Constant versus Variable Markups:

Implications for the Law of One Price[*]

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Abstract

This paper compares the implications of having constant versus variable markups on the Law of One Price (LOP) by decomposing the good-category level prices into marginal costs of production, markups, and trade costs. Using a trade model, it is shown that the case of constant markups corresponds to log-linear trade regressions, while the case of variable markups corresponds to lin-log trade regressions. Empirical results show that marginal costs of production contribute most to the deviations from LOP for both cases of constant and variable markups; the decomposition of marginal costs further shows that destination-specific quality measures play the biggest role.

JEL Classification F12, F13, F14

Key Words: The Law of One Price; Constant Markups; Variable Markups; Trade Costs.

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1   Introduction

The workhorse empirical models of international trade based on constant markups (e.g., log linear gravity studies) have been criticized by the international finance literature that they cannot match the data on international price differences, especially when exporters price discriminate across importers.[1] Accordingly, one of the most successful strategies in the international finance literature has been to nest constant elasticity of substitution (CES) models to have variable markups (i.e., markups changing with the quantity sold) such that the so-called "Penn effect", according to which the price level is higher in richer countries, can be explained.[2] Nevertheless, when it comes to measuring the effects of constant versus variable markups on international price dispersion, the existing studies have mostly focused on calibrating complicated models (e.g., the influential investigation by Atkeson and Burstein, 2008, followed by many international trade and finance studies[3]). Therefore, there is a lack of an easy-to-implement estimation strategy in the literature on this subject.

This paper introduces such an estimation strategy considering the trade implications of having constant versus variable markups by using constant relative risk aversion (CRRA) versus constant absolute risk aversion (CARA) consumer utility functions, respectively.[4] The functional form of the

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[1] The following studies are examples showing that importers with higher income levels pay higher prices for imports from a given source: Hummels and Klenow (2005), Hummels and Lugovskyy (2009), Baldwin and Harrigan (2011), Alessandria and Kaboski (2011), Johnson (2012), and Manova and Zhang (2012). Studies such as by Crucini and Yilmazkuday (2014) show how the retail sector can contribute to international price differences.

[2] Studies such as Helpman and Krugman (1985), Lapham (1995), Bergin and Feenstra (2001), Alessandria (2004), Corsetti and Dedola (2005), Hellerstein (2006), Atkeson and Burstein (2008), Simonovska (2015), among many others, have all investigated international price differences using monopolistically competitive models with non-constant elasticities of demand.

[3] Amiti et al. (2014), Berman et al. (2012), and Edmond et al. (2012) are just a few examples.

[4] As shown by Behrens and Murata (2007), CRRA corresponds to constant markups (through CES), while CARA corresponds to a specific case of variable markups (through non-CES) when the pricing decision of the producers

importer-country utility function further determines the price elasticity of demand and the elasticity of substitution (across products imported from different countries) through utility maximization. When each source country maximizes its profits using a pricing-to-market strategy, it is shown that CRRA preferences corresponds to CES and thus constant markups, while CARA preferences corresponds to non-CES and thus variable markups.

The key innovation is that, when trade implications are estimated to obtain elasticity measures (and thus implied markups), having cases of constant versus variable markups is reduced to using quantities in logs versus levels on the left hand side of the estimated equations, where the right hand sides are exactly the same; i.e., constant markups correspond to log-linear regressions (as in CES-based gravity studies), while variable markups correspond to lin-log regressions. Compared to the existing literature, this empirical innovation is closely related to a study by Novy (2013) who has shown that translog demand systems also correspond to lin-log regressions under certain circumstances. However, such regressions implied by translog demand systems cannot distinguish between the elasticity of demand/substitution and the distance elasticity of trade costs, where the former is the key to measure and identity markups as in this paper.[5]

Using the NBER-UN data on quantity traded and unit prices covering bilateral trade between 171 countries for 749 good categories, we estimate trade patterns implied by the model (i.e., log-

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is also considered; the rest of this paper will follow these utility functions in order to distinguish between constant versus variable markups. Several other papers, including Behrens and Murata (2012a,b), Behrens et al. (2012), Yilmazkuday (2013,2015a), have considered CARA preferences under different contexts. See Arkolakis et al. (2015) for other specifications in the literature under which variable markups can be obtained.

[5]Using lin-log regressions, Novy (2013) considers the endogeneity of the trade cost elasticity to focus on the heterogeneous impact of trade costs across country pairs, while this paper deviates by considering the endogeneity of the elasticity of demand to investigate the implications on LOP. Another dimension that this paper deviates from Novy (2012) is that he uses total exports data amongst 28 OECD countries, while we use a good-category level data covering the globe.

linear and lin-log trade regressions) to obtain estimates of (constant and variable) markups after controlling for source-specific quality measures and distance effects (including time-to-trade). After estimating markups by trade equations, we estimate price equations implied by the model to decompose destination prices into marginal costs of production, markups, and trade costs. While marginal costs of production are further decomposed into source-specific input costs, source-specific quality and destination-specific quality measures, trade costs are further decomposed into freight costs and border costs.

The decomposition of destination prices is further used to calculate the source of deviations from the Law of One Price (LOP) across destination countries for the cases of constant and variable markups at the good-category level. The results under the case of constant (variable) markups imply that, on average across goods, marginal costs of production has the lion's share with a contribution of about 92% (97%) to the *mean* of deviations from LOP, while trade costs contribute only about 8% (2%). The contribution of markups is almost none on average across goods in both cases, although, in the case of variable markups, they can contribute up to 10% of the deviations from LOP for certain goods. The results are very similar when the *variance* of deviations from LOP for the average good is considered: marginal costs of production contribute about 96% (98%) and trade costs contribute about 5% (2%) when constant (variable) markups are considered.

Since marginal costs of production explain the lion's share of the deviations from LOP, their decomposition into source-specific input costs, source-specific quality and destination-specific quality measures is of further interest. Such a decomposition is also directly connected to the existing literature which has mixed evidence on the quality of exports. In particular, while studies such as by Verhoogen (2008), Bastos and Silva (2010), Manova and Zhang (2012), Martin (2012), Sheu (2014), and Harrigan et al. (2015) provide evidence that is consistent with the destination-specific quality measures, other studies such as by Iacovone and Javorcik (2010), and Lugovskyy and Skiba (2015)

provide evidence that is consistent with common quality across destination countries (captured by source-specific quality measures in this paper). The corresponding results support the former set of studies by showing that destination-specific quality measures contribute most to marginal costs of production, followed by source-specific quality measures and source-specific input costs, for both cases of constant and variable markups, and for both the mean and the variance of deviations from LOP.

The rest of the paper has been organized as follows. Section 2 introduces the economic environment to motivate the empirical investigation. Section 3 depicts the methodology and data used in the estimation. Section 4 discusses the estimation results and connects them to the corresponding results in the literature. Section 5 investigates the deviations from LOP. Section 6 concludes.

2 Model

Trade patterns of countries are modeled at the good level. Each destination country maximizes its utility obtained from imported goods. Each source country maximizes its profits at the good level by following a pricing-to-market strategy. Since we do not have/use any production data, we only focus on the trade and price implications of having CRRA versus CARA utility functions, which correspond to CES versus non-CES functions (to be proved, below), respectively.

We model the utility of the destination countries at the good level to avoid any further assumptions for the aggregation across goods. Accordingly, a typical destination country d has the following utility U_d^g maximization out of consuming varieties of good g coming from different source countries, each denoted by s :

$$\max U_d^g = \sum_s u_{ds}^g \left[q_{ds}^g \right] \tag{1}$$

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subject to

$$\sum_s p_{ds}^g q_{ds}^g = E_d^g \qquad (2)$$

where q_{ds}^g is the quantity of products imported from country s, p_{ds}^g is the price of q_{ds}^g at the destination (i.e., country d), E_d^g is the total expenditure of country d on good g, and brackets $[.]$ stand for "is a function of".

