ECONOMICS

FOOD AND AGRICULTURAL PRICES ACROSS COUNTRIES AND THE LAW OF ONE PRICE

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Abstract

This paper investigates several basic characteristics of food and agricultural prices across commodities, countries and time. The first part of the paper uses consumer prices across commodities and countries from the International Comparisons Program and finds that food has a distinct tendency to be cheaper in rich countries as compared to poor ones. This possibly reflects the productivity bias effect of Balassa and Samuelson, or Engel's law. Food prices are also less dispersed in rich countries. Cross-country and cross-commodity tests reject the law of one price (LOP) more often than not with, as might be expected with consumer prices. In the second part of the paper, data on agricultural producer prices from the Food and Agriculture Organisation are used to test if deviations from the LOP are stationary, using a panel approach. As about three-quarters of the 100+ products obey the law, there seems to be some support for the LOP in this context.

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1. Introduction

Over the longer term, productivity in agriculture has grown sufficiently to keep food prices from rising substantially, thus contributing to rising living standards. Whether or not this will continue in the future is subject to much debate and conjecture.¹ But not only is the behavior of agricultural prices over time important for the evolution of living standards, so too is the distribution of these prices across countries: In the poorest countries, consumers spend, on average, one-half or more of their incomes on food, while in high-income countries food absorbs 10 percent or less. This is, of course, a manifestation of Engel's law. In this paper, we show that food becomes cheaper as we move from poor to rich countries, thus amplifying the Engel effect of the low (high) food share of the rich (poor) on their real incomes. Not only are food prices in rich countries lower, but so is the dispersion of the prices of individual food items, as we shall demonstrate.

There are at least three possible reasons for cheaper food in high-income countries. First, because of their superior endowment of agricultural land and favourable climate, these countries may simply have a comparative advantage in producing food at lower prices. More likely, however, is the productivity bias hypothesis of Balassa (1964) and Samuelson (1964). According to this hypothesis, due to their labour intensity and lack-of-commodification nature, services (read non-foods) are less amenable to productivity growth than other sectors (read food). In high-productivity, high-income countries, this leads to services being relatively more expensive, and food prices relatively lower.

A third explanation of lower food prices is Engel's law. Higher income is likely to lead to growth in the consumption of most goods, but because of Engel's law, food grows slower than average. If on the supply side all sectors (food and non-food) expand at approximately the same rate, at constant relative prices there is an excess supply of food. The end result is lower food prices in countries with higher incomes. In this paper we present a stylised model of this process in which prices depend on incomes.

When studying prices across countries, it is natural to inquire about the extent to which they differ. If when we convert to a common currency, the price of a product is equal in two countries, the price in terms of the domestic currency then responds one-for-one to exchange-rate changes, and currency values play no role in the structure of relative prices. This "law of one

¹ See, for example, FAO (2016), OECD/FAO (2016) and USDA (2016).

price” (LOP) is based on arbitrage -- the process of buying in the country where the product is cheap and selling where it is expensive will eliminate price differences. When prices are not equalised, *prima facie* there is a deadweight efficiency loss that could be eliminated by transferring the product from the low-cost location to where it is more highly valued. Of course, the LOP only holds under the stringent conditions of a product being identical in all aspects other than the currency in which it is denominated, and no barriers to trade. While these conditions are unlikely to hold in most cases, it is still of considerable interest to investigate how closely products come to satisfying the LOP. Closely related to the LOP is the purchasing power parity (PPP) hypothesis, according to which the value of the country’s currency equals the ratio of some macroeconomic index of prices at home to that abroad.²

To investigate the link between prices and exchange rates, we move from food *indexes* across countries to something approaching the prices actually paid by consumers for a large number of goods in 150+ countries. We estimate (i) a cross-country regression for the price of each good; and (ii) a cross-commodity regression for each country. These provide summary measures of the degree to which prices of each good in all countries, and the prices of all goods in each country, do/do not respond proportionately to exchange-rate changes. The LOP is rejected more often than not, but in many cases the violations did not seem particularly large.

In addition to food prices faced by consumers, we also analyse the prices of agricultural products received by producers. Using the large data set assembled by the Food and Agriculture Organisation (FAO, online), we again study the extent to which prices are equalised. These data also have a time dimension in addition to the product and country distinction, and so we are able to use panel-unit-root tests of the LOP to investigate whether deviations from the law are stationary. We find about three-quarters of the 100+ products obey the law. Although the results are subject to qualification, it still seems reasonable to conclude that there seems to be considerable support for the LOP.

² For a review of the LOP and its relation to PPP, see Marsh et al. (2012). On the basis of a substantial literature, Marsh et al. conclude that the evidence is not unanimous, but there is now increasing acceptance that the LOP and PPP hold as longer-run tendencies. In their words: “While it is fair to say that a universal consensus may not exist yet, the emerging consensus at the present time is converging toward the view that deviations from the LOP are transitory and therefore the LOP holds in the long run among a broad range of tradable goods and currencies” (p. 213). They also state: “Overall, our reading of the literature suggests that PPP is a good first approximation to the long-run behaviour of exchange rates” (p. 203). For other reviews of PPP theory, see Dornbusch (1988), Frenkel (1978), Froot and Rogoff (1995), Manzur (2008), Officer (1982), Rogoff (1996) and Taylor and Taylor (2004).

The next section of the paper presents indexes of food prices across countries from the International Comparisons Program (hereafter referred to as the “ICP”) and establishes that they fall as income rises. Section 3 deals with the dispersion of food prices, while Section 4 presents the model of prices that depend on income. Next, the relationship between exchange rates and prices is analysed in Sections 5-7 -- some foundation material on the LOP in Section 5, applications to consumer prices in Sections 6 and 7 and to producer prices in Sections 8-10. Concluding comments are contained in Section 10.

2. Eating, Drinking and Prices Across Countries

Table 2.1 provides the starting point with basic data from the World Bank on the income per capita and food consumption and prices in 155 countries in 2011, from the ICP.³ The countries range from the richest (such as the US, Norway and Switzerland) to the poorest (Comoros, Niger, Congo), with a ratio of incomes of the order of 100:1. There is also strong evidence of Engel’s law as the share of total consumption devoted to food falls from more than 50 percent in the poorest countries to about 10 percent in the richest. This effect is particularly clear in Figure 2.1, a plot of the food shares in the 155 countries against incomes.

The ICP data divides GDP into 155 categories (called “basic headings”); the first 132 are items of consumption, of which the first 32 of these are food items, including alcoholic beverages. After minor adjustments (see Appendix), we are left with 31 food basic headings and 131 consumption basic headings. Define w_i as the budget share of good i (the proportion of total consumption expenditure devoted to i), so that the budget share of all food is $W_F = \sum_{i=1}^{31} w_i$. If p_i is the price of category i , the relative price of food can be defined as

$$(2.1) \quad \log\left(\frac{P_F}{P}\right) = \log P_F - \log P = \sum_{i=1}^{31} \left(\frac{w_i}{W_F}\right) \log p_i - \sum_{i=1}^{131} w_i \log p_i.$$

This relative price is the difference between the conditional budget-share weighted logarithmic mean of the prices of the food items, $\log P_F$ and the log of the cost-of-living index, $\log P$. Table 2.1 contains, in columns 4 and 9, the food relative price (2.1), and there is a distinct tendency for food to become cheaper as income rises. For example, on average for the poorest quartile of countries, the relative price of food is 36.3 percent, while this falls to 13.7 for the richest quartile. This means that, on average, food is about 20 percent cheaper in the richest countries as

³ The data source is World Bank (unpublished). For details of the data, see the Appendix.

compared to the poorest.⁴ Panel A of Figure 2.2 plots food prices against income and the regression coefficient of log income is -6.18 and significant, implying that a 10-percent rise in income leads to food prices falling by about 6 percentage points. Panel B of this figure allows the regression line to vary across income quartiles; and as all four within-quartile slope coefficients are insignificant, the bulk of the decline in food prices must occur in moving from quartile to quartile.

As W_F is the budget share of food, the share of non-food is $1 - W_F$, while the share of non-food good i in total non-food is $w_i / (1 - W_F)$. An index of the cost of the 131-31 = 100 non-food items is then

$$\log P_N = \sum_{i=32}^{131} \left(\frac{w_i}{1 - W_F} \right) \log p_i,$$

and the cost of living can be expressed as $\log P = W_F \log P_F + (1 - W_F) \log P_N$. The relative price of food (2.1) can be reformulated as $\log P_F - \log P = (1 - W_F)(\log P_F - \log P_N)$ so that

$$(2.2) \quad \log P_F - \log P_N = \frac{1}{1 - W_F} (\log P_F - \log P).$$

In words, the relative price of food in terms of non-food is a multiple $1/(1 - W_F) > 1$ of index (2.1), the relative price of food in terms of all goods, food and non-food. Index (2.2) “strips out” the role of food prices in the deflator in index (2.1). For the top quartile countries where food accounts for roughly 10 percent of the budget, index (2.2) is about 10 percent more than (2.1). However, for the bottom quartile the share is closer to one half and index (2.2) is about twice as

⁴ If the relative price of food in country c is x_c , then a representative basket of food costs $\exp x_c \approx 1 + x_c$ times the cost of a representative basket of all goods, with $x_c = 0$ for $c =$ the US as a normalization. The relative cost of food in country c as compared to that in another country d , where the relative price is x_d , is $\exp(x_c)/\exp(x_d) = \exp(x_c - x_d)$. For countries in the top and bottom income quartiles, the averages are $x_c = 0.137$ and $x_d = 0.363$; consequently, the cost difference is $\exp(0.137 - 0.363) = 0.798$. Thus, food is 20.2 percent cheaper in the top quartile. Using the approximation that for small z , $\exp z \approx 1 + z$, the approximate cost difference is $1 + (x_c - x_d) = 1 + 0.137 - 0.363 = 0.774$, implying that food is approximately 22.6 percentage cheaper. The approximation error is $22.6 - 20.2 = 2.4$ percentage points, which is not particularly small and reflects the large difference between the top and bottom quartiles.

large as (2.1). Food in terms of non-food is about 44 percent cheaper in the richest countries as compared to the poorest.⁵

The conclusion of the above discussion is if we use the (2.2) measure, the relative price of food falls by much more as income rises. That is, the price of food in terms of non-food falls by more than that of food in terms of the cost-of-living (which includes the costs of food and non-food). This shows that the fall in the price of food is *not* an implication of Engel's law. To be sure, food is more heavily weighted in the cost-of-living index of poor countries, but when this is controlled for by index (2.2), food prices fall even faster as income rises.

3. Price Dispersion

For food item i , w_i is its share of total consumption expenditure and w_i/W_F is its share within food, or the "conditional" share. For simplicity of notation, write the conditional share as $w'_i = w_i/W_F$, with $\sum_{i=1}^{31} w'_i = 1$, so that the index of food prices in equation (2.1) can then be written as $\log P_F = \sum_{i=1}^{31} w'_i \log p_i$. The corresponding measure of dispersion of food prices is the weighted variance:

$$(3.1) \quad \Pi_F = \sum_{i=1}^{31} w'_i (\log p_i - \log P_F)^2.$$

Table 2.1 gives in columns 5 and 10 the standard deviation of prices, $\sqrt{\Pi_F}$, for each country. Figure 3.1 reveals the dispersion of prices falls significantly as income rises: But comparing Figures 2.1, 2.2 and 3.1, it can be seen that dispersion falls the fastest with income, then the budget share, and then the relative price.

What is the source of the price dispersion? Is it because of large differences in relative prices of the broad food groups (such as bread and cereals vs meats vs dairy), or is it due to more micro differences between more closely related foods within the broad groups (such as rice vs

⁵ As indicated in the previous footnote, on the basis of equation (2.1), the relative price of food in terms of all goods for the income top quartile is $x_c = 0.137$, and $x_c = 0.363$ for the bottom quartile. From Table 2.1, roughly speaking, on average countries in the top income quartile devote about 10 percent of the budget to food (W_{Fc}), while in the bottom quartile, this is about 50 percent. Thus, using equation (2.2), in the top quartile the relative price of food in terms of non-food is $x_c/(1 - W_{Fc}) = 0.137/0.9 = 0.152$. For the bottom quartile, $x_d/(1 - W_{Fd}) = 0.363/0.5 = 0.726$. The ratio of costs is now $\exp[x_c/(1 - W_{Fc})]/\exp[x_d/(1 - W_{Fd})] = \exp(x_c - x_d)\exp[(1 - W_{Fd})/(1 - W_{Fc})]$. For the two quartiles, this ratio is $\exp(0.152 - 0.726) = 0.563$, so food is now about 44 percent cheaper in the top quartile.

bread within the bread and cereals group)? Some light can be shed on this issue by aggregating the 31 food items into 7 broader groups as indicated in column 1 of Table 3.1. Denote these groups by $\mathbf{S}_F^1, \dots, \mathbf{S}_F^7$ and define the share of total food expenditure allocated to group g and the share of group expenditure devoted to $i \in \mathbf{S}_F^g$ as

$$W_F^g = \sum_{i \in \mathbf{S}_F^g} w_i', \quad \bar{w}_i = \frac{w_i'}{W_F^g}, \quad i \in \mathbf{S}_F^g,$$

so that $\sum_{g=1}^7 W_F^g = \sum_{i \in \mathbf{S}_F^g} \bar{w}_i = 1$. These budget shares are given in columns 2-6 of Table 3.1 for the income quartiles. These reveal considerable dispersion in spending patterns across the income distribution, especially for the bread and cereals group, where the share falls from 29 to 14 percent in going from the bottom to top quartile. The index of prices within group g and the corresponding variance are

$$(3.2) \quad \log P_F^g = \sum_{i \in \mathbf{S}_F^g} \bar{w}_i \log p_i, \quad \Pi_F^g = \sum_{i \in \mathbf{S}_F^g} \bar{w}_i (\log p_i - \log P_F^g)^2.$$

Columns 7-11 of Table 3.1 contain the relative prices of the groups and the items within groups. In five of the seven cases, the relative prices of the groups fall as we move from the poorest to the richest countries.

With these groups, the price variance (3.1) can be decomposed into between- and within-group components:

$$(3.3) \quad \Pi_F = \sum_{g=1}^7 W_F^g (\log P_F^g - \log P_F)^2 + \sum_{g=1}^7 W_F^g \Pi_F^g.$$

The first term on the right-hand side is the between-group component of the total variance of food prices. This is a weighted variance of the prices of the groups, or a summary measure of the dispersion of relative prices of the groups. The second term is the within-group component, which is a weighted average of the variances within each of the 7 groups, Π_F^g , $g = 1, \dots, 7$.

Table 3.2 contains decomposition (3.3) and shows in columns 3 and 4 that the within-group variability of prices exceeds the between-group component by at least 40 percent. In other words, micro price differences are more important than those of the broad groups in accounting for the overall dispersion of food prices. From columns 5-11, the group variance for bread and cereals is the largest in all but the top quartile (where meat and seafood dominate). As the group variance Π_F^g in (3.2) -- which measures the dispersion of prices of members of the group -- is

independent of the size of the group, by itself the large share for bread and cereals for poorer countries does not account for the dominance of this group's Π_F^g . That is to say, the large value reflects only the large dispersion of relative prices within this group, not its size. However, the within-group component of the total variance, the last term on the right of (3.3), is $\sum_{g=1}^7 W_F^g \Pi_F^g$, which uses budget shares to weight the individual group variances. This means that for poorer countries, the large value of Π_F^g for bread and cereals is magnified by the large weight it receives in $\sum_{g=1}^7 W_F^g \Pi_F^g$.

The conclusion is that the higher dispersion of prices in low-income countries can be attributed to (i) the larger variability of prices within the broad food groups, as opposed to that between groups; and (ii) the important role of prices within the bread and cereals group.

4. A Model of Income-Dependent Prices

In light of the above finding of the role of income in determining food prices, this section starts with a stylised model of this process. We then apply this model to the cross-country food prices. The first sub-section draws on Clements et al. (2013).

