goods will arbitrage away price differentials across countries. Traditionally, the size of observed bilateral trade flows has been used as the metric to gauge the actual degree of goods' market integration - or its absence, the degree of market segmentation. The size of deviations from the LOOP provides an alternative measure. There are two commonly cited sources of goods market segmentation that give rise to LOOP deviations; first, the costs of international transactions or barriers to trade and, second, the prevalence of non-traded input costs of distributing and retailing traded goods in local markets. Eaton and Kortum (2002) develop a multi-country Ricardian model to estimate international trade barriers, or *trade costs*, by using data on observed bilateral trade volumes. Alvarez and Lucas (2007) use estimates of trade costs to explain the observed inverse relationship between trade to GDP ratio and size of a country. This paper explores whether a multi-country Ricardian model, in which bilateral trade costs and local costs of distribution are carefully calibrated, can quantitatively account for the distribution of observed, good by good LOOP deviations.

How large are deviations from the LOOP? Although there is consensus in the literature that deviations from LOOP are large, many empirical studies are limited by the use of price index data, or of prices of a very narrow set of individual goods[1]. Until recently, due to these data limitations, very little has been known about the magnitude of absolute deviations from the LOOP for a broad cross section of goods. Crucini, Telmer and Zachariadis (2005), however, use local-currency retail prices on a broad cross-section of goods across 13 European Union (EU) countries to study good-by-good deviations from LOOP for the years 1975, 1980, 1985, and 1990. Engel and Rogers (2004), and Rogers (2001) also use a broad cross-sectional dataset of absolute retail prices to analyze European price dispersion. I use the findings

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[1] Isaard (1977) and Giovannini (1988) are examples of studies that use price indices data while Knetter (1989, 1993), Ghosh and Wolf (1994), Cumby (1996), Haskel and Wolf (2001) and Lutz (2004) are examples of studies that use prices of a narrow set of goods.

of Crucini et al. (2005) as a measure of LOOP deviations. This study provides the largest coverage of goods (1800 goods). Furthermore, the data allow the authors to look at LOOP deviations at four different points in time over a 15 year period. This ensures that the results are not being driven by a specific year of data.

Crucini et al. (2005) define the retail price of a good in a given country as the average of surveyed prices across different sales points within the capital city of that country. Prices are adjusted for differences in value added taxes across countries, and then expressed in a common currency. Denote retail price of good x in country i by $P_i(x)$. The deviation from LOOP for good x in country i is defined as the deviation of the logarithm of the common currency price of good x in country i from the cross-country geometric average price of good x, or $Q_i(x) = \log P_i(x) - \sum_{j=1}^{N} \log P_j(x)/N$, where N is the number of countries. Then standard deviation of $Q_i(x)$ across countries, given by $Var(Q_i(x)|x)^{1/2}$, is the "cross-country dispersion of LOOP deviations" in the price of good x. The authors also call this "good-by-good price dispersion".

In this paper, I focus on two measures of LOOP deviations: (i) the average good-by-good price dispersion, and (ii) the variation in good-by-good price dispersion.

Table 1: Good-by-Good Price Dispersion in Data

	1975	1980	1985	1990	Avg.
Avg.	0.2290	0.2941	0.3024	0.2855	0.2778
Max	0.7496	0.7751	0.8189	0.8319	0.7939
Min	0.0227	0.0784	0.0672	0.0458	0.0535
IQR	0.1297	0.1646	0.1749	0.1689	0.1595
P90 - P10	0.2427	0.2976	0.3281	0.3350	0.3008

The first row of Table 1 shows the average good-by-good price dispersion (average of $Var(Q_i(x)|x)^{1/2}$ over goods) for each of the four years, and also in the final column, the average of this measure over the four years. The average good-by-good price dispersion is about 28 percent over the four years. 1975 shows the smallest average price dispersion. However, average price dispersion has remained quite stable for the other three years. The jump in price dispersion between 1975 and 1980 is argued to be due to a a smaller sample of countries in the 1975 survey[2]. The same feature emerges in measures of variation in good-by-good price dispersion. The variation in good-by-good price dispersion is large, ranging from a minimum of 2 percent to a maximum of 83 percent, across the four years. However, I use the inter-quartile range (IQR) as the primary measure of variation in order to minimize the effect of extreme values on the measurement of variation in good-by-good price dispersion. IQR is the difference between the 25^{th} and the 75^{th} percentile of good-by-good price dispersion. The data show that IQR, averaged over the four years, is 0.16. I also report the difference between the 10^{th} and 90^{th} percentile of good-by-good price dispersion (P90 - P10), which is 0.30 when averaged over the four years. The fact that the value of P90 - P10 is almost double that of the IQR suggests that the distribution of good-by-good price dispersion is skewed. This is clarified in Figure 1, which depicts the kernel density of good-by-good price dispersion (reproduced from Crucini et al. (2005)) for the four years. All four distributions are skewed to the right. One striking feature of the data is that both the average good-by-good price dispersion and the variation in good-by-good price dispersion, as depicted by IQR, P90 - P10 and the kernel density, are very stable over time.

This paper investigates the ability of a multi-country Ricardian model, which incorporates international trade costs and local costs of distribution, to quantitatively account for (i) the average good-by-good price dispersion and (ii) the variation in good-by-good price dispersion measured by Crucini et al. (2005).

Although the role of bilateral trade costs for the time-series behavior of bilateral relative prices has been studied elsewhere (Atkeson and Burstein (2007), Bergin and Glick (2006), Betts and Kehoe (2001) for example), the ability of trade costs to contribute to an account of cross-sectional price dispersion has not been formally investigated. Eaton and Kortum (2002) quantify the size of trade costs using data on bilateral trade volumes for OECD countries. They find that trade costs are large, and vary substantially across trade partners. The first question that this paper attempts to answer is: In a multi-country Ricardian model in which trade costs are carefully calibrated to match bilateral trade volumes, to what extent

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[2] In total, there are 13 countries in the sample - Austria, Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain and United Kingdom. However, the 1975 survey covers nine EU countries. Greece, Portugal, and Spain were added in 1980. Austria was added in 1985.

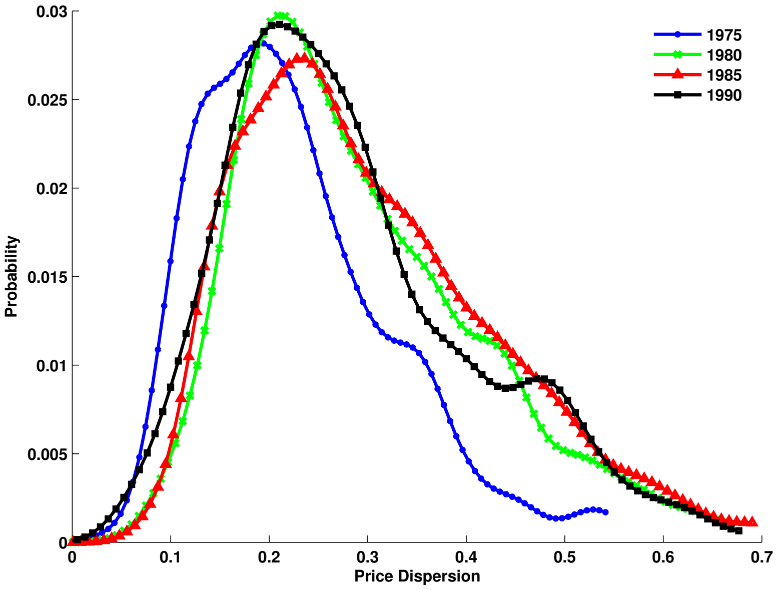

Figure 1: Empirical Distribution of $Var(Q_i(x)|x)^{1/2}$ in the Data

can measured cross-country heterogeneity in trade costs account for the average dispersion of LOOP deviations and the variation in dispersion of LOOP deviations?

If international trade costs were the only source of segmentation in goods' markets, in a world with zero international trade costs one would not observe any deviations from LOOP; all goods would be freely traded. However, Sanyal and Jones (1982) argue that there is no freely traded good. They emphasize the importance of local non-traded inputs that are used to deliver goods to final consumers in local markets. This implies that, even if a good could be traded costlessly across borders, the LOOP would not hold in retail prices as long as there are non-traded local inputs. Therefore, local non-traded inputs provide a second source of deviations from the LOOP. Several recent studies have emphasized distribution costs, in particular, as a potential source of LOOP deviations in the retail prices of goods. The function of the distribution sector in an economic system is to transfer goods and services from producers to consumers in an efficient manner. Costs of distribution include transportation and storage, wholesale trade, and retail trade. Burstein, Neves and Rebelo (2003) show that distribution costs represent more than 40 percent of the retail price for the average consumer good in the U.S., and roughly 60 percent of the retail price in Argentina.

Goldberg and Campa (2006) find that that distribution margins vary widely across countries for a given good and also across goods within a country. The second question that this paper attempts to answer is, to what extent can a version of the multi-country Ricardian model, modified to include a distribution sector in which distribution costs are carefully calibrated to data on observed distribution margins, quantitatively account for the observed dispersion in LOOP deviations?

In order to address these two question, I develop a general equilibrium version of the Eaton and Kortum (2002) trade model. The baseline variant of the model is attributable to Alvarez and Lucas (2007), except that I allow trade costs to be asymmetric and heterogeneous across trading partners. In the model, countries trade goods which are produced using labor, capital and an intermediate input. Labor and capital are non-traded factor inputs, whereas the intermediate input is produced by combining the individual traded goods. To quantify the role of local distribution costs, I extend this baseline model by embedding a distribution sector, and explicitly modeling retail goods as products of the individual traded goods, and non-traded distribution services. In this version of the model, any individual traded good, whether imported or produced domestically, must be combined with local distribution services for it to be delivered to the consumer. The number of units of distribution services that are needed to deliver 1 unit of a retail good to the consumer varies across goods. Furthermore, some countries are more efficient in delivering goods to the consumers than other countries. Thus the extended model allows for both good-specific, and country-specific, heterogeneity in distribution costs.

I follow the gravity literature to proxy trade costs by distance, language, border and membership of free trade regions. Trade costs are obtained by estimating a structural gravity equation implied by the model, using data on proxies and trade volume for each bilateral trading pair. The gravity equation implies that the share of country j in country i's total expenditure on traded goods relative to the share of country i in its own expenditure on traded goods is a function of 'country-specific' differences in costs of producing tradable goods and cost of transporting goods from country j to country i.