2.1   Case of CRRA: Constant Markups

The CRRA utility function is defined as follows:

$$u_{ds}^g \left[q_{ds}^g \right] = \chi_{ds}^g \left(q_{ds}^g \right)^{\theta^g} \qquad (3)$$

where $\theta^g > 0$ represents a good-g-specific taste parameter, and χ_{ds}^g represents a source-destination-good-specific demand shifter capturing utility due to quality (as in Hummels and Klenow, 2005) and disutility due to slow delivery of a product (as in Hummels and Schaur, 2013):

$$\chi_{ds}^g = \frac{\kappa_s^g \kappa_d^g}{(D_{ds})^{\delta_u^g}} \qquad (4)$$

where κ_s^g represents the *quality* of good g due its location of production (i.e., the source country s), κ_d^g represents the *quality* of good g due its location of consumption (i.e., the destination country d), and $(D_{ds})^{\delta_u^g} > 0$ represents the distance-related *taste* of the consumer, with D_{ds} representing distance and δ_u^g representing the elasticity of utility with respect to distance. We do not put any restrictions on the sign of δ_u^g; while the case of $\delta_u^g > 0$ (utility function decreasing in distance) would represent concerns related to time-to-trade, the case of $\delta_u^g < 0$ (utility function increasing in distance) would represent preferences toward products coming from distant countries (e.g., exotic goods). Hence, the demand shifter χ_{ds}^g captures both quality and taste; the inclusion of taste (due to distance) will be the key in the identification of quality versus taste parameters in the estimation, below.

Besides the direct effect of distance in the utility function, as will be shown below, there is also an indirect effect of distance through the trade-costs component of prices, which is typical in most trade studies. The reason for including this direct effect is to distinguish between the effects of distance in regressions explaining quantities (e.g., gravity-type regressions in international trade studies) and the effects of distance in regressions explaining prices (e.g., price regressions international finance studies), where the coefficient in front of distance is different from each other, similar to how Ruhl (2008) has compared the Armington elasticity across international trade and finance studies.[6]

We assume the very same functional form of utility across importers on purpose, because we would like to avoid explaining trade patterns by parameter heterogeneity. By maximizing the utility function with respect to the budget constraint, the demand function can be obtained as follows:

$$
q_{ds}^g = E_d^g \left(\frac{\chi_{ds}^g}{p_{ds}^g} \right)^{\frac{1}{1-\theta^g}} \left(\sum_{s'} \frac{(\chi_{ds'}^g)^{\frac{1}{1-\theta^g}}}{(p_{ds'}^g)^{\frac{\theta^g}{1-\theta^g}}} \right)^{-1}
\tag{5}
$$

According to Equation 5, after assuming that individual source countries have negligible impact on the destination price aggregates, the (absolute value of) price elasticity of demand ε_{ds}^g can be obtained as follows:

$$
\varepsilon_{ds}^g = - \frac{p_{ds}^g}{q_{ds}^g} \frac{\partial q_{ds}^g}{\partial p_{ds}^g} = \frac{1}{1-\theta^g}
\tag{6}
$$

which is good specific (i.e., $\varepsilon_{ds}^g = \varepsilon^g$ for all d, s) and independent of the quantity purchased. Regarding the elasticity of substitution σ_{ds}^g across varieties of a good, the substitutability of good g imported from source country s for good g imported from source country s' is given by:

$$
\sigma_{ds}^g (q_{ds}^g, q_{ds'}^g) = \frac{d \ln \left(\frac{q_{ds}^g}{q_{ds'}^g} \right)}{d \ln \left(\frac{dU_d^g}{dq_{ds'}^g} \Big/ \frac{dU_d^g}{dq_{ds}^g} \right)} = \frac{1}{1-\theta^g}
$$

As is evident, due to our assumption of individual source countries having negligible impact on the destination price aggregates, the expressions for the elasticity of substitution and the price elasticity

of demand are exactly the same; therefore, the case of CRRA in fact represents models based on constant-elasticity-of-substitution (CES) assumption.

Considering Equation 5, each source country s follows a pricing-to-market strategy by maximizing the profit out of sales to country d:

$$\pi_{ds}^g = q_{ds}^g \left(p_{ds}^g - c_{ds}^g \right) \tag{7}$$

where c_{ds}^g is the source-and-destination-and-good-specific marginal cost of exporting from country s to country d (including trade costs and other costs regarding the quality of good g produced in country s and consumed in country d) given by:

$$c_{ds}^g = w_s^g \left(\kappa_s^g \right)^{\beta_s^g} \left(\kappa_d^g \right)^{\beta_d^g} \tau_{ds}^g \tag{8}$$

where w_s^g represents source-specific input costs, $\left(\kappa_s^g \right)^{\beta_s^g}$ and $\left(\kappa_d^g \right)^{\beta_d^g}$ respectively represent the part of the marginal cost due to the source- and destination-specific quality (with β_s^g and β_d^g representing the elasticity of marginal cost with respect to quality), and τ_{ds}^g represents the gross trade costs from source s to destination d for good g that is further defined as:

$$\tau_{ds}^g = \left(D_{ds} \right)^{\delta_\tau^g} b_{ds}^g \tag{9}$$

where $\left(D_{ds} \right)^{\delta_\tau^g}$ represents freight costs (with D_{ds} being the distance and δ_τ^g being good-specific elasticity of trade costs with respect to distance), and b_{ds}^g represents source-and-destination-and-good-specific (gross) border costs (e.g., tariff rates or gravity-type variables other than distance).[7]

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[7]We are well aware that our definition of trade costs is very simple; however, it is good enough for the empirical analyis that we will have, below, where our data set distinguishes between FOB exporter prices and CIF importer prices. We will also treat b_{ds}^g's as a part of the residuals in our investigation using the trade implications of our model. One can easily extend this analysis by including other gravity-type variables into our trade-cost expression, but investigating such variables/costs is simply not the focus of this paper.

It is important to emphasize that the effect of distance through trade costs (i.e., parameterized by δ_τ^g) is different from the direct effect of distance in the utility function (i.e., parameterized by δ_u^g).

The profit maximization problem results in the following pricing strategy:

$$p_{ds}^g = \frac{c_{ds}^g}{\theta^g} \tag{10}$$

which implies that the price elasticity of demand (in Equation 6) can be rewritten as:

$$\varepsilon_{ds}^g = \frac{p_{ds}^g}{p_{ds}^g - c_{ds}^g} = \frac{1}{1 - \theta^g} \tag{11}$$

and that the gross markup denoted by μ_{ds}^g can be written as:

$$\mu_{ds}^g = \frac{\varepsilon_{ds}^g}{\varepsilon_{ds}^g - 1} = \frac{1}{\theta^g} \tag{12}$$

which is good-specific (i.e., $\mu_{ds}^g = \mu^g$ for all d, s) and hence common across (source and destination) countries according to Equation 10.