A Stylised Model

Let q_i^s be the quantity of good i supplied and q_i^d be the corresponding quantity demanded. Let each of these quantities depend on the relative price of the good p_i/P . Additionally, both the supply of and demand for the product are taken to depend on real income Q . Assuming log-linearity:

$$\log q_i^s = \phi_i^s + \eta_i^s (\log p_i - \log P) + \theta_i^s \log Q, \quad \log q_i^d = \phi_i^d + \eta_i^d (\log p_i - \log P) + \theta_i^d \log Q,$$

where ϕ_i^s (ϕ_i^d) is the intercept of the supply (demand) function; $\eta_i^s > 0$ ($\eta_i^d < 0$) is the price elasticity of supply (demand); and θ_i^s (θ_i^d) is the income elasticity of supply (demand). The term Q in the demand function represents a conventional income effect. The appearance of Q in supply is less conventional and represents a “scale” variable measuring the tendency for a richer economy to produce more of the good (when $\theta_i^s > 0$). Next, define $\alpha_i' = (\phi_i^d - \phi_i^s) / \Delta_i$ and

$\beta'_i = (\theta_i^d - \theta_i^s) / \Delta_i$, where $\Delta_i = \eta_i^s - \eta_i^d > 0$ is the excess supply elasticity. Then, market clearing implies that $\log q_i^s = \log q_i^d$, or

$$(4.1) \quad \log p_i - \log P = \alpha'_i + \beta'_i \log Q.$$

The additional requirement for general equilibrium for the economy as a whole is that if some relative prices increase, they must be balanced by others that decrease. This is clearest if we define the price level as a budget-share weighted average of the prices of the n goods, that is, $\log P = \sum_{i=1}^n w_i \log p_i$. This implies $\sum_{i=1}^n w_i (\log p_i - \log P) = 0$, or that that weighted average of the relative prices is zero. This requirement can be incorporated into prices by employing the following two steps: First, multiply both sides of equation (4.1) by the budget share of good i and sum over $i = 1, \dots, n$. As $\sum_{i=1}^n w_i (\log p_i - \log P) = 0$, we have $0 = A + B \log Q$, where $A = \sum_{i=1}^n w_i \alpha'_i$ and $B = \sum_{i=1}^n w_i \beta'_i$ are budget share weighted means. Second, subtract $0 = A + B \log Q$ from both sides of (4.1) and multiply both sides by w_i to give

$$(4.2) \quad w_i (\log p_i - \log P) = \alpha_i + \beta_i \log Q,$$

where $\alpha_i = w_i (\alpha'_i - A)$ and $\beta_i = w_i (\beta'_i - B)$ are weighted deviations from their weighted means.

According to model (4.2), growth in income increases the relative price of good i if $\beta_i > 0$, which occurs when $\beta'_i = (\theta_i^d - \theta_i^s) / (\eta_i^s - \eta_i^d)$ is greater than the average, B . Accordingly, income growth increases the relative price of i when the ratio of the difference in the income elasticities in demand and supply to the excess supply elasticity is greater than average, and vice versa. Model (4.2) holds for $i = 1, \dots, n$ goods and the coefficients satisfy $\sum_{i=1}^n \alpha_i = \sum_{i=1}^n \beta_i = 0$. This model also implies that β_i / w_i is the income elasticity of the relative price of good i and that a budget-share-weighted average of these elasticities, $\sum_{i=1}^n w_i (\beta_i / w_i) = \sum_{i=1}^n \beta_i$, is zero.

Equation (4.2) is a reduced form and the coefficients are somewhat complex functions of their structural counterparts. Some further insight is available in the special case when (i) the excess supply elasticity is the same for each commodity: $\eta_i^s - \eta_i^d = \Delta_i = \Delta > 0$; and (ii) each income elasticity of supply is unity: $\theta_i^s = 1$. In this situation,

$$B = \sum_{i=1}^n w_i \left(\frac{\theta_i^d - \theta_i^s}{\Delta_i} \right) = \frac{1}{\Delta} \sum_{i=1}^n w_i (\theta_i^d - 1) = 0,$$

where the third step is based on the requirement that a budget-share-weighted average of the income elasticities of demand is unity. The income coefficient in (4.2) is then

$$(4.3) \quad \beta_i = \frac{1}{\Delta} w_i (\theta_i^d - 1).$$

As $1/\Delta$ and w_i are both positive, this shows that $\beta_i > 0$ for goods that are luxuries ($\theta_i^d > 1$) and negative for necessities ($\theta_i^d < 1$). Higher income increases the relative prices of luxuries and decreases those of necessities, which is an attractively simple result. Moreover, this agrees with the finding of Section 2 of the lower relative price of food (a necessity) in rich countries.

As $\sum_{i=1}^n w_i (\beta_i / w_i) = \sum_{i=1}^n \beta_i = 0$, the weighted variance of the income elasticities of the relative prices is $\sum_{i=1}^n w_i (\beta_i / w_i)^2 = \sum_{i=1}^n \beta_i^2 / w_i$, which in the case of (4.3) becomes

$$(4.4) \quad \sum_{i=1}^n \frac{\beta_i^2}{w_i} = \frac{1}{\Delta^2} \sum_{i=1}^n w_i (\theta_i^d - 1)^2.$$

The right-hand side of the above is proportional to the (weighted) variance of the income elasticities $\sum_{i=1}^n w_i (\theta_i^d - 1)^2$, where the proportionality factor is $1/\Delta^2 > 0$. A greater diversity of the quality of goods, in the eyes of the consumer, implies greater dispersion of income elasticities of demand and, from (4.4), greater variability of the income elasticities of the prices.⁶ For example, when all goods are of the same quality, the income elasticities of demand are all unity and there is no dispersion among the elasticities of the price. In this case, each $\beta_i = 0$, so relative prices are independent of income. By contrast, the more different are goods, the greater the impact of income growth on relative prices. While based on the simplified case of identical excess demand elasticities and equiproportional responses on the supply side to growth, this is still an intuitively plausible prediction.

Application

⁶ In the log-linear case, the weighted variance of the income elasticities is the income elasticity of the demand for quality, where quality is measured by the covariance between the change in consumption of each of the n goods and the income elasticities. See Clements and Gao (2012).

We now apply model (4.2) to the 31 basic headings for food in 154 of the 155 countries in Table 2.1 (the US is omitted as it is the base country). This application refers to prices within the food sector, so we consider the price of each food item relative to the price of all foods. As before, let w'_{ic} be the share of basic heading i (or “food” i) of total food expenditure in country c ; p_{ic} be the corresponding price; $\log P_{Fc} = \sum_{i=1}^{31} w'_{ic} \log p_{ic}$ be the food price index; and $Y_c = M_c/P_c$ be real income per capita in c . It is now convenient to measure income relative to the cross-country geometric mean, $\log(Y_c/\bar{Y}) = \log Y_c - 1/154 \cdot \sum_{c=1}^{154} \log Y_c$. After some experimentation, it was found to be desirable to allow the slope coefficient in (4.2) to vary across countries by taking the value β_i for the first and second income quartiles (to be referred to as “the rich countries”) and $\beta_i + \lambda_i$ for the others (“the poor”). Accordingly, equation (4.2) becomes

$$(4.5) \quad w'_{ic} \log(p_{ic}/P_{Fc}) = \alpha_i + (\beta_i + \lambda_i D_c) \log(Y_c/\bar{Y}) + \varepsilon_{ic},$$

where D_c is dummy variable that takes the value of 1 if the country belongs to the “poor” group and is 0 otherwise; and ε_{ic} is a disturbance term with $E(\varepsilon_{ic}) = 0$ and $E(\varepsilon_{ic}^2) = \sigma_i^2$. As $\log(Y_c/\bar{Y}) = 0$ for the country with mean income, α_i/w'_{ic} is interpreted as the expectation of that country’s relative price of i . The coefficients satisfy the constraints $\sum_{i=1}^{31} \alpha_i = \sum_{i=1}^{31} \beta_i = \sum_{i=1}^{31} \lambda_i = 0$.

The estimates of model (4.5) for $i = 1, \dots, 31$ are given in Table 4.1. As can be seen, most of the intercepts are significant, which is to be expected since these are related to the prices in the average country, as discussed above. The negative sign of the first coefficient of column 2, for example, indicates that rice is significantly cheaper than other products in this average country. Many of the income coefficients for the rich countries (in column 3) are also significant, and several marginal effects for the poor are also significant (column 4). Columns 6 and 7 reveal that the largest income elasticity is for the price of rice in both the rich and poor countries; the smallest is for other cereals, again for both groups of countries. Finally, note from the last row of the table that the variance of the income elasticities of the prices for the rich countries is about 60 percent more than that for the poor. Under the simplifying assumptions mentioned above, this

implies considerably greater dispersion among the income elasticities of demand for the rich, or more diversity the quality of food consumption.⁷

⁷ We also tried other versions of model (4.5) with different specifications for the dummy for poor countries. These included (i) no poor dummy; (ii) poor dummies for the intercepts only; (iii) both intercept and slope dummies; and (iv) four income groups (one for each income quartile) instead of two. In all instances, the poor dummies were not statistically significant at the 10 percent level.

5. Exchange Rates and Prices

In the absence of trade barriers, prices of the same good in different countries are linked by the law of one price (LOP). In its simplest form, the LOP states that an identical good will sell for the same price, expressed in terms of a common currency, in different locations, so that prices will be equalised across countries. The mechanism that brings equalisation about is arbitrage -- buying where the price is low and selling where it is high -- eliminates price differences. It is difficult, however, to find many commodities that conform to LOP in this stark, unalloyed form, but gold, with its high value-to-weight ratio and lack of barriers to international trade, might come close. Below, we discuss the main impediments to the LOP holding -- transport costs (interpreted broadly) and nontraded goods.⁸

Transport Costs

In the absence to barriers to trade, a good is exported if the world price (p^*) exceeds the domestic price (p), while the good is imported if the reverse is true. In the presence of transport costs, the gap has to be sufficiently wide to cover these costs. The good does not enter into international trade when this condition is not satisfied. Thus, if transport costs are a fraction α of the producer price and assuming transport is paid for by the seller, the good is

$$(5.1) \quad \text{Exported if } p < \frac{p^*}{(1+\alpha)}; \text{ imported if } p > p^*(1+\alpha); \text{ otherwise, nontraded.}$$

Condition (5.1) gives a range of prices for which the good is not traded, as in Figure 5.1 (Dornbusch, 1980, pp. 94-95). Given transport costs and a world price of p_0^* , when the domestic price is below $\underline{p}$, and we are at a point such as X, the good is imported; and when it is above $\bar{p}$ (at Z, for example), it is exported. For a price anywhere in the range $\bar{p} - \underline{p}$ (such as Y), the good is nontraded. This shows that as transport costs fall, the area of the “nontraded cone” shrinks and more goods would enter into international trade, other things remaining unchanged. Perhaps this is consistent with the trade expansion effects of the introduction of refrigerated shipping in the 1870s and containerisation in the 1950s and beyond. The figure also demonstrates the impact of domestic costs on tradability: Suppose the commodity is initially exported (point Z). Then, if

⁸ The macroeconomic counterpart to the LOP is the purchasing power parity (PPP) hypothesis whereby the value of the country's currency is equal to the ratio of prices at home to those abroad. On an even broader scale, PPP is one of the key building blocks of the monetary approach to exchange rates (Frenkel and Johnson, 1978).

costs and the price at home rise sufficiently and the world price remains unchanged, the good could transition first to being nontraded, and then imported, as the economy moves from the point Z to Y and then X.

Nontraded Goods

Traded goods – those that enter into international trade – have prices determined in world markets. In the absence of barriers to trade, they could be expected to tend to satisfy the LOP, once transport costs are allowed for. The prices of the nontraded goods are determined by local conditions, so there is no strong reason for these to comply with the LOP. Many goods are neither purely traded nor nontraded, but a mixture made up of some raw materials, such as minerals and agricultural products (traded goods) and nontraded goods, the costs of which include wages, local taxes and charges, property rents and so on. In terms of Figure 5.1, as the relative importance of the nontraded inputs increase, the price points move (from above and below) towards the nontraded cone.

To illustrate the role of nontraded goods further, let the price of a commodity be p and the unit costs of traded and nontraded inputs be C_T and C_N . If the industry is competitive, prices are driven down to costs, so that $p = C_T + C_N$, or $p = C_T(1 + \gamma)$, where $\gamma = C_N/C_T$ is the ratio of nontraded to traded costs. Equivalently, $\gamma/(1 + \gamma) = C_N/(C_T + C_N)$ is the share of nontraded in total costs, so that if, for example, nontraded costs are one half those of traded, $\gamma = 0.5$ and $\gamma/(1 + \gamma) = 0.33$. A logarithmic comparison of the price of the good at home with that abroad, both expressed in the same currency, is

$$\log \frac{p}{p^*} = \log \frac{C_T}{C_T^*} + \log \frac{1 + \gamma}{1 + \gamma^*},$$

where the asterisk denotes the foreign country. When the traded goods costs are equalised, the first term on the right of the above vanishes, so that

$$(5.2) \quad \log \frac{p}{p^*} = \log \frac{1 + \gamma}{1 + \gamma^*} \approx \gamma - \gamma^*.$$

This reveals that if the nontraded inputs account for the same fraction of total costs in the two countries, then prices are equalised. When $\gamma = \gamma^*$ the costs of traded goods are scaled up by the same amount in each country, so that equalisation of traded goods costs amounts to equalisation

of the whole price of the commodity. This demonstrates that nontraded goods *per se* do not prevent the LOP from holding. Rather, when the fraction of the price attributable to nontraded goods differs, the two prices differ according to equation (5.2).

Examples

As a preface to the tests of the LOP in subsequent sections, we shall use a couple of simple examples that help fix ideas. The first is the price of Big Mac (BM) hamburgers in 2011 for 57 countries, converted to US dollars using market exchange rates.⁹ The second is GDP per capita in 2011 in 175 countries, converted to US dollars using (i) market exchange rates, and (ii) PPP rates from the International Comparisons Program (World Bank, unpublished). Taken literally, if these prices satisfied the LOP, there would be no dispersion across countries as the prices would be equalised. Clearly, this is not the case in Figures 5.2 and 5.3, where with the standard deviation of the BM prices at about 35 percent and those of the two versions of GDP much higher.

However, panel A of Figure 5.4 reveals a surprisingly close relation between BM prices in local currency units and exchange rates; the slope coefficient here is 0.95, close to the LOP value of 1. But the relationship is weaker in panel B for GDP and PPP exchange rates and even weaker for GDP and market rates (panel C). As GDPs are even less tradable than BMs, we would not expect them to exhibit as close a relation to exchange rates. Moreover, as PPP exchange rates include the prices of both traded and nontraded goods, they better reflect the whole spectrum of prices underlying GDP, so it is understandable that they track GDP better than market rates.

6. Prices of 198 Food Items in 175 Countries

In this section, we move from indexes of the prices of groups of goods to something closer to the actual prices paid by consumers and use unpublished data from the 2011 round of the ICP on 198 items of food in 175 countries.¹⁰

⁹ The data are from *The Economist* (ongoing). The BM prices form the basis for *The Economist*'s famous Big Mac Index and "burgernomics". The early burgernomics papers were by Click (1996), Cumby (1996) and Ong (1995, 1997); for a review, see Clements et al. (2012).

¹⁰ These product level items disaggregate the "basic headings" used earlier in the paper. For more information, see the Appendix.

Let p_{ic} be the price of item i in country c in local currency units (LCUs) and S_c be the exchange rate for the currency of c , defined as the cost in LCUs of \$US1. Thus, a depreciation of the local currency means S_c rises. Define the world price of i , measured in \$US, as p_i^* , so that $p_i^* \times S_c$ is the world price in LCUs. Under the strong version of the LOP, the domestic price equals the world price; that is, using LCUs, $p_{ic} = p_i^* \cdot S_c$. An example of the use of the strong version is the absolute PPP calculations underlying the Big Mac index of The Economist magazine. According to the weak version of the law, domestic and world prices are proportional. Suppose now that $p_{ic} = e^{k_{ic}} \cdot p_i^* \cdot S_c$, where $e^{k_{ic}}$ a proportionality “wedge” factor, defined as the ratio of prices, $e^{k_{ic}} = p_{ic} / (p_i^* \cdot S_c) \approx 1 + k_{ic}$. The strong version of the LOP corresponds to $k_{ic} = 0$. In a conventional time-series context, the weak version of the law means that the wedge between prices is a constant over time. In a cross-country (or cross-commodity) setting, the wedge is constant over countries (or commodities). The implication of the weak version is that the domestic price is proportional to the exchange rate and/or the world price; that is, the elasticity is unity. In logs, $p_{ic} = e^{k_{ic}} \cdot p_i^* \cdot S_c$ becomes

$$(6.1) \quad \log p_{ic} = k_{ic} + \log p_i^* + \log S_c .$$

We proxy the world price as a weighted average of the prices of the item in each country, with weights reflecting relative importance. Ideally, information on the relative importance at the product level should be used, but this is not available. The next best alternative is to use information from one level higher, that is, information pertaining to the corresponding basic heading. Thus, for example, for a given country, Jasmine rice and Basmati rice, both members of the basic heading “rice”, are accorded the same weight. To set out the weighting scheme, let C_i denote the set of countries in which product i ($i = 1, \dots, n$) is represented in the data and let real consumption of i in country $c \in C_i$ be q_{ic} . Products are aggregated into $G < n$ basic headings, denoted by $X_g, g = 1, \dots, G$. Measuring in US dollars so units are comparable, $Q_{gc} = \sum_{i \in X_g} q_{ic}$ is consumption of group g in $c \in C_i$, $Q_{g\cdot} = \sum_{c \in C_i} Q_{gc}$ is world consumption of i and $w_{gc} = Q_{gc} / Q_{g\cdot}$ is country c 's share, with $\sum_{c \in C_i} w_{gc} = 1$. The world price of i is defined as a weighted geometric mean of the country prices, the logarithm of which is

$$\log p_i^* = \sum_{c \in C_i} w_{gc} \log \left(\frac{p_{ic}}{S_c} \right), \quad i \in X_g, \quad i = 1, \dots, 198.$$

While this approach is not perfect, in the absence of direct information on world prices, it seems a reasonable working approximation.