In order to measure the potential heterogeneity in distribution costs across goods and countries, I construct data on distribution margins for 29 categories of goods across 19

OECD countries. I use the average distribution margin of each country, computed from the data, to calibrate the country-specific differences in efficiency of delivering goods to the consumers. The heterogeneity across goods, in a country, in units of distribution services used is controlled by matching the cross-country average of dispersion in distribution margins across goods computed from the data.

I find that the standard multi-country Ricardian trade model, featuring heterogeneous and asymmetric trade costs, does a good job of matching the average good-by-good price dispersion, but it fails to generate the variation in good-by-good price dispersion observed in the data. It can explain 85 percent of average price dispersion, but only 21 percent of the variation in price dispersion. Accounting for differences in costs of distribution across goods and across countries significantly improves the model's performance in matching the data. The model does a very good job of matching the average price dispersion - explaining 96.5 percent of the average dispersion. It can also explain 32 percent of the variation in price dispersion. Heterogeneity in distribution costs plays an important role in matching the variation in good-by-good price dispersion. In the case of trade costs, the level of trade costs is more important than the asymmetries in trade costs. As the level of trade costs declines, the distribution of good-by-good price dispersion shifts to the left, implying a decline in average good-by-good price dispersion, without any significant change in the variation of good-by-good price dispersion.

The degree of market segmentation implied by international trade barriers and differences in the costs of distribution can explain the dispersion in LOOP deviation for an "average" retail product very well. However, these two sources of market segmentation can explain only one-third of the variation in price dispersion across a broad spectrum of retail products. Heterogeneity in distribution costs is important in explaining the variation in good-by-good price dispersion, but it is not enough.

The rest of the paper is organized in the following manner: the next section discusses the Ricardian trade model and its calibration, which is followed by the discussion of the results. Then, I describe the data on distribution costs. This leads to the section where I modify the Ricardian trade model to incorporate a distribution sector and discuss the calibration of this augmented model, which is followed by the discussion of results for the augmented model. The last section concludes.

2 Ricardian Trade Model

I start by discussing the the general equilibrium version of the Eaton and Kortum model, due to Alvarez and Lucas (2007). Unlike Alvarez and Lucas (2007), trade costs in the model are country-pair specific and asymmetric, rather than homogeneous. In addition, the model in this paper, incorporates capital explicitly as an input, which was implicitly present in Alvarez and Lucas (2007)[3], largely because the calibration strategy I follow differs from that of Alvarez and Lucas (2007), as I will discuss below.

Consider a world with n countries. Country i ($i = 1, \ldots, n$) has L_i consumers and each consumer has 1 unit of labor, which is supplied inelastically (all variables are expressed in per capita terms) and k_i units of capital.

2.1 Production and Consumption

Each country produces a continuum of base goods, indexed on the unit interval, which are traded. Base good x, $x \in [0, 1]$, in country i is produced using a Cobb-Douglas technology.

$$m_i(x) = z_i(x)^{-\theta} \left[k_i(x)^{\alpha} l_i(x)^{1-\alpha}\right]^{\beta} c_i(x)^{1-\beta}$$

where $k_i(x)$, $l_i(x)$ and $c_i(x)$ are the amounts of capital, labor and intermediate composite, respectively, used to produce base good x in country i, and $z_i(x)$ is the inverse of the efficiency of country i in producing good x. In other words $z_i(x)$ is an idiosyncratic "cost". I assume that idiosyncratic cost of producing good x in country i is a random draw from a country-specific density $f_i = \exp(\lambda_i)$. The random cost draws are independent across goods, and the distributions are independent across countries. The random draws are amplified in percentage terms by the parameter θ. The parameter λ_i governs the average efficiency level of country i. A country with a relatively large λ_i is, on average, more efficient. A larger θ represents a larger variance in productivities of (producing) individual goods. Therefore, λ_i determines country i's absolute advantage in producing any good x whereas θ controls the degree of comparative advantage.

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[3] Although labor is the only input in Alvarez and Lucas (2007), for calibrating the model it is interpreted as 'equipped labor', i.e. labor equipped with capital.

Countries trade base goods. In each country there is a representative importing firm that buys each base good x, at the lowest price. Let $\overline{m}_i(x)$ be the amount of base good x that the importing firm in country i buys. Base goods are then combined in country i to produce an intermediate composite, c_i. This composite is a Spence-Dixit-Stiglitz (SDS) aggregator, with an elasticity of substitution, η, between goods:

$$c_i = \left[\int_0^\infty \overline{m}_i(z)^{1-\frac{1}{\eta}} f(z) dz \right]^{\frac{\eta}{\eta-1}}$$

Here each good, x, is identified by its cost draw, z, and $f(z)$ is the joint distribution of cost draws $((z_1(x), \ldots, z_n(x)))$, over countries.

Consumers in every country consume a non-traded final good, y_i. The final good is produced using Cobb-Douglas technology with labor, l_{yi}, capital, k_{yi}, and intermediate composite, c_{yi}, as the inputs.

$$y_i = \left[k_{yi}^{\alpha} l_{yi}^{1-\alpha} \right]^{\rho} c_{yi}^{1-\rho}$$

2.2 Market Clearing

The intermediate composite is used as an input in the production of base goods and the final good, so that the market clearing for intermediate composite yields

$$\underbrace{\int_0^1 c_i(x) dx}_{c_{mi}} + c_{yi} \leq c_i \quad ,$$

where c_{mi} is the number of units of the intermediate composite used in the production of all base goods. The labor market, as well as the market for services of capital, must clear;

$$\underbrace{\int_0^1 l_i(x) dx}_{l_{mi}} + l_{yi} \leq 1 \quad ,$$

$$\underbrace{\int_0^1 k_i(x) dx}_{k_{mi}} + k_{yi} \leq k_i \quad ,$$

where l_{mi} is the share of base goods sector in the labor force, k_{mi} is the share of base goods sector in the capital stock, and k_i is the capital-labor ratio of country i.

2.3 Retail Price of Individual Goods

The object of interest in this baseline model is the price of an individual base good. Profit maximization in the two sectors - base goods and final good - implies that that the return to capital in country i is $r_i = (\alpha/(1-\alpha))w_i k_i^{-1}$, where w_i is the wage. Then, the domestic cost of producing base good x in country i is

$$Bz_i(x)^{\theta} w_i^{\beta} p_{ci}^{1-\beta} k_i^{-\alpha\beta}, \text{ where}$$

$$B = \beta^{-\beta}(1-\beta)^{(\beta-1)}\alpha^{-\alpha\beta}(1-\alpha)^{\beta(\alpha-1)}\left[\frac{\alpha}{1-\alpha}\right]^{\alpha\beta}$$

and p_{ci} is the price of intermediate composite in country i. Price of intermediate composite in country i is given by

$$p_{ci} = \left[\int_0^{\infty} \overline{p}_{mi}(z)^{1-\eta} f(z)dz\right]^{\frac{1}{1-\eta}},$$

where $\overline{p}_{mi}(z)$ is the price, in country i, of the base good which is characterized by productivity level z.

However, to deliver 1 unit of a base good from country j to country i, country j must produce τ_{ij} units of the good. Due to geographic and other barriers to trade, $\tau_{ij} > 1$ for $i \neq j$. This is the standard “iceberg assumption” *a la* Samuelson, and $\tau_{ii} = 1$ for all i. The importing firm in each country buys each good, x, from the lowest cost supplier of that good. Therefore, the price of good x in country i is given by:

$$\overline{p}_{mi}(x) = B \min_j \left[w_j^{\beta} p_{cj}^{1-\beta} k_j^{-\alpha\beta} \tau_{ij} z_j(x)^{\theta}\right] \tag{1}$$

Thus, given the wage vector w, the vector of prices of the intermediate composite p_c, the vector of capital-labor ratios k, trade cost matrix τ and vector of productivity parameters λ, the producer prices of individual base goods can be simulated. In the absence of distribution costs these are the retail prices of the goods.

2.4 Calibration Methodology

This section discusses the methodology adopted to solve for the vector of wages w and the vector of prices of the intermediate composite p_c and the calibration of vector of productivity parameters λ, given the matrix of estimated trade costs τ and the vector of labor endowments L and the vector of capital endowment k. I start by discussing the estimation of trade costs.

Let X_i be the per capita expenditure of country i on tradable goods. Define D_{ij} as the share of country i's per capita spending on tradables that is spent on goods from country j. For country j to supply good x to country i, j must be the lowest price seller of good x to i. Then,

$$D_{ij} = (AB)^{-1/\theta} \left(\frac{w_j^{\beta} p_{cj}^{1-\beta} k_j^{-\alpha\beta} \tau_{ij}}{p_{ci}} \right)^{-1/\theta} \lambda_j \quad , \tag{2}$$

and $\sum_{j=1}^{n} D_{ij} = 1$. The steps taken to arrive at this expression for D_{ij} are explained in Appendix A.

I follow Eaton and Kortum (2002) in estimating the trade costs, τ_{ij}. Eq. (2) implies that the share of country j in country i's total expenditure on tradables, normalized by country i's share in its own total expenditure on tradables, is given by:

$$\frac{D_{ij}}{D_{ii}} = \frac{\left(w_j^{\beta} p_{cj}^{1-\beta} k_j^{-\alpha\beta} \tau_{ij} \right)^{-1/\theta} \lambda_j}{\left(w_i^{\beta} p_{ci}^{1-\beta} k_i^{-\alpha\beta} \right)^{-1/\theta} \lambda_i}$$

Let $\Omega_i = \left(w_i^{\beta} p_{ci}^{1-\beta} k_i^{-\alpha\beta} \right)^{-1/\theta} \lambda_i$, and $S_i = \ln(\Omega_i)$.

$$\Rightarrow \ln\left(\frac{D_{ij}}{D_{ii}} \right) = S_j - S_i - \frac{1}{\theta} \ln \tau_{ij} \tag{3}$$

The left-hand side of this equation is calculated from data on bilateral trade and gross output. The methodology used to calculate the left-hand side is explained in Appendix B. Trade costs are obtained by estimating Eq. (3). Since τ_{ij} is not observable, I follow the gravity equation literature to proxy trade barriers by distance, language, border and membership of free trade regions. Specifically,

$$\ln \tau_{ij} = dist_N + brdr + lang + tblk_M + dest_i + \epsilon_{ij} \quad , \tag{4}$$

where $dist_N$ $(N = 1, \ldots, 6)$ is the effect of distance between i and j lying in the Nth interval, $brdr$ is the effect of i and j sharing a border, $lang$ is the effect of i and j sharing a language, $tblk_M$ $(M = 1, 2)$ is the effect of i and j belonging to trading area M, and $dest_i$ $(i = 1, \ldots, n)$ is a destination effect. The error term ϵ_{ij} captures trade barriers due to all other factors, and is orthogonal to the regressors. The six distance intervals (in miles) are: $[0, 375)$; $[375, 750)$; $[750, 1500)$; $[1500, 3000)$; $[3000, 6000)$ and $[6000, \text{maximum}]$. The two trading areas are the European Union (EU) and the North-American Free Trade Agreement (NAFTA) area. S_i is captured as the coefficient on source-country dummies.