Using Equations 4, 8, and 9, we can rewrite Equation 5 as follows:

$$q_{ds}^g = \frac{E_d^g \left(\kappa_s^g \kappa_d^g \right)^{\frac{1}{1-\theta^g}}}{\left(p_{ds}^{g*} \left(D_{ds} \right)^{\delta^g} b_{ds}^g \right)^{\frac{1}{1-\theta^g}}} \left(\sum_{s'} \frac{(\chi_{ds'}^g)^{\frac{1}{1-\theta^g}}}{(p_{ds'}^g)^{\frac{\theta^g}{1-\theta^g}}} \right)^{-1} \tag{13}$$

which is one of the expressions we will estimate, below, where we have defined δ^g as the distance elasticity of trade according to:

$$\delta^g = \delta_u^g + \delta_\tau^g \tag{14}$$

The importance of this expression will be clearer when we will distinguish between the effects of distance on quantities versus prices, below. Finally, using Equations 8, 9, 10, and 12, the destination price in country d can be rewritten as follows:

$$p_{ds}^g = w_s^g \left(\kappa_s^g \right)^{\beta_s^g} \left(\kappa_d^g \right)^{\beta_d^g} \left(D_{ds} \right)^{\delta_\tau^g} b_{ds}^g \mu_{ds}^g \tag{15}$$

which is another equation that we will use during the estimation process, below. This price expression will also be the key expression for decomposing destination prices into its components and having implications for LOP.

2.2 Case of CARA: Variable Markups

The CARA utility function is defined as follows:

$$u_{ds}^g\left[q_{ds}^g\right] = \chi_{ds}^g - \chi_{ds}^g e^{-\alpha^g q_{ds}^g} \tag{16}$$

where χ_{ds}^g is again given by Equation 4. Maximizing this function with respect to the budget constraint results in the following demand function:

$$q_{ds}^g = \frac{E_d^g - \frac{1}{\alpha^g} \sum_{s'} \ln\left(\frac{p_{ds}^g \chi_{ds'}^g}{p_{ds'}^g \chi_{ds}^g}\right) p_{ds'}^g}{\sum_{s'} p_{ds'}^g} \tag{17}$$

Using the definition of taste parameters and trade costs given in Equations 4, 8 and 9 (that are common across CRRA and CARA cases), after some simple manipulation, we can rewrite this demand function as the following lin-log expression:

$$q_{ds}^g = \left(\frac{E_d^g - \frac{1}{\alpha^g} \sum_{s'} \ln\left(\frac{\chi_{ds'}^g}{p_{ds'}^g}\right) p_{ds'}^g}{\sum_{s'} p_{ds'}^g}\right) + \frac{\ln\left(\kappa_s^g\right)}{\alpha^g} + \frac{\ln\left(\kappa_d^g\right)}{\alpha^g} - \frac{\ln\left(p_{ds}^{g*}\right)}{\alpha^g} - \frac{\delta^g \ln\left(D_{ds}\right)}{\alpha^g} - \frac{\ln\left(b_{ds}^g\right)}{\alpha^g} \tag{18}$$

which is another expression we will estimate, below, where δ^g is again given by Equation 14. According to Equation 17, after assuming that individual source countries have negligible impact on the destination price aggregates, the (absolute value of) price elasticity of demand can be obtained as follows:

$$\varepsilon_{ds}^g = -\frac{p_{ds}^g}{q_{ds}^g} \frac{\partial q_{ds}^g}{\partial p_{ds}^g} = \frac{1}{\alpha^g q_{ds}^g} \tag{19}$$

which changes with the quantity q_{ds}^g traded.[8] Regarding the elasticity of substitution σ_{ds}^g across varieties of a good, the substitutability of good g imported from source country s for good g imported from source country s' is given by:

$$\sigma_{ds}^g\left(q_{ds}^g, q_{ds'}^g\right) = \frac{d \ln\left(\frac{q_{ds}^g}{q_{ds'}^g}\right)}{d \ln\left(\frac{dU_d^g}{dq_{ds'}^g} \middle/ \frac{dU_d^g}{dq_{ds}^g}\right)} = \frac{1}{\alpha^g q_{ds}^g}$$

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[8] This result is consistent with studies such as by Yilmazkuday (2015b) who empirically show that the elasticity of demand systematically changes from one importer country to another.

As is evident, again due to our assumption of individual source countries having negligible impact on the destination price aggregates, the expressions for the elasticity of substitution and the price elasticity of demand are exactly the same; therefore, the case of CARA implies variable elasticities of substitution (i.e., non-CES).

Considering Equation 17, source country s maximizes its profits given (again) by Equation 7. This time, the first order condition implies that:

$$\alpha^g q_{ds}^g = \frac{p_{ds}^g - c_{ds}^g}{p_{ds}^g} \tag{20}$$

which can be substituted into Equation 19 to obtain an alternative expression for the price elasticity of demand:

$$\varepsilon_{ds}^g = \frac{p_{ds}^g}{p_{ds}^g - c_{ds}^g} = \frac{1}{\alpha^g q_{ds}^g} \tag{21}$$

where the first equality is exactly the same as the first equality in Equation 11. The gross markup again denoted by μ_{ds}^g can be written as:

$$\mu_{ds}^g = \frac{\varepsilon_{ds}^g}{\varepsilon_{ds}^g - 1} = \frac{1}{1 - \alpha^g q_{ds}^g} \tag{22}$$

where the first equality is exactly the same as the first equality in Equation 12. Using the approximation of $\ln(1+x) \approx x$ for small values of x, one can also write the following approximation for log gross markups:

$$\ln \mu_{ds}^g = -\ln\left(1 - \alpha^g q_{ds}^g\right) = -\ln\left(1 - \alpha^g q_{ds}^g\right) \approx \alpha^g q_{ds}^g \tag{23}$$

when $\alpha^g q_{ds}^g$ corresponds to a small value, which is in fact supported by studies such as by Yilmazkuday (2015a).

Therefore, both CRRA and CARA imply the very same price elasticity of demand when the elasticity is expressed in terms of source prices and marginal costs, and they imply the very same gross markup when the markup is expressed in terms of the price elasticity of demand. Nevertheless,

the pricing strategy (i.e., markups) of the source country determined through different demand structures is the key factor determining the price elasticity of demand and the gross markups for the cases of CRRA versus CARA. Although the price elasticity of demand and the gross markup expressions are good specific (i.e., they are common across source and destination countries) in the case of CRRA (according to Equations 10 and 12), they change with respect to goods, together with source and destination countries, in the case of CARA (according to Equations 20 and 22). Therefore, for each good, we have constant elasticities and markups in the case of CRRA, while we have variable elasticities and markups in the case of CARA.

Finally, using Equations 8, 9, 20, and 22, the destination price in country d is given (again) by Equation 15, where the only difference is the definition of markups.

3   Estimation Methodology and Data

This section depicts the details of estimating the equations of quantity traded and price implied by the cases of constant and variable markups. The main objective is to estimate markups and trade costs to further use them in decomposing the price data into marginal costs, markups, and trade costs. Since the estimation methodology depends on the data employed, we start with depicting the details of the data set first.

3.1   Data

Trade data are from NBER-UN world trade data set as documented by Feenstra et al. (2005) which we refer for further/technical details. The data set includes value (price times quantity) of bilateral trade between 171 countries for 749 good categories classified according to 4-digit Standard International Trade Classification Revision 2 (SITC4-R2) between 1962-2000. The data also include

quantity of trade, which allows to calculate the unit prices for each good category. However, since there may be possible problems in terms of comparing unit prices at different points in time, as in Jaimovich and Merella (2012), we focus on the data (with both value and quantity observations) only for the year of 2000 (which is the latest year in the data featuring the most-recent data collection techniques) for which the number of source countries is 171 and the number of destination countries is 169. Since we need both unit prices and quantities in our analysis, we restricted ourselves to the part of the data that have both measures; accordingly, we ended up with having 527,371 bilateral trade observations (corresponding to 62% of the original data set) at the good level for the year of 2000.

We accept that the selection of the NBER-UN world trade data set categorized according to SITC4-R2, especially because it is at the 4-digit level, may be restrictive. Nevertheless, this data set has been used widely in the literature; hence, it leads to easier comparison with earlier studies. Moreover, the main objective of this paper is to focus on an easy-to-implement empirical innovation to distinguish between constant versus variable markups; therefore, the widely-used SITC4-R2 data for the year of 2000 are good enough to make a point, especially through a static trade model like ours.

