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A Look Under the Hood

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Abstract

This paper examines the structure of international relative price levels using purchasing power parities (PPP) at the product-level from the 2005 World Bank's International Comparison Program (ICP). Our examination is motivated by questions arising from two applications using economy-wide PPPs: the measurement of real effective exchange rates (REERs) and the correlation between prices and development. Specifically, how would our view on competitiveness be affected if one were to use PPP measures that exclude non-tradable categories? Is it the case that an increase in per-capita income raises the prices of non-tradable categories? These questions are not new. What is new here is the use of relative price *levels* (as opposed to indexes) at the product level for 144 countries that differ greatly in their level of development.

Key Words: International Comparison Program, Purchasing Power Parity, Competitiveness, Penn Effect, Real Effective Exchange Rates, Tradability.

JEL Codes: F41, F43.

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1 Introduction

This paper examines the structure of international relative price levels using purchasing power parities (PPP) at the product-level from the 2005 World Bank's International Comparison Program (ICP). Our examination is motivated by questions arising from two applications using the familiar economy-wide PPPs: the measurement of real effective exchange rates (REERs) and the correlation between prices and development.[2]

Economy-wide PPPs provide information on international relative price levels and hence capture a dimension of competitiveness not incorporated in indexes that measure price changes alone.[3] But a relevant question, so far neglected, is how would our view on competitiveness be affected if one were to use PPP measures that exclude non-tradable categories? In addition, since it is acknowledged that prices for some categories are particularly difficult to compare across countries, to what extent are PPP-based GDP price comparisons being influenced by the readings on these "comparison-resistant" categories? Our calculations indicate that excluding comparsion-resistant categories halves the measured difference between U.S. prices and the prices of its major trading partners; excluding non-tradable categories eliminates the difference entirely. The obvious question raised by this finding is which measure is better for making inferences about international competitiveness: the measure including all the expenditure categories or the narrower measures including only tradable or comparable products? Though we do not have a definitive

[2] For reviews on the measurement of real effective exchange rates, see Froot and Rogoff (1995), Taylor (2003), Chinn (2005), Klau and Fung (2006); other relevant papers include Lipsey, Molinari, and Kravis (1990), Hooper and Richardson (1991), and Turner and Van't dac (1993). For the relation between prices and development, see Kravis, Heston, and Summers (1978); Summers and Heston (1991); Asea and Mendoza (1994); De Gregorio, Giovannini and Wolf (1994); Canzoneri, Cumbi and Diba (1996); Bergin, Glick, and Taylor (2006); Heston, Summers, and Aten (2006); Lothian and Taylor (2008); and Ravalion (2010).

[3] See Turner and Van't dack (1993) and Thomas et al. (2008, 2011).

answer to this question, we follow Keynes (1925) and Corden (1994) and show that prices for non-tradable and comparison-resistant categories play an integral role in measuring international competitiveness.

The correlation between aggregate prices and development, known as the Penn Effect, has been examined extensively. The conventional explanation for this correlation is that as development expands, demand across all expenditure categories increases, which raises the prices of non-tradables but not the prices of tradables because these are determined in world markets. This explanation raises an interesting question: is it the case that an increase in per-capita income raises the relative prices of non-tradable categories? This question has not been addressed before and an answer to it is of interest because finding that these correlations are absent would undermine the conventional explanation for the Penn Effect. To be sure, interest in disaggregation is not new.[4] What is new here is the use the relative price *levels* (as opposed to indexes) at the product level for 144 countries that differ greatly in their level of development.

The next section describes the data; section 3 lays out the basic constructs of our PPP-based REER and demonstrates its sensitivity to the exclusion of non-tradable and non-comparable categories. Section 4 reports the results from regressions relating the within-product relative prices to relative incomes. Section 5 offers a few concluding thoughts.

[4]Both Asea and Mendoza (1994) and De Gregorio et al. (1994) use price indexes for production 20 sectors from 14 industrial countries; Canzoneri et al. (1996) uses aggregate prices for five production sectors of 13 OECD countries.

2 Data Description

2.1 ICP Data

The ICP provided the 2005 benchmark purchasing power parities for 146 countries and 126 basic headings;[5] a "basic heading" is the lowest level of disaggregation for which PPPs are computed.[6] The ICP also provided country data on population, market exchange rates, the 2005 values for GDP, PPPs for GDP, and expenditures on each basic headings; these expenditures add up to GDP.

Reliance on the 2005 ICP benchmarks has several advantages. First, they are the first to include actual price observations for China, and the first since 1985 to include actual price observations for India.[7] Second, the ICP differentiates between government expenditures and private expenditures, facilitating international price comparisons. Finally, data collection uses the concept of "Structured Product Descriptions," which is a list of standardized attributes that identifies a product as narrowly as possible, enhancing product comparability.[8] These detailed descriptions allow the ICP to identify several basic headings as *comparison-resistant*: government production of health services, collective services, social protection, education, and various medical services.

The ICP does not provide, however, a taxonomy of basic headings as being tradable or not; indeed, developing a widely accepted taxonomy of tradability has remained elusive.[9] Thus, given the difficulties of concisely defining tradability, we

[5] The data had incomplete records for Zambia and Zimbabwe, which are excluded from our analysis.

[6] For an early treatment, see Kravis and Lipsey (1990); the latest treatment is found in World Bank (2008, p. 14) and chapters 6 and 7 for details.

[7] See Chen and Ravallion (2008) and appendix G of World Bank (2008).

[8] See World Bank (2008, p. 142).

[9] De Gregorio et al. (1994) define a product as tradable if at least 10 percent of the value of its production "worldwide" is exported. DeGregorio et al. examine 20 production sectors for a world consisting of 14 industrial countries. The practical appeal of their definition diminishes as soon as one expands the list of countries included in the world and uses disaggregated expenditure categories, which is what we do here.

use a subjective but, we believe, reasonable classification of basic headings as tradable. However, one of the advantages of using the disaggregated price data is that one can examine the implications of alternative definitions by re-grouping the basic headings accordingly. So, our definition is ad-hoc but it is not rigid.