The departure from the LOP is, from (6.1),

$$(6.2) \quad k_{ic} = \log p_{ic} - \log p_i^* - \log S_c.$$

International competitiveness is sometimes measured by the price level at home (P) relative to that abroad, adjusted for the exchange rate ($S \cdot P^*$), in the form $\log(P/S \cdot P^*)$, which is known as the real exchange rate. Accordingly, measure (6.2) can be termed the “real relative price of commodity i in country c ”. The measure is “real” as there are no currency units, and “relative” as it compares the domestic and world prices. As it is unit free, it is comparable across commodities and countries.

To apply the above to the ICP data, the countries in the set C_i are those for which prices are available. The left part of panel A of Figure 6.1 is a frequency distribution of k_{ic} for all commodities and countries. The mean is about 16 percent and the distribution seems to be reasonably symmetric. Importantly, there is substantial dispersion as the logarithmic standard deviation is 0.55, or more than 50 percent; and from the cumulative distribution on the right of the panel, only 40 percent of observations lie in the range $[-0.3, +0.3]$. Panel B shows that if we average over commodities, there is some compression -- the dispersion of the country means is considerably lower at about 27 percent and 65 percent now lie in the range $[-0.3, +0.3]$. Somewhat more compression emerges with the commodity means in panel C. One might imagine that with price differences of this order of magnitude, there must be major barriers that prevent arbitrage. But it is worth repeating that these are consumer goods, many of which contain large nontraded components; and by their very nature, the “prices” of nontraded components are not (cannot) be equalised across countries. Add to that the additional barriers such as transport costs, costs implicit in complying with health and safety regulations and the usual explicit taxes and charges that many governments impose on imported goods, and it becomes easier to understand the price differentials.

Figure 6.2 gives some more detail of the distribution of prices. Box plots of the commodities with the smallest and largest price dispersion are given in panel A. Irish whiskey

and cream liqueur have the lowest spread, perhaps reflecting these are fairly standardised products. Additionally, international travellers are known to actively arbitrage price differences for spirits.¹¹ Then comes whole chicken and tomato paste. Interestingly, these low-spread commodities have standard deviations (SDs) of the same order of magnitude as that of Big Mac hamburgers, viz., 20-35 percent. The agreement between the minimum-dispersion ICP commodities and Big Macs would seem reassuring if only because The Economist magazine regards the Big Mac as an “idealised” homogeneous good, well suited to PPP calculations based on the LOP. Chilies, cassava and bean curd are at the other end of the distribution with the highest dispersion (again in panel A of Figure 6.2). The SDs of these fall in the range 75-100 percent, which is substantially less than that of the two measures of GDP discussed in Section 5 (120-160 percent). Evidently, even the high-dispersion commodities are more tradable than GDP, which is quite reasonable. Panel B of the figure contains the countries with the lowest and highest dispersion – the differences between the low- and high-dispersion countries are smaller than the low-high differences for the commodities discussed above.

What might be the role of country affluence on relative prices? Richer countries possibly have deeper, more sophisticated markets and more often than not, fewer distortions, so prices in richer countries could be closer to their world counterparts, at least on average. If this were the case, the dispersion of prices in rich countries would be lower than that in poor ones. Figure 6.3, a cross-country scatter of the standard deviation of prices against income per capita, seems to support this idea as there is a broad tendency for dispersion to fall as income increases.

7. More on Exchange Rates and Prices

In this section, we test the law of one price using the ICP data presented in the previous section. Most tests of the LOP involve time-series data; by contrast, the tests that follow are carried out across countries for each item, and across items for each country.

Cross-Country Regressions

In view of equation (6.1), consider a cross-country regression for item i :

$$(7.1) \quad \log p_{ic} = \tilde{\alpha}_i + \beta_i \log S_c + \phi_i k_{ic} + \tilde{\varepsilon}_{ic},$$

¹¹ It should also be noted that these prices come mostly from richer countries.

where the intercept $\tilde{\alpha}_i = \log p_i^*$, a constant for all countries; β_i and ϕ_i are coefficients; and $\tilde{\varepsilon}_{ic}$ is a zero-mean disturbance term. Under the LOP, $\beta_i = \phi_i = 1$. Suppose that for a given i , the wedge has a constant component, α_{k_i} , so that $k_{ic} = \alpha_{k_i} + (k_{ic} - \alpha_{k_i})$. The problem is that we cannot observe k_{ic} in equation (7.1), so it becomes an omitted variable in the implementable regression

$$(7.2) \quad \log p_{ic} = \alpha_i + \beta_i \log S_c + \varepsilon_{ic},$$

where $\alpha_i = \tilde{\alpha}_i + \phi_i \alpha_{k_i}$ is the intercept and $\varepsilon_{ic} = \phi_i (k_{ic} - \alpha_{k_i}) + \tilde{\varepsilon}_{ic}$ is a new disturbance term. As long as k_{ic} and $\log S_c$ are uncorrelated, the OLS estimator of β_i will be unbiased (but inefficient). Obviously, if for a given item i , k_{ic} is the same across countries and only the intercept is affected, but this would seem unlikely to occur in practice.

Equation (7.2) is estimated across countries for $c = 1, \dots, C_i \leq 175$ observations for item i ; and this regression is repeated for each of the $i = 1, \dots, 198$ food items. The 198 estimates of the slope coefficient β_i are given in Table 7.1 and plotted in Figure 7.1. The mean and median of the estimates are 0.96 and 0.97, respectively. The majority are not too far away from 1, the value implied by the LOP; from the cumulative distribution on the left of panel C of Figure 7.1, about 58 percent of the estimates are within the range 1 ± 0.05 . There is still considerable dispersion among the estimates, which range from 0.81 (for sweet potatoes) to 1.06 (lemonade) and their standard deviation is 0.05. It must also be acknowledged that a number of coefficients are significantly different from unity (from the right side of panel C of the figure, 65 percent), contradicting the LOP. But there does not seem to be any particular pattern to the estimates, other than the important property that the slope coefficients are clearly centred on a value close to unity.

The above tests use consumer prices that typically contain substantial elements of packaging and retailing, components that are mostly non-traded goods/services. For this reason, it might be plausibly argued that the LOP rejections are surprisingly modest. This position cannot be stated too firmly, however, due to the omitted-variable problem and the substantial percentage of slope coefficients significantly different from unity.

Cross-Commodity Regressions

For a given country c the exchange rate S_c is constant, so the cross-commodity version of equation (7.1) is $\log p_{ic} = \tilde{\alpha}'_c + \beta'_c \log p_i^* + \phi'_c k_{ic} + \tilde{\varepsilon}'_{ic}$, where the intercept $\tilde{\alpha}'_c = \log S_c$. Expressing the wedge as $k_{ic} = \alpha'_{kc} + (k_{ic} - \alpha'_{kc})$, where α'_{kc} is the constant component for country c , the cross-commodity implementable regression takes the form

$$(7.3) \quad \log p_{ic} = \alpha'_c + \beta'_c \log p_i^* + \varepsilon'_{ic},$$

where $\tilde{\alpha}'_c = \log S_c + \phi'_c \alpha'_{kc}$, a constant for all items; β'_c is a coefficient; and $\varepsilon'_{ic} = \phi' (k_{ic} - \alpha'_{kc}) + \tilde{\varepsilon}'_{ic}$ is a disturbance. The LOP for the country as a whole implies $\beta'_c = 1$, or that the elasticity of domestic prices with respect to world prices is unity. As before, there is an omitted-variable issue due to the neglect of the wedge factor.¹²

For country c equation (7.3) is estimated with data on $n_c \leq 198$ items and the estimated slope coefficients are given in Table 7.2 and Figure 7.2. These estimates are somewhat lower than previously -- the mean and median are 0.92 and 0.93. Their standard deviation is now about twice as large at 0.11. The proportion of the slopes falling in the range 1 ± 0.05 is now smaller at 27 percent (previously 58 percent); 53 percent are significantly different from unity (less than before, when this percentage was 65). There is no clear pattern in the estimates across countries.

That the estimates are, on average, not so far from unity in this case is perhaps also surprising. In addition to the issue of using of consumer prices mentioned above, there are two more reasons for surprise for this result. First, the approach used to proxy world prices is only a first approximation and certainly imperfect. Any measurement error in the world price leads to a downward bias in the estimated slope coefficients. Second, the orthogonality condition for unbiasedness with the omitted variable would seem more problematic in this case. This condition requires that the price wedge be uncorrelated with world prices. This would appear to rule out the (probably not unusual) case when following a decline in world prices, a country imposes import tariffs and the like in order to stabilise prices and protect its import-competing producers.

8. Producer Prices

¹² It is to be noted that (7.3) does not involve a regression of prices on themselves. Rather, it is a regression of the prices of the commodities produced in country c on the corresponding world prices. The world prices are the cross-country weighted means of the prices, converted from local currency units to \$US.

The previous material analysed the law of one price with a cross section of countries for one year. We now augment this with tests with an added time dimension to consider the prices of a number of commodities across countries and time, so the data are in the form of a series of panels. Another difference is that previously prices paid by consumers were used, while in this section prices received by producers are employed. Producer prices possibly come closer to international trade transaction prices, so the arbitrage mechanism underlying the LOP might operate more effectively in this case.

For domestic prices, we use annual price data from the Food and Agriculture Organization (FAO) on 208 food and agricultural items in 162 countries over the 24-year period 1991 – 2014 (FAO, online). These are prices “received by farmers...as collected at the point of initial sale (prices paid at the farm-gate)” (FAO, online). For the world price, we adopt the approach of Mundlak and Larson (1992) and use a weighted average of export prices, with weights reflecting the relative importance of each country in international trade. Let x_{ict} be the real value of exports of commodity i ($i = 1, \dots, n$) from country c ($c = 1, \dots, C$) in year t , measured in \$US, so that $X_{ct} = \sum_{c=1}^C x_{ict}$ is “world” trade in the commodity and $w_{ict} = x_{ict}/X_{ct}$ is country c ’s share. The world price, in logarithmic form, of i in t is defined as

$$(8.1) \quad \log p_{it}^* = \sum_{c=1}^C w_{ict} \log \left(\frac{p_{ict}^x}{S_{ct}} \right), \quad i = 1, \dots, n \text{ items},$$

where p_{ict}^x is the corresponding export price in c , in local currency units, and S_c is country c ’s exchange rate against the \$US. This approach to measuring world prices is similar to that used in Section 6. The export data are also from FAO (online).

As before, the deviation from the LOP is $k_{ict} = \log p_{ict} - \log p_{it}^* - \log S_{ct}$, the difference between the domestic price and the world price. The term k_{ict} is also called the real relative price of commodity i in country c . Panel A of Figure 8.1 presents distributions of the k_{ict} . The mean is -0.27, which may not be considered to be too large in view of recent estimates of trade costs.¹³

¹³ Anderson and van Wincoop (2004) roughly estimate the total trade cost for a rich country to be equivalent to a 170-percent ad-valorem tax. This encompasses both domestic (retail and wholesale distribution) and international (transport and border-related trade barriers) costs of around 55 percent and 74 percent, respectively. The authors draw upon a mixture of literature that employ direct and indirect (inference from trade volumes and prices) measures to determine trade costs; however, they emphasise the incomplete and sparseness of data available across countries. According to Anderson and van Wincoop, policies that directly affect trade, such as tariffs and quotas, are less

But the dispersion is high as the standard deviation is 0.86 and the tails of the distribution are long with only about 25 percent of the observations lying in the range $[-0.3, 0.3]$. Panels B and C of the figure plot, for all years, the distribution of the country means, $\bar{k}_{\cdot t} = \frac{1}{n} \sum_{i=1}^n k_{ict}$, and the commodity means, $\bar{k}_{i \cdot t} = \frac{1}{C} \sum_{c=1}^C k_{ict}$. The variance of the former (which measures the country effect) is $0.58^2 = 0.34$, while that of the latter (the commodity effect) is $0.53^2 = 0.28$, reconfirming the dominance of the country effect. The greater variance of the cross-country component is largely due to extreme values in both tails.¹⁴

9. Variance Decompositions

In this section, we use the FAO data to investigate the source of deviations from the LOP with descriptive decompositions of their variance. Assuming for simplicity a balanced structure for each panel, the mean and variance of the deviations, over all countries and commodities, at time t are:

$$\bar{k}_{\cdot t} = \frac{1}{nC} \sum_{i=1}^n \sum_{c=1}^C k_{ict}, \quad \sigma_{\cdot t}^2 = \frac{1}{nC} \sum_{i=1}^n \sum_{c=1}^C (k_{ict} - \bar{k}_{\cdot t})^2.$$

These can be termed the grand mean and variance at time t . If there are T years, we have T grand variances, $\sigma_{\cdot 1}^2, \dots, \sigma_{\cdot T}^2$. Define the overall grand variance as the mean

$$\sigma_{\cdot \cdot}^2 = \frac{1}{T} \sum_{t=1}^T \sigma_{\cdot t}^2.$$

Is it the variability over commodities or countries that contribute most to the grand variance? We shall investigate this issue using two decompositions of $\sigma_{\cdot t}^2$.

A Commodity Decomposition

Consider the real price of commodity i in the C countries, $k_{i1t}, \dots, k_{iCt}$. The mean and variance are

$$\bar{k}_{i \cdot t} = \frac{1}{C} \sum_{c=1}^C k_{ict}, \quad \sigma_{i \cdot t}^2 = \frac{1}{C} \sum_{c=1}^C (k_{ict} - \bar{k}_{i \cdot t})^2.$$

important for trade costs than other policies such as those pertaining to transport infrastructure, property rights, regulation and language. Thus, developing countries generally have much higher trade costs. Trade costs also vary substantially across products.

¹⁴ Comparing Figures 6.1 and 8.1, it can be seen that the dispersion of the deviations of the producer prices exceeds that of the consumer prices. This might be accounted for by the additional time variation in the producer prices.

A natural measure of the dispersion of prices of all n commodities is the mean of $\sigma_{i,t}^2, \dots, \sigma_{n,t}^2$, that is, $\frac{1}{n} \sum_{i=1}^n \sigma_{i,t}^2$. The conventional label for this mean might be the “within-commodity variance”. But $\sigma_{i,t}^2$ refers to differences across countries of the prices of the same commodity; the more dispersion among the deviations across countries, the larger is $\frac{1}{n} \sum_{i=1}^n \sigma_{i,t}^2$. Accordingly, it is more useful to refer to this mean as the cross-country component of the grand variance:

$$\theta_{\text{Cross-country},t}^2 = \frac{1}{n} \sum_{i=1}^n \sigma_{i,t}^2.$$

The corresponding “between-commodity variance” is the dispersion of the commodity means around the grand mean, which shall be referred to as the cross-commodity variance:

$$\theta_{\text{Cross-comm},t}^2 = \frac{1}{n} \sum_{i=1}^n (\bar{k}_{i,t} - \bar{k}_{..t})^2,$$

where $\bar{k}_{..t} = \frac{1}{n} \sum_{i=1}^n \bar{k}_{i,t} = \frac{1}{nC} \sum_{i=1}^n \sum_{c=1}^C k_{ict}$ is the grand mean. Using the above concepts, it can be easily shown that the grand variance is made up of the country and commodity components:

$$(9.1) \quad \sigma_{..t}^2 = \theta_{\text{Cross-country},t}^2 + \theta_{\text{Cross-comm},t}^2.$$

A Country Decomposition

Next, consider the price of each of the n commodities in country c , $k_{1ct}, \dots, k_{nct}$. The mean and variance are

$$\bar{k}_{.ct} = \frac{1}{n} \sum_{i=1}^n k_{ict}, \quad \sigma_{.ct}^2 = \frac{1}{n} \sum_{i=1}^n (k_{ict} - \bar{k}_{.ct})^2.$$

The mean of the C variances, $\sigma_{.1t}^2, \dots, \sigma_{.Ct}^2$, is the within-country dispersion of prices. As this measures the variability of prices across commodities, we shall call this the cross-commodity variance,

$$\phi_{\text{Cross-comm},t}^2 = \frac{1}{C} \sum_{c=1}^C \sigma_{.ct}^2.$$

The dispersion of the country means around the grand mean is

$$\phi_{\text{Cross-country},t}^2 = \frac{1}{C} \sum_{c=1}^C (\bar{k}_{.ct} - \bar{k}_{..t})^2,$$

where $\bar{k}_{..t} = \frac{1}{C} \sum_{c=1}^C \bar{k}_{.ct} = \frac{1}{nC} \sum_{i=1}^n \sum_{c=1}^C k_{ict}$. The grand variance can then be decomposed into new commodity and country effects:

$$(9.2) \quad \sigma_{..t}^2 = \phi_{\text{Cross-comm},t}^2 + \phi_{\text{Cross-country},t}^2.$$

Decompositions (9.1) and (9.2) both yield measures of the commodity and country variance. Due to the different basis underlying each decomposition, in general the effects are not the same, however. Something can be said about the discrepancy as equations (9.1) and (9.2) imply that the differences in the two types of variances coincide:

$$(9.3) \quad \theta_{\text{Cross-country},t}^2 - \phi_{\text{Cross-country},t}^2 = \phi_{\text{Cross-comm},t}^2 - \theta_{\text{Cross-comm},t}^2 \neq 0.$$

Application

Column 2 of Table 9.1 gives the grand standard deviation of the deviations from the LOP in each year for the FAO data.¹⁵ As can be seen, this starts off at about 1 in the early 1990s and then tends to decrease to end up at 0.80 in 2013. This 20-percent decrease in variability suggests markets are becoming more integrated over time, which is indirect evidence of reduced trade barriers of all kinds (trade policy, transport costs, information gaps, etc.).