The data set gives primacy to trade flows reported by the importing country, whenever they are available, assuming that these are more accurate than reports by the exporters. If the importer report is not available for a country-pair, however, then the corresponding exporter report is used instead. The value of bilateral trade reported by the importer is CIF (cost, insurance, freight), whereas the data reported by the exporter is FOB (free on board). Therefore, in order to employ as many observations as possible, we need to distinguish between CIF and FOB based unit prices in our estimation; the corresponding details will be provided below.

The other data we use in the estimation are for great circle distances between countries (where

latitudes and longitudes have been obtained from The Google Geocoding API).

3.2 Estimation of Trade Equations

We start with the implications for trade patterns in the case of constant markups given by Equation 13, which can rewritten in a log-linear format as follows after controlling for the difference between CIF and FOB based unit prices by an indicator function:

$$
\ln\left(q_{ds}^g\right) = \underbrace{\ln\left(E_d^g\left(\sum_{s'}\frac{(\chi_{ds'}^g)^{\frac{1}{1-\theta^g}}}{(p_{ds'}^g)^{\frac{\theta^g}{1-\theta^g}}}\right)^{-1}\right) + \frac{\ln\left(\kappa_d^g\right)}{1-\theta^g}}_{\text{Destination-and-Good Fixed Effects}} + \underbrace{\frac{\ln\left(\kappa_s^g\right)}{1-\theta^g}}_{\text{Source-and-Good Fixed Effects}} \tag{24}
$$

$$
- \underbrace{\frac{\ln\left(p_{ds}^{g*}\right)}{1-\theta^g}}_{\text{Source-Price Effects}} - \underbrace{I_{ds}^g}_{\text{Indicator Function}}\times\underbrace{\frac{\delta^g\ln\left(D_{ds}\right)}{1-\theta^g}}_{\text{Distance Effects}} - \underbrace{\frac{\ln\left(b_{ds}^g\right)}{1-\theta^g}}_{\text{Residuals}}
$$

where the indicator function I_{ds}^g, which is also available in our data set under the title of "Direction of Trade", takes a value of 1 (or 0) when prices p_{ds}^{g*} are calculated according to the data reported by the exporter (or importer). The trade patterns in the case of variable markups given by Equation 18 is already given in lin-log format as follows:

$$
q_{ds}^g = \underbrace{\left(\frac{E_d^g - \frac{1}{\alpha^g}\sum_{s'}\ln\left(\frac{\chi_{ds'}^g}{p_{ds'}^g}\right)p_{ds'}^g}{\sum_{s'}p_{ds'}^g}\right) + \frac{\ln\left(\kappa_d^g\right)}{\alpha^g}}_{\text{Destination-and-Good Fixed Effects}} + \underbrace{\frac{\ln\left(\kappa_s^g\right)}{\alpha^g}}_{\text{Source-and-Good Fixed Effects}} \tag{25}
$$

$$
- \underbrace{\frac{\ln\left(p_{ds}^{g*}\right)}{\alpha^g}}_{\text{Source-Price Effects}} - \underbrace{I_{ds}^g}_{\text{Indicator Function}}\times\underbrace{\frac{\delta^g\ln\left(D_{ds}\right)}{\alpha^g}}_{\text{Distance Effects}} - \underbrace{\frac{\ln\left(b_{ds}^g\right)}{\alpha^g}}_{\text{Residuals}}
$$

As is evident, both expressions can be estimated using trade data in quantities, destination-and-good-fixed effects, source-and-good-fixed effects, price data, and distance data (to measure the combination of freight costs and time-to-trade) if the unobserved border costs are assigned the role of residuals (of which details/restrictions we discuss, below). Therefore, they turn out to be very

similar to each other in terms of their estimated expressions; the only difference is to have quantities in logs for the former and quantities in levels for the latter on the left hand side of the expressions. Accordingly, Equation 24 is attempting to explain the quantities in logs, while Equation 25 is attempting to explain the quantities in levels. Since we employ residuals as border costs, when we take the implications literally, both models have explanatory power of 100% regardless.[9]

Since we have data for both quantities and prices, in order to avoid any simultaneity bias, we estimate Equations 24 and 25 at the good level using two-stage least squares (TSLS), for which we estimate the implications of the model regarding prices in the first stage and use their fitted values in the second stage; the details are given in the next subsection.

3.3   Estimation of the Price Equation

Since the unit-price data we have are either CIF or FOB, they do not include any border costs b_{ds}^g's. Hence, in order match the data with the model, using the same indicator function I_{ds}^g, we can write the log version of Equation 15 after dropping b_{ds}^g's as follows:

$$\ln p_{ds}^{g*} = \ln w_s^g + \beta_s^g \ln \kappa_s^g + \beta_d^g \ln \kappa_d^g + \delta_\tau^g \left(1 - I_{ds}^g\right) \ln D_{ds} + \ln \mu_{ds}^g + v_{ds}^g \tag{26}$$

where we have included the stochastic term of v_{ds}^g to capture any measurement errors due to using unit values as the measure of prices. In Equation 26, the only difference between the cases of constant versus variable markups is due to the definition of $\ln \mu_{ds}^g$. In particular, for the case of constant markups, Equation 26 can be rewritten (using Equation 12) and estimated as the first

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[9]We consider border-related costs as residuals that are not shocks but rather part of the trade model; within this context, one cannot select one of the two models just because it implies lower border-related costs.

stage of TSLS as follows:

$$\ln p_{ds}^{g*} = \underbrace{\ln w_s^g + \beta_s^g \ln \kappa_s^g}_{\text{Source-and-Good Fixed Effects}} + \underbrace{\delta_\tau^g \left(1 - I_{ds}^g\right) \ln D_{ds}}_{\text{Distance-Related Effects}}$$

$$+ \underbrace{\beta_d^g \ln \kappa_d^g}_{\text{Destination-and-Good Fixed Effects}} - \underbrace{\ln \theta^g}_{\text{Constant}} + \underbrace{v_{ds}^g}_{\text{Residuals}} \tag{27}$$

while, for the case of variable markups, it can be approximated by using Equations 23 and 25 to be estimated as the first stage of TSLS as follows:

$$\underbrace{2 \ln p_{ds}^{g*}}_{\text{Two Times Source Price Data}} \approx \underbrace{\ln w_s^g + \left(1 + \beta_s^g\right) \ln \kappa_s^g}_{\text{Source-and-Good Fixed Effects}} + \underbrace{\delta_\tau^g \left(1 - I_{ds}^g\right) \ln D_{ds} - \delta^g I_{ds}^g \ln D_{ds}}_{\text{Distance-Related Effects}}$$

$$+ \underbrace{\left(\frac{\alpha^g E_d^g - \sum_{s'} \ln \left(\frac{\chi_{ds'}^g}{p_{ds'}^g}\right) p_{ds'}^g}{\sum_{s'} p_{ds'}^g} \right)}_{\text{Destination-and-Good Fixed Effects}} + \left(1 + \beta_d^g\right) \ln \kappa_d^g + \underbrace{v_{ds}^g - \ln b_{ds}^g}_{\text{Residuals}} \tag{28}$$

where the difference between measurement errors and log border costs (indirectly coming from the demand function due to variable markups) is assigned the role of residuals.[10]

Once the price expressions are estimated, the fitted values for log prices $\widehat{\ln p_{ds}^{g*}}$ are used in the estimation of Equations 24 and 25 at the good level as the second stage of TSLS. Regarding the identification of δ^g in the case of variable markups, since it shows up in both price and quantity regressions, we take the estimates of it coming from the first-stage of TSLS (i.e., the price regression of Equation 28) as given and estimate the second-stage of TSLS (i.e., the quantity regression of 25)