2.2 Cross-country Distributions of Relative Prices

We measure the 2005 bilateral price level of the United States with respect to country j in basic heading i as

$$q^i_{j,us} = \frac{E_{\frac{j}{\$}}}{PPP^i_{\frac{j}{us}}},\ i = 1, ...126;\ j = 1, ..., 144, \tag{1}$$

where $E_{\frac{j}{\$}}$ is the 2005 market exchange rate for country j with respect to the U.S. dollar and $PPP^i_{\frac{j}{us}}$ is the PPP exchange rate of the ith basic heading in the jth country, defined as $\frac{P^i_j}{P^i_{us}}$ where P^i_j is the price level (local currency per unit) of the ith basic heading in the jth country. A value of 2 for $q^i_{j,us}$ means that the price of the ith basic heading in the United States is twice that of the same basic heading in country j, when both are expressed in a common currency.

Given equation (1), we assemble the cross-country distributions of relative prices for each basic heading to examine two questions: Are the prices of a given basic heading equalized across countries?[10] Is the dispersion of relative prices across countries related to whether the product is tradable?

Figure 1 shows the cross-country distributions of relative prices ($q^i_{j,us}$) for each basic heading; the figure shows the basic headings that the ICP identifies as comparison resistant and the basic headings that we identify as tradable and non-tradable. For each distribution, we show the median and four percentiles; these distributions are arranged in descending order of their medians. The data show that most of the

[10] For an earlier treatment of this question, see Isard (1977).

medians are well above one, especially for comparison-resistant products. Further, the medians of the distributions for tradable products are generally lower than those for non-tradable products. Finally, the dispersion of relative prices for non-tradables is considerably larger than that for tradables. These properties resonate with our priors that international trade tends to equate prices across countries and that this tendency is greatest for the most readily tradable products.

3 U.S. Relative Price Levels in 2005

We now assess the importance of the product mix for measuring U.S. international relative price levels. To this end, we begin by assembling the cross-country distributions of relative prices for the largest trading partners of the United States.[11] Figure 2 shows that the median for most of these distributions is quite close to one and well below the median for the distributions using 144 countries. To emphasize the importance of the country mix, figure 3 compares the distributions of relative prices without differentiating across basic headings. The figure shows that the cross-country distribution of relative prices for U.S. trading partners is considerably narrower and more symmetrical than the one for the 144 countries.

To provide some perspective on what we are after, figure 4 depicts U.S. relative price levels based on the ICP's published GDP parities for the 34 countries included in figure 2. By this measure, U.S. GDP prices were twice as high as the GDP prices in India and 30 percent below those in Switzerland. The question of interest is to what extent are these measures of relative prices influenced by the prices of basic

[11] We use the 34 countries included in the broad measure of the Federal Reserve's real effective value of the dollar (Leahy 1998): Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, China, Colombia, Finland, France, Germany, Hong Kong, India, Indonesia, Ireland, Israel, Italy, Japan, Korea, Malaysia, Mexico, Netherlands, Philippines, Portugal, Russia, Singapore, Spain, Sweden, Switzerland, Taiwan, Thailand, United Kingdom, and Venezuela; these countries account for roughly 92 percent of 2005 total U.S. trade. The data come from the U.S. Commerce Department.

headings that are either non-tradable or comparison-resistant?

Addressing this question involves two steps. The first one is to measure the aggregate relative price level between the United States and the jth trading partner using alternative basic headings. To this end, we use a weighted geometric average:

$$q_{j,L} = \prod_{i \in L} \left(q^i_{j,us}\right)^{w_{ij,L}}, j = 1, ..., 34, \tag{2}$$

where L is a list of basic headings, $q^i_{j,us}$ is defined in equation (1), $w_{ij,L}$ is the share of the jth country's expenditure on the ith basic heading, and $\sum_{i \in L} w_{ij,L} = 1$. A value of 2 for q_{jL} means that U.S. prices are twice as high as those in the jth country in list L. We consider three lists:

L_1 : All headings

L_2 : Authors' defined tradable headings

L_3 : All headings excluding ICP's "comparison resistant" headings

The second step is to map the $q_{j,L}$ into alternative measures of the U.S. real effective exchange rate. To this end, we use a weighted geometric mean:

$$Q_L = \prod_{j=1}^{34} \left(q_{j,L}\right)^{\delta_j}, L = L_1, L_2, L_3, \tag{3}$$

where Q_L is the level of the U.S. real effective exchange rate for list L, $q_{j,L}$ is defined in equation (2), and δ_j is the U.S. bilateral trade weight associated with the jth country.[12] A value of 2 for Q_L means that the aggregate of U.S. prices in list L is

[12] We use the weighting scheme adopted by the Federal Reserve (Leahy, 1998). In this scheme, the un-normalized broad weight for a given country is $\omega_j = 0.5 \cdot \mu_j + 0.25 \cdot \xi_j + 0.25 \cdot \varsigma_j$, where μ_j is the share of non-oil imports from the jth country; ξ_j is the export share to the jth country; and ς_j is the extent to which exports to the jth country compete with exports from other countries; the normalized broad weight of the jth country is $\delta_j = \frac{\omega_j}{\Sigma_v \omega_v}$. The data come from the U.S. Commerce Department.

twice as high as the average of aggregate prices of U.S. trading partners in the same list.

Figure 5 reports our calculations. As a check on our procedures, we compare the "all-headings" measure q_{j,L_1} to the published ICP's GDP relative prices, denoted as $q_{j,GDP}$ and shown earlier in figure 4. Excluding Thailand and Malaysia, the two measures are very close and two factors help explain this gap. First, q_{j,L_1} is measuring prices of domestic expenditures whereas $q_{j,GDP}$ is measuring prices of expenditures on domestic products–that is, excluding imports and including exports. Second, equation (2) might differ from the one used by the ICP.

Taking q_{j,L_1} as our benchmark of economy-wide relative prices, we find that the relative-price measure excluding non-tradable headings (q_{j,L_2}) shifts down the structure of U.S. relative price levels with the shift being particularly pronounced vis-à-vis emerging economies. For example, U.S. aggregate prices are measured to be 105 percent above those in India; whereas, if we exclude non-tradable headings, the gap shrinks to 60 percent. In contrast, vis-à-vis Switzerland, the measured differential shrinks by only one percent with the exclusion of non-tradables. The relative-price measure excluding comparison-resistant headings (q_{j,L_3}) also shifts down the structure of relative prices, but to a lesser extent than when prices in non-tradable headings are excluded.

The rightmost column of figure 5 shows the sensitivity of Q_L to changes in the mix of basic headings. Specifically, if one includes the prices of all headings (Q_{L_1}), then U.S. prices appear to be 25 percent above the average of its trading partners. If we exclude prices of headings that are difficult to compare across countries, then the measured wedge shrinks to about 10 percent (Q_{L_2}). Finally, if we limit ourselves to prices for tradable basic headings (Q_{L_3}), then there appears to be little difference between U.S. prices and the average of prices of its major trading partners.

