ENGEL'S LAW, DIET DIVERSITY AND THE QUALITY OF FOOD CONSUMPTION*

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Abstract

Increasing income brings about a decline in the relative importance of food consumption, a wider spread of spending patterns and a demand for higher-quality goods. Using an index-number approach, this article analyses these three closely related tendencies. Stripping out the impact of prices from the dispersion of food expenditures gives a volume-based measure of diet diversity that is relevant for nutrition. Using unpublished International Comparison Program data for 31 items of food in more than 150 countries, we find that diets of rich countries are substantially more diverse than those of the poor; and that volumes are the more appropriate way to measure the inequality of diversity. The quality of the food basket, based on the luxury-necessity distinction of consumption, increases with income, but the elasticity is small. There is a modest tendency for the structure of prices to be regressive, since prices of luxuries relative to necessities are lower in richer countries. Additionally, our diversity and quality measures are shown to have implications for demand analysis and wellbeing.

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In 1857, Engel (pp. 28-29) stated “the poorer a family, the greater the proportion of its total expenditure that must be devoted to the provision of food,” and then extended this to whole countries by arguing the richer a country, the smaller the food share (Stigler, 1954). This is now known as “Engel’s law”, a law that enjoys such elevated status due to empirical support that is near overwhelming. To describe it as immutable would be an overstatement, but still the widespread applicability of Engel’s law gives it an almost unique place in economics.¹

Engel’s law has broader implications for the structure of all consumption expenditure. First, with food occupying a larger part of the poor’s budget, this tendency to specialise means that their budgets are less diversified than those of more affluent consumers. The very poor might spend as much as one-half of their income on food, so their budgets can be said to be food-intensive, or specialised. Relatedly, within the food budget, cheaper, more starchy foods (such as rice, potatoes and bread) are likely to be predominant for the poor, leading to less nutritious, less diversified diets.²

A second implication of Engel’s law is its relationship with quality. As the budget shares of luxuries increase with affluence, relatively more is spent on these goods and they can be said to be preferred, or of higher quality, in the eyes of the consumer. For necessities, the reverse is true, so these goods are regarded as being of lower quality. Thus, if the composition of the budget moves in the direction of containing more luxuries and fewer necessities, the overall quality of consumption can be said to improve. The declining food share that accompanies income growth is exactly this -- the quality of consumption rises. This approach to the measurement of quality that is based on the luxury/necessity distinction, due to Theil (1975/76) and extended by Clements and Gao (2012), involves a covariance between the income

¹ The classic reference for the validity of Engel’s law is Houthakker (1957). See also Chakrabarty and Hildenbrand (2009); Gao (2012); Houthakker (1987); and Ogaki (1992). Chai and Moneta (2010) provide a useful retrospective on Engel’s work.

² For research on the diversity of consumption patterns and its relation to income, see, e.g., Chai and Moneta (2012); Drescher, Thiele and Weiss (2008); Falkinger and Zweimüller (1996); Jackson (1984); Li (2011); Shonkwiler, Lee and Taylor (1987); Theil and Finke (1983); and Thiele and Weiss (2003); for a survey, see Chai, Rohde and Silber (2015). Somewhat relatedly, Khoury et al. (2014) examine food supplies of 152 countries from 1962 to 2009 and find increasing diversity and homogeneity across countries.

elasticities and consumption of the n goods in the budget. That high-quality goods tend to be intensively consumed by the rich is an uncontroversial statement. The converse that the budgets of the poor are intensive in low-quality goods, especially food, provides a link between Engel's law and the measurement of quality.³ This article deals with three related themes: Engel's law, the diversity of food consumption patterns and their quality. The article shows how measures of diet diversity and food quality are of use in demand analysis and for the study of wellbeing. In what follows in this section, we give some details of the workings and implications of Engel's law and relate our research to the previous literature.

Engel's law can be thought of as reflecting a fixed component of food consumption that is independent of income, needed to sustain life. This leads to a budget share of food that declines with income. Something more precise can be said about the rate at which the food share falls with income growth. In a series of studies, Seale, Theil and others mostly from Florida use Working's (1943) model to analyse cross-country consumption patterns with the data from the International Comparisons Program.⁴ According to this model, the budget share is a linear function of the logarithm of income,

³ There are two conventional approaches to measuring quality. The first is the hedonic approach, according to which prices paid are regressed on the important physical characteristics of the goods to obtain their shadow prices; constant-quality prices are then obtained by stripping out the effects of characteristics of the goods (Griliches, 1961). The second approach involves using prices themselves as a measure of quality. On the understanding that prices are approximately constant in a cross section of consumers, the income elasticity of food can be measured by the elasticity of expenditure, $\eta \equiv \partial \log e / \partial \log M$, where $e = p \times q$. But when prices paid vary with the income of consumers, η becomes the sum of (i) a quantity elasticity $\partial \log q / \partial \log M$; and (ii) a quality elasticity $\partial \log p / \partial \log M$ (on account of the rich purchasing higher-priced items, which is taken to represent higher quality). Houthakker (1987) describes the distinction between the two components as "agriculture produces quantity, while food processing and trade produce quality". This second approach to quality is due to Prais and Houthakker (1955) and Theil (1953). For related research, see Bils and Klenow (2001); Cox and Wohlgenant (1986); Cramer (1973); Deaton (1988); Gale and Hang (2007); Hicks and Johnson (1968); and Yu and Abler (2009).

⁴ See Clements and Theil (1979); Seale and Regmi (2006); Theil (1987); Theil, Chung and Seale (1989); and Theil and Suhm (1981). Related research includes Meade et al. (2014); Muhammad et al. (2011); Regmi and Seale (2010); Seale, Walker and Kim (1991); Seale, Regmi and Bernstein (2003); Seale and Regmi (2009); Seale and Solano (2012); and Theil (1996).

$$(1) \quad w = \alpha + \beta \log M,$$

with $\beta < 0$. After embedding (1) in a system-wide model of n goods and allowing for differences in prices, Theil, Chung and Seale (1989), estimate β to be in the vicinity of -0.15 , a value in broad agreement with estimates from a number of other studies.⁵ To interpret this value, suppose one country has income M_0 and another's is $2M_0$, so it is twice as rich and the logarithmic difference is $\Delta \log M = \log(2M_0/M_0) = \log 2 \approx 0.69$. Working's model then implies that the difference in the food share is $\Delta w = \beta \Delta \log M = -0.15 \times 0.69 \approx -0.10$. In words, a doubling of income leads to a fall in the food budget share by 10 percentage points, a result Theil, Chung and Seale (1989) refer to as "the strong version of Engel's law".⁶ Engel's law in its conventional form states that the food share declines as income rises, while the strong version is a specific numerical statement of the nature of the decline in the share.⁷ The logical extension of the strong version is to use the food share itself as an inverse measure of living standards; see Clements and Chen (2010) and the references therein. The advantage is the ready availability of this share and because it is unit free and dimensionless, immediate comparisons of incomes can be made across countries and time without tricky exchange rate or inflation adjustments.

The article is structured as follows. The next section introduces the data to be used -- unpublished disaggregated data on consumption of 31 food items in more than 150 countries from the International Comparison Program. As these data virtually span the whole of the economic spectrum and contain large variations in income and consumption patterns, there is the possibility of obtaining special insight into consumer behaviour. Also included is an examination of the implications of Engel's law for the individual items of food. Using elements of index-number theory, in the

⁵ See Chen (1999); Chung and Lopez (1988); and Yuen (1999).

⁶ It should be noted, however, that there is some other evidence indicating that Working's food β is closer to -0.10 , rather than -0.15 (Izan and Clements, 1979; Clements and Chen, 2010). In such a case, a doubling of income leads to a fall in the budget share of about 7 percentage points (rather than 10 points).

⁷ The strong version of Engel's law also has implications for the price elasticity of demand for food. If the Slutsky price elasticity is approximately constant, then under preference independence a doubling of income leads to the Cournot price elasticity also falling in absolute value by about 0.10. For details, see Clements and Chen (1996).

following two sections we measure diversity of food consumption with a weighted variance of the budget shares. The key innovation here is to show how this measure can be split into components due to dispersion in prices and quantities. This distinction is fundamental, since it is the diversity among the quantities of food types that makes for a more varied, more nutritional diet. This material also examines a further decomposition of diversity into between- and within-group components, a distinction that has important implications for food: A balanced diet entails a spread of consumption across the major food types, which is exactly what between-group diversity measures. The subsequent section analyses the quality of food consumption based on the luxury/necessity distinction of goods. This also includes measures of the quality of spending and the price of quality. There we find food quality increases with income, but the elasticity is small. There is a modest tendency for the structure of prices to be regressive, since the prices of luxuries relative to necessities tend to be lower in rich countries. To demonstrate the broader applicability of our proposed measures, the next section explores some of their implications for demand analysis. The penultimate section provides limitations and qualifications of our results and concluding comments are given in the final section.

The Structure of Food Budgets

Table 1 lists 155 countries in terms of decreasing 2011 income per capita (which we measure by real total consumption per capita).⁸ The richest is Bermuda, while the Democratic Republic of Congo is the poorest. Countries are grouped into income quartiles and, roughly speaking, these correspond to the rich, middle income, poor and very poor, respectively. The average income of countries in the first quartile is \$25,974, \$12,341 in the second, \$6,010 in the third and \$1,525 in the bottom. Thus, on average, the rich are about 17 times as affluent as the poorest. The table also contains the food budget shares, the proportions of total consumption devoted to food. From the bottom of the table it can be seen that in the rich countries, on average, food absorbs just a bit more than 10 percent of the budget, while this is well over 40

⁸ The data used here and subsequently are derived from unpublished disaggregated data from the 2011 International Comparison Program (World Bank, unpublished), supplied to us by the World Bank. Hereafter, we use the abbreviation “ICP” to refer to this source. For details of the data, see online supplementary appendix A1.

percent in the very poor. Figure 1 plots the food shares against the logarithm of income and as can be seen, there is a strong tendency for the share to fall with increasing affluence, in agreement with Engel's law. The regression line is of the Working form (1) with slope $\beta = -0.12$. Thus, if we move from a poor country to a richer one with twice the income, the food share falls by $\Delta w = \beta \log 2$, as discussed before, or by about 8 percentage points when $\beta = -0.12$.

If the food share falls with increasing income, which food items do most of the adjusting? Some will fall at about the same rate as total food, while others will fall faster or slower; conceivably, the shares of some items of food may even increase with higher income. To investigate this issue, consider the 31 food items listed in column 1 of table 2. Let $e_i = p_i q_i$ be expenditure on good i ($i = 1, \dots, n > 31$ consumer goods), so that $w_i = e_i / M$ is the budget share of i , where $M = \sum_{i=1}^n e_i$ is total expenditure. If the n goods are ordered so that the food items are the first 31, then $W = \sum_{i=1}^{31} w_i$ is the (total) food share. Averaging over all countries, it can be seen from column 6 of table 2 that the important items in the food budget are rice, other cereals, and fresh and chilled vegetables, which each absorb around 2 percent of the budget. Other notable items include bread, beef and veal, fish and seafood, and fresh or chilled fruit, which each account for around 1.2-1.3 percent of the budget. Columns 2-5 contain the budget shares for each income quartile and for many items there is considerable disparity across the income distribution. Taking rice as an example, consumers in the first quartile (the richest) spend only 0.2 percent of their income (that is, total consumption) on this item, while that proportion increases by a factor well over 20 to be 5.4 percent for the fourth quartile (the poorest). Lastly, geographical considerations may explain some of these cross-country differences, which we explore further in the penultimate section.

Specialisation and Diversification of the Menu

Table 2 showed that the budget share of food in the poorest countries is, on average, more than 40 percent, while this falls to a little above 10 percent for the richest. Thus, in this sense, the budgets of the poor tend to be specialised in food, while the rich consume a more diversified basket of goods. Within food, there is a similar pattern of

expenditure by the rich being more evenly distributed across the broad groups, less evenly by the poor. Again from table 2, spending on bread and cereals absorbs about 14 percent of the food budget for the rich, while the poor devote almost 30 percent to this group. The larger share for bread and cereals in poor countries means less is available for the other groups, giving rise to a higher dispersion of the shares, or less diversified diets in these countries.⁹ The emphasis that nutritionists place on the role of a balanced, or diversified, diet for good health is one reason for interest in the diversity of consumption. A related reason is that greater diversity is usually thought to be a good thing in and of itself, which possibly reflects a basic concavity of the utility function. This section, which draws in part on Theil (1967, Chap. 5), establishes measures of diversity of the food budget; analyses the price and quantity components of diversity; and investigates how diversity varies across countries with different incomes.