---

[10]It is important to emphasize that, since the unit-price data we have are either CIF or FOB, the estimated residuals may also be capturing export-related costs that exporters pass on importers at the port.

as follows:

$$
q_{ds}^g = \underbrace{\left(\frac{E_d^g - \frac{1}{\alpha^g} \sum_{s'} \ln\left(\frac{\chi_{ds'}^g}{p_{ds'}^g}\right) p_{ds'}^g}{\sum_{s'} p_{ds'}^g} \right) + \frac{\ln\left(\kappa_d^g\right)}{\alpha^g}}_{\text{Destination-and-Good Fixed Effects}} + \underbrace{\frac{\ln\left(\kappa_s^g\right)}{\alpha^g}}_{\text{Source-and-Good Fixed Effects}}
$$

$$
\underbrace{- \left(\frac{\widehat{\ln p_{ds}^{g*}} + I_{ds}^g \delta^g \widehat{\ln\left(D_{ds}\right)}}{\alpha^g} \right)}_{\text{Price Effects}} - \underbrace{\frac{\ln\left(b_{ds}^g\right)}{\alpha^g}}_{\text{Residuals}}
$$

(29)

where the fitted values of $\widehat{\ln p_{ds}^{g*}}$ and $I_{ds}^g \delta^g \widehat{\ln\left(D_{ds}\right)}$ obtained in the first stage of TSLS are used.

3.4   Identification of Estimated Parameters and Variables

Using trade data in quantities q_{ds}^g's, $(1 - \theta^g)$'s and α^g's can be obtained as the coefficients in front of price expressions in Equations 24 and 29. Using estimated $(1 - \theta^g)$'s, δ^g's are identified for the case of constant markups by using the coefficients in front of $\ln\left(D_{ds}\right)$'s in Equation 24, while δ^g's are identified in the estimation of Equation 28 for the case of variable markups. Similarly, δ_τ^g's are identified as the coefficients in front of $(1 - I_{ds}^g) \ln\left(D_{ds}\right)$'s in Equations 27 and 28, which can further be used to identify δ_u^g's according to Equation 14, since δ^g's are already identified.

Estimated $(1 - \theta^g)$'s and α^g's can be used to identify markups (μ_{ds}^g's) where data on quantities are also used in the case of variable markups (according to Equation 22). Estimated $(1 - \theta^g)$'s and α^g's can be used to identify source-specific quality measures κ_s^g's in Equations 24 and 29 by using the source-and-good fixed effects. By regressing the fitted source-and-good fixed effects in Equations 27 and 28 on the identified κ_s^g's, one can also identify source wages w_s^g's and β_s^g's; hence, the component of marginal costs of production capturing source-specific quality $(\kappa_s^g)^{\beta_s^g}$ is identified. While the component of marginal costs of production capturing destination-specific quality $(\kappa_d^g)^{\beta_d^g}$ is identified as the fitted values of destination-and-good fixed effects in Equation 27 for the case of constant

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markups, they are identified by taking the difference between the fitted values of destination-and-good fixed effects in Equations 28 and 29 for the case of variable markups, where estimated α^g's are also used.

Border costs (b_{ds}^g's) are identified by combining fitted residuals in Equations 24 and 29 with the estimated $(1 - \theta^g)$'s and α^g's. Such a strategy brings two restrictions (both of which are consistent, at least, do not contradict) with the model: (i) the sum of residuals is zero; (ii) residuals are orthogonal to destination-and-good-fixed effects, source-and-good-fixed effects, price data, and distance data (i.e., the border costs will capture the pattern of trade that cannot be explained by any of these variables).[11] This completes the identification of the price components in Equation 15. It is important to emphasize that, due to using fitted fixed effects, the identification of w_s^g, $(\kappa_s^g)^{\beta_s^g}$, $(\kappa_d^g)^{\beta_d^g}$ and b_{ds}^g are all achieved in relative terms rather than in levels; however, such identifications are good enough for the main objective of this paper, which is to investigate the deviations from LOP where log relative prices (and thus log relative values of price components) are considered.

4   Estimation Results for Trade Patterns

This section depicts the estimation results and connects them to the existing literature.

4.1   Estimation Results

The identification of $\theta^g > 0$ and $\alpha^g > 0$ estimates are the key for the determination of markups, which is the main focus in this paper. The summary statistics of the good-level estimates are given in Table 1, where we have taken a conservative approach (for comparison purposes) by ignoring the

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[11]Yilmazkuday (2012) has estimated taste parameters as model residuals in a closed-economy framework. Since we already estimate taste parameters through source-and-good-fixed effects, and since we have an open-economy framework, employing the border costs as residuals is new to this paper.

goods that have negative estimates for either θ^g's or α^g's; this has resulted in having the summary statistics for 681 (out of 749) good categories. These 681 good categories are also going to be the ones that we will use while investigating the deviations from LOP, below.

As is evident in Table 1, according to the estimation of Equation 24 for the case of constant markups, the distribution of θ^g's has an average (across goods) of about 0.78, which corresponds to an average gross markup of about 1.32 (according to Equation 10). Interestingly, according to the estimation of Equation 29 for the case of variable markups, the average (across goods and countries) gross markup is also about 1.32. Nevertheless, there are significant differences across goods; when the top and bottom one percentiles are ignored, constant markups range between 1.03 and 2.10, while variable markups range between 1.00 and 3.83. Compared to the existing literature, the average (across goods) markups (of about 1.32) are in line with firm-level studies also featuring variable markups, such as De Loecker et al. (2015) that suggest a median markup of about 1.10 for Indian firms or De Loecker and Warzynski (2012) who provide estimates of markups for Slovenian manufacturing plants ranging between 1.03 and 1.28 (obtained by different estimation methodologies).

When distance elasticity of trade costs δ_τ^g's are considered, the average is about 0.25 and 0.52 for the cases of constant versus variable markups, which are relatively close to the distance elasticity estimates in the international trade literature that are about 0.3 (see Hummels, 2001; Limao and Venables, 2001; Anderson and van Wincoop, 2004). The elasticity of utility with respect to time-to-trade δ_u^g has a median value of -0.03 for the case of constant markups and a median value of -0.74 for the case of variable markups; therefore, more than half of the goods in our sample are traded due to their *exotic* nature rather than concerns due to time-to-trade. This difference between estimated δ_τ^g's and δ_u^g's clearly shows the contribution of including distance in the utility function that helps distinguishing between the effect of distance on prices (e.g., freight-related costs) versus

on quantities (e.g., preferences).

Since the residuals in Equations 24 and 29 are assigned the role of border costs, both models have 100% of an explanatory power by construction. Nevertheless, if we would take an econometric approach and accept them as residuals, the explanatory power of the regressions are given in Table 1. It is important to emphasize that the R-squared measures coming from Equations 24 and 29 cannot be directly compared, since the former has log quantities and the latter has level of quantities as left hand side variables. Accordingly, in order to make the R-squared values comparable to each other, in Table 1, we take a textbook approach by depicting the R-squared values calculated as the correlation between the *level* of quantities and the corresponding fitted values on the right hand side. This corresponds to the regular R-squared value for the case of variable markups, while it corresponds to the correlation between the exponential value of the left hand side and the exponential value of the fitted values for the case of constant markups. Therefore, the R-squared values in Table 1 correspond to comparable R-squared values in terms of the explanatory power of regressions based on the level of quantities. As is evident, both constant and variable markups have high explanatory powers with average values (across goods) of about 0.60 and 0.54, respectively.

5 Implications for the Deviations from the Law of One Price

We would like to compare the contribution of each price component to destination prices across the cases of constant and variable markups by considering the deviations from LOP.