The commodity-wise variance decomposition is given by equation (9.1). The values of the country and commodity components, expressed as percentages of the total, are contained in columns 3 and 4 of Table 9.1. The cross-country component clearly dominates as in most years it accounts for something like two-thirds or more of the grand variance. A different picture emerges for the country-wise decomposition [equation (9.2)]: From column 5, in the early years, the cross-country component is 50 percent or more; it then falls, before rising again to more than 50 percent in 2010-2012, and finally falls once more to end at 37 percent in 2013. Which measure should be relied upon? As the standard deviation of column 3 is less than one-fifth of that of column 5, it seems reasonable to use the former and conclude that the country effects dominate departures from the law of one price.

¹⁵ As the panels are unbalanced, equations (9.1)-(9.3) now hold only approximately for two reasons. First, some of the panels yield a single observation for some countries and commodities. That is, some items are only produced by one country in a year and some countries only produce one item in a year. As their inclusion would distort our measures of dispersion, these panels are omitted. Since the number of omitted panels differs between the cross-country and cross-commodity measures for the same year, equation (9.3) no longer holds exactly. Second, of the items with more than one observation in the commodity decomposition, the number of missing countries varies from item to item, whereas the above definitions of $\theta_{\text{Cross-country},t}^2$ and $\theta_{\text{Cross-comm},t}^2$ do not allow for this. Therefore, the grand variance computed directly from the unbalanced data is different from the sum of these components. The same problem also applies to the country decomposition.

10. Are the Deviations Stationary?

Suppose that in some year the domestic and world prices are not equalised. The law of one price would then mean that deviation would be eliminated in subsequent years, that is, the deviations are stationary. In this section, we use the FAO data to test for the stationarity of the mispricing terms k_{ict} using the panel model:

$$(10.1) \quad \Delta k_{ict} = \alpha_c + \beta_c k_{ic,t-1} + \sum_{p=1}^{m_c} \phi_{cp} \Delta k_{ic,t-p} + \varepsilon_{ict}, \quad c = 1, \dots, C_i.$$

The hypothesis is then $H_0 : \beta_c = 0$ for $c = 1, \dots, C_i$. A popular approach was proposed by Choi (2001), whereby the alternative is $H_A : \beta_c < 0$ for at least one c ; that is, the deviation is mean-reverting in at least one country. The lag order m_c is determined by the Akaike Information Criterion, and varies across countries. Significant negative values of β_c provide evidence against the null hypothesis, implying that the deviations mean revert.

This approach uses the combination of significance levels derived from individual unit-root test statistics as follows:

- Let G_c be the one-sided unit-root test statistic for country c (this is an ADF test statistic in our case, but it could be any unit root test). The asymptotic p-value for G_c is $p_c = F(G_c)[1 - F(G_c)]$, where $F(\cdot)$ denotes the continuous distribution function corresponding to the random variable G_c under the null.
- The combined test statistic is $Z = \frac{1}{\sqrt{C_i}} \sum_{c=1}^{C_i} \Phi^{-1}(p_c)$, where $\Phi(\cdot)$ is the standard normal cumulative distribution function and C_i is the number of countries producing item i . Here the p-values are used to define the so-called “probits” $t_c = \Phi^{-1}(p_c)$. Because each probit has a standard normal distribution by construction, this procedure is commonly referred to as an “inverse-normal method”. Under the assumption of independent disturbances, Choi (2001) shows that Z follows an asymptotic standard normal distribution under the null.

Among the major advantages of this approach are (i) the allowance for country-specific intercepts and slope coefficients; and (ii) the number of time periods can vary across countries, that is, the panel can be unbalanced. Additionally, the test is applicable when the number of

countries is large relative to the number of time periods. However, the main problem is that the Choi test does not account for cross-sectional dependence among the disturbances. This would seem to be important in agricultural market where common shocks to prices (such as a surge in demand) frequently occur. The dominant role of the US dollar in world markets means that a shock to that currency would possibly be transmitted to prices across countries, giving rise to further cross-sectional dependence. Ignoring such dependence could lead to size distortion and reduce much of the gain in power associated with the panel approach (O'Connell, 1998).

Hartung (1999) pointed out that dependency in the original test statistics G_c can be characterized by the correlation among the probits t_c . He assumes a constant correlation structure of the t_c and derives a consistent estimator using the observed t_c together with a weighted inverse-normal test statistic that shall be denoted Z^* -stat. Demetrescu et al. (2006) show this test is robust to deviation from the constant correlation assumption when the original statistics G_c are multivariate normal. Even when normality does not hold, Z^* -stat has a superior performance for medium and strong correlations relative to tests that ignore cross-sectional dependence.

For each commodity, we estimate system (10.1) and Table 10.1 and Figure 10.1 contain the results. The mean Z^* -stat and p-value are -3.24 and 0.06. Panel B of Figure 10.1 shows that in more than 75 percent of cases (commodities), the Z^* -stat is smaller than the 5-percent critical value of a standard normal distribution (which is about -1.64, using a one-tail test). Thus, for about three-quarters of the commodities we reject the null of a unit root with a 95-percent confidence. It seems safe to conclude the deviations mean-revert, which is evidence favourable to the law of one price.

11. Concluding Comments

The law of one price (LOP) states that identical goods sell at the same price. From microeconomic fundamentals, when prices are not equalised welfare can be improved by reallocating the product from the cheap location to the expensive one. The LOP is also important as it is at the heart of the purchasing power parity (PPP) theory of exchange rates, according to which the international value of the currency is the ratio of prices at home to those abroad. In the strong form of the LOP, prices are equalised absolutely. An example of an application of the strong version of the LOP is the popular Big Mac Index (BMI) of The Economist magazine. The

BMI declares the currency of a country vis-à-vis the US dollar is over-valued when its hamburger price exceeds that in the US (and vice versa for an undervalued currency). The weak version of the law says domestic prices are only proportional to their world counterparts, and are not necessarily equal. When the proportionality factor is constant over time, for example, the weak version implies that the elasticity of domestic prices with respect to world prices is unity. One objective of the paper was to instigate the workings of the LOP with food and agricultural products. Another objective was to examine key characteristics of food prices paid by consumers – how the relative price of food and the dispersion of the prices of food items vary with the country's per capita income.

There were two basic parts to the paper. In the first part, we used data from the International Comparisons Project of the World Bank on consumer prices of food in a large number of countries in 2011 to show that (i) prices decline substantially as countries become richer; (ii) the dispersion of prices also falls with increasing affluence of countries; (iii) the prices of (a) rice and (b) other cereals and flour are particularly sensitive to country income, but the effects differ depending on whether the country is in the “rich” or “poor” group; and (iv) the LOP is rejected more often than not.

The second part of the paper dealt with producer prices of 124 agricultural products over countries and time. Using a panel-unit-root procedure, we tested for the LOP and found that in about three-quarters of the cases, the deviations from the law are stationary. Thus, prices mean revert to satisfy the LOP in its weak form. That the LOP seems to hold for such a large proportion of products might come as a surprise, especially as there was no attempt to control for commodity-specific factors, such as transport costs, import tariffs and other impediments to the equalisation of prices.

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Table 2.1 Income and Food in 155 countries in 2011

Country	Income	Food (×100)			Country	Income	Food (×100)		
	US = 100	Budget share	Relative price	Price SD		US = 100	Budget share	Relative price	Price SD
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
A. First quartile					B. Second quartile				
1. Bermuda	110.7	10.0	8.4	27.6	40. Anguilla	47.3	14.6	30.0	29.9
2. United States	100.0	6.9	0.0	0.0	41. Bahrain	47.2	13.5	20.2	43.9
3. Cayman Islands	95.3	7.0	35.0	28.6	42. Czech	43.4	16.3	16.9	21.3
4. Hong Kong	88.1	11.4	24.1	30.2	43. Bahamas	43.1	10.5	27.6	32.7
5. Norway	87.7	10.5	23.1	26.1	44. Trini. & Tob.	42.6	21.7	51.7	31.8
6. Luxembourg	85.2	9.4	-20.9	30.6	45. Poland	40.9	19.0	14.4	22.9
7. Switzerland	82.0	9.5	-7.6	43.3	46. Slovakia	40.3	17.4	20.6	21.8
8. UAE	77.2	11.8	10.1	32.7	47. Barbados	39.0	15.0	35.5	39.4
9. Sweden	76.3	9.9	0.7	23.9	48. Lithuania	38.6	25.5	19.7	24.3
10. Germany	75.1	10.2	1.1	31.2	49. Oman	37.5	19.5	30.0	36.8
11. Australia	74.6	10.2	7.2	19.8	50. St. Kitts & Nevis	37.2	19.2	60.1	30.8
12. Austria	74.5	9.6	7.2	29.6	51. Croatia	36.5	22.2	34.9	19.8
13. Denmark	73.6	9.0	1.6	26.8	52. Hungary	36.4	17.2	30.3	26.5
14. Canada	73.5	9.0	18.5	15.1	53. Russia	35.6	30.4	38.0	24.5
15. Iceland	72.9	12.6	15.6	29.2	54. Chile	35.5	15.9	32.8	29.9
16. Finland	72.5	11.6	2.2	24.9	55. Estonia	35.5	21.4	24.3	20.8
17. France	72.0	11.4	1.7	32.9	56. Turkey	34.9	22.4	41.5	34.0
18. Belgium	71.2	11.2	-1.2	28.6	57. Montserrat	34.5	17.6	51.7	42.1
19. United Kingdom	70.3	8.5	-7.1	19.4	58. Uruguay	34.3	19.4	33.3	29.5
20. Netherlands	70.3	9.3	-11.8	26.7	59. Seychelles	33.7	41.3	39.6	52.7
21. Singapore	70.0	7.1	30.3	36.6	60. Latvia	33.6	21.9	29.6	25.8
22. Taiwan	68.1	12.4	42.8	31.5	61. Antigua & Barb.	32.3	16.7	58.2	35.1
23. Aruba	66.9	7.9	41.2	26.5	62. Montenegro	29.7	35.6	29.5	27.2
24. Macao	65.4	9.8	28.9	33.2	63. Kazakhstan	29.7	22.0	36.6	28.1
25. Japan	65.4	12.4	29.4	34.2	64. Mexico	29.4	23.1	12.9	20.6
26. Ireland	63.1	9.6	7.8	19.4	65. Mauritius	28.2	32.6	31.6	39.1
27. Italy	62.0	12.7	7.9	25.5	66. Malaysia	27.7	17.5	31.5	34.2
28. Cyprus	60.7	13.9	20.3	22.7	67. Virgin Islands	27.5	18.7	17.2	31.6
29. New Zealand	60.5	14.6	18.3	20.0	68. Panama	27.1	17.5	36.8	37.4
30. Spain	57.5	12.6	-0.7	20.1	69. Belarus	26.8	36.9	41.4	40.0
31. Israel	55.6	13.8	22.1	31.4	70. Romania	26.5	24.8	25.6	28.1
32. Sint Maarten	55.4	8.7	35.7	26.1	71. Bulgaria	25.9	21.6	33.3	30.1
33. Greece	55.1	16.0	13.3	29.7	72. Serbia	25.6	25.8	35.6	32.1
34. Curaçao	53.9	11.4	28.2	23.1	73. Brazil	24.9	15.2	4.7	30.3
35. Malta	51.4	16.0	26.6	17.3	74. Costa Rica	24.4	20.6	35.6	34.5
36. Portugal	49.1	16.0	1.1	25.4	75. Grenada	24.2	20.9	42.3	43.0
37. Slovenia	48.8	14.4	12.5	23.8	76. Jordan	24.0	27.9	58.2	41.1
38. South Korea	48.8	11.9	57.6	33.0	77. Dominican Rep.	22.9	29.3	29.3	30.9
39. Qatar	48.6	10.7	-11.8	40.4	78. Dominica	22.8	17.8	47.9	45.8
Mean	62.8	11.0	13.7	27.5	Mean	29.8	21.7	33.1	32.1
Mean Income (\$ p.c.)	25,974				Mean Income (\$ p.c.)	12,341			

(continued on next page)

Table 2.1 Income and Food in 155 countries in 2011 (continued)

Country	Income	Food (×100)			Country	Income	Food (×100)		
	US = 100	Budget share	Relative price	Price SD		US = 100	Budget share	Relative price	Price SD
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
C. Third quartile					D. Fourth quartile				
79. St. Vin. & Gren.	21.7	22.8	52.3	36.1	118. Bolivia	8.9	34.8	35.0	33.6
80. Macedonia	21.7	31.7	26.3	29.6	119. Honduras	8.6	31.0	27.7	34.2
81. Thailand	21.4	28.0	32.6	39.5	120. Kyrgyzstan	7.8	41.1	56.7	38.8
82. South Africa	20.9	20.6	28.9	30.7	121. Vietnam	7.7	27.6	34.6	48.3
83. Colombia	20.6	18.5	28.8	37.9	122. India	7.2	28.8	29.8	45.5
84. St. Lucia	20.3	21.5	45.0	33.4	123. São Tomé & P.	6.8	58.4	25.1	51.9
85. Bosnia & Herz.	20.3	30.5	35.4	23.3	124. Cambodia	5.7	47.8	31.8	52.5
86. Turks & Caicos	20.1	15.6	17.1	30.2	125. Ghana	5.7	38.4	64.6	38.3
87. Venezuela	19.3	23.7	44.2	35.7	126. Lesotho	5.6	27.4	44.5	28.8
88. Ukraine	18.8	36.0	42.2	28.7	127. Tajikistan	5.6	44.6	27.7	48.6
89. Tunisia	18.6	22.8	44.5	49.3	128. Nigeria	5.2	39.0	55.8	35.9
90. Peru	18.3	24.6	30.3	37.7	129. Kenya	5.0	38.5	60.8	42.1
91. Azerbaijan	18.3	38.2	25.7	39.4	130. Djibouti	4.7	30.6	30.0	44.9
92. Belize	18.2	19.5	71.5	42.7	131. Cameroon	4.6	48.3	13.3	62.8
93. El Salvador	17.7	27.1	38.4	28.5	132. Côte d'Ivoire	4.6	44.1	24.5	48.6
94. Ecuador	17.3	22.3	31.3	32.3	133. Senegal	4.3	49.9	29.6	56.9
95. Jamaica	16.7	29.2	44.5	26.3	134. Nepal	4.3	58.2	28.3	47.7
96. Sri Lanka	16.7	42.9	38.9	55.0	135. Zambia	3.9	59.0	27.1	46.5
97. Albania	16.7	38.8	21.8	29.0	136. Uganda	3.8	37.9	41.5	54.5
98. Namibia	15.9	23.3	57.7	33.2	137. Congo, Rep.	3.5	39.5	54.3	42.8
99. Botswana	15.7	24.4	46.0	29.2	138. Haiti	3.5	59.1	27.7	39.9
100. Armenia	14.8	58.2	35.6	37.2	139. Gambia	3.3	43.5	53.5	54.2
101. Mongolia	14.7	33.8	53.6	60.2	140. Sierra Leone	3.3	40.6	54.4	48.7
102. Iraq	14.5	30.6	52.8	39.7	141. Chad	3.1	51.4	30.7	56.3
103. Georgia	14.5	34.7	56.4	46.8	142. Benin	2.9	50.8	37.9	56.7
104. Gabon	14.2	34.6	35.5	50.4	143. Rwanda	2.9	50.7	39.0	76.8
105. Guatemala	14.1	39.8	33.7	32.6	144. Zimbabwe	2.7	58.5	30.9	42.7
106. Swaziland	13.4	46.3	40.0	46.9	145. Madagascar	2.7	45.6	11.6	53.0
107. Fiji	13.3	31.3	17.3	42.8	146. Guinea-B.	2.2	52.3	12.4	53.2
108. Paraguay	12.9	28.6	22.9	23.7	147. Mali	2.2	46.6	18.8	52.0
109. Moldova	12.6	31.4	34.0	34.4	148. Mozambique	1.8	55.3	38.4	51.3
110. Eq. Guinea	12.6	39.4	44.4	49.6	149. Liberia	1.8	29.0	50.6	53.7
111. Suriname	12.3	38.4	34.4	37.4	150. Burkina Faso	1.8	55.6	32.1	56.2
112. Indonesia	12.3	37.9	29.3	47.6	151. Comoros	1.8	51.5	27.1	58.1
113. Philippines	11.7	41.4	23.8	40.4	152. C. Africa	1.6	63.5	28.1	57.0
114. Cape Verde	11.6	38.5	38.1	34.2	153. Guinea	1.5	58.2	54.4	67.4
115. China	11.2	19.6	31.0	46.2	154. Niger	1.5	41.9	47.3	46.1
116. Morocco	10.9	34.6	52.1	42.0	155. Congo, D.R.	0.9	56.7	43.2	44.0
117. Bhutan	10.0	30.6	38.8	51.2					
Mean	14.5	31.1	37.9	38.2	Mean	3.7	45.7	36.3	49.2
Mean Income (\$ p.c.)		6,010			Mean Income (\$ p.c.)		1,525		

Notes: Countries are ranked in terms of per capita income and are divided into 4 quartiles. Income, contained in columns 2 and 7, is defined as real total consumption per capita with US = 100. More precisely, income is total consumption expenditure, defined as the sum of expenditure by households, non-profits serving households and individual government on 131 food and non-food items, deflated by the cost of living. That is, income is $\exp(\log M - \log P)$, where M is total consumption expenditure, and $\log P = \sum_{i=1}^{131} w_i \log p_i$ is a cost-of-living index, with w_i the budget share of good i (the proportion of total consumption expenditure devoted to i) and p_i its PPP price. Food is defined as the sum of all 31 food items, including alcoholic beverages. These items are the first 31, so the total food budget share is $W_F = \sum_{i=1}^{31} w_i$ and $w'_i = w_i / W_F$ is the share of i within food (known as the “conditional budget-share”). The relative price of food is $\log(P_F/P) = \log P_F - \log P$, the difference between the conditional budget-share weighted logarithmic mean of the prices of the food items, $\log P_F = \sum_{i=1}^{31} w'_i \log p_i$, and the log of the cost-of-living index, $\log P$. The food price standard deviation (SD) is $\sqrt{\sum_{i=1}^{31} w'_i (\log p_i - \log P_F)^2}$. The US is omitted from price means as it is the reference country.