Suppose there are n goods in the consumption basket with prices $p_1, \dots, p_n$ and quantities demanded $q_1, \dots, q_n$. Thus, $p_i q_i$ is expenditure on good i , $M = \sum_{i=1}^n p_i q_i$ is total expenditure and $w_i = p_i q_i / M$ is the i^{th} budget share; for brevity, we shall refer to M as “income”. Obvious measures of central tendency of these are budget-share weighted averages, which in logarithmic form are

$$(2) \quad \log P = \sum_{i=1}^n w_i \log p_i, \quad \log Q = \sum_{i=1}^n w_i \log q_i, \quad \log \bar{W} = \sum_{i=1}^n w_i \log w_i.$$

The first equation defines the Stone (1954) index, a budget-share weighted average of the logarithms of the prices. The quantity and budget share indexes in (2) are analogous.

The above indexes can be considered as weighted first-order moments of the n prices, quantities and budget shares. The corresponding second-order moments are:

⁹ Within the bread and cereals group, for the poorest countries the standard deviation (SD) of the five conditional shares is 22 percent, while this falls to 15 percent for the richest. As a lower SD implies more equal shares, this means more diversity of consumption.

$$(3) \quad \begin{cases} \Pi_p = \sum_{i=1}^n w_i (\log p_i - \log P)^2, & \Pi_q = \sum_{i=1}^n w_i (\log q_i - \log Q)^2, \\ \Pi_w = \sum_{i=1}^n w_i (\log w_i - \log \bar{W})^2. \end{cases}$$

These are measures of dispersion of prices, quantities and budget shares around their weighted means. There is also the weighted price-quantity covariance and the associated correlation

$$(4) \quad \Pi_{pq} = \sum_{i=1}^n w_i (\log p_i - \log P)(\log q_i - \log Q), \quad \rho = \frac{\Pi_{pq}}{\sqrt{\Pi_p \cdot \Pi_q}}.$$

As the consumer tends to move away from those goods with higher prices towards those with lower prices, we expect the covariance and correlation to usually be negative. The measures in (3) and (4) are all pure numbers and satisfy

$$(5) \quad \Pi_w = \Pi_p + \Pi_q + 2\Pi_{pq}.$$

To apply the above concepts to the food basket, w_i is interpreted as the conditional budget share of food i . The term q_i is interpreted as the per capita volume consumed of food item i and n is the number of food items. The conditional shares, averaged over countries, for $n = 31$ food items are contained in the middle panel of table 2. The volume index in (2) for food, by income quartile, is contained in column 2 of table 3. Thus, for example, the log difference in the volume of food consumption per capita between the second and first quartiles is $4.39 - 4.68 = -0.29$, or $100 \times (e^{-0.29} - 1) = -25$ percent, so that food consumption is 25 percent lower in the second quartile. There is a much bigger drop in going from the third to the fourth quartile, where the log difference is $3.23 - 4.08 = -0.85$, or almost 60 percent.¹⁰ The budget-share variance of (3) is an *inverse* measure of diet diversity as a more specialised diet has a larger variance of the shares and is thus less diverse. As can be seen from column 3 of table 3, this variance rises noticeably as income falls, which confirms the greater diversity of the diets of the rich and the lower diversity of those of the poor. For the first quartile, the standard deviation (SD) is

¹⁰ For a further discussion of the food volume index, see online supplementary appendix A2.

$\sqrt{\Pi_w} = \sqrt{50.86 \times 10^{-2}} \approx 71$ percent, while this is about 100 percent for the fourth quartile.

As shown by equation (5), the budget-share variance comprises price, quantity and covariance terms. As nutrition is associated with the quantities consumed, the quantity variance Π_q is the relevant measure as it strips out the influence of prices. Columns 4 and 5 of table 3 reveal that quantities contribute a reasonably large part of the budget-share variance. The effect of prices is modest for the richer countries, but becomes increasingly important as income falls. For the fourth income quartile, prices account for $25.12/99.55 = 25$ percent of the budget-share variance. On average, quantities are more than six times more variable than prices on the basis of the variances, or more than twice as large if the SDs are used. A scatter plot of the quantity variance against income reveals that the income elasticity is -0.29. Therefore, a 10-percent increase in income lead to a 3-percent fall in the quantity variance. The negative price-quantity correlations of column 7 of table 3 imply a clear tendency of food consumption to move away from more expensive items, towards cheaper ones, other factors remaining unchanged.¹¹

The Components of Diversity

What more can be said about the nature of diversity of food consumption? Dividing goods into broader groups means that the dispersion of the whole budget can be partitioned into within-group and between-group components. It might be expected that if goods within each group are sufficiently similar, diversity is mainly confined to the between-group component. But in view of the huge differences in incomes that cause a large dispersion of budget shares, this might not be the case. What are the implications of diversity for a balanced diet and nutrition? Does it matter if we use budget shares or quantities to measure diet diversity? Do particular items dominate in driving overall diversity? This section analyses these matters.

¹¹ The variance-income plots and further results are given in online supplementary appendix A3.

Suppose the n goods are combined into $G < n$ groups, to be denoted by $\mathbf{S}_1, \dots, \mathbf{S}_G$, such that each good belongs to one group only. Define the share of income spent on group g and the share of group expenditure devoted to $i \in \mathbf{S}_g$ as

$$W_g = \frac{\sum_{i \in \mathbf{S}_g} p_i q_i}{M} = \sum_{i \in \mathbf{S}_g} w_i, \quad w'_i = \frac{p_i q_i}{\sum_{i \in \mathbf{S}_g} p_i q_i} = \frac{w_i}{W_g}, \quad i \in \mathbf{S}_g.$$

The indexes of prices, volumes and budget shares for group g are

$$\log P_g = \sum_{i \in \mathbf{S}_g} w'_i \log p_i, \quad \log Q_g = \sum_{i \in \mathbf{S}_g} w'_i \log q_i, \quad \log \bar{W}_g = \sum_{i \in \mathbf{S}_g} w'_i \log w'_i.$$

These indexes are the group counterparts of the indexes for the n goods in equation (2).¹² The variance of the n budget shares can then be decomposed into between- and within-group components:

$$(6) \sum_{i=1}^n w_i (\log w_i - \log \bar{W})^2 = \sum_{g=1}^G W_g (\log \bar{W}_g - \log \bar{W})^2 + \sum_{g=1}^G W_g \left[\sum_{i \in \mathbf{S}_g} w'_i (\log w'_i - \log \bar{W}_g)^2 \right].$$

The between-group component -- the first term on the right-hand side -- is a weighted variance of the (logarithmic) group shares. The second term is the within-group component, which is a weighted average of the group variances $\sum_{i \in \mathbf{S}_g} w'_i (\log w'_i - \log \bar{W}_g)^2$, $g = 1, \dots, G$. The price and quantity variances of (3) can also be decomposed in an analogous manner.

We apply the decomposition (6) to the $n = 31$ food items that are divided into the $G = 7$ groups of column 1 of table 2.¹³ Columns 12-15 contain, for each quartile, two sets of budget shares, those for the group (the emboldened figures) and the conditional shares (not emboldened). Consider first the seven group shares. Column 16 refers to all countries and shows that with a budget share of 23 percent, meat and seafood account for the largest part of the budget, on average. Then follows bread and cereals with a budget share of 19 percent, and fruit and vegetables are a close third (18 percent). As before, there is considerable diversity of the budget shares across the income distribution. This diversity is particularly large for the bread and cereals

¹² Note that $\log \bar{W}_g$ is not the same as $\log W_g$ where $W_g = \sum_{i \in \mathbf{S}_g} w_i$.

¹³ The broad guiding principles of the classification scheme are that (i) groups contain items that could reasonably be considered to be "similar" in the eyes (mouths?) of consumers; and (ii) the number of items in each group is fairly similar.

group, where the share rises from 14 percent for the first quartile (the richest countries) to almost 30 percent for the fourth (the poorest). The conditional budget shares describe the allocation within the group. Thus, from column 16 again, on average for all countries, spending on bread and cereals is made up of 22 percent for rice, 24 percent for other cereals, 30 percent bread and so on.¹⁴

Table 4 applies the decomposition to the variances of the budget shares, price and quantities.¹⁵ From columns 3 and 4 for the quantity variances of panel C, in the first three income quartiles the between-group components are approximately one-half of the within-group components; but in the fourth quartile, the two components are approximately equal.¹⁶ The between-group component of the quantity variance is an inverse measure of diet diversity among the food groups – the spread of food consumption across bread and cereals, meat and seafood, dairy, fruit, etc. Arguably, diversity of consumption at the broad food-group level is what brings substantial nutritional value; this diversity is measured by the quantity variance. Column 3 of panel C of the table reveals huge differences in this component of the quantity variance across the income distribution: The ratio for the richest to the poorest countries is $\frac{22.07}{75.29}$, so that the diversity of the diets of the rich, relative to that of the poor, is $\frac{1/22.07}{1/75.29} = \frac{75.29}{22.07} \approx 3.4$. That is, the diets of the rich are about three-and-one-half times more diverse than the poor's. Contrast this with the total variance (column 2), for which the diversity ratio is $\frac{149.85}{64.58} \approx 2.3$, considerably less than the between-group measure. The conclusion is clear: Ignoring the between-within distinction for the broader food groups, and just focusing on the total variance, masks a substantial part of the inequality of diet diversity.

What if instead of the quantity variance, we were to use the variance of the budget shares to measure diet diversity? At least part of the inequality is then missed: From panel A of table 4, the rich-poor diversity ratio for the between measure is

¹⁴ For a further discussion of diversity within bread and cereals, see online supplementary appendix A4.

¹⁵ Online supplementary appendix A3 contains the decomposition of the price-quantity covariance.

¹⁶ The same pattern also holds for the budget shares (panel A). For prices (panel B), the ratio of the between-to- within component increases as income falls, but possibly not as rapidly as it does for quantities and budget shares.

$\frac{47.63}{16.90} \approx 2.8$, while the corresponding ratio for the total is $\frac{99.55}{50.89} \approx 2.0$. Here, the between ratio is again higher than that for the total, so if we use the budget-share variance, the conclusion remains the same, viz., inequality is underestimated. But now there are two differences: (i) The total-between gap is smaller, so the underestimation of inequality now appears to be less severe. (ii) The between ratio is now noticeably smaller than before (2.8 vs 3.4), again leading to a reduction in apparent inequality. For these reasons, it seems preferable to exclude the impact of prices from diet diversity and use quantities, rather than budget shares, in measures of dispersion.

Before leaving table 4, one further pattern from panel C is worth noting. In all cases except the first quartile, bread and cereals has the largest dispersion among the seven groups. As this measure refers to group dispersion only [the term in square brackets on the right of equation (6)], the predominance of bread and cereals cannot be attributed to its large budget share. This result points to the special role played by bread and cereals.

Food Quality

As emphasised previously, the fall in the food budget share as income rises is dramatic, from 46 percent in the poorest countries to 11 percent in the rich (table 1). Thus, as affluence rises, the intensity of spending moves away from the dominant necessity of life to goods with a less-of-a-necessity status. In a fundamental sense, the nature of the basket improves if the dominant necessity accounts for a smaller fraction of consumption. The “quality” of the consumption basket of the rich could reasonably be described as being of higher “quality”, that is, as spending moves away from necessities towards luxuries, the quality of consumption improves. Here, quality is based on the revealed preference of the consumer, not on any outside judgments as to what constitutes quality. This notion of quality differs from the usual hedonic approach that deals with the physical characteristics of the good (Griliches, 1961). The luxury/necessity quality framework, due to Theil (1975/76) and extended by

Clements and Gao (2012), leads to indexes of quality of the consumption basket and its price.¹⁷

To explain our measure of quality further, write the budget constraint, $M = \sum_{i=1}^n p_i q_i$, in change form as $d(\log M) = d(\log P) + d(\log Q)$, where $d(\log P) = \sum_{i=1}^n w_i d(\log p_i)$ and $d(\log Q) = \sum_{i=1}^n w_i d(\log q_i)$ are Divisia (1925) price and volume indexes, with $w_i = p_i q_i / M$ the budget share of good i . Define the i^{th} income elasticity as $\eta_i = \partial(\log q_i) / \partial(\log M)$. The relative importance of the growth in consumption of good i can be measured by its deviation from average, $d(\log q_i) - d(\log Q)$. Luxuries are preferred to necessities by the consumer as when income rises, spending on the former rises by proportionately more than spending on the latter. Thus, suppose we observe for a certain good i that $d(\log q_i) - d(\log Q) > 0$; if the good is a luxury ($\eta_i > 1$), its above-average growth then contributes to the desirability, or quality, of the basket. Alternatively, if the good were a necessity ($\eta_i < 1$), its above-average growth diminishes the quality of the basket. The general proposition is, therefore, that faster (slower) growth of a luxury (necessity) enhances quality, while slower (faster) growth of a luxury (necessity) detracts from quality. Quality consequently involves the sign of the product $(\eta_i - 1) \times [d(\log q_i) - d(\log Q)]$. To apply this to all n goods simultaneously, we take a budget-share weighted average of these products:

¹⁷ This approach to quality avoids the problem of hedonic analysis that there are only a limited number of commodities that possess easily-identified physical characteristics -- many services (such as education and medicine) have little or no physicality. Another problem is that if the baseline "constant-quality" good of hedonics is no longer available to consumers, the meaning of a decline in the price of a now non-existent good is unclear. For a further discussion, see Clements and Gao (2012).