5.1 Methodology

In our data set, since prices reported by importers are CIF and by exporters are FOB, the first step is to convert all prices into destination prices (i.e., to construct destination prices) using the following deviations-from-LOP expression (for both cases of constant and variable markups) at the good level:

$$
\underbrace{\ln\left(\frac{p_{ds}^g}{p_{d's'}^g}\right)}_{\text{Relative Destination Prices}} = \underbrace{\ln\left(\frac{w_s^g}{w_{s'}^g}\right)}_{\text{Relative Source Input Costs}} + \underbrace{\ln\left(\frac{(\kappa_s^g)^{\beta_s^g}}{(\kappa_{s'}^g)^{\beta_{s'}^g}}\right)}_{\text{Relative Source-Specific Quality}} + \underbrace{\ln\left(\frac{(\kappa_d^g)^{\beta_d^g}}{(\kappa_{d'}^g)^{\beta_{d'}^g}}\right)}_{\text{Relative Destination-Specific Quality}} \quad (30)
$$

$$
+ \underbrace{\ln\left(\frac{\mu_{ds}^g}{\mu_{d's'}^g}\right)}_{\text{Relative Markups}} + \underbrace{\delta_\tau^g \ln\left(\frac{D_{ds}}{D_{d's'}}\right)}_{\text{Relative Freight Costs}} + \underbrace{\ln\left(\frac{b_{ds}^g}{b_{d's'}^g}\right)}_{\text{Relative Border Costs}}
$$

where all variables were estimated/identified, above. We will consider both the mean and the variance of the deviations from LOP (as in Crucini et al., 2005); while the mean is important to understand the magnitude of the deviations, the variance is the common measure of price dispersion in the literature. One difference is that we will consider the absolute value of relative-price expressions by multiplying all negative relative-price values (and the corresponding right-hand-side variables) with -1; such a strategy is important in measuring the actual (absolute value of) deviations from LOP.

Since LOP is a concept at the good level, we will consider the mean and the variance of the variables in Equation 30 across destination countries at the good level. Therefore, when the mean deviations from LOP will be considered, we will investigate the portions explained by mean (log) relative source-specific input costs, source-specific quality measures, destination-specific quality measures, markups, freight costs, and border costs. When the variance of deviations from LOP will be considered, we will consider the following variance decomposition analysis to compare the contributions

of marginal costs, markups, freight costs, and border costs:

$$
\underbrace{var\left(\ln\left(\frac{p_{ds}^g}{p_{d's'}^g}\right)\right)}_{\text{Relative Destination Prices}} = \underbrace{cov\left(\ln\left(\frac{w_s^g}{w_{s'}^g}\right),\ln\left(\frac{p_{ds}^g}{p_{d's'}^g}\right)\right)}_{\text{Relative Source Input Costs}} + \underbrace{cov\left(\ln\left(\frac{(\kappa_s^g)^{\beta_s^g}}{(\kappa_{s'}^g)^{\beta_{s'}^g}}\right),\ln\left(\frac{p_{ds}^g}{p_{d's'}^g}\right)\right)}_{\text{Relative Source-Specific Quality}}
$$

$$
+\underbrace{cov\left(\ln\left(\frac{(\kappa_d^g)^{\beta_d^g}}{(\kappa_{d'}^g)^{\beta_{d'}^g}}\right),\ln\left(\frac{p_{ds}^g}{p_{d's'}^g}\right)\right)}_{\text{Relative Destination-Specific Quality}} + \underbrace{cov\left(\ln\left(\frac{\mu_{ds}^g}{\mu_{d's'}^g}\right),\ln\left(\frac{p_{ds}^g}{p_{d's'}^g}\right)\right)}_{\text{Relative Markups}}
$$

$$
+\underbrace{cov\left(\delta_\tau^g\ln\left(\frac{D_{ds}}{D_{d's'}}\right),\ln\left(\frac{p_{ds}^g}{p_{d's'}^g}\right)\right)}_{\text{Relative Freight Costs}} + \underbrace{cov\left(\ln\left(\frac{b_{ds}^g}{b_{d's'}^g}\right),\ln\left(\frac{p_{ds}^g}{p_{d's'}^g}\right)\right)}_{\text{Relative Border Costs}}
$$

which holds with exact equality, where var is the variance operator, and cov is the covariance operator.

5.2 Results

The results are given in Table 2, where the mean deviations from LOP are about 1.46 and 3.25 for the cases of constant and variable markups, respectively. As is evident, the differences in marginal costs of production explain pretty much the whole deviations from LOP in both cases of constant and variable markups. Although the contribution of markups in the case of variable markups can go up to 10% for certain goods, on average across goods, their effect is none. Similarly, although freight (border) costs contribute up to 21% (23%), their average effect across goods is very small, about 3% (5%) for the case of constant markups and about 3% (−1%) for the case of variable markups. The results are very similar in Table 3 where the variance of deviations from LOP are considered. Compared to the existing literature, the high contribution of marginal costs and low contribution of trade costs are consistent with studies such as by Yilmazkuday (2014) who investigates the deviations from LOP using actual data on trade costs.

In order to support the summary statistics given in Table 2 and Table 3, we also consider a

visual representation of results in Figure 1 and Figure 2, where good-level results are provided. In these figures, goods have been ranked in the horizontal axis with respect to their variance of log relative prices obtained in the case of variable markups; we depict the average across 80 goods for presentational purposes. As is evident, the results are very similar across individual good groups in terms of the percentage contribution of price components to the deviations from LOP.

Since marginal costs contribute the most to the deviations from LOP, their decomposition is of further interest. As is evident for both cases of constant and variable markups in Table 2, destination-specific quality measures contribute most to the deviations from LOP, followed by source-specific quality measures and source-specific input costs. Since we calculate the deviations from LOP across destination countries after pooling across source countries, this result literally means that destination-specific quality measures explain most of the price dispersion across destination countries on average across source countries. In other words, for a typical source country, export quality measures differ across destination countries in a significant way. This result is also supported across goods in Figure 1; the results are very similar in Table 3 and Figure 2 as well, where the variance of deviations from LOP are considered. Overall, the results based on the decomposition of marginal costs of production support the evidence in the literature regarding destination-specific quality measures as shown in studies such as by Verhoogen (2008), Bastos and Silva (2010), Manova and Zhang (2012), Martin (2012), Sheu (2014), and Harrigan et al. (2015).

The results have important implications for our understanding of international price differences. Although the existing literature mostly advocates for the role trade costs in explaining the deviations from LOP, the results in this paper suggest that the role of trade costs are relatively minor. Accordingly, if the deviations from LOP are considered as the degree of global integration, the main role is played by the quality of exports across destination countries, leaving a small room for welfare improvement through the reduction of trade costs. Apparently, in explaining the low degrees of

global integration, the preferences of destination countries revealed through their demand for higher quality products are even more important than source-country specific factors such as their comparative advantage through input costs or source-specific quality measures. Therefore, the future of global integration might be achieved mostly through changes in preferences of consumers toward similar quality products, rather than reduction in other barriers to trade.

6   Conclusion

This paper has introduced an easy-to-implement empirical strategy that can distinguish between constant and variable markups. In particular, by considering the utility maximization of destination countries and the profit maximization of source countries by a pricing-to-market strategy, we have shown that the case of constant markups (obtained by CRRA utility function) corresponds to log-linear regressions estimating trade patterns (as in CES-based gravity studies), while a special case of variable markups (obtained by CARA utility function) corresponds to lin-log regressions. Combining the information coming from the estimation of trade patterns and implied prices, markups and trade costs are identified, which are further used to decompose destination prices into marginal costs, markups, and trade costs. The decomposition of destination prices is used to investigate the source of deviations from the Law of One Price (LOP). The results show that marginal costs of production contribute most in both cases of constant and variable markups. The decomposition of marginal costs of production further suggests that destination-specific quality measures contribute most to the deviations from LOP, followed by source-specific quality measures and source-specific input costs. Hence, preferences of destination countries toward alternative quality of products show up as additional barriers to global integration.