Table 3.1 Budget Shares and Prices of Food in 155 Countries

Group/Item (1)	Budget shares					Relative prices				
	First (2)	Second (3)	Third (4)	Fourth (5)	All (6)	First (7)	Second (8)	Third (9)	Fourth (10)	All (11)
1. BREAD AND CEREALS	14.28	14.81	18.76	29.47	19.26	-0.96	-14.22	-8.14	-0.56	-6.04
Rice	9.87	15.86	25.05	38.24	22.15	-21.65	-12.44	-28.55	-42.16	-26.12
Other cereals and flour	13.57	17.04	26.93	38.84	24.00	13.89	50.34	63.10	66.24	48.50
Bread	37.65	37.79	28.21	15.03	29.76	-1.54	-21.44	-28.39	-37.77	-22.32
Other bakery products	30.80	21.57	13.40	3.85	17.49	-2.94	1.70	-0.28	7.29	1.43
Pasta products	8.11	7.75	6.40	4.04	6.59	11.04	39.15	44.21	47.73	35.61
2. MEAT AND SEAFOOD	24.36	24.53	22.41	21.10	23.11	9.06	-3.60	-10.70	-20.67	-6.49
Beef and veal	15.18	13.98	21.16	25.08	18.81	24.16	4.50	2.15	4.34	8.72
Pork, lamb, mutton and goat	15.67	16.63	15.14	17.44	16.21	-3.94	-12.61	-6.86	-23.15	-11.61
Poultry	15.66	24.21	24.56	13.77	19.59	23.98	22.57	36.71	71.37	38.54
Other meats and preparations	28.62	24.09	13.74	7.93	18.66	11.62	14.80	30.29	61.29	29.41
Fresh or frozen fish and seafood	15.40	14.59	19.83	20.39	17.53	-39.75	-36.31	-33.81	-46.90	-39.14
Preserved fish and seafood	9.48	6.51	5.57	15.41	9.20	-20.33	-8.09	-3.91	13.24	-4.79
3. DAIRY	13.16	15.89	15.76	11.64	14.13	7.05	20.79	30.07	49.16	26.75
Fresh milk	19.94	15.53	16.71	18.67	17.71	1.69	-4.91	-4.58	11.76	0.92
Preserved milk and milk products	28.16	30.82	27.70	17.59	26.12	-2.52	-5.11	-3.27	-6.06	-4.24
Cheese	25.75	18.46	13.24	4.12	15.47	0.23	0.45	-1.05	10.26	2.43
Eggs and egg-based products	8.28	10.97	13.57	10.24	10.77	28.29	14.81	12.38	6.05	15.36
Butter and margarine	7.65	8.08	7.88	10.58	8.54	-27.84	-33.68	-32.97	-41.98	-34.11
Other edible oils and fats	10.22	16.14	20.89	38.80	21.40	16.85	23.27	19.35	11.94	17.90
4. FRUIT AND VEGETABLES	16.25	17.25	19.12	20.56	18.28	-5.00	-5.27	-12.00	-19.87	-10.51
Fresh or chilled fruit	35.71	30.98	27.42	18.50	28.22	-0.13	-5.60	-6.09	-12.23	-6.01
Frozen, preserved or processed fruits	7.64	5.43	3.78	4.85	5.43	23.42	52.29	69.19	77.18	55.59
Fresh or chilled vegetables	33.43	39.30	44.52	38.58	38.96	-6.34	-10.36	-11.32	-19.83	-11.95
Fresh or chilled potatoes	8.11	11.74	14.00	26.61	15.04	9.59	13.78	12.56	4.68	10.19
Frozen or preserved vegetables	15.11	12.54	10.28	11.46	12.35	0.97	20.58	28.65	57.82	26.97
5. SWEET THINGS	5.95	5.16	4.93	4.06	5.03	-2.48	2.75	0.13	20.21	5.11
Sugar	10.55	38.97	49.82	75.62	43.53	-6.99	-6.51	-9.82	-0.38	-5.96
Jams, marmalades and honey	10.29	12.33	12.30	6.01	10.26	23.77	38.21	40.51	24.02	31.73
Confectionery, chocolate and ice cream	79.16	48.69	37.88	18.37	46.21	-1.85	3.34	5.15	-3.72	0.78
6. OTHER FOOD	15.51	12.78	12.06	8.83	12.32	-2.32	8.54	13.11	34.48	13.42
Food products n.e.c.	35.65	30.74	40.67	50.97	39.44	1.87	-5.88	-6.52	0.28	-2.61
Coffee, tea and cocoa	17.06	20.42	17.89	16.16	17.89	9.02	18.17	10.55	-8.06	7.51
Min. waters, soft drinks, fruit and veg. juices	47.29	48.83	41.44	32.87	42.67	-2.23	-1.45	0.35	2.59	-0.19
7. ALCOHOL	10.48	9.59	6.96	4.34	7.87	-5.10	9.56	16.37	25.80	11.67
Spirits	25.02	35.62	28.31	23.66	28.18	21.69	9.50	10.06	4.47	11.41
Wine	37.34	21.65	16.50	23.43	24.74	-3.47	16.28	40.46	36.90	22.62
Beer	37.64	42.73	55.19	52.91	47.08	-4.25	-13.26	-16.57	-15.93	-12.54

Notes:

- Columns 2-6: These are budget shares of food. **Emboldened** figures are the proportions of food expenditure devoted to the food groups; for a given income category these shares have a unit sum. Non-emboldened figures are the proportions of group expenditure devoted to items within the group; these also have a unit sum for a given income category.
- Columns 7-11: These are relative food prices. **Emboldened** figures are $\log P_F^g - \log P_F$, the deviations of the price of food group g from the overall price of food, where $\log P_F^g = \sum_{i \in S_F^g} \bar{w}_i \log p_i$ is the price of group g , with $\bar{w}_i$ the share of i in expenditure on g , S_F^g the set of goods belonging to group g and $\log P_F = \sum_{i=1}^{31} w_i' \log p_i$ the price of all 31 food items, with w_i' the proportion of food expenditure devoted to i . Non-emboldened are log price deviations of food items from that of the group, $\log p_i - \log P_F^g$.
- The US is omitted from price calculations as it is the reference country. All values are averaged over countries and $\times 100$.

Table 3.2 Dispersion of Food Prices

Income quartile	Total variance	Components		Group variances						
		Between group	Within group	Bread and cereals	Meat and seafood	Dairy	Fruits and vegetables	Sweet things	Other food	Alcohol
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	7.95	3.24	4.72	4.80	8.00	3.88	2.82	1.52	1.22	7.51
2	10.86	4.05	6.81	12.31	7.62	4.51	5.29	4.84	2.28	6.71
3	15.38	6.25	9.13	19.69	10.77	4.65	6.72	8.58	1.97	8.32
4	25.12	10.98	14.14	21.41	18.76	5.49	10.24	2.69	1.47	6.43
All	14.81	6.12	8.69	14.57	11.26	4.63	6.26	4.44	1.74	7.24

Notes:

1. Column 2: This contains the weighted logarithmic variance of the 31 food prices, $\Pi_F = \sum_{i=1}^{31} w'_i (\log p_i - \log P_F)^2$, where w'_i is the proportion of food expenditure devoted to item i and $\log P_F = \sum_{i=1}^{31} w'_i \log p_i$ is an index of the price of food.
2. Columns 3 and 4: Dividing the 31 food prices into seven groups, S_g , $g = 1, \dots, 7$, the total price variance can be decomposed into between- and within-group components:

$$\Pi_F = \underbrace{\sum_{g=1}^7 W_F^g (\log P_F^g - \log P_F)^2}_{\text{Between-group variance}} + \underbrace{\sum_{g=1}^7 W_F^g \left[\sum_{i \in S_F^g} \bar{w}_i (\log p_i - \log P_F^g)^2 \right]}_{\text{Within-group}}$$

Total price variance

Here, $W_F^g = \sum_{i \in S_F^g} w'_i$ is the budget share of group g ; $\log P_F^g = \sum_{i \in S_F^g} \bar{w}_i \log p_i$ is the index of the price of g , where $\bar{w}_i = w'_i / W_F^g$ is the share of group expenditure devoted to $i \in S_F^g$; $\log P_F = \sum_{i=1}^{31} w'_i \log p_i = \sum_{g=1}^7 W_F^g \log P_F^g$ is the price of all 31 food items. Columns 3 and 4, respectively, contain the above between- and within-group components.

3. Columns 5-11: These columns contain each of the seven within-group variances, $\sum_{i \in S_F^g} \bar{w}_i (\log p_i - \log P_F^g)^2$, $g = 1, \dots, 7$.
4. All entries are averages over countries and $\times 100$.

Table 4.1 Prices and Incomes, 31 Food Items in 154 countries in 2011

$$w'_{ic} \log(p_{ic}/P_{Fc}) = \alpha_i + (\beta_i + \lambda_i D_c) \log(Y_c/\bar{Y}) + \varepsilon_{ic}$$

Commodity	Intercept α_i ($\times 100$)	Income coefficient ($\times 100$)		SEE ($\times 100$)	Income elasticity of price	
		Rich β_i	Marginal effect for poor λ_i		Rich β_i/w'_i	Poor $(\beta_i + \lambda_i)/w'_i$
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. Rice	-1.95 (0.46)	1.30 (0.55)	1.00 (0.83)	3.22	0.65	0.28
2. Other cereals and flour	1.89 (0.37)	-1.28 (0.45)	-1.40 (0.67)	2.60	-0.58	-0.31
3. Bread	-2.16 (0.22)	1.43 (0.27)	-1.82 (0.40)	1.55	0.26	-0.09
4. Other bakery products	-0.29 (0.06)	0.09 (0.08)	-0.29 (0.11)	0.45	0.02	-0.12
5. Pasta products	0.34 (0.07)	-0.17 (0.08)	0.12 (0.12)	0.46	-0.15	-0.05
6. Beef and veal	-0.40 (0.21)	1.13 (0.25)	-0.82 (0.38)	1.47	0.32	0.06
7. Pork, Lamb, mutton and goat	-0.74 (0.29)	0.48 (0.35)	0.07 (0.52)	2.03	0.12	0.15
8. Poultry	1.06 (0.16)	0.03 (0.20)	-0.16 (0.30)	1.16	0.01	-0.03
9. Other meats and preparations	0.45 (0.19)	0.75 (0.23)	-0.95 (0.34)	1.34	0.12	-0.08
10. Fresh or frozen fish and seafood	-2.02 (0.37)	0.26 (0.44)	0.64 (0.66)	2.57	0.07	0.20
11. Preserved fish and seafood	-0.25 (0.11)	-0.01 (0.14)	0.18 (0.21)	0.81	0.00	0.08
12. Fresh milk	0.52 (0.13)	-0.36 (0.16)	-0.04 (0.24)	0.95	-0.14	-0.15
13. Preserved milk and milk products	1.20 (0.12)	-0.80 (0.15)	1.03 (0.22)	0.87	-0.19	0.08
14. Cheese	0.67 (0.08)	-0.44 (0.09)	0.67 (0.14)	0.53	-0.13	0.16
15. Eggs and egg-based products	0.89 (0.08)	-0.41 (0.10)	0.59 (0.14)	0.56	-0.30	0.11
16. Butter and margarine	-0.03 (0.06)	-0.21 (0.07)	0.15 (0.10)	0.39	-0.18	-0.05
17. Other edible oils and fats	1.57 (0.15)	-0.95 (0.19)	0.44 (0.28)	1.08	-0.49	-0.14
18. Fresh or chilled fruit	-1.18 (0.20)	0.77 (0.24)	-0.86 (0.36)	1.38	0.14	-0.02
19. Frozen, preserved or processed fruits	0.37 (0.07)	-0.06 (0.08)	-0.05 (0.12)	0.48	-0.06	-0.13
20. Fresh or chilled vegetables	-2.17 (0.35)	1.34 (0.42)	-0.89 (0.63)	2.45	0.22	0.06
21. Fresh or chilled potatoes	0.04 (0.38)	-0.01 (0.46)	1.25 (0.69)	2.69	-0.01	0.28
22. Frozen or preserved vegetables	0.37 (0.13)	-0.35 (0.15)	0.03 (0.23)	0.89	-0.15	-0.15
23. Sugar	-0.27 (0.12)	0.21 (0.15)	-0.64 (0.23)	0.88	0.17	-0.16
24. Jams, marmalades and honey	0.25 (0.03)	-0.09 (0.03)	0.18 (0.05)	0.19	-0.16	0.20
25. Confectionery, chocolate and ice cream	0.17 (0.07)	-0.37 (0.08)	0.41 (0.12)	0.48	-0.10	0.03
26. Food products n.e.c.	0.15 (0.19)	-0.36 (0.23)	-0.59 (0.34)	1.31	-0.07	-0.18
27. Coffee, tea and cocoa	0.48 (0.06)	-0.21 (0.08)	0.30 (0.11)	0.45	-0.09	0.06
28. Min. water, soft drink, fruit & veg juice	0.66 (0.14)	-0.68 (0.17)	0.55 (0.26)	1.01	-0.10	-0.03
29. Spirits	0.36 (0.17)	0.10 (0.21)	0.01 (0.31)	1.21	0.03	0.07
30. Wine	0.31 (0.17)	-1.10 (0.21)	1.06 (0.31)	1.19	-0.36	-0.05
31. Beer	-0.29 (0.16)	-0.02 (0.19)	-0.18 (0.29)	1.11	-0.01	-0.06
Sum	0	0	0	-	-	-
Weighted variance $100 \times \sum_{i=1}^{31} (\beta_i + \lambda_i D)^2 / w'_i$	-	-	-	-	4.45	2.78

Notes: For food item i in country c , w'_{ic} is its expenditure share of food, w'_i its cross-country mean, $\log p_{ic}$ its log price and $\log P_{Fc} = \sum_{i=1}^{31} w'_{ic} \log p_{ic}$ is an index of food prices. Per capita income of c relative to the cross-country geometric mean is $\log(Y_c/\bar{Y})$. D_c is a dummy variable that takes the value of 1 if c belongs to the “poor” group (the third and fourth income quartiles) and is 0 otherwise; and ε_{ic} is a disturbance term. Results exclude the USA, the base country. The income elasticities of price in columns 6 and 7 are evaluated at mean expenditure shares for the rich and poor countries. Standard errors in parentheses.