Deaton (1988) proposes another approach to quality when unit values reflect both "true" prices and quality differences. He seeks to estimate price elasticities from survey data where prices differ across villages, but are more or less unchanged within each village. Because the quality of each group of goods is subject to choice, the use of unit values leads to an overstatement of own-price elasticities. When the price of, say, meat in general rises, households move towards cheaper, lower quality cuts and the unit value rises by less than otherwise. Accordingly, when quality is not controlled for and the given quantity change is related to the smaller price increase, the result is a higher price elasticity. With the group forming a separable block in the utility function, Deaton is able to allow for quality change and obtain elasticities not contaminated by changing compositional changes.

$$(7) \quad y_q = \sum_{i=1}^n w_i (\eta_i - 1) [d(\log q_i) - d(\log Q)].$$

This is an index of the change in quality of consumption. The price y_p and spending y_{pq} quality indexes are defined analogously and satisfy $y_{pq} = y_q + y_p$.¹⁸

This notion of quality can be applied specifically to food, although it must be noted that higher quality does not necessarily mean better nutrition. To clarify this, consider the case of beef consumption when we move from a poor country to a richer one. We might expect to see two effects. First, a move away from lower- to higher-quality cuts of meat (such as from hamburger to sirloin) and/or a move to higher grades of a given cut (from select, to choice, to prime in the US, for example). The second effect is that in the richer country more services would be provided with the meat (such as packaging, safer food and retailing services), with the cut, grade and other physical attributes held constant. Although greater beef consumption in the rich country would probably represent improved quality under our measure, the implications for nutrition are unclear. More generally, much of what is recorded as “food” in high-income countries comes bundled with substantial “nonfood” components that are mostly services, such as additional processing of the food like frozen pizzas or dinners. Notwithstanding this, the quality index plays a useful role in providing an alternative way to compare diets across countries in a consistent manner that reflects consumption behaviour only, not what external parties deem desirable, or healthy.¹⁹

To apply the quality index (7) to food, w_i is interpreted as the proportion of total food expenditure devoted to the i^{th} food item and η_i as this good’s income elasticity within food.²⁰ With cross-country data, we compare country c with country d , so that the relative change in consumption of good i is $\log q_i^{cd} = \log(q_i^c / q_i^d)$ and

¹⁸ For details of the income elasticities to be used subsequently, see online supplementary appendices A5-A7; and for more details of the quality indexes, see online supplementary appendix A8.

¹⁹ We are grateful to a referee for suggesting the beef example to clarify the quality index.

²⁰ That is, this share and the elasticity are now conditional. However, in order not to overburden the notation, we simply reinterpret equation (7) as referring to food. This interpretation will be clear from the context.

the corresponding budget share is $w_i^{cd} = (w_i^c + w_i^d)/2$. Defining the two-country income elasticity as $\eta_i^{cd} = w_i^c / (w_i^c + w_i^d) \cdot \eta_i^c + w_i^d / (w_i^c + w_i^d) \cdot \eta_i^d$, the index of the quality of consumption in country c relative to d is thus:

$$(8) \quad y_q^{cd} = \sum_{i=1}^{31} w_i^{cd} (\eta_i^{cd} - 1) (\log q_i^{cd} - \log Q^{cd}),$$

where $\log Q^{cd} = \sum_{i=1}^{31} w_i^{cd} \log q_i^{cd}$ is the Divisia volume index in c relative to d . As before, the price and spending indexes are defined analogously. Online supplementary appendix A8 contains a histogram of all pairs of y_q^{cd} , as well as analogous ones for prices and spending, y_p^{cd} and y_{pq}^{cd} .

To investigate the role of income on our bilateral indexes with the ICP data, figure 2 gives the distribution by income quartile of the quality of consumption, as measured by equation (8). The first row refers to the differences between countries in the first quartile and others in the first, second, third and fourth quartiles, successively. As the centre-of-gravity of the distribution moves to the right as we go across the row from left to right, on average, the quality differences increase as rich countries are compared to successively poorer ones. The other three rows of the figure are interpreted similarly. In short, the quality of food consumption is lower for poorer consumers, as is to be expected. Another aspect of figure 2 is that the dispersion within the fourth quartile is substantially less than that in the other three. Consequently, if you are poor, the quality of your consumption is not only lower than that of the more affluent, it is also quite similar to that of most of your immediate neighbours (who are also poor).

When one country is compared with another in the form of the above bilateral indexes, there are a large number of pairs to be considered. To compress the results, we convert the bilateral to multilateral indexes where each country has one value only. Following Clements and Gao (2012), we average over all pairwise comparisons to give the multilateral indexes for country c : $\hat{\alpha}_q^c = 1/155 \cdot \sum_{d=1}^{155} y_q^{cd}$, $\hat{\alpha}_p^c = 1/155 \cdot \sum_{d=1}^{155} y_p^{cd}$ and $\hat{\alpha}_{pq}^c = 1/155 \cdot \sum_{d=1}^{155} y_{pq}^{cd}$. These indexes for the 155 countries are given in online supplementary appendix A8. The quartile means for multilateral index

of consumption quality are given in column 2 of table 5. From columns 4-6 of the first row panel A, the quality of consumption for countries in the first quartile is, on average, about 12, 24 and 36 percent greater than that of countries in the second, third and fourth quartiles, respectively. The price of quality falls modestly as income rises, as can be seen from panel B. Due to the small price differences, the spending results of panel C of the table are similar to those for consumption.

Panel A of figure 3 plots multilateral quality of consumption against income and as is clear, higher quality food comes with higher income, at least on average. The coefficient of log income in the regression is 12.06, which is 100 times the elasticity (the dependent variable is $\times 100$). With an income elasticity of $12.06/100 = 0.12$, when we move from one country to another that is 50-percent richer, the quality of the food basket improves by about 6 percent. While this income sensitivity might be considered low, it can also be interpreted as simply saying that it is not easy to increase the quality of the food basket.

Panel B of figure 3 is a similar scatter for the multilateral index of the price of quality, $\hat{\alpha}_p^c$. If $\hat{\alpha}_p^c > 0$, then the prices of luxuries are higher, on average, in country c as compared to other countries. As the rich spend relatively more on luxuries, in this case, if c is richer than average, the structure of prices has a progressive impact on the distribution of real income: If nominal income remains unchanged, a rich person's real income falls after moving from the rest of the world to c , from where luxuries are cheap to where they are more expensive. Conversely, when $\hat{\alpha}_p^c < 0$, prices are regressive in c relative to other countries since necessities are relatively more expensive.²¹ The figure shows that the price of quality declines with income, as indicated by the negatively sloped regression line. As quality is the covariance between the income elasticities and the relative prices, the implication is that luxuries are relatively cheaper and necessities more expensive in richer countries. In other words, the price of quality is lower in rich countries and higher in poor countries. Taken literally, the richer the country, the more regressive (or less progressive) the

²¹ For other approaches to measuring the impact of the structure of prices on income distribution, see Broda and Romalis (2009); Muellbauer (1974); Nicholas, Ray and Valenzuela (2010); and Pendakur (2002).

structure of prices. Although the coefficient of log income is significant, this tendency is small with an elasticity of only -0.01. This small effect is in agreement with the low dispersion of the bilateral price index, as shown in online supplementary appendix A8. Panel C of the figure, which shows the dependence of the quality of spending on income, is similar to panel A, due to the relatively small role for the price of quality.²²

Diversity, Quality and Demand Analysis

The above concepts of diversity and quality are linked to aspects of demand analysis. This section articulates these links to demonstrate the wider applicability of our measures. For further details and derivations of this material, see online supplementary appendix A11.

Under “want-independence” (Frisch, 1959), where the marginal utility of each good is independent of the consumption of all others, the differential demand equation for good i can be written as:

$$(9) \quad d(\log q_i) = \eta_i d(\log Q) + \phi \eta_i [d(\log p_i) - d(\log P')],$$

where $d(\log Q) = \sum_{i=1}^n w_i d(\log q_i)$ is the Divisia (1925) quantity index and $d(\log P') = \sum_{i=1}^n \theta_i d(\log p_i)$ the Frisch (1932) price index which uses marginal weights $\theta_i = \partial(p_i q_i) / \partial M$.²³ The income elasticity of good i is η_i and ϕ is the income flexibility, the reciprocal of the income elasticity of the marginal utility of income. As emphasised by Frisch (1959), knowledge of the value of ϕ is extremely useful as under want independence, all the price elasticities can be computed from ϕ and the income elasticities. Of course, this comes at the cost of the assumption that the marginal utilities depend only on the own consumption, something that is usually thought to be more applicable to broader aggregates.

When the income elasticities are known, equation (9) can be viewed as a cross-commodity regression: The income flexibility ϕ can be estimated by regressing

²² Further results are given in online supplementary appendix A9. Also, online supplementary appendix A10 examines how an aspect of government policy may affect the prices across countries.

²³ In previous sections, much of the analysis was formulated in terms of levels of variables as that facilitated measurement for each country. It is convenient to express the concepts of this section in terms of differentials, but this entails no essential differences.

$d(\log q_i) - \eta_i d(\log Q)$ on $\eta_i [d(\log p_i) - d(\log P')]$ for $i = 1, \dots, n$. As shown in online supplementary appendix A11, the weighted least-squares estimator, with budget shares used as weights, is

$$(10) \quad \hat{\phi} = \frac{\Pi'_{p,q} - y_p d(\log Q)}{\Pi'_p}.$$

This is the ratio of an income-adjusted price-quantity covariance to a price variance. The numerator is the difference between two terms: (i) $\Pi'_{p,q} = \sum_{i=1}^n w_i [d(\log p_i) - d(\log P')] [d(\log q_i) - d(\log Q)]$, a weighted price-quantity covariance; and (ii) $y_p d(\log Q)$, where y_p is the price of quality, $y_p = \sum_{i=1}^n w_i [\eta_i - 1] [d(\log p_i) - d(\log P)]$, with $d(\log P) = \sum_{i=1}^n w_i d(\log p_i)$ the Divisia price index, as before. Thus, the covariance is adjusted for the price of quality, scaled by income. Using $\eta_i = \theta_i / w_i$, the price of quality becomes the excess of the Frisch price index over its Divisia counterpart, $y_p = d(\log P') - d(\log P)$. The quality term in (10), $y_p d(\log Q) = [d(\log P') - d(\log P)] d(\log Q)$, is larger (i) the more the prices of luxuries grow relative to those of necessities; and (ii) the higher is income growth. The denominator on the right of (10) is the Frisch variance of prices, $\Pi'_p = \sum_{i=1}^n \theta_i [d(\log p_i) - d(\log P')]^2$, which can be interpreted as a measure of the dispersion of the price of quality. It is thus clear that expression (10) involves elements of dispersion and quality.

We apply equation (9) to the allocation of total food to the seven groups of table 2 using the previous approach with pairs of countries and then converting the bilateral estimates into multilateral versions. The application to food groups means that utility is taken to be separable in the groups and that the income flexibility ϕ becomes $\phi^F = \phi \eta^F$, where η^F is the income elasticity of food. This ϕ^F is also $(\partial \log \lambda / \partial \log M^F)^{-1}$, where λ is the marginal utility of income and M^F is food expenditure. Thus, as ϕ^F is the reciprocal of the elasticity of λ with respect to food spending, we shall refer to it as the “food flexibility”.

Table 6 shows that the estimates of ϕ^F that are of the order -1.4 to -2.0, with only modest differences across the income distribution. When the food flexibility ϕ^F is -1.6, the elasticity of the marginal utility of income is $1/-1.6 \approx -0.6$, so a 50-percent increase in food spending leads to a reduction in the marginal utility of income of about 30 percent. Suppose, for illustrative purposes, the income elasticity of food η^F is 0.5 and that ϕ^F is -1.6. Then, the income flexibility $\phi = \phi^F / \eta^F \approx -3$ and the income elasticity of λ is $1/-3 \approx -0.3$. Taken at face value, this means that a doubling of income leads to the marginal utility of income falling by about one-third.²⁴

The qualification to the above is that several other studies have estimated ϕ to be of the order of minus one-half, implying that income growth leads to a faster decline in the marginal utility of income.²⁵ Why is the above estimate of ϕ so different? One possibility is that the previous estimates are all based on much broader aggregates such as food as a whole, clothing, housing, etc., as opposed to just food groups. Another possibility is that the income elasticity of food is larger than one-half. Yet another is that want-independence at the group level might be too strong. Further research is needed to reconcile these apparently disparate findings. This application nonetheless serves to illustrate one of the additional ways in which the diversity and quality measures can be used.