This finding suggests that excluding either comparison-resistant or non-tradable basic headings from the product mix lowers the measure of U.S. relative prices. We do not take this finding as evidence for designating either Q_{L_2} or Q_{L_3} as the better measure for making inferences about international competitiveness. Rather, we consider the comparison-resistant and non-tradable basic headings essential to analyzing international price positions.

Our view is not new. Indeed, Keynes noted in 1925 (p. 301): "it is the price of sheltered [non-tradable] goods that determines the competitiveness of a country because it is those prices that determine the cost of producing tradable goods. The price of unsheltered goods will be equalized by trade."[13] Further, Keynes' view is formalized by Corden (1994, p. 267) who argues that a country's international competitiveness is determined by the profitability in industries producing tradables. Specifically, Corden measures international competitiveness in the ith industry as the ratio of the jth country's price markup to that of the United States:

$$\rho_i = \left(\frac{P_{j,i}}{MC_{j,i}}\right) / \left(\frac{P_{us,i}}{MC_{us,i}}\right), \tag{4}$$

where $P_{j,i}$ is the dollar price of the ith tradable industry in the jth country, and $MC_{j,i}$ is the associated marginal cost, also in dollars. Thus, if $\rho_i > 1$, then the jth country is said to be more competitive than the United States because it has a higher price markup. Further, if one assumes that international trade equalizes prices of tradable products, then

$$\rho_i = \left(\frac{P_i}{MC_{j,i}}\right) / \left(\frac{P_i}{MC_{us,i}}\right) = \frac{MC_{us,i}}{MC_{j,i}}. \tag{5}$$

[13] Of course, productivity differentials also figure importantly into the mapping from the prices of non-tradables to the cost of producing tradables. Unfortunately, broad, cross-country data that compare the levels of productivity are not available.

Again, if $\rho_i > 1$, then the jth country is more competitive than the United States because it has lower marginal costs. Marginal costs are directly related to factor prices, such as wages that are, in turn, directly related to the importance of non-tradables (e.g. housing, medical services) in domestic expenditures. Given that comparison-resistant and non-tradable basic headings account for more than half of U.S. total domestic expenditures (figure 6), abstracting from them yields an incomplete characterization of international competitiveness.

4 Development and Relative Price Levels

In this section we study the correlation between the level of economic development and the level of relative prices across countries, known as the Penn Effect. Intuitively, higher levels of income raise the demands for tradable and non-tradable goods and services. The higher demand for tradables is met through international trade with no change in tradable's prices. But the higher demand for non-tradables is met by the fixed, local supply, raising the price of non-tradables and, thus, the overall price level. So the natural question to ask is whether the data support the view that an increase in income raises the relative prices of non-tradable categories.

To this end, we begin by replicating the Penn Effect and postulate that

$$\ln q_{GDP} = \alpha + \beta \cdot \ln y + u, \;\; u \tilde{} N(0, \sigma^2), \tag{6}$$

where

$q_{GDP} = (q_{1,GDP} \cdots q_{144,GDP})'$

$q_{j,GDP}$ is the U.S. price relative to the price of the jth country using ICP's published GDP parities

$y = (\frac{y_1}{y_{us}} \cdots \frac{y_{144}}{y_{us}})'$

$\frac{y_j}{y_{us}} = (\frac{GDP_j}{POP_j} \cdot \frac{1}{PPP_{\frac{j}{\$}}})/\frac{GDP_{us}}{POP_{us}}$

GDP_j is the GDP of the jth country

POP_j is the population of the jth country

For the conventional explanation of the Penn Effect to be consistent with the aggregate data, one needs to find that $\beta < 0$: An increase in the per-capita income of the jth country relative to U.S. per-capita income raises the price in the jth country relative to the corresponding U.S. price and, hence, lowers $q_{j,GDP}$. The regression yields

$$\ln q_{GDP} = \underset{}{0.1715} - \underset{(0.0219)}{0.2354}\ \ln y \quad , \qquad \underset{(0.0502)}{}$$

where the standard errors of the coefficients are corrected for potential heteroskedasticity of the residuals.[14] The result confirms that $\beta < 0$ when using the ICP's published parities for GDP.

To examine whether this correlation holds at the level of basic headings, we use

$$\ln q_i = \alpha_i + \beta_i \cdot \ln y + u_i,\ \ i = 1, ..., 126,\ \ u_i \tilde{} N(0, \sigma_i^2), \tag{7}$$

where $q_i = (q^i_{1,us} \cdots q^i_{144,us})'$ and $q^i_{j,us}$ is defined in equation (1). For the conventional explanation of the Penn Effect to be consistent with the data at the disaggregate level, one needs to find that $\beta_i < 0$: An increase in the per-capita income of the jth country relative to U.S. per-capita income tends to raise the price of the ith good in the jth country relative to the corresponding U.S. price, which then lowers $q^i_{j,us}$.

[14] The regression statistics are SER: 0.289; $\overline{R}^2$: 0.55. The Jarque-Bera test for normality is 4.3466 and one cannot reject the hypothesis that the residuals are normally distributed at the 5 percent significance level.

Thus finding that $\beta_i = 0$ for non-tradables would undermine the usefulness of the conventional explanation for the Penn Effect.

Figure 7 shows the estimates of β_i and their 95 percent confidence bands.[15] For the vast majority of basic headings, the estimated β_i is negative and significantly different from zero. That is, for most of the basic headings, higher prices in the jth country are associated with higher incomes in the jth country. We also note that the estimates of β_i tend to be larger (in absolute value) for the headings that we denoted non-tradables than for the headings we denoted tradables. This finding strengthens the empirical support of the conventional explanation of the Penn Effect.

This pattern for the β_is is not a necessary consequence of the pattern seen in figure 1, as the estimated intercept could absorb the variation in the medians. Indeed, the estimated standard errors of the regressions bear no relationship to the ordering of the basic headings (figure 8). Finally, note that for three of these products (motorcars, motorcycles, and passenger transport by air), the estimated β is significantly positive, meaning that higher prices are associated with lower incomes, a deviation from the Penn Effect. This seemingly contradictory finding might be the result of some countries treating these products as luxuries and thus levying taxes on them.

5 Conclusions

The view under the hood yields two insights that might be useful for practical analyses and further research.