Eq. (1) implies that the price of the intermediate composite is given by

$$p_{ci} = AB\left(\sum_{j=1}^{n}\left(w_j^{\beta}p_{cj}^{1-\beta}k_j^{-\alpha\beta}\tau_{ij}\right)^{-1/\theta}\lambda_j\right)^{-\theta}, \tag{5}$$

where $A = \left(\int_0^\infty h^{\theta(1-\eta)}e^{-h}dh\right)^{\frac{1}{1-\eta}}$. The integral in brackets is the Gamma function $\Gamma(\xi)$ evaluated at $\xi = 1 + \theta(1 - \eta)$. Convergence of this integral requires that $1 + \theta(1 - \eta) > 0$, which I assume holds throughout this paper. The derivation of p_{ci} is explained in Appendix A.

The vector of wages is determined by imposing balanced trade - the revenue of country i must equal its expenditure.

$$\sum_{j=1}^{n} L_j X_j D_{ji} = L_i X_i$$

In the base goods sector $L_i w_i l_{mi} = \beta(1-\alpha)\sum_{j=1}^{n} L_j X_j D_{ji} = \beta(1-\alpha)L_i X_i$. Since $l_{mi} = 1 - l_{yi} = 1 - \rho$, $\forall\ i$, the balanced trade condition can be written as

$$\sum_{j=1}^{n} L_j w_j D_{ji} = L_i w_i \tag{6}$$

I take a stand on the endowment of labor and capital of each country by taking them from the data. Then, given the estimated trade cost matrix τ, Eq. (5) and Eq. (6) are used to solve for the equilibrium w and p_c for a given initial guess for λ. The guess for λ is updated by using Eq. (2), for $j = i$.

$$\lambda_i = (AB)^{1/\theta}\left[\frac{w_i}{p_{ci}}\right]^{\beta/\theta} k_i^{-\alpha\beta/\theta} D_{ii} \tag{7}$$

Therefore, Eq. (5), Eq. (6) and Eq. (7) form a system of $3n$ equations in $3n$ unknowns. In solving this system of equations, bilateral expenditure shares D_{ij} are replaced by the bilateral expenditure shares computed from the data, $\widehat{D}_{ij}$. This implies that the vector of productivity parameters, λ, is a function of bilateral trade shares observed in the data, adjusted for differences in endowments of labor and capital. A similar calibration strategy is adopted by Waugh (2007). Alvarez and Lucas (2007) calibrate λ by matching the relative price of non-tradables. I adopt a different calibration strategy for two reasons. First, since I am interested in characterizing the behavior of prices implied by the model, I do not want to use information on prices to calibrate λ. Second, and more importantly, one of the objectives of the paper is to evaluate whether the degree of market segmentation implied by flows of goods across borders can explain the deviations from the LOOP in prices of individual goods. By computing λ and τ as functions of bilateral trade shares, I impose the discipline on the model needed to answer this question.

2.5 Variance of LOOP Deviations

Given the endowment of capital, k_i, the equilibrium wage, w_i, the equilibrium price of the intermediate composite, p_{ci}, estimated trade costs, τ_{ij}, and the calibrated productivity parameter, λ_i, I simulate the prices of base goods. Using Eq. (1), the prices are simulated for 1500 goods. For each good, x, a cost vector $(z_1(x), \ldots, z_n(x))$ is drawn, where n is the number of countries, from the joint density function $f(z) = (\prod_{i=1}^{n} \lambda_i) \exp\{-\sum_{i=1}^{n} \lambda_i z_i\}$.

The deviation from the LOOP for a good in country i is computed as the log deviation of the price of the good in country i from the geometric-average (across countries) price of the good.

$$Q_{mi}(x) = \log p_{mi}(x) - \frac{\sum_{j=1}^{n} \log p_{mj}(x)}{n}, \qquad x = \{1, \ldots, 1500\} \tag{8}$$

The variance of LOOP deviations is measured as the cross-country dispersion in LOOP deviations in Crucini et al. (2005). This is denoted by $Var(Q_{mi}(x)|x)$. Good-by-good price dispersion is the square root of the variance of LOOP deviations.

2.6 Parameterization

There are 22 OECD countries in the sample[4]. The set of countries I examine is larger than that examined by Crucini et al. (2005). In addition to the 13 EU countries included in Crucini et al. (2005), I include 9 other countries. Using only the 13 EU countries would not take into account all major trading partners of the countries. This will result in underestimation of total trade volume, which will affect the estimates of trade costs. Therefore, I choose a broader set of countries to account for as large a share of total trade as possible, but at the same time, I ensure that the chosen countries have similar levels of per capita GDP as the 13 EU countries in Crucini et al. (2005). The model is calibrated to the year 1996. The choice of the year is driven by the availability of data on capital-labor ratios. Although the data used by Crucini et al. (2005) are for 1975, 1980, 1985 and 1990, the average good-by-good price dispersion and the variation in good-by-good price dispersion (as measured by IQR) are very stable over time. Therefore, the averages over the four years, of average good-by-good price dispersion and variation in good-by-good price dispersion can be compared with results of the model.

Agriculture, hunting, forestry and fishing, mining and quarying, and manufacturing are treated as the traded goods sector. All other sectors form the final good sector.

Following Alvarez and Lucas (2007), θ, which controls the variability of the national idiosyncratic component of productivity, is 0.15 and η, which is the substitution parameter, is 2. The choice of η is important only for the convergence of the gamma function and it does not have any implications for the results of the model.

The parameter β is calibrated as the share of value added in gross output of the traded goods sector. The data used to compute this ratio come from the OECD Structural Analysis (STAN) database. Details of the data and the methodology are provided in Appendix B. For the sample of countries β is 0.36. α is the share of capital in GDP. Gollin (2002) finds that the share of labor in value added for a wide cross-section of countries is around 2/3,

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[4] Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Mexico, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States.

which implies that α is 0.33. ρ is the share of value added in the gross output of the final good sector. Since the value of the output of the final good sector is the GDP of a country, ρ is calibrated as one minus the share of traded goods sector in GDP. Using data from the OECD STAN database I find that the share of traded goods sector in GDP is 0.25 which implies that ρ is 0.75. β and ρ are computed as averages for the period 1995-1997, in order to remove any potential idiosyncrasies in value added and gross output in the year 1996.

The labor force vector $L = (L_1, \ldots, L_n)$ and the vector of capital-labor ratios $k = (k_1, \ldots, k_n)$ are taken from the data in Caselli (2005)[5]. Appendix B explains the procedure used to calculate these vectors.

Table 2 reports estimated coefficients for the geographic barriers, the corresponding standard error and the implied effect on cost relative to home sales. An increase in distance has a negative effect on trade. A country in the closest distance category faces 76 percent higher costs relative to home sales whereas a country in the farthest distance category faces a 171 percent higher trade cost. On the other hand, sharing a border with a trade partner reduces trade costs by 9 percent, while sharing a language reduces it by 4 percent. EU and NAFTA membership do not play an important role. The destination effect shows that it costs 36 percent less to export to the United States than to the average country and it costs 55 percent more to export to Greece than to the average country. The costs imposed by trade barriers are comparable to the costs obtained by Eaton and Kortum (2002) both, quantitatively and qualitatively. Since I include all traded goods - agricultural goods, fuels and mining goods and manufacturing goods - in computing bilateral trade shares, whereas Eaton and Kortum (2002) consider only manufacturing goods, I get slightly higher estimates of costs imposed by trade barriers.

Table 2: Geographic Barriers

Variable	Denoted by	Coefficient	Std. Error	Implied % Effect on Cost
Distance [0,375)	$-\frac{1}{\theta}dist_1$	-3.76	0.16	75.85
Distance [375,750)	$-\frac{1}{\theta}dist_2$	-3.91	0.13	79.80
Distance [750,1500)	$-\frac{1}{\theta}dist_3$	-4.25	0.12	89.09

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[5] I thank Michael E. Waugh for sharing this data with me.

Table 2: (continued)

Variable	Denoted by	Coefficient	Std. Error	Implied % Effect on Cost
Distance [1500,3000)	$-\frac{1}{\theta}dist_4$	-4.47	0.17	95.43
Distance [3000,6000)	$-\frac{1}{\theta}dist_5$	-6.26	0.08	155.67
Distance [6000,maximum]	$-\frac{1}{\theta}dist_6$	-6.65	0.09	171.15
Shared Border	$-\frac{1}{\theta}brdr$	0.65	0.13	-9.34
Shared Language	$-\frac{1}{\theta}lang$	0.30	0.10	-4.41
EU	$-\frac{1}{\theta}tblk_1$	0.19	0.14	-2.88
NAFTA	$-\frac{1}{\theta}tblk_2$	-0.39	0.35	6.01
Destination Country				
Australia	$-\frac{1}{\theta}dest_1$	1.03	0.24	-14.38
Austria	$-\frac{1}{\theta}dest_2$	-1.45	0.18	24.31
Belgium	$-\frac{1}{\theta}dest_3$	0.74	0.18	-10.55
Canada	$-\frac{1}{\theta}dest_4$	1.42	0.24	-19.13
Denmark	$-\frac{1}{\theta}dest_5$	-0.69	0.18	10.90
Finland	$-\frac{1}{\theta}dest_6$	-1.21	0.18	19.86
France	$-\frac{1}{\theta}dest_7$	0.08	0.18	-1.12
Germany	$-\frac{1}{\theta}dest_8$	1.07	0.18	-14.85
Greece	$-\frac{1}{\theta}dest_9$	-2.92	0.18	55.07
Ireland	$-\frac{1}{\theta}dest_{10}$	-0.76	0.17	12.01
Italy	$-\frac{1}{\theta}dest_{11}$	0.06	0.18	-0.85
Japan	$-\frac{1}{\theta}dest_{12}$	2.20	0.21	-28.11
Mexico	$-\frac{1}{\theta}dest_{13}$	-0.63	0.22	9.89
Netherlands	$-\frac{1}{\theta}dest_{14}$	0.95	0.18	-13.29
New Zealand	$-\frac{1}{\theta}dest_{15}$	0.03	0.24	-0.43
Norway	$-\frac{1}{\theta}dest_{16}$	-0.62	0.23	9.82
Portugal	$-\frac{1}{\theta}dest_{17}$	-2.26	0.18	40.34
Spain	$-\frac{1}{\theta}dest_{18}$	-0.64	0.17	10.01
Sweden	$-\frac{1}{\theta}dest_{19}$	0.01	0.17	-0.16
Switzerland	$-\frac{1}{\theta}dest_{20}$	-0.60	0.22	9.44
United Kingdom	$-\frac{1}{\theta}dest_{21}$	1.10	0.18	-15.25
United States	$-\frac{1}{\theta}dest_{22}$	3.09	0.45	-37.06

Note: Given an estimated coefficient, b, the implied percentage effect on cost is estimated as $100(e^{-\theta b} - 1)$.