Table 7.1 Slope Coefficients, Cross-Country Regressions, 198 Food Items
$$\log p_{ic} = \alpha_i + \beta_i \log S_c + \varepsilon_{ic}, \quad c = 1, \dots, C_i \text{ consuming countries; } i = 1, \dots, 198 \text{ food items}$$

Item (1)	Slope (2)	t-stat (3)	Obs (4)	Item (5)	Slope (6)	t-stat (7)	Obs (8)
1. Long grain rice – Parboiled	0.90	5.80	121	63. Mackerel, un-cleaned	0.91	4.22	92
2. Long grain rice – Non-Parboiled	0.93	5.65	95	64. Sea Bass	0.83	6.67	64
3. Long grain rice – Family Pack	1.01	0.37	59	65. Whole Shrimps	0.92	3.88	69
4. Jasmine Rice	1.02	1.24	60	66. Shrimps	0.94	4.82	131
5. Basmati Rice	0.96	2.40	119	67. Squid	0.90	5.22	84
6. White rice, 25% broken	0.94	3.12	59	68. Red snapper	0.91	3.62	39
7. White rice, Medium Grain	0.93	4.22	66	69. Sea Crab	0.96	1.73	46
8. Brown rice – Family Pack	0.97	1.44	48	70. Tilapia	0.93	3.90	73
9. Short-grained rice	0.92	5.15	66	71. Black Pomfret	0.90	4.32	30
10. Cornflakes [Specified brand]	1.02	2.49	161	72. Mullet	0.88	4.78	33
11. Wheat flour, not self-rising	1.00	0.02	166	73. Canned sardine with skin	0.94	4.90	161
12. Wheat Semolina (Suji)	1.05	1.66	60	74. Canned tuna without skin	0.99	1.23	161
13. Oats, rolled	1.00	0.31	141	75. Canned mackerel fillet in vegetable oil	0.99	0.61	111
14. Maize Flour White	0.98	1.19	75	76. Smoked salmon	0.93	2.71	75
15. Couscous	1.00	0.07	46	77. Dried Shrimp	0.95	1.15	51
16. Baguette	0.90	5.82	124	78. Milk, un-skimmed Pasteurized	1.01	0.66	151
17. White bread	0.94	3.13	118	79. Milk, un-skimmed UHT	1.02	2.44	158
18. Whole wheat bread	0.95	3.05	138	80. Milk, low-fat, Pasteurized	1.01	0.60	147
19. Roll	0.91	3.67	88	81. Milk, condensed	0.95	3.28	75
20. Sliced White bread	0.95	3.67	158	82. Milk, powdered	1.00	0.41	114
21. Pita bread	0.95	1.53	52	83. Yoghurt, plain	0.98	1.59	157
22. Sandwich biscuits/cookies	0.98	1.45	155	84. Sour cream	1.04	1.33	108
23. Chocolate cake (Individual serving)	0.96	2.15	68	85. Cheese, Cheddar	1.01	0.97	110
24. Chocolate cake (Whole)	0.93	4.22	96	86. Cream cheese	1.02	1.44	149
25. All-butter croissant	0.96	2.88	141	87. Cheese, processed	1.00	0.04	161
26. Butter biscuits	0.96	2.85	150	88. Cheese, Camembert Type	1.02	1.28	96
27. Flavored biscuits/cookies sweet	0.98	1.34	160	89. Cheese, Gouda Type	1.01	0.84	124
28. Salted crackers	0.96	2.57	140	90. Bean Curd – Tofu	0.95	0.72	32
29. Short pasta	1.02	1.54	138	91. Large size chicken eggs	0.98	1.88	153
30. Spaghetti	0.97	3.07	171	92. Medium size chicken eggs	0.97	2.33	108
31. Dried Noodles	0.96	2.25	102	93. Butter, unsalted	0.98	2.60	164
32. Instant Noodles	0.95	2.96	141	94. Salted Butter	0.98	2.53	160
33. Vermicelli (Angel Hair)	1.03	1.70	128	95. Margarine, regular fat	0.99	0.88	168
34. Macaroni	0.97	2.22	118	96. Sunflower oil	1.01	1.20	151
35. Beef, Fillet	0.87	6.70	155	97. Olive oil	1.00	0.27	167
36. Beef, Rump steak	0.94	3.73	156	98. Palm oil	0.99	0.33	58
37. Beef, Center brisket	0.92	6.72	134	99. Soybean oil	1.00	0.24	94
38. Beef, for stew or curry	0.95	3.70	73	100. Peanut oil	0.99	0.38	45
39. Beef with bones	0.93	5.02	116	101. Vegetable oil	0.95	4.31	148
40. 100% Beef, minced	0.96	4.24	161	102. Apple, Red Delicious	0.96	2.84	112
41. Veal chops	0.97	1.36	61	103. Banana, Standard	0.90	7.38	173
42. Veal breast (non-refrig.), w/ bones	0.91	5.28	74	104. Grapes, green	1.03	1.77	126
43. Pork, loin chop	0.94	5.26	138	105. Grapefruit	0.92	4.64	100
44. Pork, fillet	0.95	3.56	134	106. Orange	0.93	4.65	169
45. Pork, shoulder	0.96	2.21	60	107. Papaya	0.85	8.44	96
46. Pork, ribs	0.96	3.17	150	108. Pineapple	0.89	6.53	159
47. Lamb whole leg	0.90	6.35	132	109. Lemon	0.91	5.77	160
48. Lamb chops	0.91	5.44	129	110. Mango	0.85	6.39	93
49. Mutton mixed cut	0.95	2.86	64	111. Watermelon	0.91	4.99	162
50. Goat mixed cut non-refri. w/ bones	0.92	4.27	59	112. Apple, Typical Local Variety	1.01	0.32	108
51. Whole chicken – Broiler	1.00	0.47	144	113. Peach	0.99	0.60	104
52. Whole chicken	1.00	0.43	149	114. Melon	0.91	3.90	99
53. Chicken breast without skin	0.96	2.87	150	115. Tinned pineapple	1.05	3.82	120
54. Chicken legs	0.98	2.11	159	116. Dried almonds	1.01	0.57	58
55. Live chicken	1.00	0.28	65	117. Roasted groundnuts/peanuts	0.92	4.74	118
56. Chicken breast with skin and bones	1.00	0.04	96	118. Mixed Fruits in Syrup	0.99	0.51	106
57. Pork ham, pressed	0.95	3.09	109	119. Dried dates	0.98	1.43	98
58. Bacon, smoked	0.98	1.73	115	120. Cucumber	0.90	6.35	172
59. Beef liver	0.97	2.04	113	121. Bell pepper	0.93	3.48	160
60. Corned beef	1.00	0.16	63	122. Carrots	0.96	2.40	172
61. Canned chicken	1.02	0.70	47	123. Onion	0.97	2.18	170
62. Carp	0.89	7.09	90	124. Maize	0.82	7.65	92

(continued on next page)

Table 7.1 Slope Coefficients, Cross-Country Regressions, 198 Food Items (continued)
$$\log p_{ic} = \alpha_i + \beta_i \log S_c + \varepsilon_{ic}, \quad c = 1, \dots, C_i \text{ consuming countries; } i = 1, \dots, 198 \text{ food items}$$

Item (1)	Slope (2)	t-stat (3)	Obs (4)	Item (5)	Slope (6)	t-stat (7)	Obs (8)
125. Round tomato, loose	0.88	7.21	169	162. Mayonnaise	0.97	2.40	124
126. Green cabbage	0.93	3.51	119	163. Cooking salt	1.00	0.09	162
127. Lettuce	0.91	5.86	158	164. Tomato ketchup	1.02	1.67	166
128. Avocado	0.84	7.78	93	165. Black Pepper, ground	0.92	4.55	144
129. Eggplant (aubergine)	0.87	6.72	163	166. Thin Soya Sauce	0.93	3.51	148
130. Cauliflower	0.96	1.89	155	167. Curry Powder	1.00	0.13	71
131. Spinach	0.86	5.80	131	168. Chicken Extract (bouillon/stock cube)	0.92	4.46	117
132. Chilies (Long)	0.90	3.68	115	169. Baking powder	0.96	2.70	102
133. Ginger (Mature)	0.97	1.40	80	170. Baby food	0.98	1.19	117
134. Garlic (White)	0.98	1.22	134	171. Chili sauce	1.02	0.80	75
135. Brown Potatoes	0.95	2.98	164	172. Chili powder	1.00	0.01	81
136. Sweet Potatoes	0.81	9.47	110	173. Baby cereals	0.99	0.76	152
137. Cassava – Manioc – Yuka	0.82	5.86	49	174. Cocoa Powder, Tin	1.01	1.04	144
138. Dried white beans	0.96	2.63	100	175. Instant coffee [Specified brand]	0.96	4.00	170
139. Tinned white beans tomato sauce	1.01	0.43	112	176. Coffee Roasted 100% Arabica	0.96	2.46	134
140. Green Olives (with stones)	1.00	0.07	136	177. Coffee Roasted 100% Robusta	0.99	1.06	100
141. Potato chips	0.95	3.68	162	178. Tea bags, black	0.98	1.87	160
142. Frozen chipped potatoes	1.03	2.53	120	179. Tea, green	0.93	3.34	77
143. Tomato paste (Small)	0.95	3.86	155	180. Tea, black	0.93	2.20	70
144. Tomato paste (Large)	1.03	2.43	59	181. Mineral water	0.97	1.98	168
145. Tinned green peas	1.02	1.96	129	182. Carbonated Soft Drink (Small)	0.98	1.69	166
146. Tinned sweet corn/Maize	1.06	5.28	139	183. Carbonated Soft Drink (Large)	1.01	0.57	168
147. Lentils, Dry	1.01	0.67	132	184. Apple juice	1.02	2.58	130
148. Green/Mung Beans, dried	0.96	3.00	30	185. Orange juice	1.02	2.22	128
149. Tinned Button Mushrooms	1.05	2.90	73	186. Lemonade	1.06	3.03	66
150. White sugar	0.99	1.17	161	187. Vodka	0.95	3.19	154
151. Brown sugar	0.97	1.48	89	188. Whisky	0.97	2.79	155
152. Strawberry/Apricot Jam	0.97	2.80	170	189. Gin [Specified Brand]	0.98	1.98	97
153. Pineapple Jam	0.99	0.71	106	190. Irish whiskey & cream liq. [Specified]	1.01	0.60	55
154. Orange marmalade	1.00	0.33	116	191. Superior Light/White Rum	0.96	2.79	125
155. Natural honey, Mixed blossoms	0.98	1.83	156	192. Red wine, table wine	1.04	2.12	154
156. Chocolate bar	0.97	2.44	117	193. Red wine, Bordeaux Supérieur	1.03	1.00	48
157. Ice cream, Cornetto-type	0.97	1.75	141	194. White wine, table wine	1.03	1.29	127
158. Chewing gum	0.95	3.59	154	195. Sparkling wine	0.98	1.39	131
159. Fruit drops (Hard candies)	0.94	4.03	135	196. Domestic Canned Beer	0.97	2.48	130
160. Ice cream, packed	0.98	1.41	145	197. Domestic Beer Bottle	0.94	5.16	151
161. Toffee	0.97	1.74	106	198. Beer [Specified brand]	0.98	2.58	152
<i>Summary statistics</i>							
Mean	0.96	2.78	117				
Median	0.97	2.45	123				
SD	0.05	1.98	39				
Min	0.81	0.01	30				
Max	1.06	9.47	173				

Note: Food items are arranged in the order in which they appear in the ICP data. “Slope” refers to the estimated coefficient β_i and the t-statistic is for $H_0: \beta_i = 1$. “Obs” is the number of observations in each regression, that is, the number of countries C_i .

Table 7.2 Slope Coefficients, Cross-Commodity Regressions, 175 Countries
$$\log p_{ic} = \alpha'_c + \beta'_c \log p_i^* + \varepsilon'_{ic}, \quad i = 1, \dots, n_c \text{ food items consumed in } c; \quad c = 1, \dots, 175 \text{ countries}$$

Country (1)	Slope (2)	t-stat (3)	Obs (4)	Country (5)	Slope (6)	t-stat (7)	Obs (8)
1. Bermuda	0.70	4.76	118	63. Estonia	1.01	0.36	124
2. Cayman Islands	0.76	4.17	127	64. Latvia	1.00	0.03	125
3. United States	0.92	2.10	109	65. Uruguay	0.82	3.97	86
4. Hong Kong SAR, China	1.00	0.10	134	66. Montenegro	1.01	0.24	117
5. Norway	0.95	1.04	115	67. Kazakhstan	1.02	0.58	155
6. Luxembourg	0.91	1.85	127	68. Mexico	1.04	1.07	122
7. Switzerland	1.01	0.16	127	69. Mauritius	0.98	0.31	146
8. Taiwan, China	0.98	0.61	130	70. Bulgaria	0.97	0.74	131
9. Singapore	1.04	0.75	139	71. Malaysia	0.96	0.94	151
10. United Arab Emirates	0.99	0.32	196	72. Grenada	0.75	5.12	125
11. Aruba	0.78	4.47	130	73. Romania	0.99	0.36	127
12. Germany	0.99	0.22	128	74. Panama	0.81	3.89	118
13. Sweden	0.97	0.69	124	75. Serbia	1.03	0.80	131
14. Iceland	1.00	0.06	116	76. Egypt, Arab Rep.	1.12	2.18	153
15. Austria	0.94	1.24	122	77. Venezuela, RB	0.82	2.62	108
16. Australia	0.90	2.25	117	78. Jordan	1.16	3.56	189
17. Denmark	0.89	2.36	126	79. Ukraine	1.04	1.17	149
18. Macao SAR, China	0.96	0.94	136	80. Brazil	0.84	3.76	123
19. Canada	0.91	2.32	110	81. Virgin Islands, British	0.62	6.60	103
20. Finland	0.98	0.39	110	82. Dominican Republic	0.86	2.67	104
21. France	0.92	1.75	129	83. Armenia	1.01	0.21	155
22. Belgium	0.97	0.65	128	84. Macedonia, FYR	0.98	0.47	112
23. United Kingdom	0.99	0.30	130	85. Costa Rica	0.91	1.93	116
24. Netherlands	1.02	0.40	120	86. Dominica	0.80	3.31	114
25. Curaçao	0.74	5.35	128	87. St. Vincent and the Grenadines	0.71	5.32	109
26. Japan	0.81	3.10	97	88. Thailand	0.98	0.50	127
27. Ireland	0.93	1.54	130	89. Azerbaijan	1.01	0.27	154
28. Sint Maarten	0.73	5.17	119	90. Belize	0.87	2.22	115
29. Cyprus	0.94	1.92	127	91. St. Lucia	0.83	3.17	122
30. Italy	0.95	1.32	132	92. Albania	1.01	0.20	115
31. New Zealand	0.94	1.22	102	93. Colombia	0.78	3.93	78
32. Kuwait	0.95	1.09	175	94. Bosnia and Herzegovina	0.99	0.36	124
33. Spain	0.91	2.45	130	95. Algeria	1.16	2.96	130
34. Malta	0.96	1.09	133	96. El Salvador	0.86	2.41	111
35. Greece	0.98	0.54	133	97. South Africa	0.87	2.90	130
36. Israel	1.02	0.65	121	98. Tunisia	1.15	2.61	130
37. Anguilla	0.68	7.12	130	99. Sri Lanka	1.02	0.35	114
38. Korea, Rep.	1.02	0.35	108	100. Peru	0.91	1.92	110
39. Bahrain	0.99	0.30	187	101. Mongolia	0.81	3.32	122
40. Qatar	0.96	0.90	168	102. Turks and Caicos Islands	0.74	4.66	104
41. St. Kitts and Nevis	0.68	6.41	120	103. Jamaica	0.79	4.72	132
42. Portugal	0.93	1.82	126	104. Ecuador	1.02	0.34	69
43. Slovenia	0.94	1.61	129	105. Equatorial Guinea	0.74	2.64	63
44. Saudi Arabia	0.96	0.94	180	106. Namibia	0.83	3.77	181
45. Trinidad and Tobago	0.89	2.18	130	107. Moldova	0.93	1.62	158
46. Belarus	1.07	1.30	133	108. Botswana	0.82	4.73	149
47. Bahamas, The	0.67	6.16	109	109. Iraq	1.09	2.17	157
48. Brunei Darussalam	0.92	1.44	131	110. Gabon	0.89	2.27	167
49. Czech Republic	1.10	2.75	131	111. Guatemala	0.89	2.66	127
50. Lithuania	1.01	0.17	125	112. Swaziland	0.87	3.40	146
51. Seychelles	0.90	2.02	169	113. Paraguay	0.83	3.45	121
52. Poland	1.10	2.79	129	114. Kyrgyzstan	0.96	0.86	137
53. Russian Federation	1.07	1.52	110	115. Fiji	0.99	0.33	102
54. Slovakia	1.03	0.88	124	116. Maldives	0.75	3.44	86
55. Montserrat	0.54	7.17	108	117. Philippines	0.94	1.51	146
56. Antigua and Barbuda	0.68	4.96	86	118. Indonesia	1.03	0.74	139
57. Turkey	1.15	3.53	123	119. Palestinian Territory	1.10	2.28	178
58. Hungary	1.00	0.05	126	120. Suriname	0.77	4.72	133
59. Barbados	0.76	4.03	130	121. Morocco	1.11	2.47	176
60. Chile	0.96	0.95	120	122. Cape Verde	0.80	5.03	165
61. Oman	1.03	0.61	147	123. Nicaragua	0.82	3.21	110
62. Croatia	0.94	1.56	130	124. China	1.04	0.99	146

(continued on next page)

Table 7.2 Slope Coefficients, Cross-Commodity Regressions, 175 Countries (continued)
$$\log p_{ic} = \alpha'_c + \beta'_c \log p_i^* + \varepsilon'_{ic}, \quad i = 1, \dots, n_c \text{ food items consumed in } c; c = 1, \dots, 175 \text{ countries}$$

Country (1)	Slope (2)	t-stat (3)	Obs (4)	Country (5)	Slope (6)	t-stat (7)	Obs (8)
125. Tajikistan	1.05	1.21	125	151. Haiti	0.80	1.80	47
126. Vietnam	1.05	1.16	128	152. Zambia	0.87	2.71	147
127. Angola	0.82	2.92	61	153. Congo, Rep.	0.87	3.40	176
128. Bhutan	1.02	0.34	103	154. Sierra Leone	0.87	2.72	166
129. Bolivia	0.90	2.19	112	155. Gambia, The	0.88	2.63	169
130. Pakistan	1.04	0.78	113	156. Chad	0.92	1.50	102
131. Honduras	0.86	2.60	105	157. Togo	0.93	1.45	168
132. Myanmar	1.01	0.16	115	158. Rwanda	1.00	0.08	150
133. Yemen	0.94	0.96	132	159. Benin	0.88	2.24	134
134. São Tomé and Príncipe	0.91	2.01	147	160. Madagascar	0.83	3.40	170
135. India	0.99	0.24	160	161. Zimbabwe	0.85	4.10	172
136. Lao PDR	0.93	1.11	104	162. Malawi	0.84	3.14	154
137. Cambodia	0.98	0.55	133	163. Ethiopia	1.08	1.59	134
138. Ghana	0.79	5.33	184	164. Guinea-Bissau	0.82	4.45	178
139. Bangladesh	1.15	3.02	124	165. Mali	0.85	3.17	175
140. Lesotho	0.87	3.30	164	166. Liberia	0.77	4.73	176
141. Nigeria	0.73	6.95	183	167. Guinea	0.99	0.11	122
142. Sudan	0.81	3.33	125	168. Tanzania	0.88	2.60	158
143. Kenya	1.02	0.41	143	169. Mozambique	0.88	2.97	176
144. Nepal	1.14	2.89	97	170. Burkina Faso	0.95	0.82	124
145. Djibouti	0.97	0.53	153	171. Central African Republic	0.83	2.92	137
146. Côte d'Ivoire	0.92	1.63	175	172. Comoros	0.84	2.77	124
147. Senegal	0.88	2.76	161	173. Burundi	1.06	0.99	146
148. Cameroon	0.89	2.39	176	174. Niger	0.92	1.48	134
149. Mauritania	0.85	2.69	122	175. Congo, Dem. Rep.	0.89	2.40	168
150. Uganda	1.03	0.63	168				
<i>Summary statistics</i>							
Mean	0.92	2.15	132				
Median	0.93	1.92	129				
SD	0.11	1.66	26				
Min	0.54	0.03	47				
Max	1.16	7.17	196				

Note: Countries are arranged by decreasing GDP per capita. "Slope" refers to the estimated coefficient β'_c and the t-statistic is for

$H_0 : \beta'_c = 1$. "Obs" is the number of observations in each regression, that is, the number of items n_c .