First, we get a good sense of the extent to which the real effective exchange rate for the United States is affected by the inclusion of non-tradable prices. For 2005, with the full product list, the U.S. REER shows U.S. prices to be more than

[15] These bands use the heteroskedasticity-corrected standard errors.

20 percent above those of its trading partners, while for tradable products alone, there is little difference between U.S. prices and those of its trading partners. We do not view this sensitivity as an argument for excluding non-tradables when judging competitiveness because the prices of non-tradables are central to determining a country's profitability in tradable products.

Second, the Penn Effect is not an artifact of aggregation. Indeed we find that this effect holds for the majority of basic headings. Interest in this disaggregation is not new but previous work uses aggregate price indexes for selected sectors of industrial countries. In contrast, we offer evidence based on relative price *levels* (as opposed to indexes) of 126 basic headings for 144 countries that differ greatly in their level of development. This generality makes the Penn Effect an interesting subject for future research because it does not rely on aggregation formulas.

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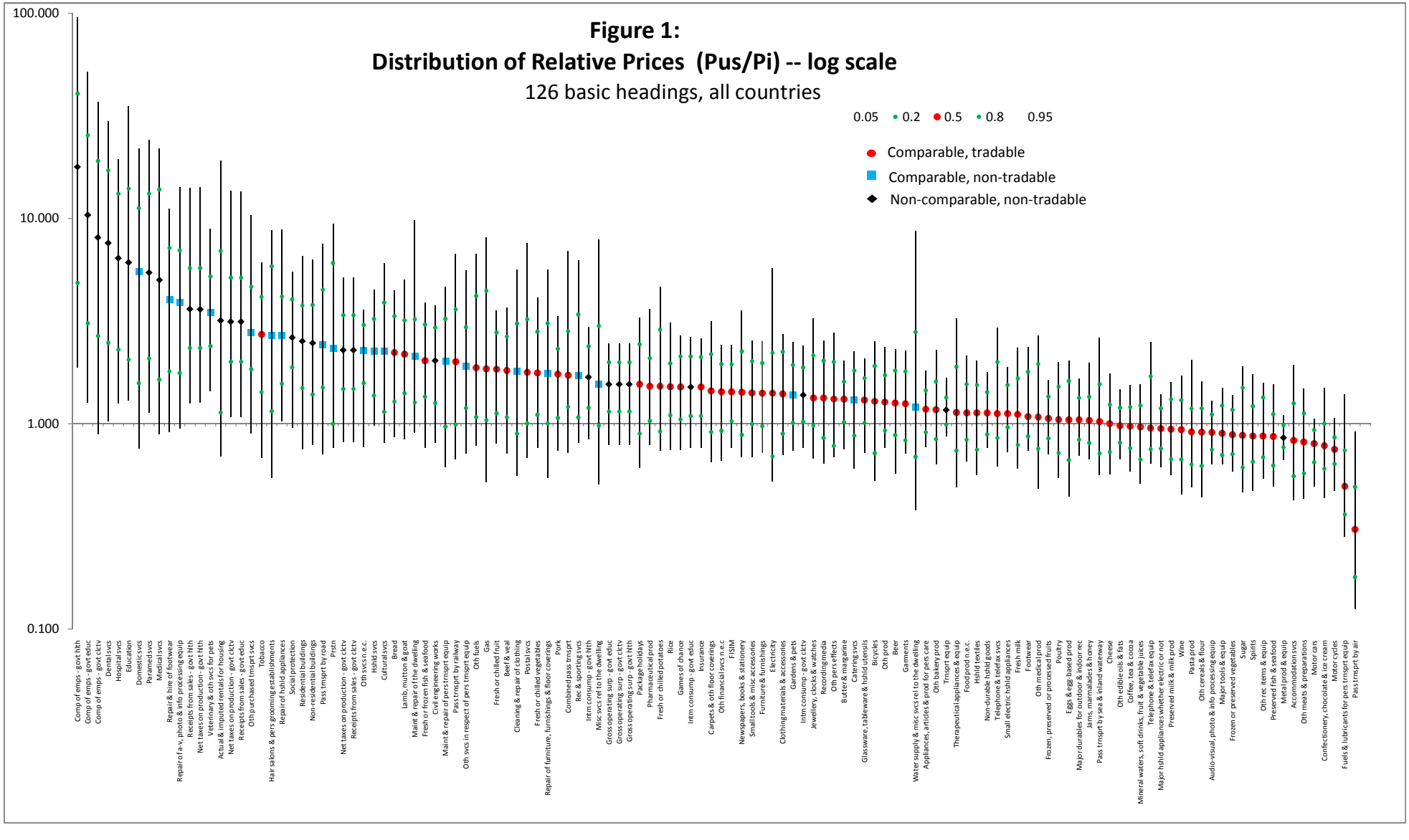