Limitations, Sensitivities and Extensions

The above analysis is obviously subject to some limitations. The issues discussed in this section are caveats to the results, as well as providing some guidance to the interpretation of the findings as they might apply to other kinds of data or other contexts.

Regions of the world. Geographical considerations can play an important role in food consumption. In many instances, food has a high weight-to-value ratio and/or is perishable, which makes for substantial transportation costs. If these costs are

²⁴ As a qualification, this hinges on the strong assumption of want independence to identify utility uniquely.

²⁵ See Brown and Deaton (1972, p. 1206); Chen (1999, p. 171); S. Selvanathan (1993, p. 198 and Sec. 6.4); Selvanathan and Selvanathan (2003, tables 3.20 and 4.19); and Theil (1987, Sec. 2.8).

sufficiently high, food consumption patterns can be significantly influenced by local food production. Thus, groups of countries sharing broadly similar climates and endowments of land may, because of their comparative advantage, have similar consumption patterns -- local production may be a more important driver of food consumption than is income. A shared culture may also contribute to common regional patterns of food consumption. To investigate this issue, we assign the 155 countries into five broad regions. Previously in an earlier section, we measured inequality of diet diversity by the ratio of diet diversity of the rich to that of the poor. When countries were grouped by income, inequality was found to be substantially understated if the total variance of quantities was used instead of the between component of the variance (which probably is a superior measure of the nutritional value of the diet). This result is summarised in the second elements of columns 2 and 3 of table 7 – diets of the rich are about 3.4 times as diverse as those of the poor on the basis of the between component, but this multiple falls to 2.3 for the total variance. Using a regional grouping of countries (see online supplementary appendix A12 for details), this result is confirmed: From the last entry of column 3 of table 7, with the between component, diets of the rich as about five times as diverse as those of the poor, but this inequality falls by almost one-half with the total variance (last entry of column 2).²⁶

Country weighting. The aggregation of the 155 countries into four groups with the same number in each is possibly a further issue. Diet diversity and quality was studied by averaging over countries within each income quartile. As these were unweighted averages, this involved according the same weight to each country no matter how large or small. This is a United-Nations type of democracy, whereby each country gets one vote independent of its size. An alternative approach would be to recognise differing country sizes by weighting by population or some measure of economic size. The attraction of population weighting is that it is consistent with our approach of using per capita consumption within each country and has democratic

²⁶ With the income grouping, diet inequality was also found to be understated when the budget share variance was used. In that case, the inequality ratio was smaller, as was the total-between gap (compare the first two entries of columns 2 and 3 of table 7 with the second two). This same result is found with the regional grouping of countries, in columns 2 and 3 of panel B of table 7.

attractions. Weighting by GDP is appealing from an economic perspective as this reflects the differing economic importance of countries. The various weighting schemes in columns 4-9 of table 7 reveal that they have little impact on the diet diversity ratio for both income and regional groupings.

Sensitivity of quality. The previous results for the index of the quality of food consumption by income quartile, with equal country weights, are reproduced in column 2 of panel A of table 8. When countries are weighted as above, there is a tendency for quality to become more dispersed – see columns 3-5 of this panel. The largest change is with GDP weights (that is, total GDP, not per capita). Here, the difference between first and fourth quartile values for the quality of consumption is $26.7 - (-15.8) = 43$ percent, whereas this difference is 36 percent with equal weighting of countries (from the first and fourth entries of columns 4 and 2 of the table). Although this difference is not huge, the greater inequality of quality points to food consumption in larger economies being more skewed towards items with higher income elasticities than that in the average country. With weighting, the price of quality continues to decline with higher incomes, but now the decline is more pronounced. However, the decline remains quite modest. Panel B of table 8 shows that the impact of weighting when countries are grouped regionally is similar to that for the income grouping; that is, weighting by GDP results in somewhat more inequality between the rich region, Europe/North America, on the one hand, and Sub-Saharan Africa on the other. The conclusion is that quality exhibits some sensitivity regarding how countries are grouped/weighted, but the equally-weighted measures do not lead us seriously astray.²⁷

Quality, nutrition and wellbeing. Finally, it should be repeated that our measure of food quality does not necessarily have nutritional connotations as it is simply based on observed differences in consumption patterns. Thus, an improvement in measured food quality simply means that the consumption of those items with a higher income elasticity is higher than average; and this may or may not entail better nutrition. However, as an extension of our measures, in online supplementary

²⁷ Further tests are given in online supplementary appendix A12.

appendix A13 we set out the key elements of a theory in which diet diversity, nutrition, income and wellbeing are jointly determined.

Concluding Comments

It is well known that as consumers become richer, the share of spending devoted to food falls. This tendency is so powerful and pervasive that it has been elevated to the status of one of the few “laws” in economics. Less well known is the strong link between Engel’s law, the variety of foods in the diet and their quality. A more varied diet brings nutritional advantages and for most, diet diversity is valued in and of itself, if not an essential part of their life. As the diversity of the diet tends to increase with income, not only does the food share fall with higher incomes, spending is also likely to be spread more evenly over foodstuffs, giving a more balanced diet. Relatedly, higher incomes bring a shift away from lower-quality items, towards more expensive, possibly more tasty and nutritious foods.

This article has used an approach based on index-number theory to analyse the interrelationships between Engel’s law, the diversity of food consumption and its quality. To study these matters, we used data on 31 food items from more than 150 countries, where the substantial differences in per capita incomes lead to sharp, almost extreme, differences in consumption patterns. Our results indicate that diet diversity increases with income with an elasticity of 0.3. Diet diversity can be decomposed into between- and within-group components, with the former likely to bring much of the nutritional value of a diverse diet. We find that this component for poor countries is much lower than that for the rich: The diets of rich countries are about three-and-one-half times more diverse than the poor’s. If the between-within distinction is ignored, measured inequality in diet diversity is substantially understated (by as much as 30 percent).

Using a weighted covariance between income elasticities and consumption to measure the quality of food consumption, we find considerable differences between pairs of countries. Higher incomes bring higher-quality food, but the overall elasticity is small: Enhanced food quality can only be achieved with substantially higher incomes. Furthermore, better quality food comes at a higher price, but, interestingly, this cost, relative to lower-quality food, falls as we move from poorer to richer

countries. The structure of food prices is thus regressive in its impact on the global distribution of real income. This effect is modest, however.

Lastly, we also demonstrated how our measures of diversity and quality had wider applicability in demand analysis; and as a further illustration of their use, we sketched the links between diet diversity and wellbeing (online supplementary appendix A13).

Supplementary Material

Supplementary material is available online at *American Journal of Agricultural Economics* online.

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Table 1 Income and Food Consumption in 155 countries in 2011

Country	Income US = 100	Food share ×100	Country	Income US = 100	Food share ×100	Country	Income US = 100	Food share ×100	Country	Income US = 100	Food share ×100
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
A. <u>First quartile</u>			B. <u>Second quartile</u>			C. <u>Third quartile</u>			D. <u>Fourth quartile</u>		
1. Bermuda	110.7	10.0	40. Anguilla	47.3	14.6	79. St. Vin. & Gren.	21.7	22.8	118. Bolivia	8.9	34.8
2. United States	100.0	6.9	41. Bahrain	47.2	13.5	80. Macedonia	21.7	31.7	119. Honduras	8.6	31.0
3. Cayman Islands	95.3	7.0	42. Czech	43.4	16.3	81. Thailand	21.4	28.0	120. Kyrgyzstan	7.8	41.1
4. Hong Kong	88.1	11.4	43. Bahamas	43.1	10.5	82. South Africa	20.9	20.6	121. Vietnam	7.7	27.6
5. Norway	87.7	10.5	44. Trini. & Tob.	42.6	21.7	83. Colombia	20.6	18.5	122. India	7.2	28.8
6. Luxembourg	85.2	9.4	45. Poland	40.9	19.0	84. St. Lucia	20.3	21.5	123. São Tomé & P.	6.8	58.4
7. Switzerland	82.0	9.5	46. Slovakia	40.3	17.4	85. Bosnia & Herz.	20.3	30.5	124. Cambodia	5.7	47.8
8. UAE	77.2	11.8	47. Barbados	39.0	15.0	86. Turks & Caicos	20.1	15.6	125. Ghana	5.7	38.4
9. Sweden	76.3	9.9	48. Lithuania	38.6	25.5	87. Venezuela	19.3	23.7	126. Lesotho	5.6	27.4
10. Germany	75.1	10.2	49. Oman	37.5	19.5	88. Ukraine	18.8	36.0	127. Tajikistan	5.6	44.6
11. Australia	74.6	10.2	50. St. Kitts & Nevis	37.2	19.2	89. Tunisia	18.6	22.8	128. Nigeria	5.2	39.0
12. Austria	74.5	9.6	51. Croatia	36.5	22.2	90. Peru	18.3	24.6	129. Kenya	5.0	38.5
13. Denmark	73.6	9.0	52. Hungary	36.4	17.2	91. Azerbaijan	18.3	38.2	130. Djibouti	4.7	30.6
14. Canada	73.5	9.0	53. Russia	35.6	30.4	92. Belize	18.2	19.5	131. Cameroon	4.6	48.3
15. Iceland	72.9	12.6	54. Chile	35.5	15.9	93. El Salvador	17.7	27.1	132. Côte d'Ivoire	4.6	44.1
16. Finland	72.5	11.6	55. Estonia	35.5	21.4	94. Ecuador	17.3	22.3	133. Senegal	4.3	49.9
17. France	72.0	11.4	56. Turkey	34.9	22.4	95. Jamaica	16.7	29.2	134. Nepal	4.3	58.2
18. Belgium	71.2	11.2	57. Montserrat	34.5	17.6	96. Sri Lanka	16.7	42.9	135. Zambia	3.9	59.0
19. United Kingdom	70.3	8.5	58. Uruguay	34.3	19.4	97. Albania	16.7	38.8	136. Uganda	3.8	37.9
20. Netherlands	70.3	9.3	59. Seychelles	33.7	41.3	98. Namibia	15.9	23.3	137. Congo, Rep.	3.5	39.5
21. Singapore	70.0	7.1	60. Latvia	33.6	21.9	99. Botswana	15.7	24.4	138. Haiti	3.5	59.1
22. Taiwan	68.1	12.4	61. Antigua & Barb.	32.3	16.7	100. Armenia	14.8	58.2	139. Gambia	3.3	43.5
23. Aruba	66.9	7.9	62. Montenegro	29.7	35.6	101. Mongolia	14.7	33.8	140. Sierra Leone	3.3	40.6
24. Macao	65.4	9.8	63. Kazakhstan	29.7	22.0	102. Iraq	14.5	30.6	141. Chad	3.1	51.4
25. Japan	65.4	12.4	64. Mexico	29.4	23.1	103. Georgia	14.5	34.7	142. Benin	2.9	50.8
26. Ireland	63.1	9.6	65. Mauritius	28.2	32.6	104. Gabon	14.2	34.6	143. Rwanda	2.9	50.7
27. Italy	62.0	12.7	66. Malaysia	27.7	17.5	105. Guatemala	14.1	39.8	144. Zimbabwe	2.7	58.5
28. Cyprus	60.7	13.9	67. Virgin Islands	27.5	18.7	106. Swaziland	13.4	46.3	145. Madagascar	2.7	45.6
29. New Zealand	60.5	14.6	68. Panama	27.1	17.5	107. Fiji	13.3	31.3	146. Guinea-B.	2.2	52.3
30. Spain	57.5	12.6	69. Belarus	26.8	36.9	108. Paraguay	12.9	28.6	147. Mali	2.2	46.6
31. Israel	55.6	13.8	70. Romania	26.5	24.8	109. Moldova	12.6	31.4	148. Mozambique	1.8	55.3
32. Sint Maarten	55.4	8.7	71. Bulgaria	25.9	21.6	110. Eq. Guinea	12.6	39.4	149. Liberia	1.8	29.0
33. Greece	55.1	16.0	72. Serbia	25.6	25.8	111. Suriname	12.3	38.4	150. Burkina Faso	1.8	55.6
34. Curaçao	53.9	11.4	73. Brazil	24.9	15.2	112. Indonesia	12.3	37.9	151. Comoros	1.8	51.5
35. Malta	51.4	16.0	74. Costa Rica	24.4	20.6	113. Philippines	11.7	41.4	152. C. Africa	1.6	63.5
36. Portugal	49.1	16.0	75. Grenada	24.2	20.9	114. Cape Verde	11.6	38.5	153. Guinea	1.5	58.2
37. Slovenia	48.8	14.4	76. Jordan	24.0	27.9	115. China	11.2	19.6	154. Niger	1.5	41.9
38. South Korea	48.8	11.9	77. Dominican Rep.	22.9	29.3	116. Morocco	10.9	34.6	155. Congo, D.R.	0.9	56.7
39. Qatar	48.6	10.7	78. Dominica	22.8	17.8	117. Bhutan	10.0	30.6			
Mean	69.5	11.0	Mean	33.0	21.7	Mean	16.1	31.1	Mean	4.1	45.7
Mean Income (\$ p.c.)	25,974		Mean Income (\$ p.c.)	12,341		Mean Income (\$ p.c.)	6,010		Mean Income (\$ p.c.)	1,525	

Note: Countries are ranked in terms of per capita income and are divided into 4 quartiles. Income is defined as total consumption per capita at PPP prices 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 132 food and non-food items, deflated by the cost of living. In logarithmic form, this is $\log Q = \log M - \log P$, where M is total consumption expenditure, and $\log P = \sum_{i=1}^{132} \log p_i$ is a cost-of-living index, with w_i the budget share of good i and p_i its PPP price. The food share is the proportion of total consumption expenditure devoted to food, expressed as a percentage. Food is defined as the sum of all food items, including alcoholic beverages. See online supplementary appendix A1 for more details on the data.