3 Results: Ricardian Model

Table 3 compares the model generated good-by-good price dispersion with that observed in Crucini et al. (2005). Remarkably, this multi-country Ricardian model can account for 85 percent of the average good-by-good price dispersion observed in the data; the model generates average price dispersion of 23.7 percent while it is 28.8 percent in the data. How does the model fair with respect to the variation in good-by-good price dispersion? In terms of the IQR, the model can generate 21 percent of the variation observed in the data. The model does a little better in terms of P90 - P10 as it can generate about 24 percent of the variation observed in the data, which suggests that the distribution of good-by-good price dispersion generated by the model exhibits some skewness. This becomes clear from the empirical distribution of the good-by-good price dispersion obtained from the model, shown in Figure 2. The distribution exhibits some positive skewness.

Table 3: Good-by-Good Price Dispersion: Model Versus Data

	Model	Data	Model as ratio of Data
Avg.	0.2365	0.2778	0.8513
IQR	0.0341	0.1595	0.2138
P90 - P10	0.0708	0.3008	0.2354

So, the standard Ricardian model does well in matching the average good-by-good price dispersion, but it is not able to generate the variation in good-by-good price dispersion observed in the data. This suggests that, for the average retail good, the degree of goods' market segmentation implied by trade barriers is fairly consistent with the degree of segmentation implied by dispersion of LOOP deviations. However, the trade barriers implied by observed bilateral trade volumes are not large enough to account for the average price dispersion fully. More importantly, despite allowing for heterogeneity and asymmetry in international trade costs, a Ricardian model with trade costs does poorly in matching the variation in good-by-good price dispersion observed in the data.

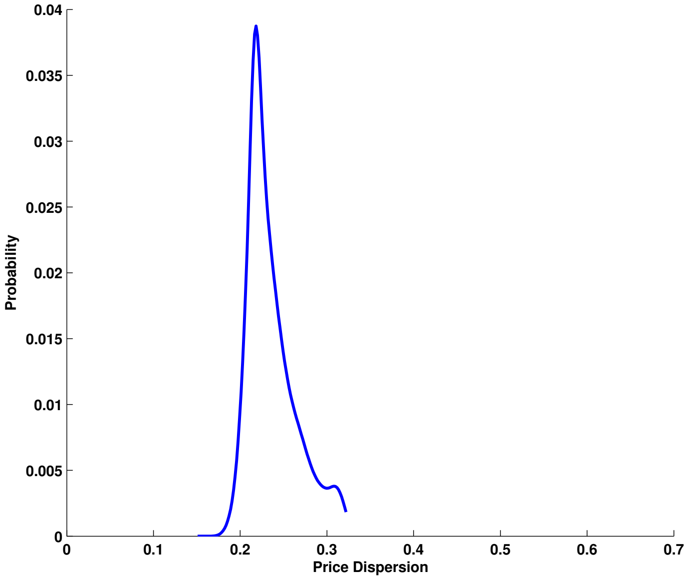

Figure 2: Distribution of $Var(Q_{mi}(x)|x)^{1/2}$: Ricardian Model

4 Data on Distribution Costs

In this section, I explore the potential for distribution costs to account for the variation in good-by-good price dispersion. In terms of national accounts, the distribution sector includes retail trade, wholesale trade and transport, storage and warehousing. The distribution sector is large, both in terms of employment and value added. According to Burstein et al. (2003), retail and wholesale trade account for 23.3 percent of total employment and 17.1 percent of total value added in the U.S. economy in 1997. The corresponding numbers for Argentina stand at 21.4 percent and 16.1 percent. Interestingly, the employment share of wholesale and retail trade is larger than that of manufacturing (15.2 percent for the U.S. and 15.1 percent for Argentina) and the share in value added of wholesale and retail trade is almost as large as that of manufacturing (18.8 percent for the U.S. and 18.2 percent for Argentina).

Burstein et al. (2003) show that distribution costs represent more than 40 percent of the retail price for the average consumer good in the U.S., and roughly 60 percent of the retail price in Argentina. Goldberg and Campa (2006) present evidence on distribution margins (distribution costs as a ratio of retail value of products) in 29 product categories across 21

OECD countries. Distribution margins vary widely across product categories within the same country and also across countries within the same product category. In light of these facts, recent literature has focused on the role of distribution costs in understanding the behavior of prices. Burstein et al. (2003) study the role of distribution services in understanding the movements of real exchange rate (RER) during exchange rate based stabilizations in Argentina's 1991 convertibility plan. Corsetti and Dedola (2005) and Goldberg and Campa (2006) study incomplete exchange rate pass-through in the presence of a distribution sector.

However, these studies have focused on the time series properties of international relative prices. Instead, I examine the role of differences in costs of distribution across goods and across countries in explaining cross-country dispersion in prices of individual goods.

How large are distribution costs as a ratio of the retail price of goods? Does this ratio vary substantially across goods and across countries? To answer these questions, I compute this ratio for 29 product categories across 19 of the 22 OECD countries in the sample. The countries are listed in Table 4. The data come from input-output tables, specifically the use tables, which provide information on the value of the supply of goods in "basic price" and the value of the same goods in "purchaser price". The difference between basic prices and purchaser prices is that purchaser prices include distribution margins and value added taxes (or subsidies), whereas basic prices do not. The use tables also report net taxes for each good. The distribution margin for a good is calculated as:

$$\text{Distribution Margin} = \frac{\text{Supply in Purchaser Prices} - \text{Supply in Basic Prices}}{\text{Supply in Purchaser Prices}}$$

Care is taken to exclude net taxes from the purchaser price value of each good. For Japan and the United States, data on net taxes are not available. Therefore, for these countries purchaser price value could not be adjusted for net taxes. For the EU countries, goods are classified according to the Classification of Products by Activities (CPA) classification of goods. Australia, New Zealand, the United States and Japan do not use the CPA classification of goods. Since the EU countries form the majority of countries in my sample the commodity classifications of the non-EU countries were mapped into the CPA classification. Only those product categories were chosen for which the distribution margins were non-negative. The data show that distribution margins are zero or negative for almost all services across countries. In addition, the CPA product category 'Uranium and thorium ores' was excluded because of missing data. For most countries in the sample the data are available for the year 1995. For Australia the data are available for 2001-02, for Norway they are available for 2001, for Ireland they are available for 1998 and for the United States they are available for 1997. Data are not available for Canada, Mexico and Switzerland.

Notice that the data on distribution margins for majority of the countries are for 1995 whereas the data on trade volumes used to compute trade costs, the data on gross output and value added used to compute the parameters of the model, and the data on endowment of labor and capital are for 1996. This inconsistency is not important for two reasons. First, for the countries for which I have data over multiple years, I find that distribution margins do not change significantly from one year to another for individual product categories. Second, for the purpose of calibrating the augmented model, in which I incorporate a distribution sector, I will use average distribution margin (across all products) of each country and the average of country-specific standard deviation of distribution margins (across goods). These averages are going to be even more stable over time than the distribution margins for individual product categories.

Table 4 provides information on distribution margins by country across all goods. It gives three statistics on distribution margins across goods - the average, the maximum and the minimum value. The second column shows that Japan has the highest average distribution margin whereas Ireland has the lowest. The last two columns show that within each country there is a large variation in distribution margins across goods.

Table 4: Distribution Margins by Countries

Country	Average	Maximum	Minimum
Australia	0.2329	0.5698	0.0794
Austria	0.1833	0.4408	0.0000
Belgium	0.1540	0.3800	0.0569
Denmark	0.1952	0.3993	0.0000
Finland	0.1683	0.6302	0.0233
France	0.1567	0.3832	0.0107
Germany	0.2012	0.4658	0.0677
Greece	0.2063	0.4734	0.0001

Table 4: (continued)

Country	Average	Maximum	Minimum
Ireland	0.1022	0.2728	0.0000
Italy	0.2041	0.4768	0.0040
Japan	0.3361	0.9275	0.1015
Netherlands	0.1752	0.4382	0.0004
New Zealand	0.1338	0.2825	0.0000
Norway	0.2352	0.7141	0.0000
Portugal	0.1489	0.3974	0.0000
Spain	0.1644	0.4301	0.0003
Sweden	0.1612	0.4851	0.0000
United Kingdom	0.1810	0.4921	0.0010
United States	0.2753	0.7215	0.0537

Table 5 lists the average, the maximum and the minimum distribution margin across countries for each CPA product category. ‘Wearing apparel; furs’ has the highest average distribution margin across countries. On the other hand ‘Other transport equipment’ has the lowest average margin. Looking at the last two columns, it is clear that even for the same good there is significant variation in distribution margins across countries.

It is clear from the data that distribution margins vary widely across goods and across countries. Using this data, I incorporate heterogeneity in distribution margins in the model and evaluate its importance in driving the dispersion in LOOP deviations.