We are well aware of a caveat that explaining everything due to the specification of the utility

function is a restrictive approach; however, many existing trade studies employing utilities in a functional form are subject to the very same criticism. Nevertheless, such a modeling strategy in this paper makes the overall analysis very simple and tractable compared to much more complicated models in the literature which practically have very similar implications for international trade and finance. Another caveat is that we do not have any relevant data on either marginal costs or markups to compare the performance of the cases of constant versus variable markups; again, the existing literature is subject to the very same criticism, since any estimated variable (of markups or marginal costs) depends on the modeling strategy employed.

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Table 1 - Summary of Good-Level Estimation Results

	Constant Markups (CRRA)						Variable Markups (CARA)					
	θ^g	μ^g	δ^g	δ_τ^g	δ_u^g	R-Squared.	$\alpha^g \times 10^3$	μ^g	δ^g	δ_τ^g	δ_u^g	R- Squared.
Average	0.78	1.32	0.10	0.25	-0.15	0.60	0.97	1.32	-0.16	0.52	-0.68	0.54
1st Percentile	0.38	1.03	-1.97	0.00	-2.16	0.03	0.00	1.00	-7.04	0.00	-7.50	0.24
10th Percentile	0.59	1.11	-0.11	0.06	-0.49	0.27	0.00	1.00	-1.35	0.13	-2.13	0.31
25th Percentile	0.68	1.17	0.07	0.13	-0.11	0.46	0.01	1.00	-0.73	0.27	-1.36	0.41
Median	0.78	1.26	0.16	0.22	-0.03	0.62	0.03	1.01	-0.29	0.46	-0.74	0.52
75th Percentile	0.85	1.40	0.28	0.33	0.02	0.77	0.15	1.04	0.02	0.67	-0.26	0.64
90th Percentile	0.91	1.58	0.43	0.45	0.12	0.91	0.68	1.18	1.14	0.90	0.61	0.80
99th Percentile	1.29	2.10	1.41	0.87	0.96	1.00	6.98	3.83	7.48	1.82	6.85	1.00

Notes: These are the summary statistics for the distribution of estimated parameters and the explanatory power of regressions that have been run at the good level. α^g 's in the table have been multiplied by 1,000 for presentational purposes. For the case of CARA, the summary statistics of μ^g have been obtained as the median across source and destination countries.

Table 2 - Summary of Mean of Deviations from LOP

Constant Markups

	Deviations	Marginal Costs			Markups	Trade Costs	
			% Contribution of				
	Average across Country Pairs	Source Input Costs	Source Quality	Destination Quality	Constant Markups	Freight Costs	Border Costs
Average	1.46	11%	26%	55%	0%	3%	5%
1st Percentile	0.41	-2%	5%	17%	0%	-7%	0%
10th Percentile	0.71	2%	12%	33%	0%	-2%	1%
25th Percentile	0.95	5%	17%	44%	0%	0%	2%
Median	1.28	9%	25%	57%	0%	2%	4%
75th Percentile	1.75	15%	33%	67%	0%	6%	7%
90th Percentile	2.49	24%	40%	75%	0%	9%	10%
99th Percentile	4.04	38%	60%	92%	0%	18%	17%

Variable Markups

	Deviations	Marginal Costs			Markups	Trade Costs	
			% Contribution of				
	Average across Country Pairs	Source Input Costs	Source Quality	Destination Quality	Variable Markups	Freight Costs	Border Costs
Average	3.25	18%	23%	56%	0%	3%	-1%
1st Percentile	0.48	-4%	6%	13%	-4%	-7%	-10%
10th Percentile	1.09	4%	12%	30%	-2%	-2%	-5%
25th Percentile	1.54	9%	16%	43%	-1%	0%	-3%
Median	2.28	16%	21%	59%	-1%	3%	-1%
75th Percentile	3.31	25%	29%	70%	0%	6%	0%
90th Percentile	4.47	35%	37%	80%	2%	10%	4%
99th Percentile	15.02	53%	50%	92%	10%	21%	23%

Notes: We consider the mean of the deviations from LOP across destination countries at the good level by pooling observations across country pairs.

Table 3 - Summary of Variance of Deviations from LOP

Constant Markups

| | Deviations | % Contribution of | | | | | |
| | Variance across Country Pairs | Marginal Costs | | | Markups | Trade Costs | |
		Source Input Costs	Source Quality	Destination Quality	Constant Markups	Freight Costs	Border Costs
Average	2.17	9%	24%	63%	0%	2%	3%
1st Percentile	0.17	-4%	-1%	0%	0%	-4%	-3%
10th Percentile	0.39	1%	5%	32%	0%	-2%	0%
25th Percentile	0.66	3%	12%	49%	0%	0%	0%
Median	1.13	7%	21%	64%	0%	2%	2%
75th Percentile	2.27	13%	30%	78%	0%	4%	4%
90th Percentile	5.20	21%	42%	92%	0%	7%	6%
99th Percentile	14.11	35%	99%	104%	0%	11%	13%

Variable Markups

| | Deviations | % Contribution of | | | | | |
| | Variance across Country Pairs | Marginal Costs | | | Markups | Trade Costs | |
		Source Input Costs	Source Quality	Destination Quality	Variable Markups	Freight Costs	Border Costs
Average	78.07	14%	20%	64%	0%	2%	0%
1st Percentile	0.27	-11%	-1%	7%	-4%	-6%	-18%
10th Percentile	0.92	-1%	6%	31%	-2%	-2%	-5%
25th Percentile	1.84	4%	10%	47%	-1%	0%	-2%
Median	3.81	11%	18%	66%	-1%	2%	-1%
75th Percentile	8.29	21%	29%	82%	0%	4%	0%
90th Percentile	17.64	33%	41%	94%	2%	6%	5%
99th Percentile	481.88	51%	54%	111%	13%	11%	37%

Notes: We consider the variance of the deviations from LOP across destination countries at the good level by pooling observations across country pairs.

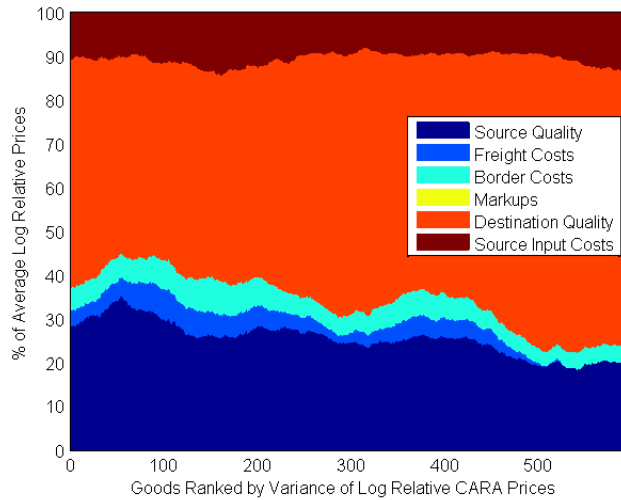# Figure 1 - Mean of Deviations from LOP – Constant versus Variable Markups