Figure 1:
Distribution of Relative Prices (Pus/Pi) -- log scale
126 basic headings, all countries
0.05 0.2 0.5 0.8 0.95
Comparable, tradable
Comparable, non-tradable
Non-comparable, non-tradable
100.000
10.000
1.000
0.100
Comp of emps - govt hlth
Comp of emps - govt educ
Comp of emps - govt cltv
Dental svcs
Hospital svcs
Education
Domestic svcs
Paramed svcs
Medical svcs
Repair & hire of footwear
Repair of a-v, photo & info. processing equip
Receipts from sales - govt hlth
Net taxes on production - govt hlth
Veterinary & oth svcs for pets
Actual & imputed rentals for housing
Net taxes on production - govt cltv
Receipts from sales - govt educ
Oth purchased transport svcs
Tobacco
Hair salons & pers grooming establishments
Repair of hshld appliances
Social protection
Residential buildings
Non-residential buildings
Pass trnsprt by road
Prsnl trnsprt
Net taxes on production - govt cltv
Receipts from sales - govt cltv
Oth svcs n.e.c.
Hshld svcs
Cultural svcs
Bread
Lamb, mutton & goat
Maint & repair of the dwelling
Fresh or frozen fish & seafood
Civil engineering works
Maint & repair of pers trnsprt equip
Pass trnsprt by railway
Oth svcs in respect of pers trnsprt equip
Oth fuels
Gas
Fresh or chilled fruit
Beef & veal
Cleaning & repair of clothing
Postal svcs
Fresh or chilled vegetables
Repair of furniture, furnishings & floor coverings
Pork
Combined pass trnsprt
Rec & sporting svcs
Intm consump - govt hlth
Misc svcs rel to the dwelling
Gross operating surp - govt educ
Gross operating surp - govt cltv
Gross operating surp - govt hlth
Package holidays
Pharmaceutical prod
Fresh or chilled potatoes
Rice
Games of chance
Intm consump - govt educ
Insurance
Carpets & oth floor coverings
Oth financial svcs n.e.c
FISIM
Newspapers, books & stationery
Small tools & misc accessories
Furniture & furnishings
Electricity
Clothing materials & accessories
Gardens & pets
Intm consump - govt cltv
Jewellery, clocks & watches
Recording media
Oth pers effects
Butter & margarine
Catering svcs
Glassware, tableware & hshld utensils
Bicycles
Oth prod
Beer
Garments
Water supply & misc svcs rel to the dwelling
Appliances, articles & prod for pers care
Oth bakery prod
Trnsprt equip
Therapeutical appliances & equip
Food prod n.e.c.
Hshld textiles
Non-durable hshld goods
Telephone & telefax svcs
Small electric hshld appliances
Fresh milk
Footwear
Oth medical prod
Frozen, preserved or processed fruits
Poultry
Eggs & egg based prod
Major durables for outdoor & indoor rec
Jams, marmalades & honey
Pass trnsprt by sea & inland waterway
Cheese
Oth edible oils & fats
Coffee, tea & cocoa
Mineral waters, soft drinks, fruit & vegetable juices
Telephone & telefax equip
Major hshld appliances whether electric or not
Preserved milk & milk prod
Wine
Pasta prod
Oth cereals & flour
Audio-visual, photo & info processing equip
Major tools & equip
Frozen or preserved vegetables
Sugar
Spirits
Oth rec items & equip
Preserved fish & seafood
Metal prod & equip
Accommodation svcs
Oth meats & preparations
Motor cars
Confectionery, chocolate & ice cream
Motor cycles
Fuels & lubricants for pers trnsprt equip
Pass trnsprt by air

Figure 2:
Distribution of Relative Prices -- log scale
126 basic headings, 34 FRB countries

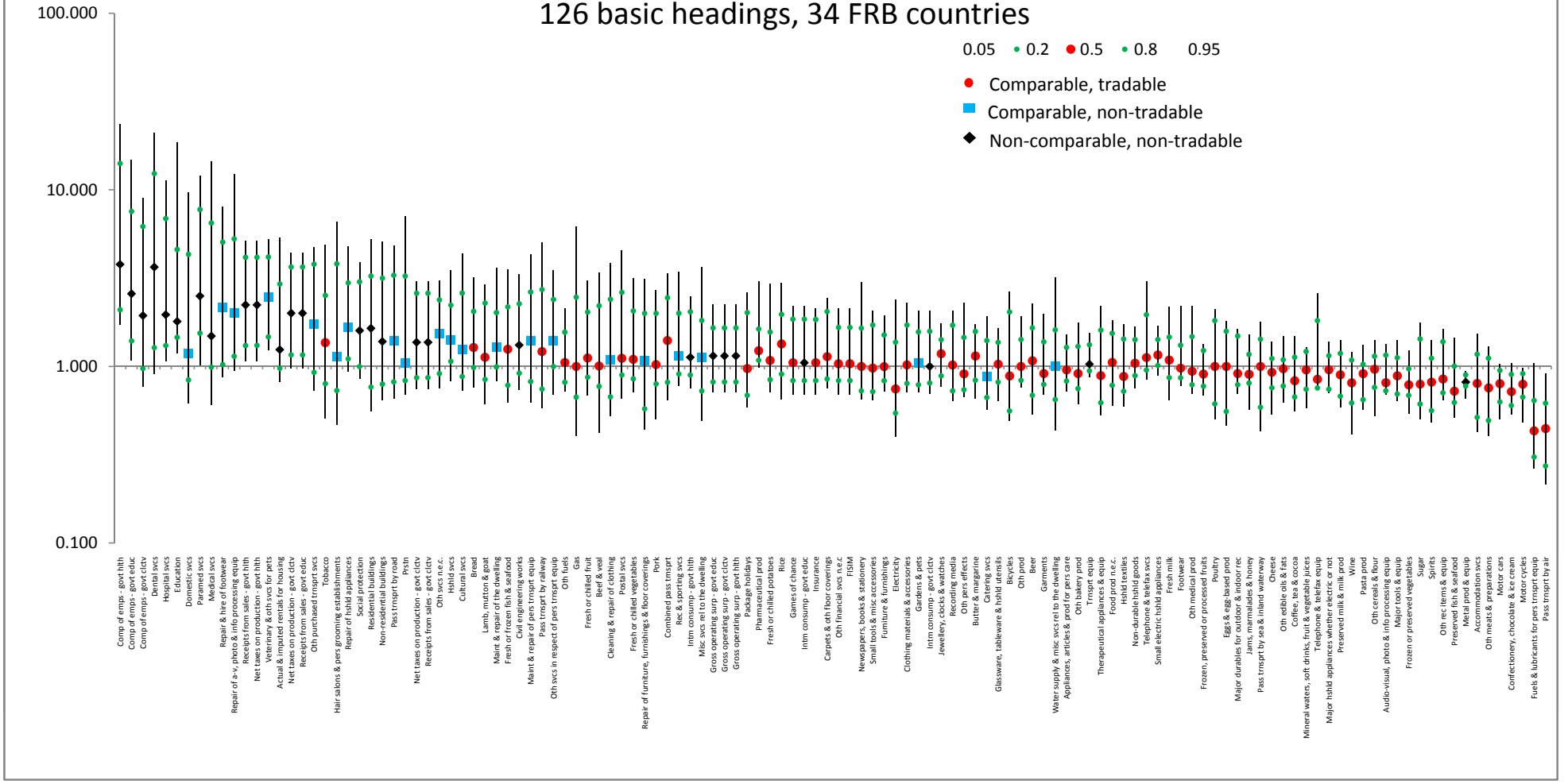
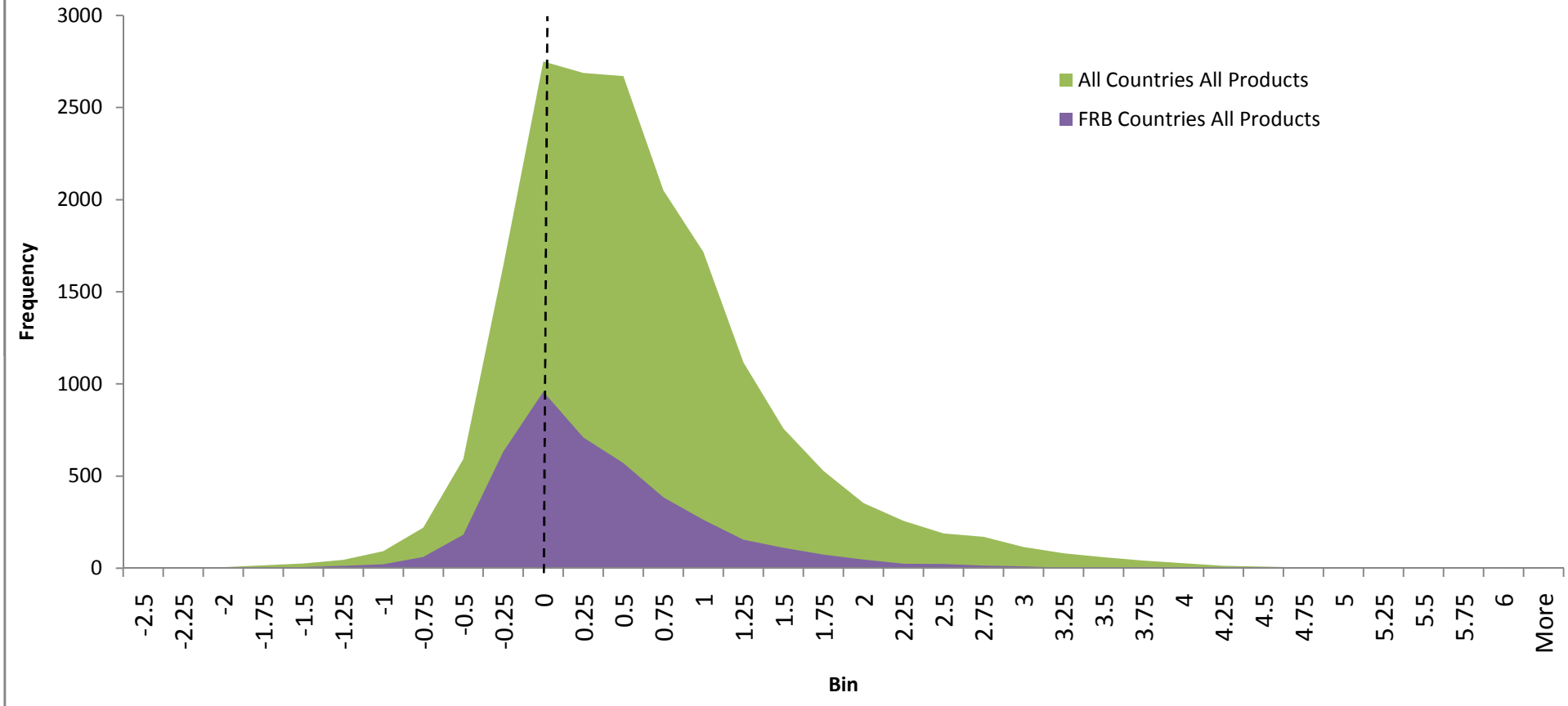