Table 5: Distribution Margins by Goods

CPA Product	Average	Maximum	Minimum
Products of agriculture, hunting and related services	0.1662	0.3015	0.0141
Products of forestry, logging and related services	0.1449	0.4301	0.0000
Fish and other fishing products; services incidental of fishing	0.2424	0.4768	0.0000
Coal and lignite; peat	0.1530	0.6833	0.0000
Crude petroleum and natural gas; services incidental to oil and gas extraction excluding surveying	0.1022	0.8925	0.0000
Metal ores	0.1262	0.9275	0.0000
Other mining and quarrying products	0.2015	0.4109	0.0000
Food products and beverages	0.2187	0.3901	0.0954
Tobacco products	0.3650	0.7141	0.1102

Table 5: (continued)

CPA Product	Average	Maximum	Minimum
Textiles	0.2250	0.4327	0.0978
Wearing apparel; furs	0.3979	0.6000	0.2112
Leather and leather products	0.3582	0.7215	0.1237
Wood and products of wood and cork (except furniture); articles of straw and plaiting materials	0.1452	0.3085	0.0306
Pulp, paper and paper products	0.1383	0.2282	0.0472
Printed matter and recorded media	0.1657	0.2752	0.0570
Coke, refined petroleum products and nuclear fuels	0.2118	0.4323	0.0000
Chemicals, chemical products and man-made fibres	0.1827	0.2767	0.0348
Rubber and plastic products	0.1468	0.2647	0.0523
Other non-metallic mineral products	0.1730	0.2906	0.0574
Basic metals	0.1013	0.1633	0.0371
Fabricated metal products, except machinery and equipment	0.1400	0.2728	0.0718
Machinery and equipment n.e.c.	0.1499	0.2632	0.0410
Office machinery and computers	0.2073	0.3993	0.0448
Electrical machinery and apparatus n.e.c.	0.1537	0.3557	0.0581
Radio, television and communication equipment and apparatus	0.1513	0.2384	0.0729
Medical, precision and optical instruments, watches and clocks	0.2099	0.3975	0.0667
Motor vehicles, trailers and semi-trailers	0.1815	0.3376	0.0744
Other transport equipment	0.0819	0.2825	0.0213
Furniture; other manufactured goods n.e.c.	0.2904	0.4821	0.1300

5 Ricardian Trade Model with A Local Distribution Sector

In this section I extend the benchmark multi-country Ricardian trade model to account for local costs of distribution. Now, base goods, besides being used to produce the intermediate composite, are also delivered to the consumers as retail goods. However, every base good, x, whether imported or produced domestically, requires some units of distribution services to be delivered to the consumers. Thus, a retail good is produced by combining distribution services and a base good. Distribution services and retail goods are not traded. Individual retail goods are combined to produce a composite retail good. Each country also produces a homogeneous non-traded good. The final good that consumers consume in each country is a composite of the homogeneous non-traded good and the composite retail good.

5.1 Production and Consumption

The production technology of base goods is unchanged. However, now, the amount of base good x bought by the importing firm, $\overline{m}_i(x)$, is divided into two parts.

$$\overline{m}_i(x) = \overline{m}_{ci}(x) + \overline{m}_{qi}(x)$$

$\overline{m}_{ci}(x)$ is used to produce the intermediate composite in country i and $\overline{m}_{qi}(x)$ is bought by the retailer of good x in country i. The production technology for intermediate composite good also remains unchanged.

$$c_i = \left[\int_0^{\infty} \overline{m}_{ci}(z)^{1-\frac{1}{\eta}} f(z)dz\right]^{\frac{\eta}{\eta-1}}$$

The retailer of good x combines $\overline{m}_{qi}(x)$ with distribution services to deliver the base good to the consumer in the form of a retail good. Retail good, x, is denoted by $m_{qi}(x)$. Distribution services, d_i, are produced using Cobb-Douglas technology with labor, l_{di}, capital, k_{di}, and intermediate composite, c_{di}, as the inputs.

$$d_i = [k_{di}^{\alpha} l_{di}^{1-\alpha}]^{\delta} c_{di}^{1-\delta}$$

To deliver 1 unit of base good x to the consumer, $\phi_i(x)$ units of distribution services are required,

$$\phi_i(x) = \zeta_i u(x)^{\nu} \quad ,$$

where ζ_i denotes the units of distribution services required to deliver any good to the consumer in country i, and reflects country i's efficiency in distribution of goods, and u is a random draw from a common density function $g = \exp(1)$. The draws are assumed to be independent across goods. For a given base good, x, u and z (random cost draw for base good x) are assumed to be independent.

Bringing one unit of a base good to the consumer requires a fixed proportion of distribution services. This assumption is made in the spirit that production and retailing are complements, and consumers consume them in fixed proportions. Erceg and Levin (1996), Burstein et al. (2003) and Corsetti and Dedola (2005) also adopt the same production structure for retail goods. However, I allow the units of distribution services used to deliver a unit of a good to vary across goods, as well as countries, whereas these studies do not. Furthermore, these studies, for simplicity, do not differentiate between nontradable consumption goods, which directly enter the agents' utility, and nontraded distribution services, which are jointly consumed with traded goods. However, I make this distinction. This is necessary because the parameters ν and ζ_i, which govern heterogeneity in the use of distribution services, are calibrated using the data on distribution margins and not from the data on all services. It also ensures that the distribution sector does not get more weight in GDP in the model than that observed in the data, and thereby helps to map the model clearly into the data.

Therefore, in addition to producing distribution services each country also produces a homogeneous non-traded good. Production of the non-traded good also combines labor, l_{si}, capital, k_{si}, and the intermediate composite, c_{si}, using a Cobb-Douglas technology.

$$s_i = [k_{si}^{\alpha} l_{si}^{1-\alpha}]^{\gamma} c_{si}^{1-\gamma}$$

The consumer in country i therefore consumes a final good y,

$$y_i = q_i^{\mu} s_i^{1-\mu} \quad ,$$

where q_i is a composite retail good.

$$q_i = \left[\int_0^1 m_{qi}(x)^{1-\frac{1}{\eta}} dx \right]^{\frac{\eta}{\eta-1}}$$

Notice that now the final good consumed is a composite of a homogeneous non-traded good, and a composite retail good.

5.2 Market Clearing

The intermediate composite is used as an input in the production of base goods, distribution services and the homogeneous non-traded good. Therefore, market clearing requires that

$$\underbrace{\int_0^1 c_i(x)dx}_{c_{mi}} + c_{di} + c_{si} \leq c_i \quad ,$$

where c_{mi} is the number of units of the intermediate composite used in the production of all base goods. The total units of distribution services required to deliver base goods to the consumer cannot exceed the output of distribution services.

$$\int_0^1 \phi_i(x)\overline{m}_{qi}(x)dx \leq d_i$$

The labor market as well as the capital market must clear;

$$\underbrace{\int_0^1 l_i(x)dx}_{l_{mi}} + l_{di} + l_{si} \leq 1 \quad ,$$

$$\underbrace{\int_0^1 k_i(x)dx}_{k_{mi}} + k_{di} + k_{si} \leq k_i \quad ,$$

where l_{mi} is the share of base goods sector in the labor force, k_{mi} is the share of base goods sector in the capital stock, and k_i is the capital-labor ratio of country i.

5.3 Retail Prices

The price at which the importing firm buys good x, $\overline{p}_{mi}(x)$, remains unchanged and is given by Eq. (1). However, now I am going to refer to this as the producer price of good x. Since delivering 1 unit of base good x to the consumer requires $\phi_i(x)$ units of distribution services, the retail price of base good x is the sum of the producer price of good x and the value of distribution services used to deliver 1 unit of the good.

$$p_{mi}(x) = \overline{p}_{mi}(x) + \phi_i(x)p_{di} \tag{9}$$

where the price of distribution services, p_{di}, is given by

$$p_{di} = Cw_i^{\delta}p_{ci}^{1-\delta}k_i^{-\alpha\delta} \text{ , and} \tag{10}$$

$$C = \delta^{-\delta}(1-\delta)^{(\delta-1)}\alpha^{-\alpha\delta}(1-\alpha)^{\delta(\alpha-1)}(\alpha/(1-\alpha))^{\alpha\delta} \quad .$$

Eq. (9) shows that the retail price of good x is going to differ across countries for two reasons: (i) the producer price can be different across countries because of the presence of trade costs, and (ii) the costs of distribution can be different across countries because of differences in the price of distribution services, and differences in the number of units of distribution services used.

Since $\overline{p}_{mi}(x)$ is unchanged, it implies that the price of intermediate composite is also unchanged and is given by Eq. (5).

5.4 Calibration Methodology

With the inclusion of a distribution sector, the share of the base goods sector in the labor force, $l_{mi} = 1 - l_{di} - l_{si} = 1 - \mu\delta\vartheta_i - \gamma(1-\mu)$. ϑ_i is the ratio of value of distribution services and retail value of base goods in country i. It comes from the zero profit condition in the retail goods sector, which is given by:

$$L_i V_{mi} = L_i \overline{V}_{mi} + L_i p_{di} d_i$$

V_{mi} is the per capita retail value of all base goods, and $\overline{V}_{mi}$ is the per capita producer price value of all base goods., where the second term on the right-hand side of the expression for $\overline{V}_{mi}$ is total value of distribution services in country i.

$$\overline{V}_{mi} = \frac{(1-\vartheta_i)}{\vartheta_i} p_{di} d_i \tag{11}$$

Appendix A discusses the derivation of the sectoral shares of labor, capital and the intermediate composite.

Now, the balanced trade condition is given by:

$$\sum_{j=1}^{n} L_j w_j l_{mj} D_{ji} = L_i w_i l_{mi} \tag{12}$$

The solution methodology remains the same; I take the endowment of labor and capital from data, and estimate trade costs from the gravity equation, Eq. (3), solve for w_i and p_{ci} using Eq. (12) and Eq. (5), and calibrate λ_i using Eq. (7).

5.5 Variance of LOOP Deviations and Distribution Margins for Individual Goods

In order to compute the retail prices I simulate the producer prices and the units of distribution services used. The prices are simulated for 1500 goods. For each good, x, a cost vector $(z_1(x), \dots, z_n(x))$ is drawn, where n is the number of countries, from the joint density function $f(z) = (\prod_{i=1}^{n} \lambda_i) \exp\{-\sum_{i=1}^{n} \lambda_i z_i\}$. Using Eq. (1), I calculate producer prices of goods. Then, for each country i, a vector $(u_i(1), \dots, u_i(M))$, where M is the number of goods, is drawn from the density function $g = e^{-u}$. Each element of the vector represents the units of distribution services used in delivering good x to the consumer. The retail price of each good is calculated using Eq. (9). The deviation from the LOOP, $(Q_{mi}(x)|x)$, is computed using Eq. (8), but for retail prices. Good-by-good price dispersion is given by $Var(Q_{mi}(x)|x)^{1/2}$.

The distribution margin for good x is calculated as:

$$dm_i(x) = 1 - \frac{\overline{p}_{mi}(x)}{p_{mi}(x)} \tag{13}$$

5.6 Parameterization

The sample of countries and the year to which the model is calibrated are the same as those in the Ricardian model. As in the Ricardian model, agriculture, hunting, forestry and fishing, mining and quarying, and manufacturing are treated as the traded goods sector. Wholesale trade, retail trade and transport and storage form the distribution services sector. All other sectors form the non-traded good sector.