Table 9.1 Law of One Price Deviations,
Variance Decompositions

Year	Grand standard deviation $\sqrt{\sigma^2}$	Commodity decomposition (Percentages of total)		Country decomposition (Percentages of total)	
		Cross-country	Cross-commodity	Cross-country	Cross-commodity
		$\frac{\theta^2_{\text{Cross-country}}}{\sigma^2} \times 100$	$\frac{\theta^2_{\text{Cross-comm}}}{\sigma^2} \times 100$	$\frac{\phi^2_{\text{Cross-country}}}{\sigma^2} \times 100$	$\frac{\phi^2_{\text{Cross-comm}}}{\sigma^2} \times 100$
(1)	(2)	(3)	(4)	(5)	(6)
1991	1.01	63.9	36.1	53.7	46.3
1992	1.01	69.6	30.4	52.9	47.1
1993	0.97	67.2	32.8	47.3	52.7
1994	1.13	73.1	26.9	62.5	37.5
1995	0.94	65.6	34.4	39.3	60.7
1996	0.88	67.2	32.8	39.1	60.9
1997	0.89	68.1	31.9	35.7	64.3
1998	0.91	68.1	31.9	37.9	62.1
1999	0.92	67.6	32.4	33.2	66.8
2000	0.91	68.7	31.3	32.0	68.0
2001	0.90	68.9	31.1	32.0	68.0
2002	0.90	67.4	32.6	31.7	68.3
2003	0.90	69.7	30.3	32.6	67.4
2004	0.88	67.9	32.1	32.1	67.9
2005	0.87	69.8	30.2	32.0	68.0
2006	0.89	67.4	32.6	32.3	67.7
2007	0.84	67.0	33.0	32.6	67.4
2008	0.83	66.9	33.1	33.0	67.0
2009	0.85	67.0	33.0	29.6	70.4
2010	0.94	67.5	32.5	53.6	46.4
2011	0.93	66.7	33.3	57.1	42.9
2012	0.90	68.3	31.7	57.2	42.8
2013	0.80	70.4	29.6	37.4	62.6
Mean	0.91	68.0	32.0	40.3	59.7
SD	0.07	1.8	1.8	10.2	10.2

Notes: See text for details.

Table 10.1 Panel Unit Root Tests,
124 Food and Agriculture Items, 1991-2013

Item (1)	Obs (2)	Z*-stat (3)	p-value (4)	Item (5)	Obs (6)	Z*-stat (7)	p-value (8)
1. Anise, badian, fennel, coriander	46	-1.94	0.03	51. Kiwi fruit	157	-1.18	0.12
2. Apples	1,307	-5.68	0.00	52. Leeks, other alliaceous vegetables	242	-3.83	0.00
3. Apricots	751	-7.91	0.00	53. Lemons and limes	826	-4.48	0.00
4. Artichokes	277	-1.37	0.09	54. Lentils	546	-3.7	0.00
5. Asparagus	406	-2.64	0.00	55. Lettuce and chicory	955	-4.21	0.00
6. Avocados	489	-3.89	0.00	56. Linseed	320	-2.02	0.02
7. Bananas	962	-4.35	0.00	57. Maize	2,044	-7.6	0.00
8. Barley	1,484	-3.35	0.00	58. Maize, green	220	-2.51	0.01
9. Beans, dry	1,241	-5.28	0.00	59. Mangoes, mangosteens, guavas	507	-2.63	0.00
10. Beans, green	960	-3.44	0.00	60. Meat, cattle	1,339	-3.97	0.00
11. Beeswax	127	0.94	0.83	61. Meat, chicken	1,319	-4.1	0.00
12. Blueberries	82	-1.03	0.15	62. Meat, duck	260	-3.02	0.00
13. Broad beans, horse beans, dry	359	-4.77	0.00	63. Meat, game	66	-3.35	0.00
14. Buckwheat	219	-4.45	0.00	64. Meat, goat	816	-0.86	0.19
15. Cabbages and other brassicas	1,715	-5.56	0.00	65. Meat, goose and guinea fowl	125	-3.05	0.00
16. Canary seed	98	-2.8	0.00	66. Meat, horse	283	-0.19	0.43
17. Carrots and turnips	1,643	-4.87	0.00	67. Meat, pig	1,334	-5.1	0.00
18. Cashew nuts, with shell	207	-2.85	0.00	68. Meat, rabbit	273	-3.33	0.00
19. Cauliflowers and broccoli	991	-5.03	0.00	69. Meat, sheep	1,212	-4.11	0.00
20. Cherries	864	-3.49	0.00	70. Meat, turkey	322	-1.36	0.09
21. Cherries, sour	399	-4.51	0.00	71. Melons, other (inc.cantaloupes)	720	-4.3	0.00
22. Chestnut	177	-0.74	0.23	72. Milk, whole fresh cow	1,981	-2.43	0.01
23. Chick peas	458	-2.85	0.00	73. Millet	591	-2.93	0.00
24. Chillies and peppers, dry	138	-0.23	0.41	74. Mushrooms and truffles	546	-1.47	0.07
25. Chillies and peppers, green	1,035	-3.75	0.00	75. Mustard seed	189	-3.29	0.00
26. Cloves	43	-0.09	0.46	76. Nutmeg, mace and cardamoms	62	-0.01	0.50
27. Cocoa, beans	414	-4.65	0.00	77. Nuts, nes	101	-3.13	0.00
28. Coconuts	404	-0.62	0.27	78. Oats	1,164	-7.77	0.00
29. Coffee, green	637	-4.2	0.00	79. Oil, palm	187	-2.91	0.00
30. Cotton lint	204	-4.34	0.00	80. Oilseeds nes	55	-0.69	0.25
31. Cottonseed	223	-1.66	0.05	81. Olives	466	-0.83	0.20
32. Cranberries	46	-1.31	0.10	82. Onions, dry	1,623	-9.93	0.00
33. Cucumbers and gherkins	1,583	-4.66	0.00	83. Onions, shallots, green	534	-2.95	0.00
34. Currants	267	-2.01	0.02	84. Oranges	1,174	-4.47	0.00
35. Dates	256	-1.64	0.05	85. Papayas	439	-1.94	0.03
36. Eggplants (aubergines)	666	-4.73	0.00	86. Peaches and nectarines	857	-4.5	0.00
37. Eggs, hen, in shell	2,058	-5.72	0.00	87. Pears	1,080	-5.24	0.00
38. Eggs, other bird, in shell	55	-4.76	0.00	88. Peas, dry	730	-2.1	0.02
39. Figs	424	-3.08	0.00	89. Peas, green	837	-3.27	0.00
40. Flax fibre and tow	176	-0.74	0.23	90. Pepper (piper spp.)	203	-1.67	0.05
41. Fruit, fresh nes	228	-2.98	0.00	91. Persimmons	62	-0.87	0.19
42. Garlic	1,076	-4.84	0.00	92. Pineapples	658	-1.21	0.11
43. Ginger	283	-4	0.00	93. Pistachios	137	-4.26	0.00
44. Gooseberries	154	0.04	0.51	94. Plantains	489	-3.89	0.00
45. Grain, mixed	39	-3.23	0.00	95. Plums and sloes	922	-6.43	0.00
46. Grapefruit (inc. pomelos)	526	-2.09	0.02	96. Poppy seed	105	-2.55	0.01
47. Grapes	1,141	-1.49	0.07	97. Potatoes	2,139	-3.46	0.00
48. Honey, natural	1,102	-2.67	0.00	98. Pumpkins, squash and gourds	822	-4.69	0.00
49. Hops	273	-2.27	0.01	99. Quinces	387	-1.81	0.04
50. Jute	126	-0.39	0.35	100. Rapeseed	740	-6.17	0.00

(continued on next page)

Table 10.1 Panel Unit Root Tests,
124 Food and Agriculture Items, 1991-2013 (continued)

Item (1)	Obs (2)	Z*-stat (3)	p-value (4)	Item (5)	Obs (6)	Z*-stat (7)	p-value (8)
101. Roots and tubers, nes	142	-2.15	0.02	116. Tobacco, unmanufactured	1,121	-1.93	0.03
102. Rubber, natural	193	-0.61	0.27	117. Tomatoes	2,094	-5.85	0.00
103. Rye	843	-3.34	0.00	118. Triticale	318	-2.86	0.00
104. Sesame seed	524	-1.59	0.06	119. Vanilla	63	-1.04	0.15
105. Silk-worm cocoons, reelable	129	-0.86	0.20	120. Vegetables, fresh nes	421	-3.68	0.00
106. Sorghum	973	-4.09	0.00	121. Walnuts, with shell	540	-4.16	0.00
107. Soybeans	1,054	-3.39	0.00	122. Watermelons	969	-5.63	0.00
108. Spices, nes	54	-3.58	0.00	123. Wheat	1,720	-3.97	0.00
109. Spinach	642	-5.04	0.00	124. Wool, greasy	851	-5.06	0.00
110. Strawberries	1,002	-3.82	0.00	<i>Summary statistics</i>			
111. Sugar beet	847	-1.33	0.09	Mean	639	-3.24	0.06
112. Sunflower seed	793	-8.97	0.00	Median	516	-3.28	0.00
113. Sweet potatoes	930	-2.41	0.01	SD	516	1.89	0.13
114. Tanger., manda., clemens, satsumas	599	-4.1	0.00	Min	39	-9.93	0.00
115. Tea	367	-2.47	0.01	Max	2,139	1.89	0.83

Notes: The panels are unbalanced and “Obs” denotes the total number of non-missing country-year observations for each commodity. We exclude commodities with less than two producing countries and less than a total of 30 country-year observations. The Z^* -stat is the inverse-normal statistic that tests $H_0: \beta_{ic} = 0 \forall c$ in $\Delta k_{ict} = \alpha_c + \beta_c k_{ic,t-1} + \sum_{p=1}^{m_c} \phi_{cp} \Delta k_{ic,t-p} + \varepsilon_{ict}$, $c = 1, \dots, C_i$ producing countries of commodity. Here, $k_{ic,t} = \log p_{ict} - \log p_{it}^* - \log S_{ct}$, where p_{ict} is the price (in local currency units) of commodity i in country c in year t , p_{it}^* is the world price of i (in \$US) and S_{ct} is the exchange rate of c (the domestic currency cost of \$US1). That is, k_{ict} is the logarithmic deviation from the LOP. See text for further details.

Figure 2.1 Food Consumption and Incomes, 155 countries in 2011

Note: The food budget share is the proportion of total consumption devoted to food. Income (total consumption) is in \$US per capita, as in the note to Table 2.1. The equation is for a regression of the food share on the logarithm of income. Standard errors in parentheses.

Figure 2.2 Food Prices and Incomes, 155 countries in 2011**A. All Countries** **B. Income Quartiles**

Note: The relative price of food is $\log(P_F/P) = \log P_F - \log P$, the difference between the conditional budget-share weighted logarithmic mean of the prices of the food items, $\log P_F$, and the log of the cost-of-living index, $\log P$. Income (total consumption) is in \$US per capita, as in the note to Table 2.1. The solid line is the regression line. The equation is for a regression of the relative price of food on the logarithm of income. The US, the base country, is excluded. Standard errors in parentheses..

Figure 3.1 Food Price Dispersion and Incomes

Notes: The variance of the 31 food prices is $\Pi_F = \sum_{i=1}^{31} w'_i (\log p_i - \log P_F)^2$, where w'_i is the proportion of food expenditure devoted to item i and $\log P_F = \sum_{i=1}^{31} w'_i \log p_i$ is an index of the price of food. Income (total consumption) is in \$US per capita, as in the note to Table 2.1. The solid line is the regression line. The equation is for a regression of the logarithm of the variance on the logarithm of income. Standard errors in parentheses.

Figure 5.1 When is a Good Traded?

Figure 5.2 Cross-Country Box Plots and Standard Deviations

Notes: The Big Mac (BM) prices are for 57 countries, refer to 2011 and are in \$US; these are logged and demeaned. GDPs are per capita, are for 175 countries and defined similarly to the BM prices (that is, they also refer to 2011, are in \$US, logged and demeaned). The standard deviation of (the logs of) BM prices is 0.35; GDP-PPP, 1.25; and GDP-MER, 1.55.

Source: Market exchange rates for Big Macs are from *The Economist* (<http://www.economist.com/content/big-mac-index>), whilst the PPP and market exchange rates for GDP p.c. are from the ICP spreadsheet (World Bank, unpublished). Though similar, the two versions of the market exchange rate vary slightly due to different measurement horizon.

Figure 5.3 Distributions of Three Items Globally

Notes: These are kernel densities of the Epanechnikov form. Items are logged and demeaned. See note to Figure 5.2

Figure 5.4 Prices and Exchange Rates: Three Illustrations

Notes:

1. Panel A: This is a scatter of the log of Big Mac prices for 57 countries in 2011 in local currency units (LCUs) against the log of market exchange rates (Ers). The solid line is the OLS regression line. Standard errors are in parentheses. SEE is the standard error of the regression.
2. Panels B and C: These are scatters of the log of GDP per capita for 175 countries in 2011 in LCUs against the log of the PPP Ers from the ICP (panel B) and the market Ers (panel C).

Figure 6.1 Distribution of Real Relative Prices,
198 commodities in 175 countries in 2011

Note: The “real relative” price of commodity i in country c compares the domestic price (p_{ic}) with the world price (p_i^*), after adjusting for differing currencies via the exchange rate (S_c). The measure is expressed in logarithmic form as $k_{ic} = \log p_{ic} - \log p_i^* - \log S_c$, which is 0 when prices coincide, and is positive (negative) when the domestic price is above (below) the world price. The country (commodity) means are across commodities (countries).

Figure 6.2 Box Plots of Real Relative Prices,
Selected Commodities and Countries

A. Commodities

B. Countries

Note: Panel A contains box plots for the three commodities with the lowest interquartile range (IQR), and the three highest. The panel B box plots refer to the three countries with the lowest IQR and the three highest. See notes to Figure 6.1 for details of the “real relative price”.

Figure 6.3 Price Dispersion and Income, 175 countries in 2011

Note: The logarithmic real relative prices of the n_c goods in country c are $k_{ic} = \log p_{ic} - \log p_i^* - \log S_c$, $i = 1, \dots, n_c$. Price dispersion in c is measured by the standard deviation (SD), $\sigma_c = \sqrt{1/n_c \cdot \sum_{i=1}^{n_c} (k_{ic} - k_{\cdot c})^2}$, where $k_{\cdot c} = 1/n_c \cdot \sum_{i=1}^{n_c} k_{ic}$ is the country mean.