Figure 3:
Histogram of Relative Prices - Ln(Pus/Pi)



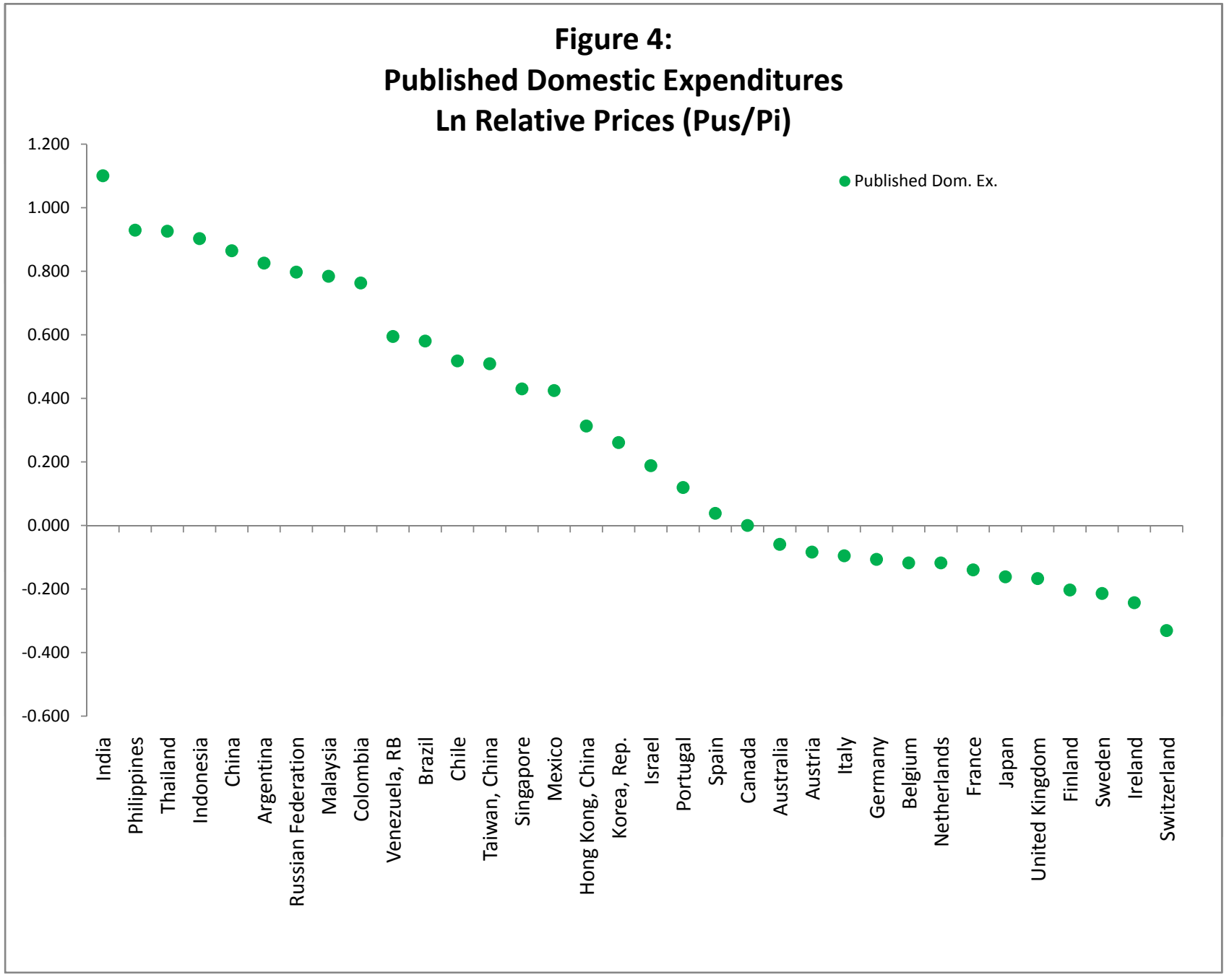


Figure 4:
Published Domestic Expenditures
Ln Relative Prices (Pus/Pi)
Published Dom. Ex.
1.200
1.000
0.800
0.600
0.400
0.200
0.000
-0.200
-0.400
-0.600
India
Philippines
Thailand
Indonesia
China
Argentina
Russian Federation
Malaysia
Colombia
Venezuela, RB
Brazil
Chile
Taiwan, China
Singapore
Mexico
Hong Kong, China
Korea, Rep.
Israel
Portugal
Spain
Canada
Australia
Austria
Italy
Germany
Belgium
Netherlands
France
Japan
United Kingdom
Finland
Sweden
Ireland
Switzerland

Figure 5:
Selected Domestic Expenditure Groupings
Ln Relative Prices (Pus/Pi)