The calibrated values of β, α, η and θ remain unchanged. δ and γ are calibrated as the share of value added in gross output of distribution services sector and the non-traded good sector, respectively. μ is the share of the composite retail good in value of output of the final good sector. Since the value of output of the final good sector is the GDP of a country, μ is computed as one minus the share of the non-traded good sector (all services except retail trade, wholesale trade and transport and storage) in GDP. The data used to compute these parameters come from the OECD STAN Structural Analysis database. Details of the data and the methodology are provided in Appendix B. For the sample of countries δ is 0.58, γ is 0.62 and μ is 0.42. Again, these are averages for the period 1995-1997.

The parameter ν, controls the variance in the number of units of distribution services required to deliver 1 unit of a base good to the consumers, irrespective of the country. Heterogeneity in distribution margins is used as a target in calibrating ν. First, using the model simulated distribution margins, the standard deviation of distribution margins across all goods in each country is computed. Then, an average of these country-specific standard deviations is computed. ν is chosen so that this model generated average standard deviation is equal to its data counterpart. I find ν to be 0.75. ζ_i represents the units of distribution services required to deliver 1 unit of a base good to the consumer in country i, irrespective of the good. ζ_i is chosen so that the average of the simulated distribution margins of all goods in country i equals the average of distribution margins of all goods in country i observed in the data. The average distribution margin for countries with missing data (Canada, Mexico and Switzerland) is replaced by the sample average in the data. Table 6 gives the calibrated ζ for each country.

Table 6: Country-Specific Distribution Parameter: ζ_i

Country	ζ	Country	ζ
Australia	0.33	Japan	0.37
Austria	0.21	Mexico	0.23
Belgium	0.11	Netherlands	0.14
Canada	0.22	New Zealand	0.16
Denmark	0.19	Norway	0.20
Finland	0.15	Portugal	0.17
France	0.14	Spain	0.19
Germany	0.17	Sweden	0.12
Greece	0.23	Switzerland	0.17
Ireland	0.06	United Kingdom	0.18
Italy	0.18	United States	0.30

6 Results: Ricardian Model with Distribution

Accounting for the differences in costs of distribution across goods and across countries helps the model to better match the data. The model can match the average price dispersion very well. Table 7 shows that the model accounts for 96.5 percent of the average price dispersion observed in the data. Furthermore, the model can account for 32 percent of the IQR (inter-quartile range) observed in the data. As compared to the benchmark Ricardian model, the Ricardian model with heterogeneity in distribution brings 13 percent improvement in matching average price dispersion, and a 48 percent improvement in matching the variation in good-by-good price dispersion as measured by IQR.

Table 7: Good-by-Good Price Dispersion: Model Versus Data

	Model	Data	Model as ratio of Data
Avg.	0.2680	0.2778	0.9648
IQR	0.0505	0.1595	0.3167
P90 - P10	0.0978	0.3008	0.3251

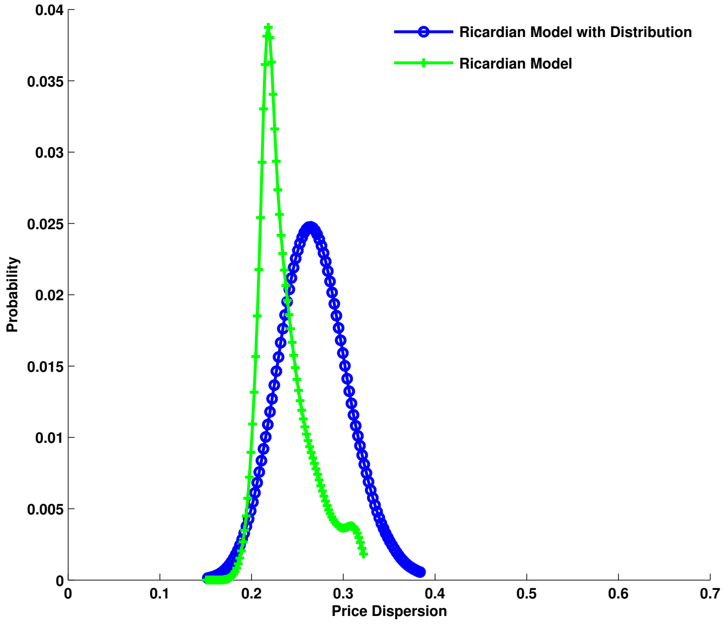

Figure 3: Distribution of $Var(Q_{mi}(x)|x)^{1/2}$

These differences are reflected in Figure 3, which plots the empirical distribution of good-by-good price dispersion generated by the Ricardian model with distribution, as well as that generated by the benchmark Ricardian model. Notice that the distribution generated by the Ricardian model with distribution is more symmetric than the distribution generated by the benchmark Ricardian model. This is due to the fact that the improvement in matching the data brought about by including distribution generates a 38 percent improvement in matching P90 - P10, which is lower than the 48 percent improvement in accounting for IQR.

Accounting for local distribution costs and incorporating heterogeneity in distribution services requirement of goods in the benchmark Ricardian model results in a significant improvement in the model's ability to match the data. Furthermore, distribution costs play a more important role in matching the variation in good-by-good price dispersion than in matching the average good-by-good price dispersion in retail prices observed in the data.

6.1 Role of Heterogeneity in Distribution

In order to evaluate the role of heterogeneity in distribution costs in matching the data, I consider a simpler version of the model in which there is no heterogeneity in distribution services requirement of goods. So, $\phi_i(x) = \phi \; \forall \, x, \; \forall \, i$. Using the model simulated distribution margins, I calculate the average of distribution margins over all goods in each country, to compute the average distribution margin for each country. Then, an average of the average country distribution margins is computed, to arrive at an average cross-country distribution margin. ϕ is calibrated so that the model generated average cross-country distribution margin is equal to the average cross-country distribution margin in the data. Consequently, ϕ is set at 0.15.

Table 8 shows that the average good-by-good price dispersion generated by this variant of the model is 23 percent. This implies that the model can explain 83 percent of the average dispersion observed in the data. The IQR generated by the model is 22 percent of that observed in the data. Relative to the model with heterogeneity in distribution, this represents a 16 percent decline in the model's ability to match the average good-by-good price dispersion and a 44 percent decline in the model's ability to match the variation in good-by-good price dispersion. Therefore, ignoring the heterogeneity in distribution costs, by assuming that all goods use the same amount of non-traded inputs, adversely affects the model's performance in matching the data, especially in matching the variation in good-by-good price dispersion.

This is illustrated by Figure 4, which plots the empirical distribution generated by the model without heterogeneity in distribution, as well as that generated by the model with heterogeneity in distribution.

Table 8: Good-by-Good Price Dispersion: Model Versus Data

	Model	Data	Model as ratio of Data
Avg.	0.2311	0.2778	0.8320
IQR	0.0350	0.1595	0.2197
P90 - P10	0.0661	0.3008	0.2197

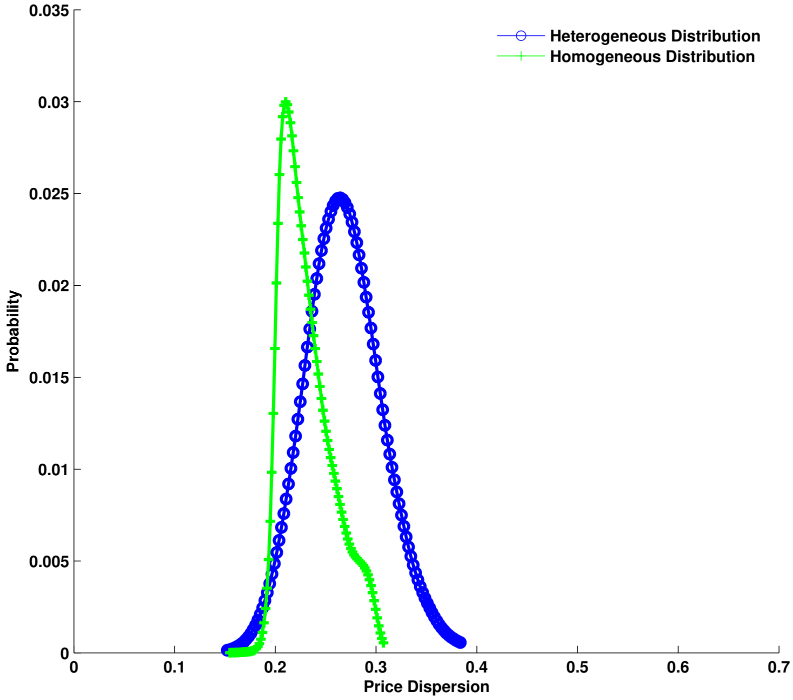

Figure 4: Distribution of $Var(Q_{mi}(x)|x)^{1/2}$: Role of Heterogeneity in Distribution

Interestingly, the average good-by-good price dispersion explained by the model without heterogeneity in distribution is actually lower than that explained by the benchmark

Ricardian model. In addition, the IQR generated by the model is only slightly higher than the IQR generated by the benchmark Ricardian model. However, the latter can account for a higher proportion of P90 - P10 observed in the data. The restriction that all goods in every country require the same number of units of distribution services to be delivered to the consumer dampens the difference in the value of distribution services used to deliver the same good in different countries. This, in turn, reduces cross-border differences in the retail price of the same good. Since the model with no heterogeneity in distribution accounts for a higher proportion of IQR but a lower proportion of P90 - P10 than the benchmark Ricardian model, it suggests that the dampening effect of the constancy in units of distribution services used primarily affects the tails of the distribution of good-by-good price dispersion.

Comparing the empirical distribution of good-by-good price dispersion generated by the model without heterogeneity with the distribution generated by the benchmark Ricardian model, shown in Figure 2, reveals that the two distributions have identical left tails but the right tail of the latter is more skewed than that of the former. Thus, the dampening effect works on the right tail of the distribution, reducing the average good-by-good price dispersion.