Table 2 Budget Shares of 31 Food Items in 155 Countries by Income Quartile

Group/Item (1)	Unconditional food shares					Conditional food shares					Food group shares				
	First (2)	Second (3)	Third (4)	Fourth (5)	All (6)	First (7)	Second (8)	Third (9)	Fourth (10)	All (11)	First (12)	Second (13)	Third (14)	Fourth (15)	All (16)
1. BREAD AND CEREALS											14.28	14.81	18.76	29.47	19.26
Rice	0.16	0.58	1.65	5.41	1.93	1.42	2.50	5.09	11.64	5.12	9.87	15.86	25.05	38.24	22.15
Other cereals and flour	0.21	0.53	1.63	5.79	2.02	1.91	2.52	5.14	12.06	5.37	13.57	17.04	26.93	38.84	24.00
Bread	0.61	1.24	1.73	1.72	1.32	5.42	5.65	5.19	3.70	5.00	37.65	37.79	28.21	15.03	29.76
Other bakery products	0.49	0.65	0.66	0.43	0.56	4.35	3.01	2.23	0.95	2.65	30.80	21.57	13.40	3.85	17.49
Pasta products	0.13	0.24	0.33	0.50	0.30	1.17	1.13	1.11	1.12	1.13	8.11	7.75	6.40	4.04	6.59
2. MEAT AND SEAFOOD											24.36	24.53	22.41	21.10	23.11
Beef and veal	0.40	0.75	1.50	2.32	1.24	3.55	3.47	4.73	4.96	4.17	15.18	13.98	21.16	25.08	18.81
Pork, lamb, mutton and goat	0.44	0.90	1.07	1.67	1.01	3.90	4.07	3.56	3.73	3.82	15.67	16.63	15.14	17.44	16.21
Poultry	0.41	1.27	1.62	1.25	1.14	3.75	5.99	5.33	2.74	4.46	15.66	24.21	24.56	13.77	19.59
Other meats and preparations	0.74	1.30	0.94	0.84	0.96	6.72	5.72	3.01	1.76	4.32	28.62	24.09	13.74	7.93	18.66
Fresh or frozen fish and seafood	0.47	0.76	1.46	2.15	1.20	4.13	3.66	4.58	4.54	4.23	15.40	14.59	19.83	20.39	17.53
Preserved fish and seafood	0.26	0.33	0.38	1.52	0.62	2.32	1.60	1.21	3.37	2.11	9.48	6.51	5.57	15.41	9.20
3. DAIRY											13.16	15.89	15.76	11.64	14.13
Fresh milk	0.30	0.56	0.91	1.08	0.71	2.59	2.54	2.86	2.42	2.61	19.94	15.53	16.71	18.67	17.71
Preserved milk and milk products	0.40	1.05	1.26	0.87	0.90	3.61	4.86	4.06	2.04	3.65	28.16	30.82	27.70	17.59	26.12
Cheese	0.41	0.66	0.76	0.21	0.51	3.60	2.96	2.37	0.46	2.36	25.75	18.46	13.24	4.12	15.47
Eggs and egg-based products	0.11	0.37	0.69	0.54	0.43	0.98	1.71	2.11	1.23	1.51	8.28	10.97	13.57	10.24	10.77
Butter and margarine	0.12	0.27	0.39	0.60	0.34	1.05	1.27	1.21	1.29	1.21	7.65	8.08	7.88	10.58	8.54
Other edible oils and fats	0.16	0.56	1.00	1.93	0.90	1.32	2.54	3.15	4.19	2.79	10.22	16.14	20.89	38.80	21.40
4. FRUIT AND VEGETABLES											16.25	17.25	19.12	20.56	18.28
Fresh or chilled fruit	0.66	1.16	1.59	1.64	1.26	5.90	5.30	5.24	3.77	5.06	35.71	30.98	27.42	18.50	28.22
Frozen, preserved or processed fruits	0.13	0.20	0.22	0.44	0.25	1.23	0.99	0.71	0.97	0.97	7.64	5.43	3.78	4.85	5.43
Fresh or chilled vegetables	0.60	1.52	2.73	3.14	1.99	5.47	6.83	8.59	7.28	7.04	33.43	39.30	44.52	38.58	38.96
Fresh or chilled potatoes	0.14	0.47	0.82	2.95	1.08	1.27	1.97	2.51	6.43	3.02	8.11	11.74	14.00	26.61	15.04
Frozen or preserved vegetables	0.26	0.44	0.67	1.03	0.60	2.38	2.16	2.08	2.11	2.18	15.11	12.54	10.28	11.46	12.35
5. SWEET THINGS											5.95	5.16	4.93	4.06	5.03
Sugar	0.06	0.42	0.76	1.36	0.65	0.52	1.92	2.42	3.02	1.96	10.55	38.97	49.82	75.62	43.53
Jams, marmalades and honey	0.06	0.12	0.19	0.12	0.12	0.57	0.59	0.63	0.25	0.51	10.29	12.33	12.30	6.01	10.26
Confectionery, chocolate and ice cream	0.53	0.58	0.59	0.35	0.51	4.86	2.65	1.88	0.79	2.56	79.16	48.69	37.88	18.37	46.21
6. OTHER FOOD											15.51	12.78	12.06	8.83	12.32
Food products n.e.c.	0.66	0.85	1.55	2.18	1.30	6.19	4.06	5.45	4.91	5.15	35.65	30.74	40.67	50.97	39.44
Coffee, tea and cocoa	0.25	0.52	0.54	0.50	0.45	2.26	2.31	1.68	1.11	1.84	17.06	20.42	17.89	16.16	17.89
Min. waters, soft drinks, fruit and veg. juices	0.75	1.29	1.44	1.19	1.17	7.06	6.41	4.93	2.82	5.32	47.29	48.83	41.44	32.87	42.67
7. ALCOHOL											10.48	9.59	6.96	4.34	7.87
Spirits	0.28	0.78	0.55	0.42	0.51	2.58	3.52	1.81	0.96	2.23	25.02	35.62	28.31	23.66	28.18
Wine	0.43	0.46	0.31	0.37	0.39	3.98	2.08	1.01	0.79	1.97	37.34	21.65	16.50	23.43	24.74
Beer	0.41	0.86	1.11	1.15	0.88	3.92	3.99	4.14	2.60	3.67	37.64	42.73	55.19	52.91	47.08
Total	11.05	21.71	31.07	45.66	27.26	100	100	100	100	100					

Note: Unconditional food shares - proportions of total consumption expenditure devoted to each commodity. Conditional budget shares - proportions of total food expenditure devoted to the food items. Food group budget shares - **emboldened** figures are group budget shares, the proportions of food expenditure devoted to the groups. Non-emboldened figures are conditional budget shares, the proportions of group expenditure devoted to items within the group. All values are averaged over countries and $\times 100$.

Table 3 Food Moments

Income quartile	Food volume index log Q	Variances $\times 100$			Price-quantity $\times 100$	
		Budget shares Π_w	Prices Π_p	Quantities Π_q	Covariance Π_{pq}	Correlation ρ
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	4.68	50.86	7.95	64.58	-10.84	-42.29
2	4.39	50.42	10.86	70.50	-15.47	-52.95
3	4.08	66.28	15.38	98.12	-23.61	-58.38
4	3.23	99.55	25.12	149.85	-37.71	-57.27
All	4.10	66.67	14.81	95.61	-21.88	-53.01

Note: Income is real income (consumption) per capita, defined as $\log(M/P)$, as in the note to table 1. The food volume index for country c is $\log Q_c = \sum_{i=1}^{31} w_{ic} \log q_{ic}$, where w_{ic} is the proportion of food expenditure devoted to food item i and q_{ic} is the per capita quantity consumed of i . The variance of the budget shares is $\Pi_w = \sum_{i=1}^{31} w_{ic} (\log w_{ic} - \log \bar{W}_c)^2$, where $\log \bar{W}_c = \sum_{i=1}^{31} w_{ic} \log w_{ic}$. The variances of the prices and quantities, and the price-quantity covariance are all weighted and defined analogously. Values are averaged over countries.

Table 4 Decomposition of Food Diversity

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)
A. Budget shares										
1	50.89	16.90	33.96	40.06	34.41	38.34	34.53	59.79	23.40	16.51
2	50.42	15.23	35.19	43.14	44.06	33.43	38.08	30.63	21.33	20.77
3	66.28	23.96	42.32	49.44	44.62	36.23	47.15	32.23	23.99	34.98
4	99.55	47.63	51.92	68.02	45.16	53.11	46.01	48.16	36.38	31.15
All	66.67	25.85	40.82	50.11	42.09	40.21	41.46	42.56	26.23	25.88
B. Prices										
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
C. Quantities										
1	64.58	22.07	42.51	44.10	42.83	45.21	43.42	67.00	28.14	31.35
2	70.50	22.87	47.62	72.68	46.69	37.69	58.65	49.82	27.63	31.28
3	98.12	36.66	61.46	81.92	63.80	41.05	73.13	53.97	26.94	56.55
4	149.85	75.29	74.56	90.23	83.49	55.69	75.64	55.47	36.16	46.47
All	95.61	39.10	56.51	72.30	59.15	44.84	62.75	56.51	29.69	41.45

Notes:

1. **Column 2 of panel A:** This contains the weighted logarithmic variance of the 31 food budget shares, $\Pi_w = \sum_{i=1}^{31} w_i (\log w_i - \log \bar{W})^2$, where w_i is the proportion of food expenditure devoted to item i and $\log \bar{W} = \sum_{i=1}^{31} w_i \log w_i$. The elements of this column are averages over countries.
2. **Columns 3 and 4 of panel A:** Dividing food into seven groups and using equation (6), the total variance of the budget shares can be decomposed into between- and within-group components:

$$\Pi_w = \underbrace{\sum_{g=1}^7 W_g (\log \bar{W}_g - \log \bar{W})^2}_{\text{Between-group}} + \underbrace{\sum_{g=1}^7 W_g \left[\sum_{i \in S_g} w'_i (\log w'_i - \log \bar{W}_g)^2 \right]}_{\text{Within-group}}.$$

Total variance Between-group Within-group

Here, $W_g = \sum_{i \in S_g} w_i$ is the budget share of group g ; S_g is the set of goods belonging to group g ; $w'_i = w_i / W_g$ is the share of group expenditure devoted to $i \in S_g$; and $\log \bar{W}_g = \sum_{i \in S_g} w'_i \log w'_i$. Columns 3 and 4, respectively, contain the above between- and within-group components, averaged over countries.

3. **Columns 5-11 of panel A:** These columns contain each of the seven within-group variances of the equation above, $\sum_{i \in S_g} w'_i (\log w'_i - \log \bar{W}_g)^2$, $g = 1, \dots, 7$, averaged over countries.
 4. **Panels B and C:** These panels are defined analogously to panel A.
- All entries are $\times 100$.