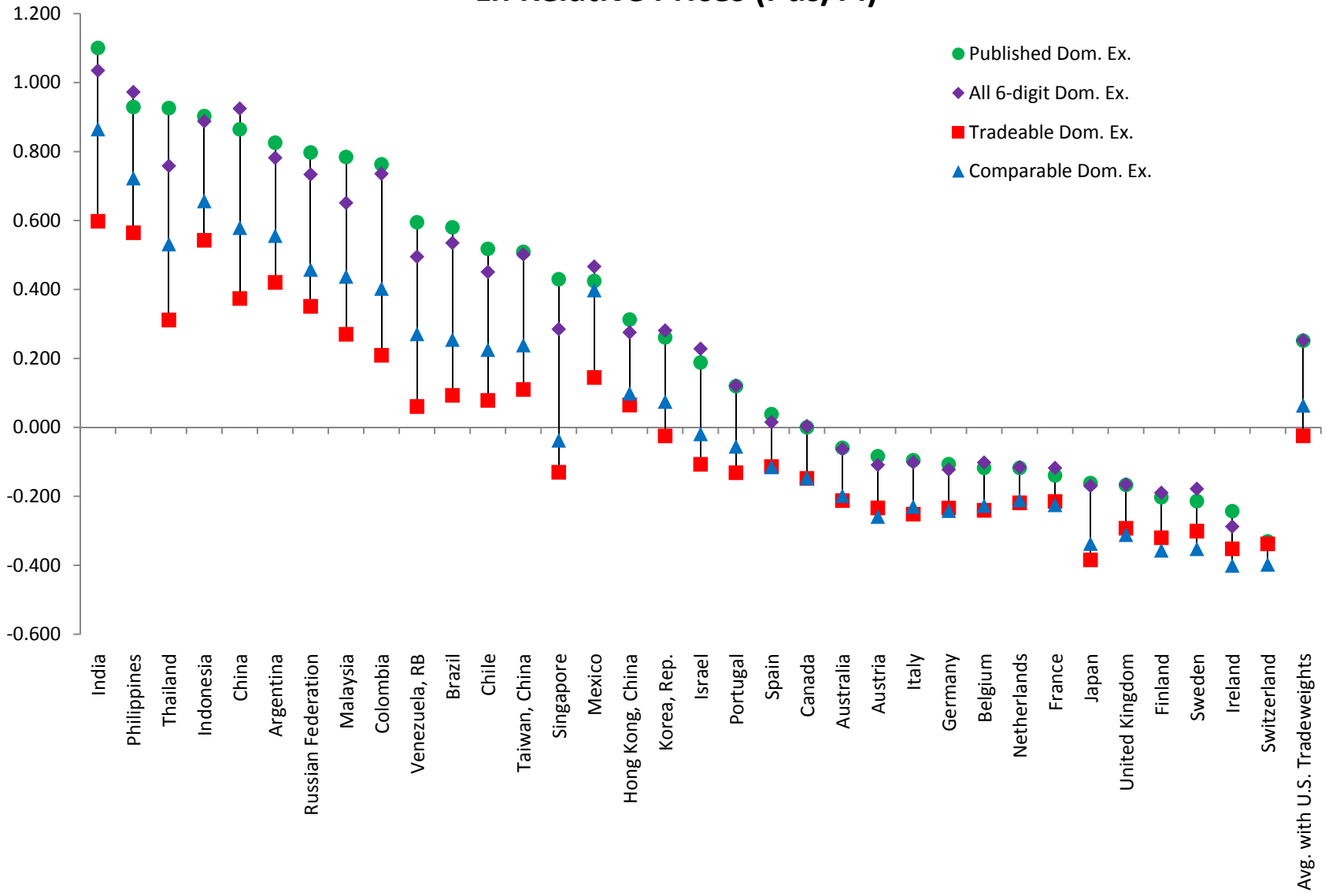


Figure 6:
Selected Expenditure Shares

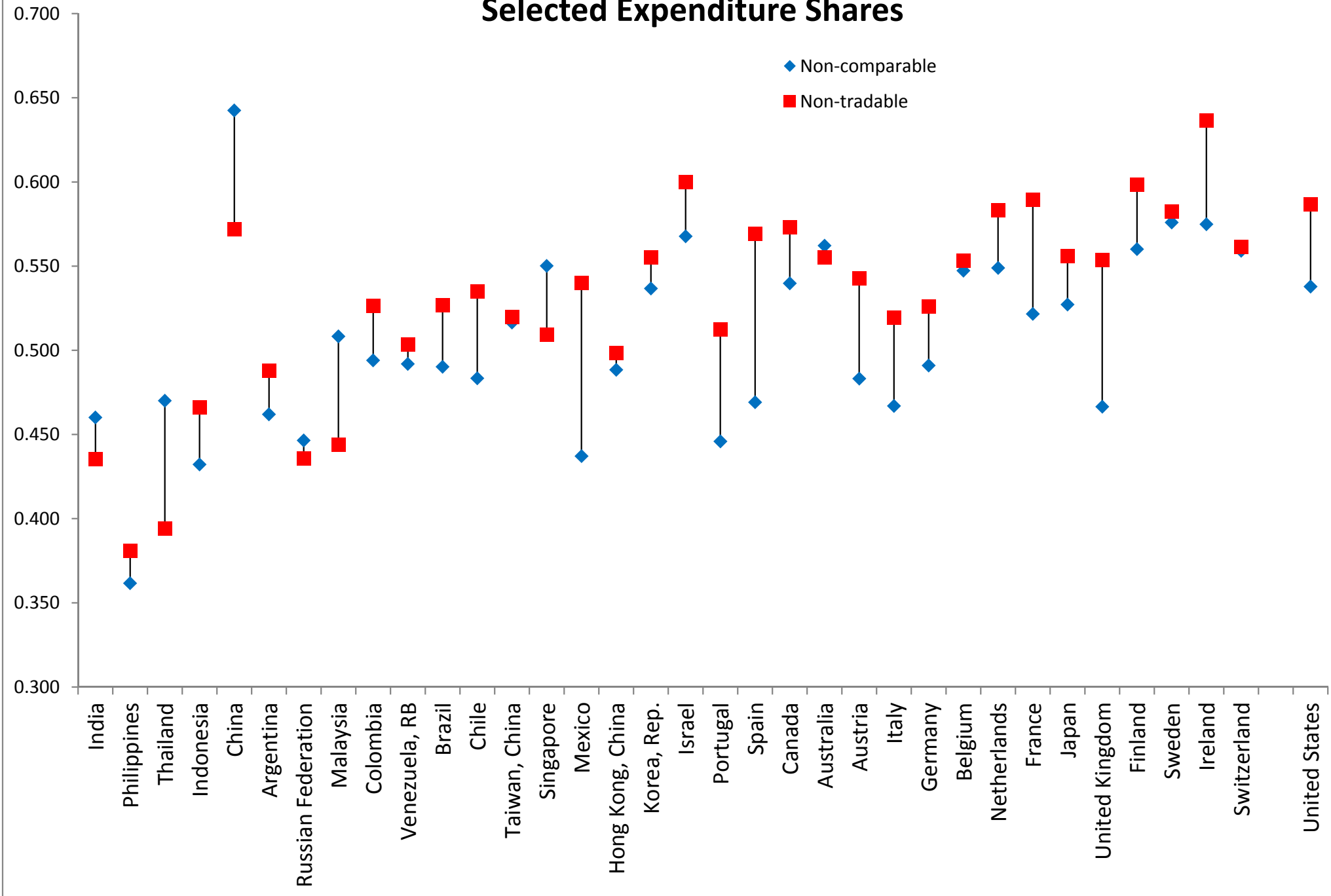


Figure 7:
Corrrelation Between Relative Prices