6.2 Role of Trade Costs

In this section I examine the role of trade costs in driving good-by-good price dispersion. I start by removing the heterogeneity in trade costs - all countries face uniform trade costs as in Alvarez and Lucas (2007), i.e. $\tau_{ij} = \tau \; \forall \; i \neq j$. Using the matrix of trade cost parameters estimated in the benchmark Ricardian model, I calculate the average trade cost an exporter faces in exporting to any other country. τ is calculated as the average of these exporter specific trade costs. I find τ to be 2.19. Note that this trade barrier does not apply when a country buys a good from its own producers rather than importing it, i.e. $\tau_{ij} = 1, \; i = j$. The next (obvious) question to ask is how important is the magnitude of trade cost in driving good-by-good price dispersion? For this purpose, I set τ at lower value of 1.33. This is the uniform trade cost estimate used in Alvarez and Lucas (2007) for a much larger set of countries. As the last step, trade costs are reduced to zero, i.e. $\tau_{ij} = 1 \; \forall \; i, j$.

In conducting these experiments, ν and ζ_i must be recalibrated so that (i) the OECD average standard deviation of distribution margins (the average of country-specific standard deviations of distribution margins) generated by the model is the same as that in the data, and (ii) the average of the distribution margins of all goods in country i generated by the model equals the average of distribution margins of all goods in country i observed in the data. This ensures that the magnitude of, and heterogeneity in, distribution margins is the same as that in the model with heterogeneity in distribution and trade costs.

Table 9: Role of Trade Costs

	Avg.	IQR	P90 - P10
Model with heterogeneity in trade costs and distribution	0.2680	0.0505	0.0978
Uniform Trade Costs $\tau_{ij} = \tau = 2.19 \ \forall \ i \neq j$	0.2483	0.0507	0.0991
Alvarez-Lucas Trade Costs $\tau_{ij} = \tau = 1.33 \ \forall \ i \neq j$	0.1753	0.0533	0.1033
Zero Trade Costs $\tau_{ij} = 1 \ \forall \ i = j$	0.1647	0.0542	0.1053
Data	0.2778	0.1595	0.3008

Table 9 reveals that removing the heterogeneity in trade costs, but with a uniform average trade cost, there is a small decline in the average good-by-good price dispersion to 0.2483 compared to the model with heterogeneity in trade costs and distribution (0.2680). The model with uniform trade costs can generate 89 percent of average price dispersion observed in the data, compared to 96.5 percent explained by the model with heterogeneity in trade costs and distribution. The variation in good-by-good price dispersion increases by a negligible amount.

Reducing the level of uniform trade costs from 2.19 to 1.33 results in a sharp decline in the average good-by-good price dispersion to 0.1753. With the lower uniform trade cost, the model can account for only 63 percent of the average good-by-good price dispersion. On the other hand, variation in good-by-good price dispersion increases marginally. As compared to the fall in average price dispersion, the increase in variation in good-by-good price dispersion is very small - the model with lower uniform trade costs can account for

33 percent of IQR observed in the data as compared to 32 percent explained by the model with higher uniform trade costs. For P90 - P10, the corresponding numbers are 34 percent and 33 percent. Finally, reducing trade costs to zero reveals the same qualitative trend. Average good-by-good price dispersion declines further (the proportion accounted for by the model falls to 59 percent) and there is a very small increase in the variation in good-by-good price dispersion. Essentially, as trade costs decline, the distribution of good-by-good price dispersion shifts to the left, without any significant change in the variation in good-by-good price dispersion. Thus, the level of trade costs determines the location of the distribution of good-by-good price dispersion. Figure 5 shows the leftward shift of the distribution in response to a decline in trade costs.

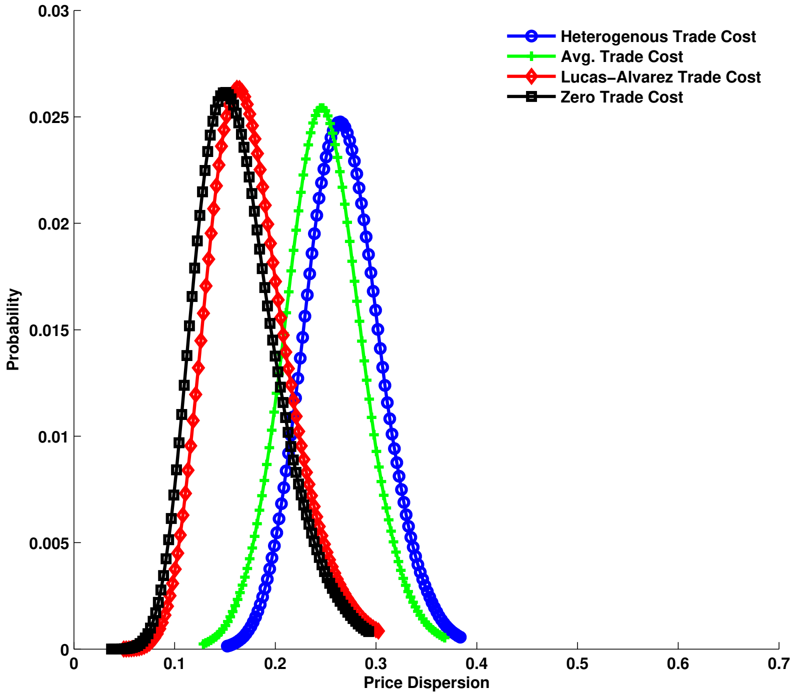

Figure 5: Effect of Trade Costs on Empirical Distribution of $Var(Q_{mi}(x)|x)^{1/2}$

The experiments show that heterogeneity in trade costs plays a very small role in determining the average price dispersion. Removal of heterogeneity in trade costs, by assuming that trade cost between country i and country j $(i \neq j)$ is equal to the average trade cost for the OECD countries, leads to a small decline in average price dispersion. Furthermore, it has no significant impact on the variation in good-by-good price dispersion. It is the magnitude of trade costs which is important for the model's ability to match average price dispersion. A decline in the level of trade costs, from the uniform average trade cost computed for the OECD countries to the uniform trade cost used in Alvarez and Lucas (2007), results in a decline in the average good-by-good price dispersion and a comparatively negligible increase in the variation in good-by-good price dispersion. Basically, a decline in trade costs reduces the producer price of a good. It also reduces the heterogeneity in producer price across countries. However, since trade costs are country specific and not good specific, a reduction in trade costs affects all goods symmetrically. Therefore, all goods experience a decline in cross-country heterogeneity in producer prices. This is what causes the distribution of good-by-good price dispersion to shift to the left, without any significant change in the variance of good-by-good price dispersion.

7 Conclusion

This paper poses two questions. First, given that the new multi-country Ricardian trade models, which allow for trade costs, can account well for the "quantity" of goods traded across international borders, what are the implications of these models for deviations from the LOOP in the prices of goods? Second, can accounting for differences in local costs of distribution across goods and across countries, help to better match the data on LOOP deviations?

With respect to the first question, I find that the degree of market segmentation implied by international trade barriers is not enough to account for good-by-good dispersion in LOOP deviations observed in the data. The benchmark multi-country Ricardian trade model, featuring heterogeneous and asymmetric trade costs, does a good job of matching the average good-by-good price dispersion, but it is not able to generate the variation in good-by-good price dispersion observed in the data. It can explain 85 percent of average price dispersion, but only 21 percent of the variation in price dispersion.

With respect to the second question, I find that accounting for differences in costs of distribution across goods and across countries significantly improves the model's performance in matching the data. The model does a very good job of matching the average price dispersion - it explains 96.5 percent of the average price dispersion. And, it can explain 32 percent of the variation in price dispersion. This implies a 13 percent improvement in explaining average good-by-good price dispersion and 48 percent improvement in explaining variation in good-by-good price dispersion over the benchmark Ricardian model. Furthermore, imposing the assumption that all goods in all countries require the same amount of distribution services to be delivered to consumers severely limits the model's ability to match the data, especially the variation in good-by-good price dispersion. Therefore, heterogeneity in distribution costs plays an important role in matching the variation in good-by-good price dispersion.

On the other hand, heterogeneity in trade costs does not play an important role in driving good-by-good price dispersion. Removal of heterogeneity in trade costs, keeping the average trade cost for the sample unchanged, leads to a small decline in average price dispersion and has no significant impact on the variation in good-by-good price dispersion. The level of trade costs is important, however, for average good-by-good price dispersion. As the level of trade costs declines the distribution of good-by-good price dispersion shifts to the left, implying a decline in average good-by-good price dispersion, without any significant change in the variation in good-by-good price dispersion. With zero trade costs, the model can explain only 59 percent of the average price dispersion observed in the data.

The two sources of market segmentation - international trade costs and local costs of distribution - can explain the dispersion in LOOP deviations for an "average" retail product very well. By contrast, they can account for only one-third of the variation in dispersion in LOOP deviations observed in the data across a broad spectrum of retail products. Although, heterogeneity in distribution costs is crucial in explaining the variation in good-by-good price dispersion, it is clearly not enough.

There are three main avenues to extend this framework in order to better explain the large variation in good-by-good price dispersion. First, the good-by-good price dispersion in retail prices of non-traded goods is captured through the difference in price of a single homogeneous non-traded good in the model. Crucini et al. (2005) find that the average good-by-good price dispersion is higher for non-traded goods than for traded goods and that most non-traded goods lie on the right end of the distribution of good-by-good price dispersion. Incorporating heterogeneity within the non-traded good sector will allow the model to capture the right end of the empirical kernel density of dispersion in LOOP deviations.

Second, in this paper and in most of the literature, trade costs are modeled at the level of countries and not at the level of goods. Moreover, following the literature, I estimate trade costs by using distance, language, border and membership of free trade regions as proxies. Hummels (2001) provides direct evidence on freight rates for 2-digit SITC commodity groups. There are large differences in freight rates across the commodity groups and across exporting countries within a commodity group. One may conjecture that combining the direct evidence on good-specific international transportation costs with the country-specific indirect estimates of trade barriers can improve the model's ability to match the variation in price dispersion observed in the data. However, given the trade costs, due to the ability of countries to arbitrage away the differences in producer prices of individual goods the heterogeneity in distribution costs is still going to play a more important role than the heterogeneity in trade costs in determining the variation in good-by-good price dispersion.

Third, this paper abstracts from strategic behavior between producers and retailers of goods. The current model assumes perfectly competitive producers as well as retailers of goods, and therefore it does not allow for markups (over marginal cost). Changing the vertical market structure between the upstream producer of a good and the downstream retailer of a good to allow for markups that vary across goods provides another avenue to improve the model's ability to generate larger variation in good-by-good price dispersion.