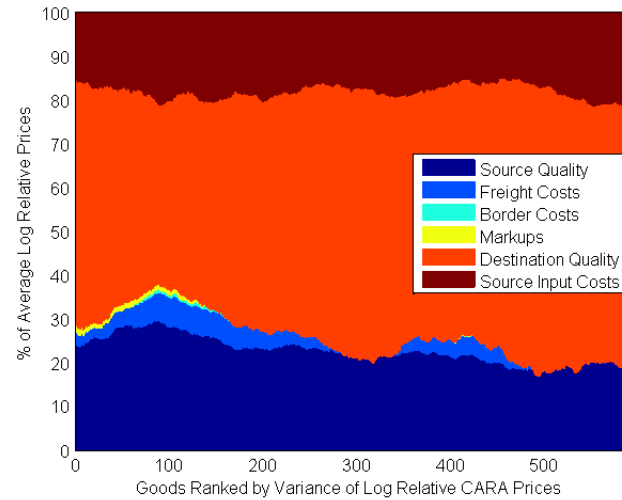**(a) Level of Price Dispersion - Constant Markups**
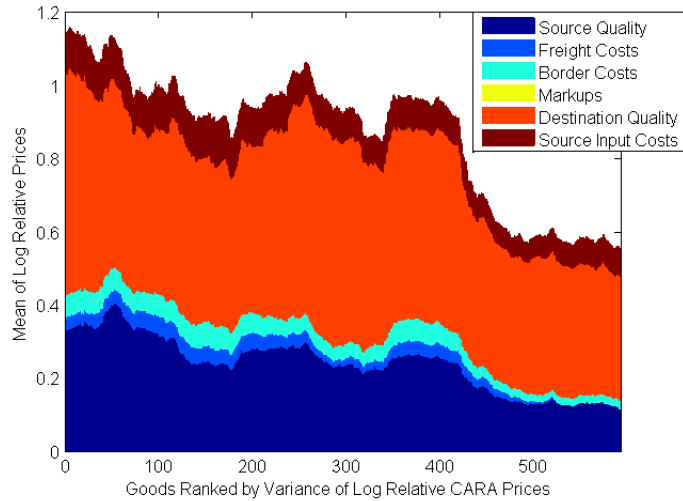
(b) Level of Price Dispersion - Variable Markups
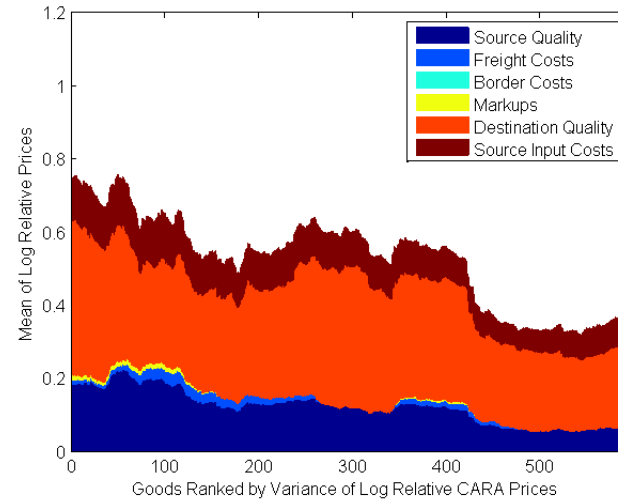
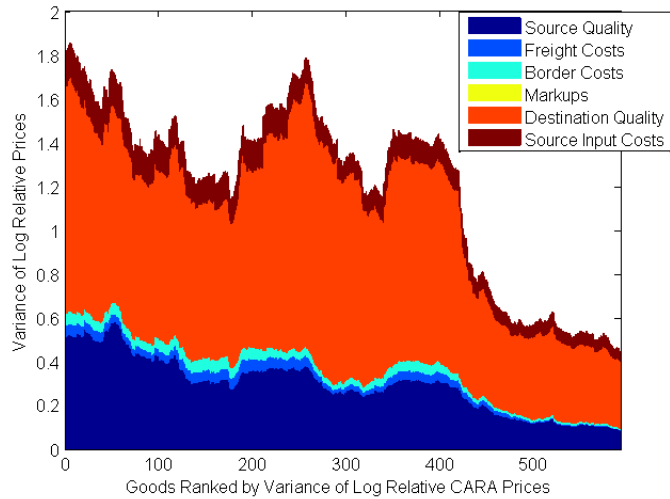**(c) % of Price Dispersion - Constant Markups**

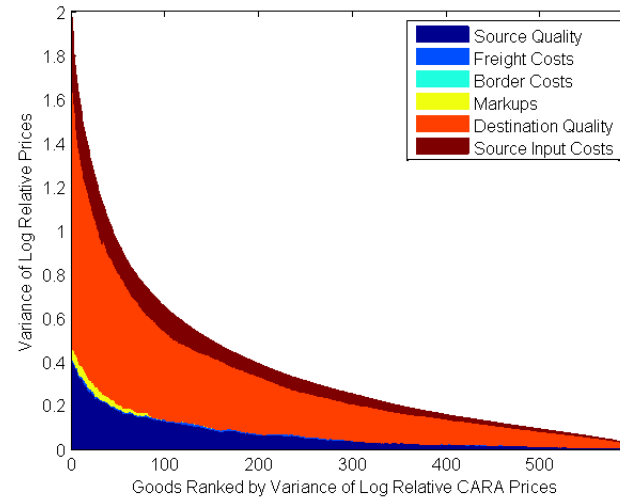**(d) % of Price Dispersion - Variable Markups**

Notes: The goods have been ranked according to variance of log relative prices based on CARA preferences. The average across 80 goods is shown.

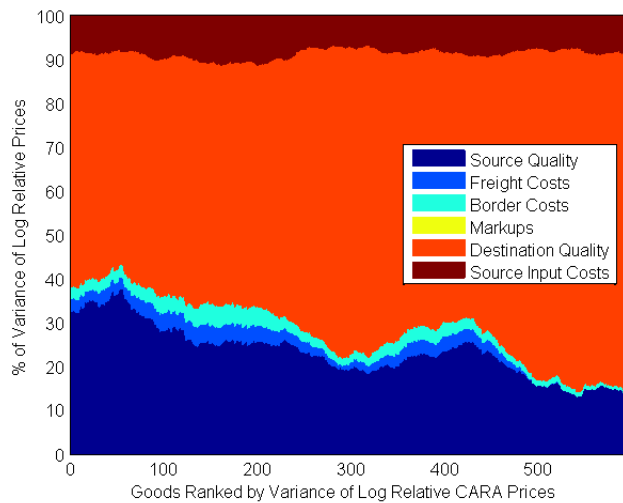# Figure 2 - Variance of Deviations from LOP – Constant versus Variable Markups

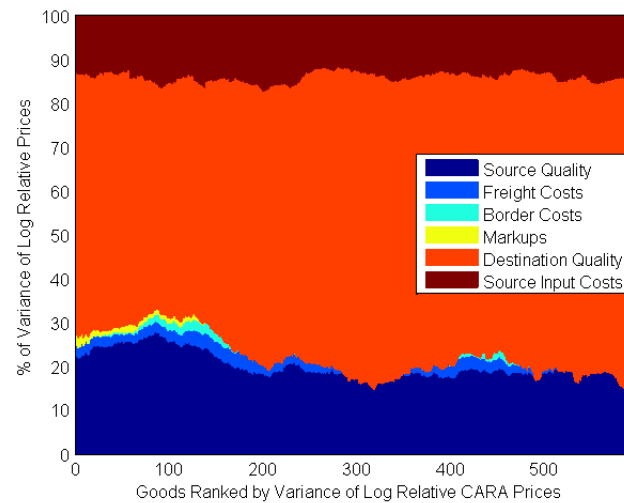**(a) Level of Price Dispersion - Constant Markups**

(b) Level of Price Dispersion - Variable Markups

(c) % of Price Dispersion - Constant Markups

(d) % of Price Dispersion - Variable Markups

Notes: The goods have been ranked according to variance of log relative prices based on CARA preferences. The average across 80 goods is shown.