Table 5 Multilateral Food Quality Indexes by Income Quartile, 155 Countries in 2011

Income quartile	Index	Interquartile differences			
		First	Second	Third	Fourth
(1)	(2)	(3)	(4)	(5)	(6)
A. <u>Quality of Consumption</u>					
First	17.88		11.84	24.13	36.00
Second	6.04			12.30	24.17
Third	-6.26				11.87
Fourth	-18.13				
B. <u>Price of Quality</u>					
First	-1.68		-1.59	-2.27	-2.91
Second	-0.10			-0.69	-1.32
Third	0.59				-0.64
Fourth	1.23				
C. <u>Quality of Spending</u>					
First	16.19		10.25	21.86	33.10
Second	5.94			11.61	22.84
Third	-5.67				11.23
Fourth	-16.90				

Note: Column 2 of panel A contains the mean for each income quartile of the multilateral index of the quality of food consumption. The multilateral index of the quality of consumption of the 31 goods in the food basket in country c is defined as the average of that country's bilateral indexes, $1/155 \cdot \sum_{d=1}^{155} y_q^{cd}$, where $y_q^{cd} = \sum_{i=1}^{31} w_i^{cd} (\eta_i^{cd} - 1) (\log q_i^{cd} - \log Q^{cd})$ is the bilateral index of c relative to d ; $w_i^{cd} = (w_i^c + w_i^d)/2$ and $\eta_i^{ab} = w_i^a / (w_i^a + w_i^b) \cdot \eta_i^a + w_i^b / (w_i^a + w_i^b) \cdot \eta_i^b$ are the budget share and income elasticity of good i averaged over countries c and d ; $\log q_i^{cd} = \log(q_i^c / q_i^d)$ is relative consumption of good i ; and $\log Q^{cd} = \sum_{i=1}^{31} w_i^{cd} \log q_i^{cd}$ is the Divisia volume index in c relative to d . The other columns of this panel are the differences between the quartile means. Panels B and C contain analogous measures for prices and spending. The results in panel A differ somewhat from the quartile means of figure 2. The reason is that the former results are based on all elements of the 155×155 matrix of the bilateral index for country pairs, while the latter uses only the upper triangle of this matrix. All entries are $\times 100$.

Table 6 Multilateral Estimates of the Food Flexibility by Income Quartile

Income quartile (1)	Food flexibility ϕ^F (2)	Interquartile differences			
		First (3)	Second (4)	Third (5)	Fourth (6)
First	-1.38		0.20	0.08	0.65
Second	-1.58			-0.12	0.45
Third	-1.46				0.57
Fourth	-2.03				

Note: The food flexibility, ϕ^F , is the reciprocal of the elasticity of the marginal utility of income with respect to food expenditure. The elements of column 2 are averages of estimates of ϕ^F over countries within each income quartile. Columns 3-6 give the differences between the quartile means.

Table 7 Diversity of Diets, Rich versus Poor Countries

Type of variance	Weighted							
	Unweighted		Population		GDP		GDP per capita	
	Total variance	Between component	Total variance	Between component	Total variance	Between component	Total variance	Between component
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
A. <u>Income groups</u> (First quartile vs. Fourth quartile)								
Budget share	1.96	2.82	1.74	1.95	1.73	1.87	1.75	2.28
Quantity	2.32	3.41	2.14	2.61	2.18	2.57	1.95	2.61
B. <u>Regional groups</u> (Eur/N. Am & NZ vs S-S Africa)								
Budget share	2.16	4.21	2.13	4.20	1.86	3.76	1.77	3.17
Quantity	2.61	5.05	2.53	5.57	2.23	4.69	2.23	3.54

Note: The elements of this table give the diversity of diets of rich countries as compared to that of poor countries, using a cross-commodity variance as an inverse measure of diversity. These results pertain to (i) two types of variance (that of budget shares and quantities consumed); (ii) the total variance and the between-group component of that variance; (iii) the allocation of countries into regional and income groups; and (iv) various country-weighting schemes. Thus, for example, the first element in column 2, 1.96, means that on the basis of the total variance of the budget shares, and when countries are equally weighted and grouped by income, the diets of the rich are almost twice as diversified as those of the poor. Panels A and B are derived from tables A12.3 and A12.4 of the online supplementary appendix, respectively. See the Section “The Components of Diversity” for details of the variances.

Table 8 Multilateral Quality Indexes, Income and Regional Grouping of Countries, Unweighted and Weighted

Quality index	Unweighted	Weighted		
		Population	GDP	GDP p.c.
(1)	(2)	(3)	(4)	(5)
A. <u>Income groups</u>				
<i>(i) Consumption</i>				
First	17.88	21.29	26.70	22.69
Second	6.04	8.02	2.77	1.81
Third	-6.26	-10.83	-14.12	-10.03
Fourth	-18.13	-18.96	-15.76	-14.86
<i>(ii) Prices</i>				
First	-1.68	-3.13	-3.42	-2.12
Second	-0.10	-0.89	-0.07	0.16
Third	0.59	2.32	2.25	0.77
Fourth	1.23	1.75	1.28	1.21
<i>(iii) Spending</i>				
First	16.19	18.16	23.28	20.58
Second	5.94	7.13	2.69	1.98
Third	-5.67	-8.51	-11.87	-9.26
Fourth	-16.90	-17.21	-14.48	-13.64
B. <u>Regional groups</u>				
<i>(i) Consumption</i>				
Eur/N. Am	19.18	20.77	25.79	23.49
E./S. Asia	-9.88	-37.54	-24.21	-11.87
M. East	1.89	4.97	-1.38	-2.78
L. Am	-0.46	2.68	-3.68	-3.91
S-S Africa	-17.73	-10.09	-13.15	-15.86
<i>(ii) Prices</i>				
Eur/N. Am	-1.39	-2.43	-2.28	-1.80
E./S. Asia	1.72	7.62	3.68	1.36
M. East	-0.98	-1.73	-0.68	-0.02
L. Am	0.09	-0.34	0.42	0.23
S-S Africa	1.14	0.15	0.68	1.17
<i>(iii) Spending</i>				
Eur/N. Am	17.80	18.34	23.51	21.69
E./S. Asia	-8.16	-29.93	-20.52	-10.51
M. East	0.91	3.24	-2.06	-2.80
L. Am	-0.37	2.33	-3.26	-3.68
S-S Africa	-16.59	-9.94	-12.47	-14.69

Note: The entries in this table are averages over countries within each group. The population-weighted quality index for country c is $\sum_{d=1}^{155} w^{cd} y_q^{cd}$, where $w^{cd} = (w^c + w^d)/2$, with w^c the share of c in total population; and y_q^{cd} is the quality index for country c compared to d . The two other weighting schemes are analogous. The indexes of the quality of spending and prices are also defined analogously. For each of the two country-grouping schemes and each of the three quality measures, the weighted average of the values for each group is equal to zero by construction. The weights are the shares of the total number of countries in each group. All entries are $\times 100$.

Figure 1 Food and income, 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 1. The equation is for a regression of the food share on the logarithm of income. The “x” (“y”) refers to the variable on the horizontal (vertical) axis. Standard errors in parentheses.

Figure 2 Bilateral index of quality of food consumption, differences by income quartile

Note: These histograms refer to the bilateral index of the quality of consumption of the 31 goods in the food basket in country c relative to d , that is, y_q^{cd} , $c < d$, $c \in \text{quartile } g$, $d \in \text{quartile } h$, $g \leq h$, $g, h = 1, \dots, 4$. Countries are ranked in terms of decreasing income, so country c is richer than d when $c < d$. Indexes are $\times 100$.

Figure 3 Multilateral food quality indexes and income

Note: Panel A is a scatter plot of the multilateral index of the quality of consumption of the 31 goods in the food basket in country c , $\hat{\alpha}_q^c = \frac{1}{155} \sum_{d=1}^{155} y_q^{cd}$, against income measured as a deviation from the mean, $\log(M/P)^c = \log(M/P)^c - \frac{1}{155} \sum_{d=1}^{155} \log(M/P)^d$, $c = 1, \dots, 155$. The term y_q^{cd} is the bilateral index of the quality of consumption of the 31 goods in the food basket in country c relative to d , $y_q^{cd} = \sum_{i=1}^{31} w_i^{cd} (\eta_i^{cd} - 1) (\log q_i^{cd} - \log Q^{cd})$. Income is real income (consumption) per capita, defined as $\log(M/P)$, as in the note to table 1. Panels B and C are analogous plots for the quality indexes of prices and spending. Indexes are $\times 100$. The equation in each panel is for a regression of quality on the logarithm of income. The “x” (“y”) refers to the variable on the horizontal (vertical) axis. Due to the scaling of the dependent variables in the regressions, the slope coefficients are 100 times the elasticities. Standard errors in parentheses.

ONLINE SUPPLEMENTARY APPENDIX

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A1. The ICP Data and Computing

The 2011 round of ICP data contains GDP data disaggregated into 155 basic headings, given in table A1.1, for 182 countries. These are unpublished data supplied to us by the World Bank which differs from the publically available 2011 ICP publications where GDP is only disaggregated into some 19 broad categories. As we have an agreement not to pass on the data to third parties, others wishing to obtain the basic data have to prepare a written and signed request to be sent to the Director of the Development Data Group, World Bank. Details of this are set out in Annex 5 on pages 14-15 of the following document: http://siteresources.worldbank.org/ICPINT/Resources/270056-1255977254560/121120_ICPDataAccessPrinciples&Procedures.pdf

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, the first 32 are considered food items, details of which are given in table A1.2.

Some discussion on the data cleaning is warranted. Firstly, we remove duplicate entries for three countries (Russia, Sudan and Egypt), each of which is a dual participant in the ICP, leaving 179 unique countries. Next, Cuba and Bonaire do not have complete data and are omitted. Lastly, many countries have little to no PPP real expenditure per capita on

certain food items, be it for income, geographical or religious reasons. The most prominent example is pork in many West Asian countries. Table A1.3 contains a summary of the extent of this problem.

The issue of zero or very small expenditure can be partially “solved” by combining the “Pork” and “Lamb, mutton and goat” groups. 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 cut-off of \$0.01, the number of affected countries falls from 34 in column 3 of table A1.3 to 22 in column 7. The 22 omitted countries are: 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 1.

Next, we provide some interpretation of the ICP data. The basic data consist of expenditure on item i in country c , which we write as v_{ic} , and the corresponding PPP price, denoted by p_{ic} . These are both expressed in terms of domestic currency units. To interpret p_{ic} , suppose p_i^* is the world price of a unit of item i , measured in US dollars. Denote by q_i^* the quantity of i that costs \$US1 in terms of the world price, that is, $p_i^* q_i^* = 1$. Obviously, $q_i^* = 1/p_i^*$, so that $1/p_i^*$ is one US dollar’s worth of the item. Thus, if, for example, the world price of a litre of wine is \$US10, one dollar buys one-tenth of a litre ($q_i^* = 0.1$). If p'_{ic} is the price of a unit of i in c in terms of c ’s currency, then the local-currency cost of one US dollar’s worth is $p'_{ic} q_i^* = p'_{ic} (1/p_i^*)$, which is the PPP price, p_{ic} . In words, this PPP price is the local-currency cost of one US dollar’s worth of item i . The corresponding quantity is defined as $q_{ic} = v_{ic}/p_{ic}$, the units of which are US dollars ($\frac{\text{domestic currency units}}{\text{domestic currency units}/\$US} = \$US$). If a litre of wine in Britain costs £20, its PPP price is $p_{ic} = 20/10 = £2$, the cost of one-tenth of a litre; and if British wine expenditure is £1,000, then its “volume” of consumption is $q_{ic} = 1,000/2 = \$US500$.

Finally, the vast major of the calculations involve straightforward algebraic steps with countries grouped in various ways. Full details of the calculations are provided in the notes to the tables and figures. These calculations were carried out in Excel. A sample of the calculations for a pair of hypothetical countries, A and B, is provided in the Excel spreadsheet and STATA code in the paper’s online supplementary material. Due to the

confidential nature of the data, the values of the data for these countries are also hypothetical. These files can be used with the actual data obtained from the World Bank.

A2. Measuring Food Consumption

The food volume index for country c is

$$(A2.1) \log Q_c = \sum_{i=1}^{31} w_{ic} \log q_{ic},$$

where w_{ic} is the proportion of food expenditure devoted to food item i and q_{ic} is per capita consumption of i . This index is a weighted average of the consumption of the 31 items, where the weights are the expenditure shares.

The quantities are in terms of US dollars, so they are comparable across commodities. Thus, a reasonable alternative approach to measuring food consumption might be just to add the q_i 's over commodities, or to make this comparable with index (A2.1), average them by dividing by 31:

$$(A2.2) \frac{1}{31} \sum_{i=1}^{31} q_i.$$

Figure A2.1 is a scatter plot of the logarithm of index (A2.2) against (A2.1) for the 155 countries and shows that the two are closely related and roughly proportional. Although the estimated elasticity is somewhat above unity at 1.1, it is sufficiently close to confirm that the indexes are roughly proportional, so the two approaches would yield very similar results.

A3. More on Diversity

To provide further insight into the income sensitivity of the variances, figure A3.1 plots the logs of three variances against log income. The coefficient of the log of income in panel C is -0.29 and significant. This represents the income elasticity of the variance, therefore a 10-percent increase in income leads to a 3-percent fall in the quantity variance. Diet diversity thus increases with income, but the income sensitivity is not particularly high. The other two panels reveal that both the budget share and price variances fall with income, with the former (latter) less (more) than the quantity variance. A 10-percent increase in income leads to a 2-percent fall in the budget share variance, while the price variance falls by 4 percent.