8 Appendix A

8.1 Price of Intermediate Composite

Relabeling good x by its productivity level z

$$\overline{p}_{mi}(z)^{1/\theta} = B^{1/\theta} \min_{j} \left[\left(w_j^{\beta} p_{cj}^{1-\beta} k_j^{-\alpha\beta} \tau_{ij} \right)^{1/\theta} z_j \right]$$

Two properties of the exponential distribution are useful here: (i) if $v \sim \exp(\kappa) \Rightarrow av \sim \exp(\kappa/a)$. If v_1 and v_2 are independent, with $v_1 \sim \exp(\kappa_1)$ and $v_2 \sim \exp(\kappa_2)$, and $s = \min(v_1, v_2) \Rightarrow s \sim \exp(\kappa_1 + \kappa_2)$. Then

$$\overline{p}_{mi}(z)^{1/\theta} \sim \exp\left(B^{-1/\theta} \sum_{j=1}^{n} \psi_{ij} \right), \text{ where } \psi_{ij} = \left(w_j^{\beta} p_{cj}^{1-\beta} k_j^{-\alpha\beta} \tau_{ij} \right)^{-1/\theta} \lambda_j$$

Since the price of the intermediate composite is given by

$$p_{ci}^{1-\eta} = \int_0^{\infty} \overline{p}_{mi}(z)^{1-\eta} f(z) dz$$

where

$$f(z) = \left(\prod_{i=1}^{n} \lambda_i \right) \exp\left(- \sum_{i=1}^{n} \lambda_i z_i \right)$$

Let $R = \overline{p}_{mi}(z)^{1/\theta}$ and $S = \overline{p}_{mi}(z)^{1-\eta}$, and therefore $R = S^{1/(\theta(1-\eta))}$. Then

$$p_{ci}^{1-\eta} = \left(B^{-1/\theta} \sum_{j=1}^{n} \psi_{ij} \right)^{-\theta(1-\eta)} \int_0^{\infty} h^{\theta(1-\eta)} e^{-h} dh$$

where $\int_0^{\infty} h^{\theta(1-\eta)} e^{-h} dh$ is a Gamma function. Let $A = \left(\int_0^{\infty} h^{\theta(1-\eta)} e^{-h} dh \right)^{\frac{1}{1-\eta}}$. Substituting for ψ_{ij} gives

$$p_{ci} = AB \left(\sum_{j=1}^{n} \left(w_j^{\beta} p_{cj}^{1-\beta} k_j^{-\alpha\beta} \tau_{ij} \right)^{-1/\theta} \lambda_j \right)^{-\theta}$$

8.2 Expenditure Shares

$$D_{ij} = \Pr\left[p_{mj}(x) \leq \min_{k \neq j} p_{mk}(x)\right]$$

Using the two properties of exponential distribution discussed earlier and a third property, which says that: if $v_1 \sim \exp(\kappa_1)$ and $v_2 \sim \exp(\kappa_2)$ and v_1 and v_2 are independent then $\Pr\{v_1 \leq v_2\} = \frac{\kappa_1}{\kappa_1 + \kappa_2}$, we get

$$D_{ij} = \frac{\psi_{ij}}{\sum_{k=1}^{n} \psi_{ik}}$$

Combining this with Eq. (5) and substituting for ψ_{ij} gives:

$$D_{ij} = (AB)^{-1/\theta} \left(\frac{w_j^{\beta} p_{cj}^{1-\beta} k_j^{-\alpha\beta} \tau_{ij}}{p_{ci}} \right)^{-1/\theta} \lambda_j$$

8.3 Sectoral Allocations of Inputs in the Ricardian Model with Distribution Sector

The first order conditions with respect to labor and intermediate composite in the base goods sector, distribution services sector and non-traded good sector give the following relations between sectoral labor allocations:

$$l_{di} = \frac{\delta(1-\beta)}{\beta(1-\delta)} \frac{c_{di}}{c_{mi}} l_{mi} \tag{14}$$

$$l_{si} = \frac{\gamma(1-\beta)}{\beta(1-\gamma)} \frac{c_{si}}{c_{mi}} l_{mi} \tag{15}$$

Substituting these in the market clearing condition for labor implies

$$l_{mi} \left[1 + \frac{\delta(1-\beta)}{\beta(1-\delta)} \frac{c_{di}}{c_{mi}} + \frac{\gamma(1-\beta)}{\beta(1-\gamma)} \frac{c_{si}}{c_{mi}} \right] = 1 \tag{16}$$

The importing firm in each country makes zero profit.

$$L_i p_{ci} c_i + L_i \overline{V}_{mi} = L_i X_i$$

Substituting for $\overline{V}_{mi}$ from Eq. (11), using the relations $p_{ci}c_{di} = (1-\delta)p_{di}d_i$ and $p_{ci}c_{mi} = (1-\beta)X_i$ to substitute for $p_{di}d_i$ and X_i and employing the market clearing condition for intermediate composite gives

$$\frac{c_{si}}{c_{mi}} = \frac{\beta}{(1-\beta)} - \frac{c_{di}}{c_{mi}}\frac{(1-\delta\vartheta_i)}{\vartheta_i(1-\delta)} \tag{17}$$

Since GDP equals factor income and $p_{ci}c_{si} = (1-\gamma)p_{si}s_i$, it implies that $(1-\alpha)p_{ci}c_{si} = (1-\mu)(1-\gamma)w_i$. Combining this with Eq. (16) and using the relation that $w_i l_{mi} = (\beta(1-\alpha)/(1-\beta))p_{ci}c_{mi}$ implies

$$\frac{c_{si}}{c_{mi}}\left[\frac{1-\gamma(1-\mu)}{(1-\gamma)(1-\mu)}\right] = \frac{\beta}{(1-\beta)} - \frac{c_{di}}{c_{mi}}\frac{\delta}{(1-\delta)} \tag{18}$$

Using Eq. (17) and Eq. (18) to solve for the two ratios - c_{di}/c_{mi} and c_{si}/c_{mi} - and using Eq. (16) gives the share of labor force employed in the base goods sector.

$$l_{mi} = 1 - \mu\delta\vartheta_i - \gamma(1-\mu)$$

Substituting for l_{mi} in Eq. (14) and Eq. (15) gives the share of distribution services sector and non-traded good sector in labor force, respectively.

$$l_{di} = \mu\delta\vartheta_i$$

$$l_{si} = \gamma(1-\mu)$$

Since $r_i = (\alpha/(1-\alpha))w_i k_i^{-1}$, the first order conditions from firms' profit maximization in base goods sector, distribution services sector and non-traded good sector imply that a sector's capital share is proportional to its labor force share where the factor of proportionality is the country's capital-labor ratio.

$$k_{mi} = k_i l_{mi}, \quad k_{di} = k_i l_{di}, \quad k_{si} = k_i l_{si} \quad .$$

The first order conditions with respect to labor and intermediate composite in the base goods sector, distribution services sector and non-traded good sector give the following relations between sectoral labor allocations and sectoral allocation of intermediate composite:

$$l_{di} = \frac{\delta(1-\beta)}{\beta(1-\delta)}\frac{c_{di}}{c_{mi}}l_{mi}$$

$$l_{si} = \frac{\gamma(1-\beta)}{\beta(1-\gamma)}\frac{c_{si}}{c_{mi}}l_{mi}$$

c_{mi}, c_{di} and c_{si} are determined by combining these two conditions with the market clearing condition for intermediate composite and market clearing condition for labor.

9 Appendix B

9.1 Data on Gross Output and Value Added

The data used to compute the share of value added in gross output of the three sectors come from the OECD STAN Structural Analysis database[6]. Value added and gross output of the sub sectors are added to get the data at the sectoral level, i.e. for traded good sector, distribution services sector and non-traded good sector. Ratio of value added and gross output is calculated for each country in each sector for three years - 1995, 1996 and 1997, and then averaged over three years to remove any idiosyncrasies associated with the year 1996. The ratios are then averaged across countries for each sector to get the sector's value added as a ratio of gross output. Australia and Ireland are not included in this exercise because of missing data on gross output. The share of traded goods sector in GDP is calculated as the value added in traded good sector as a ratio of the total value added in a country. The share of non-traded good sector in GDP is computed in the same manner. Again, both ratios are averages for the period 1995-1997.

9.2 Bilateral Trade Data and Expenditure Shares

Data on bilateral trade volumes for the 22 OECD countries is obtained from the NBER-United Nations Trade Data, 1962-2000. Feenstra et al. (2005) provide the documentation for the data. The data are organized by the 4 digit Standard International Trade Classification, revision 2. Imports of each country in the sample from the other 21 countries are extracted for the year 1996.

To compute the expenditure shares, I follow Eaton and Kortum (2002). Summing the exports of a country across all trading partners gives the country's total exports. Using the OECD STAN database, gross output of the traded goods sector for the year 1996 is obtained by adding gross output of the sub sectors. Gross output is expressed in nominal local currency units. Nominal yearly exchange rates with respect to the U.S. dollar for the year 1996 are

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[6] STAN Industry, ISIC Rev. 2 Vol 1998 release 01

used to convert local currency units into U.S. dollars. Data on nominal exchange rates come from OECD Economic Outlook, June, 2003, Annex Table 37. Then, subtracting total exports of a country from its gross output gives each country's home purchases. Adding home purchases and total imports of a country gives the country's total expenditure on traded goods. Normalizing home purchases and imports of an importing country from its trading partners by the importer's total expenditure on traded goods creates expenditure shares that are used in the model.

The data on distance, border and language used in the estimation of trade costs comes from Centre D'Etudes Prospectives Et D'Informations Internationales (http://www.cpeii.fr).

9.3 Labor Force and Capital-Labor Ratio

Capital-labor ratio data are obtained from Caselli (2005), and are constructed using the perpetual inventory method which uses purchasing power parity investment rates in Heston et al. (2002). Data on labor force also come from Caselli (2005), and are again based on Heston et al. (2002). Since the data for Germany are missing, capital-labor ratio is computed as the average of capital-labor ratios of other countries. Missing data on labor force were replaced by data from World Development Indicators (WDI). The data are for the year 1996.

9.4 Basic Price Value of Traded Goods as a ratio of Purchaser Price Value of Traded Goods

ϑ_i is computed from the data as 1 minus the ratio of basic price value of all traded goods and purchaser price value of all traded goods. These data come from the use tables of the countries. The basic price value of all traded goods is calculated as the sum of the supply of the 29 categories of goods valued in basic prices. The purchaser price value of all traded goods is calculated as the sum of the supply of the 29 categories of goods valued in purchaser prices. Since data for Canada, Mexico and Switzerland are not available, ϑ for these countries is assumed to be the average of ϑs of the remaining 19 countries.

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