and Development: 95% Confidence Band
126 Basic Headings

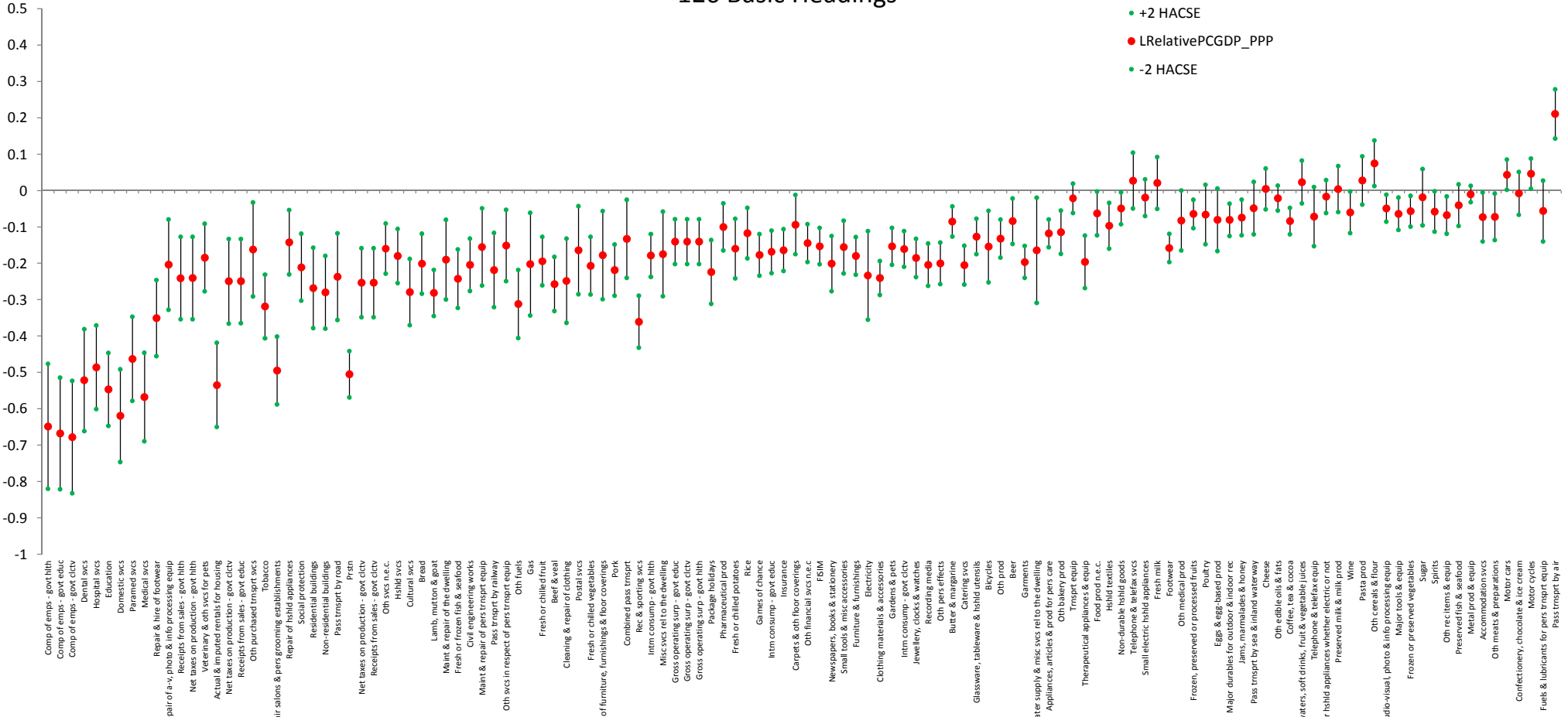


Figure 8:
Standard Error of Regression: Equation (7)
126 Basic Headings