Panel A of figure A3.2 is a visualisation of the decompositions of the budget-share variances. As can be seen, the within component is always more than one-half and less than 80 percent, not too far away from two-thirds. The other panels of this figure summarise the decompositions for prices, quantities and the price-quantity covariance. In the majority of the 20 cases, the within-group component of the total variance dominates.

The results for the group-wise decomposition of the price-quantity covariance are given in Table A3.1. The behaviour of the within-between split of the total covariance is similar to that for the quantity variances of panel C of table 4 – the between-group component is particularly important for the fourth quartile countries. The covariances for bread and cereals, meat and seafood, and fruits and vegetables are among the highest.

A4. Bread and Cereals Consumption

On the basis of the budget shares, rice and cereals stand out, especially for poorer countries. At the other end of the income distribution, within the “bread and cereals” classification of the ICP (the first five items of table 2), the items bread and other bakery products are important for the richer countries. Expenditure on the i^{th} member of the bread and cereals group, expressed as a fraction of total spending on that group, is $e_i / \sum_{j=1}^5 e_j$, which is the conditional budget share. The contrast between spending on rice and bread can be summarised by the following conditional shares ($\times 100$):

Commodity	Income quartile				
	First	Second	Third	Fourth	All
Rice	10	16	25	38	22
Bread	38	38	28	15	30

The shaded elements reveal that bread consumption dominates rice in the higher-income countries (the first and second quartiles), while this pattern is reversed for the fourth. There are similar large changes across the income distribution for other cereals (from table 2, the conditional share is 14 and 39 percent for the top and bottom quartiles, respectively), as well as that for other bakery products (31 vs 4 percent).

There is a further aspect of specialisation within bread and cereals. The first row of table A4.1 shows that in 37 of the 155 countries, spending on rice is the largest among the five members of the bread and cereals group; these countries can be labeled “rice eaters”. Among the other countries, 38 are cereal eaters, 63 are bread eaters and the remaining 17 have a diversified pattern of bread and cereals consumption. As can be seen from column 5, the diversified group is the richest, on average, with a per capita income more than three times that of rice eaters, the poorest group. But it is to be emphasised there is considerable (huge?) diversity within groups of countries, especially the rice eaters, where the standard deviation of income exceeds 100 percent of mean income. There is also an interesting difference regarding spending on all bread and cereals: From the last row of the table, rice and cereal eaters spend almost one-quarter of their food budget on bread and cereals, while in

the two other groups, this share is about 10 points lower at around 15 percent. In large part, this difference reflects the lower incomes of the rice and cereal eaters.²⁸

Cross classifying countries by income and the dominant item among bread and cereals in panel A of table A4.2 reveals a preponderance of lower income countries among rice and cereal eaters, while richer countries are over-represented in the bread eaters and diversified groups. Panel B gives the expected number under the null hypothesis of independence. The largest departures from independence occur in the first and fourth income quartiles. In the first, there are fewer rice and cereal eaters, and more bread eaters and more countries with diversified consumption. For the fourth quartile, this pattern is exactly reversed – rice and cereals prevail and bread is scarce. Testing independence gives $\chi^2 = 70.33$, so we reject the hypothesis.

A5. The Income Elasticities

This appendix gives details of the income elasticities used in the quality indexes in the article.

A Demand System

To estimate the income elasticities while controlling for the influence of prices, we use the CBS model (Keller and van Driel, 1985), the i^{th} equation of which is

$$(A5.1) \quad w_i = \alpha_i + \beta_i \log Q + \lambda \gamma_i \log \frac{p_i}{P^*},$$

with real income and the relative price defined in logarithmic terms as

$$\log Q = \log M - \sum_{i=1}^n w_i \log p_i, \quad \log \frac{p_i}{P^*} = \log p_i - \sum_{i=1}^n \gamma_i \log p_i, \quad \sum_{i=1}^n \gamma_i = 1.$$

This model is linear in real income and the relative price and is easy to interpret and estimate. Note that the price elasticities play no role in the analysis – the objective of using model (A5.1) is to control for prices when estimating income elasticities.

Let $\theta_i = \partial(p_i q_i) / \partial M$ be the marginal share of good i . This θ_i answers the question, when income rises by one dollar, by how much does spending on i increase? To derive the implied marginal share, multiply both sides of (A5.1) by M to give

²⁸ In somewhat related research, Jensen and Miller (2010) argue that at very low levels of income, as the marginal utility of calories is high, consumption is concentrated on those goods providing the cheapest calories; these goods are identified as staples. As income rises, the marginal utility of calories declines and consumption moves away from staples towards foods that provide other attributes (such as protein and taste), as well as calories. Thus, the “calories budget” is less intensive in staples for a more affluent consumer. Consequently, Jensen and Miller propose the proportion of calories provided by staples (the “staples calorie share”, SCS) as a measure of an individual’s nutritional sufficiency. They argue that as the SCS deals more closely with what the consumer is actually concerned (his/her utility of consumption), it has advantages over other approaches to the measurement of hunger and undernutrition such as caloric intake. Jensen and Miller (2010, p 24) state that “SCS gives a sense of whether consumers have begun the ‘diet transition’, away from a traditional diet dependent on a staple good, and towards a more diversified or modern diet focusing on non-nutritional attributes of food”.

$$p_i q_i = M \left[\alpha_i + \beta_i \left(\log M - \sum_{i=1}^n w_i \log p_i \right) + \lambda \gamma_i \left(\log p_i - \sum_{i=1}^n \gamma_i \log p_i \right) \right]$$

so that

$$\theta_i = w_i + M \beta_i \left(\frac{1}{M} \right) = w_i + \beta_i.$$

The income elasticity of i is defined as $\eta_i = \partial \log q_i / \partial \log M = \theta_i / w_i$. Thus, model (A5.1) implies an income elasticity of the form

$$(A5.2) \quad \eta_i = \frac{\beta_i}{w_i} + 1.$$

Aggregating Commodities

Next, suppose the 31 food items are aggregated into a composite. What can be said about the demand for this composite good? To answer this question, we first define a logarithmic index of the price of food as a weighted average of the 31 prices with weights that are proportional to the γ_i in the original index $\log P^*$:

$$\log P_F^* = \sum_{i=1}^{31} \left(\frac{\gamma_i}{\Gamma_F} \right) \log p_i, \text{ with } \Gamma_F = \sum_{i=1}^{31} \gamma_i.$$

Then, if we add both sides of (A5.1) over $i = 1, \dots, 31$, we obtain

$$(A5.3) \quad W_F = A_F + B_F \log Q + \lambda \Gamma_F \log \frac{P_F^*}{P^*},$$

where $W_F = \sum_{i=1}^{31} w_i$ is the food budget share, while $A_F = \sum_{i=1}^{31} \alpha_i$ and $B_F = \sum_{i=1}^{31} \beta_i$ are parameters. Equation (A5.3) states that the demand for food as a group depends on real income and the relative price of food, $\log(P_F^*/P^*)$. This equation is just an “uppercase” version of (A4.1), the demand for an individual item of food.

Proceeding as before, the marginal share of food is

$$\Theta_F = \frac{\partial \left(\sum_{i=1}^{31} p_i q_i \right)}{\partial M} = W_F + B_F$$

and the corresponding income elasticity is

$$(A5.4) \quad N_F = \frac{\Theta_F}{W_F} = \frac{\sum_{i=1}^{31} \theta_i}{W_F} = \sum_{i=1}^{31} \frac{w_i}{W_F} \frac{\theta_i}{w_i} = \sum_{i=1}^{31} \frac{w_i}{W_F} \eta_i.$$

In words, the group income elasticity is a weighted average of the elasticities of the components, where the i^{th} weight is the conditional budget share of this component, that is, the share of food item i in total expenditure on food.

Estimation

For $i = 1, \dots, 32$ commodities (31 foods and 1 non-food), equation (A5.1) satisfies the budget constraint in the form $\sum_{i=1}^{32} w_i = 1$ if $\sum_{i=1}^{32} \alpha_i = 1$, $\sum_{i=1}^{32} \beta_i = 0$ and $\sum_{i=1}^{32} \lambda \gamma_i \log(p_i/P^*) = 0$. This is a singular system so one equation must be omitted in estimation. A problem is that the price index in the model, $\log P^*$, depends on the unknown weights γ_i . This can be solved by a simple iterative process:

Step 1: Set the initial values of γ_i to all be equal and define the corresponding price index

$$\gamma_i^{(0)} = \frac{1}{32}, \quad \log P^{(0)} = \sum_{i=1}^{32} \gamma_i^{(0)} \log p_i.$$

Step 2: Estimate as a SUR system $\alpha_i^{(1)}, \beta_i^{(1)}, \delta_i^{(1)}$ in

$$w_{ic} = \alpha_i^{(1)} + \beta_i^{(1)} \log Q_c + \delta_i^{(1)} \log \frac{p_{ic}}{P_c^{(0)}} + \varepsilon_{ic}, \quad i = 1, \dots, 32 \text{ goods}; c = 1, \dots, 155 \text{ countries},$$

where $\delta_i^{(1)} = (\lambda \gamma_i)^{(1)}$ is estimated as a free composite coefficient and ε_{ic} is a disturbance term. As the weights γ_i sum over $i = 1, \dots, 32$ to unity, it follows that $\sum_{i=1}^{32} \lambda \gamma_i = \lambda$. Thus, the first-round estimates of λ and γ_i can be recovered as

$$\lambda^{(1)} = \sum_{i=1}^{32} \delta_i^{(1)}, \quad \gamma_i^{(1)} = \frac{\delta_i^{(1)}}{\lambda^{(1)}}.$$

Step 3: Replace $\gamma_i^{(0)}$ in Step 1 with $\gamma_i^{(1)}$ to give $\log P_i^{(1)}$. Re-estimate the model in Step 2 with

$$\log P_i^{(1)} \text{ to give the second-round estimates } \alpha_i^{(2)}, \lambda_i^{(2)} \text{ and } \gamma_i^{(2)}.$$

Step 4: Continue until convergence, that is, when $\alpha_i^{(k+1)} \approx \alpha_i^{(k)}$, $\lambda_i^{(k+1)} \approx \lambda_i^{(k)}$ and $\gamma_i^{(k+1)} \approx \gamma_i^{(k)}$.

Using our 155-country data, this procedure converges in under 100 iterations and the results are in table A5.1.²⁹ The vast majority of the food items have negative β_i , indicating they are necessities, as is to be expected. Only cheese and confectionary etc. (items 14 and 25) have significantly positive β_i and it is reasonable that these goods are luxuries. The γ_i are weights in the price index $\log P^*$. As can be seen from column 5 of the table, all but two of the estimated weights for the food items are positive.³⁰ The majority of the weights are estimated quite precisely. The weights for rice and other cereals are large, which would seem to agree with their large budget shares. Finally, the estimated value of the parameter λ is - 8.66 ($\times 100^{-1}$).

²⁹ For the price of non-food, we divide the sum of nominal expenditure of all non-food items by the sum of their real expenditures.

³⁰ The negative semi-definiteness of the substitution matrix does not depend on all weights being positive.

Table A5.2 gives the implied income elasticities by income quartile, evaluated using budget shares from table 2. The several negative elasticities in the upper quartiles reflect the low budget shares for these goods and should not be taken at face value. The income elasticity of all food as a composite is a weighted average of the elasticities of the 31 components, as indicated by (A5.4), which, from (A5.2), takes the form

$$N_F = \sum_{i=1}^{31} \frac{w_i}{W_F} \left(\frac{\beta_i}{w_i} + 1 \right) = \frac{\sum_{i=1}^{31} \beta_i}{W_F} + 1 = \frac{-\beta_{32}}{W_F} + 1,$$

where the last step follows from $\sum_{i=1}^{32} \beta_i = 0$. The estimate of the income coefficient for non-food, given as the last element of column 3 of table A5.1, is $10.17 (\times 100^{-1})$. Using the negative of this value in the above expression gives the income elasticity for food. This elasticity, for each quartile, is given in the second last row of table A5.3. These values agree reasonably well with those from Gao (2012), given in the last row. The only notable difference is the elasticity for the first quartile – this is 0.09, whereas Gao obtained 0.31.