Figure 7.1 Slope Coefficients, Cross-Country Regressions, 198 Food Items

$$\log p_{ic} = \alpha_i + \beta_i \log S_c + \varepsilon_{ic}, \quad c = 1, \dots, C_i \text{ consuming countries; } i = 1, \dots, 198 \text{ food items}$$

Figure 7.2 Slope Coefficients, Cross-Commodity Regressions, 175 countries

$\log p_{ic} = \alpha'_c + \beta'_c \log p_i^* + \varepsilon'_{ic}$, $i = 1, \dots, n_c$ food items consumed in c ; $c = 1, \dots, 175$ countries

Figure 8.1 Real Relative Prices,
133 Food and Agriculture Commodities across 158 Countries, 1991 – 2013

Notes:

The “real relative” price of commodity i in country c in year t compares the domestic price (p_{ict}) with the world price (p_{it}^*) after adjusting for differing currencies via the exchange rate (S_{ct}). In logarithmic form, this is $k_{ict} = \log p_{ict} - \log p_{it}^* - \log S_{ct}$, which is 0 when prices coincide, and positive (negative) when the domestic price is above (below) the world price. Calculations are done using producer prices from the Food and Agriculture Organisation (FAO, online); see Appendix B for more details of the data.

Figure 10.1 Summary of Unit Root Tests,
124 Food and Agriculture Items, 1991 – 2013

Note: The Z*-stat tests $H_0: \beta_c = 0 \forall c$ in $\Delta k_{ict} = \alpha_c + \beta_c k_{ic,t-1} + \sum_{p=1}^{m_c} \phi_{cp} \Delta k_{ic,t-p} + \varepsilon_{ict}$. See text for details.

APPENDIX

A. THE ICP DATA

In this appendix, we provide an overview of the underlying data from the World Bank's International Comparison Program (ICP). Sections 2 to 4 draws upon the price and expenditure data at the so-called "basic heading level" from the ICP, whilst Sections 6 and 7 use the ICP's "product level" average price data. These are all from the end-user's point of view, that is, consumers.

Basic Heading Level Data

The 2011 round of ICP data contains disaggregated expenditures and prices of 155 basic headings for 182 countries. These are unpublished data supplied to us by the World Bank, listed in Table A.1. Total consumption is defined as the sum of the first 132 basic headings; this follows the ICP's definition of "Actual Household Consumption", which is the total value of the individual consumption expenditures of households, non-profit institutions serving households, and general government at purchasers' prices. Within the 132 basic headings, we consider the first 32 as food items.

We make two adjustments to the data. Firstly, we remove duplicate entries for three countries (Russia, Sudan and Egypt), each of which is a dual participant in the ICP. Next, Cuba and Bonaire do not have complete data and are omitted.

Second, we combine some commodities. Many West Asia countries have little to no PPP real expenditure per capita on pork due to religious reasons. We partially "solve" this by combining the "Pork" and "Lamb, mutton and goat" groups; so food now consists of 31 basic headings. To maintain internal consistency when we combine, expenditures (in both domestic currency units and in US dollars, that is, real expenditures) are summed over the sub-components, whilst the purchasing power parity of the combination is the ratio of nominal to real expenditures. Using a minimum cut-off of \$0.01, the following 22 countries are omitted: Algeria, Angola, Bangladesh, Brunei Darussalam, Burundi, Egypt, Ethiopia, Iran, Kuwait, Lao PDR, Malawi, Maldives, Mauritania, Myanmar, Nicaragua, Pakistan, Palestinian Territory, Saudi Arabia, Sudan, Tanzania, Togo and Yemen. Our final sample thus contains 182 (the starting number of countries) $- 3$ (duplicates) $- 2$ (Cuba and Bonaire) $- 22$ (small consumption) $= 155$ countries, listed in Table 2.1.

One limitation of the ICP data is that the 32 basic headings exclude food consumed away from home, which is important in some high-income countries. Another limitation is

that expenditure data is only available down to the basic heading level, which we use as a proxy for product-level expenditures in the weights for the world prices in Section 6.

Product-Level Prices

Also available are average prices, but not expenditures, of 1,244 products disaggregated from the 155 basic headings; Table A.2 lists the food products. Over half of the initial sample of product $\times$ country observations are missing, reflecting: (i) too few outlets selling the product for its average price to be estimated with sufficient precision; or (ii) the costs of searching out a sufficient number of outlets considered to be too high.

As before, Russia, Sudan and Egypt are dual participants in the ICP, so we keep only the entry that contains more observations. Cuba and Bonaire are also omitted as they have incomplete data. Additionally, average prices are unavailable for Iran and Georgia. This leaves $182 - 2 - 3 - 2 = 175$ unique countries. Finally, 257 products were removed as they were represented in less than 30 countries. The final sample consists of $1,244 - 257 = 987$ products, 198 foods and 789 non-foods, in 175 countries. If no prices were missing, there would be $987 \times 175 = 172,725$ valid observations. But as 81,266 are missing, there are $172,725 - 81,266 = 91,459$ product $\times$ country observations remaining.

B. THE FAO DATA

Producer price data from the Food and Agriculture Organisation (FAO) are used in Sections 8 to 10 of the paper. Our sample is made from combining two data sets from the FAO (FAO, online): (i) Annual domestic producer prices on 208 food and agricultural items in 162 countries over the 24-year period 1991 – 2014. (ii) The export quantities and values of 387 items from a varying number of countries over the period 1986 – 2013. These export data are used in calculating world prices.

In combining these datasets, we omit items with no observations, leaving 133 items, over 158 countries, from 1991 to 2013; this yields 97,274 commodity-country-year observations. These form the basis of the relative price calculations in Sections 8 and 9. For the panel unit root tests in Section 10, we further exclude items with less than two producing countries and less than a total of 30 country-year observations. This leaves 124 items, covering 158 countries, from 1991 to 2013, with a total of 79,194 observations. Table B.1 (available on request) presents the matching scheme for FAO data.

Table A.1 ICP Basic Headings

No.	ICP Basic Heading	No.	ICP Basic Heading
1.	Rice	63.	Medical Services
2.	Other cereals, flour and other products	64.	Dental services
3.	Bread	65.	Paramedical services
4.	Other bakery products	66.	Hospital services
5.	Pasta products	67.	Motor cars
6.	Beef and veal	68.	Motor cycles
7.	Pork	69.	Bicycles
8.	Lamb, mutton and goat	70.	Animal drawn vehicles
9.	Poultry	71.	Fuels and lubricants for personal transport equipment
10.	Other meats and meat preparations	72.	Maintenance and repair of personal transport equipment
11.	Fresh, chilled or frozen fish and seafood	73.	Other services in respect of personal transport equipment
12.	Preserved or processed fish and seafood	74.	Passenger transport by railway
13.	Fresh milk	75.	Passenger transport by road
14.	Preserved milk and other milk products	76.	Passenger transport by air
15.	Cheese	77.	Passenger transport by sea and inland waterway
16.	Eggs and egg-based products	78.	Combined passenger transport
17.	Butter and margarine	79.	Other purchased transport services
18.	Other edible oils and fats	80.	Postal services
19.	Fresh or chilled fruit	81.	Telephone and telefax equipment
20.	Frozen, preserved or processed fruit and fruit-based prod.	82.	Telephone and telefax services
21.	Fresh or chilled vegetables other than potatoes	83.	Audio-visual, photo. and information processing equipment
22.	Fresh or chilled potatoes	84.	Recording media
23.	Frozen, presser. Or processed veg. & veg.-based products	85.	Repair of audio-visual, photo. And info. Processing equipment
24.	Sugar	86.	Major durables for outdoor and indoor recreation
25.	Jams, marmalades and honey	87.	Maint. & repair of other major durables for recreation & culture
26.	Confectionery, chocolate and ice cream	88.	Other recreational items and equipment
27.	Food products nec	89.	Garden and pets
28.	Coffee, tea and cocoa	90.	Veterinary and other services for pets
29.	Mineral waters, soft drinks, fruit and vegetable juices	91.	Recreational and sporting services
30.	Spirits	92.	Cultural services
31.	Wine	93.	Games of chance
32.	Beer	94.	Newspapers, books and stationery
33.	Tobacco	95.	Package holidays
34.	Narcotics	96.	Education
35.	Clothing mats, articles of clothing & clothing accessories	97.	Catering services
36.	Garments	98.	Accommodation services
37.	Cleaning, repair and hire of clothing	99.	Hairdressing salons and personal grooming establishments
38.	Shoes and other footwear	100.	Appliances, articles and products for personal care
39.	Repair and hire of footwear	101.	Prostitution
40.	Actual and imputed rentals for housing	102.	Jewellery, clocks and watches
41.	Maintenance and repair of the dwelling	103.	Other personal effects
42.	Water supply	104.	Social protection
43.	Miscellaneous services relating to the dwelling	105.	Insurance
44.	Electricity	106.	Financial Intermediation Services Indirectly Measured (FISIM)
45.	Gas	107.	Other financial services
46.	Other fuels	108.	Other services nec
47.	Furniture and furnishings	109.	Final cons. Exp. Of resident households in the rest of the world
48.	Carpets and other floor coverings	110.	Final cons. Exp. of non-resident households in the eco. Territory
49.	Repair of furniture, furnishings and floor coverings	111.	Individual consumption expenditure by NPISHs
50.	Household textiles	112.	Housing
51.	Major household appliances whether electric or not	113.	Pharmaceutical products
52.	Small electric household appliances	114.	Other medical products
53.	Repair of household appliances	115.	Therapeutic appliances and equipment
54.	Glassware, tableware and household utensils	116.	Out-patient medical services
55.	Major tools and equipment	117.	Out-patient dental services
56.	Small tools and miscellaneous accessories	118.	Out-patient paramedical services
57.	Non-durable household goods	119.	Hospital services
58.	Domestic services	120.	Compensation of employees
59.	Household services	121.	Intermediate consumption
60.	Pharmaceutical products	122.	Gross operating surplus
61.	Other medical products	123.	Net taxes on production
62.	Therapeutic appliances and equipment	124.	Receipts from sales

(continued on next page)

Table A.1 ICP Categories (continued)

No.	ICP Basic Heading	No.	ICP Basic Heading
125.	Recreation and culture	141.	Electrical and optical equipment
126.	Education benefits and reimbursements	142.	Other manufactured goods nec
127.	Compensation of employees	143.	Motor vehicles, trailers and semi-trailers
128.	Intermediate consumption	144.	Other road transport
129.	Gross operating surplus	145.	Other transport equipment
130.	Net taxes on production	146.	Residential buildings
131.	Receipt from sales	147.	Non-residential buildings
132.	Social protection	148.	Civil engineering works
133.	Compensation of employees	149.	Other products
134.	Intermediate consumption	150.	Opening value of inventories
135.	Gross operating surplus	151.	Closing value of inventories
136.	Net taxes on production	152.	Acquisitions of valuables
137.	Receipts from sales	153.	Disposals of valuables
138.	Fab. Metal products, except machinery & equipment	154.	Exports of goods and services
139.	General purpose machinery	155.	Imports of goods and services
140.	Special purpose machinery		

Source: World Bank (unpublished).

Table A.2 Food Products

No. (1)	Product (2)	No. (3)	Product (4)	No. (5)	Product (6)
1.	Long grain rice – Parboiled	67.	Squid	133.	Ginger (Mature)
2.	Long grain rice – Non-Parboiled	68.	Red snapper	134.	Garlic (White)
3.	Long grain rice – Family Pack	69.	Sea Crab	135.	Brown Potatoes
4.	Jasmine Rice	70.	Tilapia	136.	Sweet Potatoes
5.	Basmati Rice	71.	Black Pomfret	137.	Cassava – Manioc – Yuka
6.	White rice, 25% broken	72.	Mullet	138.	Dried white beans
7.	White rice, Medium Grain	73.	Canned sardine with skin	139.	Tinned white beans in tomato sauce
8.	Brown rice – Family Pack	74.	Canned tuna without skin	140.	Green Olives (with stones)
9.	Short-grained rice	75.	Canned mackerel fillet in veg. oil	141.	Potato chips
10.	Cornflakes [Specified brand]	76.	Smoked salmon	142.	Frozen chipped potatoes
11.	Wheat flour, not self-rising	77.	Dried Shrimp	143.	Tomato paste (Small)
12.	Wheat Semolina (Suji)	78.	Milk, un-skimmed Pasteurized	144.	Tomato paste (Large)
13.	Oats, rolled	79.	Milk, un-skimmed UHT	145.	Tinned green peas
14.	Maize Flour White	80.	Milk, low-fat, Pasteurized	146.	Tinned sweet corn/Maize
15.	Couscous	81.	Milk, condensed	147.	Lentils, Dry
16.	Baguette	82.	Milk, powdered	148.	Green/Mung Beans, dried
17.	White bread	83.	Yoghurt, plain	149.	Tinned Button Mushrooms
18.	Whole wheat bread	84.	Sour cream	150.	White sugar
19.	Roll	85.	Cheese, Cheddar	151.	Brown sugar
20.	Sliced White bread	86.	Cream cheese	152.	Strawberry/Apricot Jam
21.	Pita bread	87.	Cheese, processed	153.	Pineapple Jam
22.	Sandwich biscuits/cookies	88.	Cheese, Camembert Type	154.	Orange marmalade
23.	Chocolate cake (Individual serving)	89.	Cheese, Gouda Type	155.	Natural honey, Mixed blossoms
24.	Chocolate cake (Whole)	90.	Bean Curd – Tofu	156.	Chocolate bar
25.	All-butter croissant	91.	Large size chicken eggs	157.	Ice cream, Cornetto-type
26.	Butter biscuits	92.	Medium size chicken eggs	158.	Chewing gum
27.	Flavored biscuits/cookies sweet	93.	Butter, unsalted	159.	Fruit drops (Hard candies)
28.	Salted crackers	94.	Salted Butter	160.	Ice cream, packed
29.	Short pasta	95.	Margarine, regular fat	161.	Toffee
30.	Spaghetti	96.	Sunflower oil	162.	Mayonnaise
31.	Dried Noodles	97.	Olive oil	163.	Cooking salt
32.	Instant Noodles	98.	Palm oil	164.	Tomato ketchup
33.	Vermicelli (Angel Hair)	99.	Soybean oil	165.	Black Pepper, ground
34.	Macaroni	100.	Peanut oil	166.	Thin Soya Sauce
35.	Beef, Fillet	101.	Vegetable oil	167.	Curry Powder
36.	Beef, Rump steak	102.	Apple, Red Delicious	168.	Chicken Ext. (bouillon/stock cube)
37.	Beef, Center brisket	103.	Banana, Standard	169.	Baking powder
38.	Beef, for stew or curry	104.	Grapes, green	170.	Baby food
39.	Beef with bones	105.	Grapefruit	171.	Chili sauce
40.	100% Beef, minced	106.	Orange	172.	Chili powder
41.	Veal chops	107.	Papaya	173.	Baby cereals
42.	Veal breast (non-refrigerated), with bones	108.	Pineapple	174.	Cocoa Powder, Tin
43.	Pork, loin chop	109.	Lemon	175.	Instant coffee [Specified brand]
44.	Pork, fillet	110.	Mango	176.	Coffee Roasted 100% Arabica
45.	Pork, shoulder	111.	Watermelon	177.	Coffee Roasted 100% Robusta
46.	Pork, ribs	112.	Apple, Typical Local Variety	178.	Tea bags, black
47.	Lamb whole leg	113.	Peach	179.	Tea, green
48.	Lamb chops	114.	Melon	180.	Tea, black
49.	Mutton mixed cut	115.	Tinned pineapple	181.	Mineral water
50.	Goat mixed cut/with bones (non-refrigerated)	116.	Dried almonds	182.	Carb. S.Drink [Spec. brand] (Small)
51.	Whole chicken – Broiler	117.	Roasted groundnuts/peanuts	183.	Carb. S.Drink [Spec. brand] (Large)
52.	Whole chicken	118.	Mixed Fruits in Syrup	184.	Apple juice
53.	Chicken breast without skin	119.	Dried dates	185.	Orange juice
54.	Chicken legs	120.	Cucumber	186.	Lemonade
55.	Live chicken	121.	Bell pepper	187.	Vodka
56.	Chicken breast with skin and bones	122.	Carrots	188.	Whisky
57.	Pork ham, pressed	123.	Onion	189.	Gin [Specified Brand]
58.	Bacon, smoked	124.	Maize	190.	Irish whiskey & cream liquor [Spec. brand]
59.	Beef liver	125.	Round tomato, loose	191.	Superior Light/White Rum
60.	Corned beef	126.	Green cabbage	192.	Red wine, table wine
61.	Canned chicken	127.	Lettuce	193.	Red wine, Bordeaux Supérieur
62.	Carp	128.	Avocado	194.	White wine, table wine
63.	Mackerel, un-cleaned	129.	Eggplant (aubergine)	195.	Sparkling wine
64.	Sea Bass	130.	Cauliflower	196.	Domestic Canned Beer
65.	Whole Shrimps	131.	Spinach	197.	Domestic Beer Bottle
66.	Shrimps	132.	Chilies (Long)	198.	Beer [Specified brand]

Note: Listed in this table are the 198 food products out of the total 987 products.

Source: World Bank (unpublished).

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