The Final Elasticities

Whilst the income elasticities for all food agree tolerably well with Gao (2012), the difficulty is that several commodities have negative income elasticities, including rice and other cereals for the higher income groups. This result cannot be ruled out, especially for rich consumers; but as these are fairly broad items, it seems unlikely that they are inferior goods.³¹ Large negative income elasticities of the order of -7 can certainly be ruled out as implausible. As a way to avoid the above problems, we use prior studies as a guide to amending the elasticities in table A5.2. Our approach involves four steps. First, we start with the table A5.2 elasticities. Second, the negative values for rice are replaced with 0.1. In Appendix A6 below, we summarise prior estimates and while there is considerable dispersion, the value 0.1 is not inconsistent with this previous evidence. It seems reasonable to suppose that in the eyes

³¹ Ito, Peterson and Grant (1989) study per capita consumption of rice in 14 Asian countries for the 25 years up to the mid-1980s. They use a demand model with an inverted U-shaped income response. Thus, consumption grows with income as long as income is below some critical value; thereafter, consumption falls and the good becomes inferior. In 5 of the 14 countries, the income elasticity changes from positive to negative over the sample period; and in two cases (Nepal and Bangladesh), the elasticity is always negative. A more general result is that in almost all cases, the elasticity declines over time. The decline in the income elasticity of a necessity as income grows is plausible on economic grounds. Several points need to be noted about this study, however. First, apparent consumption of rice is used and there are well-known problems with this residual measure associated with uncertain estimates of stock holdings. Second, some of the changes in the income elasticity over time are large, perhaps too large to be entirely plausible. The largest change is for Malaysia, where the elasticity falls from 0.33 in 1961 to -0.71 in 1984. The falls for Japan, Singapore and Thailand are of a similar order of magnitude. Third, the elasticity is always negative in Nepal. The inferiority of rice in one of Asia's poorest countries would not seem to agree well with the model that says the good is normal for low levels of income. A similar issue applies to Bangladesh, although its elasticity is much closer to zero. Fourth, in controlling for the influence of prices on consumption, the world prices of rice and wheat (a substitute for rice) are used, not the domestic prices. In short, the study raises the possibility of the inferiority of rice, but the findings need to be interpreted with due care in light of these issues.

(mouths?) of consumers other cereals are fairly close to rice, so in this step we assume the two commodities are sufficiently similar to have the same income elasticity, 0.1. Third, the negative values for other food items are also replaced with 0.1. In most cases, the initial values are close to zero, and, most likely, insignificantly different from 0.1; thus, this step is in all probability innocuous. Fourth, the elasticities are renormalised such that a budget-share weighted average equals unity. Most of the above adjustments pertain to the first and second quartiles.

The new set of income elasticities is given in table A5.4, which is used in the quality indexes in the article. As can be seen, six food items have elasticities greater than unity in some income quartiles – other bakery products (item number 4), other meats (9), cheese (14), confectionary, chocolate and ice cream (25), spirits (29) and wine (30). It is plausible that these are luxuries, although none is a strong luxury.

Conditional budget shares and income elasticities are given in table A5.5. Four features are worthy of note. First, the case of rice and other cereals (commodities 1 and 2). As previously mentioned, these commodities dominate the food budget in the poorest countries: In the fourth income quartile, on average these commodities jointly absorb more than 20 percent of all food expenditure. In contrast, the first-quartile countries devote only about 3 percent to these commodities. The income elasticities move in the same direction – they fall from a little below 1 to 0.2 in moving from the fourth to the first quartile. Second, mineral water, soft drinks etc. (commodity 28) accounts for more than 7 percent in the richest countries (with an income elasticity of 1.6), but less than 3 percent in the poorest (income elasticity somewhat greater than 1). Third, for the richest countries alcoholic beverages as a group (spirits, wine and beer, commodities 29-31) represent more than 10 percent of spending, while in the poorest, the share is less than one-half that figure. Fourth, the budget share of beef (commodity 6) is not too different across the income distribution. The same pattern also applies to pork etc. (commodity 7). This is at least partially offset by other meats (commodity 9), whose share rises from 1.8 percent in the poorest to 6.7 in the richest and has an income elasticity substantially above 1.

A6. Previous Income Elasticities for Rice

Table A6.1 lists prior estimates of income elasticities for rice. In order to compare these estimates with ours, we convert income per capita of the prior studies into our concept of income that is measured in term of 2011 international dollars. Our income is the sum of individual consumption by households, non-profit institutions' expenditure on households and individual government expenditure on households. We use 1960-2015 data from the World Bank's World Development Indicators (WDI) to calculate this for the previous

studies. Whilst the first two components of income are readily available, the third requires some inferences as the WDI only provides total government expenditure. To do so, we use education and health as a proxy for individual government spending. For missing years, we use the long-term average share of education and health in GDP multiplied by GDP in the relevant year. This yields income per capita for the year applicable to the previous study. We then inflate this to domestic 2011 dollars using the change in the country's consumer price index. To convert to real income, we deflate nominal income by the country's cost-of-living index $\log P_c = \sum_i^n w_i \log p_i$. Finally, we allocate countries to income quartiles. This assignment of countries is given in column 5 of table A6.1.

Panel A of table A6.2 summarises the prior elasticities of the rice income elasticities. In total there are 54 and from column 7, the mean and median are 0.10, but there is substantial dispersion (SD = 0.36). Of the 54 estimates, 37 can be cross classified by income (columns 2-6).

A7. Muhammad, Seale, Meade and Regmi

Muhammad et al. (2011) is an important prior study that uses the 2005 ICP data with food split into eight group, including tobacco. In this appendix, we show when we aggregate our results, the two sets of income elasticities are not identical, but acceptably close to each other.

Table A7.1 contains a comparison of our results, after appropriate aggregation of commodities, with those of Muhammad et al. With the exception of cereals, meat and beverages in the higher income countries, the elasticities in panel A are similar in the two studies. Panel B contains the two sets of budget shares, while the last row of the table gives the weighted sum of the income elasticities, which is the elasticity for food as a whole. For the richest countries in this study, the total food elasticity is 6.49×100^{-1} (last element of column 2). This is about 30 percent lower than Muhammad et al.'s estimate of 10.71×100^{-1} (last element of column 7). With elasticities of 0.07 and 0.10 and annual income growth in rich countries of the order of only a couple of percent, the differences are of limited practical significance. The elasticities for the poorest countries are reasonably close: 35.70×100^{-1} vs. 39.24×100^{-1} (last elements of columns 5 and 9). Table A7.2 gives the intermediate calculations underlying table A7.1.

Figure A7.1 plots the two sets of weighted income elasticities (which are given in panel C of table A7.1), and, except for other food, the agreement is fairly close.

A8. Indexes of Quality

This appendix contains further details on the quality indexes introduced in the article. Recall the index of the quality of consumption, equation (7) of the article:

$$(A8.1) \quad y_q = \sum_{i=1}^n w_i (\eta_i - 1) [d(\log q_i) - d(\log Q)].$$

The use of budget shares as weights in equation (A8.1) recognises that some goods are more important than others to the consumer and serves to make y_q a representative index. As $\sum_{i=1}^n w_i \eta_i = 1$, the term $(\eta_i - 1)$ in (A8.1) is the deviation of the income elasticity from its weighted mean, while $d(\log q_i) - d(\log Q)$ is also the deviation of $d(\log q_i)$ from its weighted mean. Thus, the index y_q is interpreted as a weighted covariance between the n income elasticities, $\eta_1, \dots, \eta_n$, and the growth in consumption of the n goods, $d(\log q_1), \dots, d(\log q_n)$. In the special case when each $\eta_i = 1$, all goods are neutral (neither luxuries nor necessities) and quality is constant, that is, $y_q = 0$. Equation (A8.1) also implies constant quality when each good grows at the same rate, that is, when $d(\log q_i) = d(\log Q)$, $i = 1, \dots, n$.

Consider the situation when consumption is log-linear in income, that is, $d(\log q_i) = \alpha_i + \eta_i d(\log Q)$, $i = 1, \dots, n$. Substituting this back into (A8.1), the quality index takes the form $y_q = V \cdot d(\log Q) + A$, where $V = \sum_{i=1}^n w_i (\eta_i - 1)^2$ is a weighted variance of the income elasticities and $A = \sum_{i=1}^n w_i (\eta_i - 1) \alpha_i$. This shows the income elasticity of quality is the variance V . When all income elasticities are unity, $V = 0$ and the elasticity of quality is zero, which agrees with the discussion of the previous paragraph. When all the income elasticities are not unity, $V > 0$ and quality increases with income. In general, the more dispersion there is among the elasticities, the greater is the income sensitivity of quality.

The quality of spending (price times quantity) can also be measured by a weighted covariance between the income elasticities and the growth in expenditure on the n goods, $d(\log p_1 q_1), \dots, d(\log p_n q_n)$:

$$(A8.2) \quad y_{pq} = \sum_{i=1}^n w_i (\eta_i - 1) \left[d(\log p_i q_i) - \sum_{j=1}^n w_j d(\log p_j q_j) \right].$$

This index satisfies $y_{pq} = y_q + y_p$, where

$$(A8.3) \quad y_p = \sum_{i=1}^n w_i (\eta_i - 1) [d(\log p_i) - d(\log P)]$$

is a weighted covariance between the income elasticities and the n prices. As $y_q = y_{pq} - y_p$, the index y_p acts as a deflator that transforms the quality of spending, y_{pq} , a nominal

concept, into the quality of consumption, y_q , a real concept. This means that y_p can be interpreted as an index of the price of quality.

Equation (8) of the article defines the quality index of country c relative to country d for 31 goods:

$$(A8.4) \quad y_q^{cd} = \sum_{i=1}^{31} w_i^{cd} (\eta_i^{cd} - 1) (\log q_i^{cd} - \log Q^{cd}),$$

where, for good i , $w_i^{cd} = (w_i^c + w_i^d)/2$, the average of budget shares in the two countries; $\eta_i^{ab} = \theta_i^{ab} / w_i^{ab} = w_i^a / (w_i^a + w_i^b) \cdot \eta_i^a + w_i^b / (w_i^a + w_i^b) \cdot \eta_i^b$ is a weighted average of the two income elasticities; $\log q_i^{cd} = \log(q_i^c / q_i^d)$ is the relative quantity change; and $\log Q^{cd} = \sum_{i=1}^n w_i^{cd} \log q_i^{cd}$ is the Divisia volume index. Panel A of figure A8.1 is a histogram of y_q^{cd} for $c \neq d$, $c, d = 1, \dots, 155$. The standard deviation (SD) of the quality differences is about 25 percent, indicating fairly substantial dispersion across countries. For some pairs involving a very rich country and a very poor one, the quality difference exceeds 70 percent. All in all, there is a considerable diversity in the quality of food consumption around the world.

Next, we compare across countries the price of quality and spending, using an analogous approach to equation (A8.4). For c relative to d , the price and spending indexes are

$$(A8.5) \quad y_p^{cd} = \sum_{i=1}^{31} w_i^{cd} (\eta_i^{cd} - 1) (\log p_i^{cd} - \log P^{cd}), \quad y_{pq}^{cd} = \sum_{i=1}^{31} w_i^{cd} (\eta_i^{cd} - 1) [\log(p_i q_i)^{cd} - \log(PQ)^{cd}],$$

where $\log p_i^{cd} = \log(p_i^c / p_i^d)$, $\log P^{cd} = \sum_{i=1}^{31} w_i^{cd} \log p_i^{cd}$, $\log(p_i q_i)^{cd} = \log(p_i^c q_i^c / p_i^d q_i^d)$ and $\log(PQ)^{cd} = \sum_{i=1}^{31} w_i^{cd} \log(p_i q_i)^{cd}$. As can be seen from panel B of figure A8.1, the SD of the price of quality is about 4 percent, so there is substantially less dispersion than for the quality of consumption (panel A). As noted early in the article, the variance of quantities is more than six times that of prices. In large part, this accounts for the lower dispersion of the price of quality. As the spending index satisfies $y_{pq}^{cd} = y_q^{cd} + y_p^{cd}$, the corresponding histogram, given in panel C of figure A8.1, can be derived from the other two panels. Since price dispersion is modest, the SD of spending is of the same order as that of consumption at about 23 percent.

The article used the multilateral quality indexes in country c for consumption, prices and spending, defined as $\hat{\alpha}_q^c = 1/155 \cdot \sum_{d=1}^{155} y_q^{cd}$, $\hat{\alpha}_p^c = 1/155 \cdot \sum_{d=1}^{155} y_p^{cd}$ and $\hat{\alpha}_{pq}^c = 1/155 \cdot \sum_{d=1}^{155} y_{pq}^{cd}$. These are listed in table A8.1. Thus, for example, the multilateral index of consumption quality in the US is 18.3×100^{-1} (from the second entry of column 2), or $100 \times (e^{0.183} - 1) \approx 20$

percent above the average for all countries. As some of the poorest countries are about 25 percent below average, the quality inequality gap is almost 50 percent. Roughly speaking, the richest 50 percent of countries have a positive quality index, the others negative. As in most cases the differences in the price of quality are modest, the quality of spending tends to mirror the quality of consumption.

A9. Quality of Food Groups and Diversity

This appendix decomposes the quality index into between- and within-group components, applies this to food and examines the relationship between quality and diversity.

Decomposing Quality

Write the bilateral quality index of consumption (A8.4) for n goods as

$$(A9.1) \quad y_q^{cd} = \sum_{i=1}^n w_i^{cd} (\eta_i^{cd} - 1) (\log q_i^{cd} - \log Q^{cd}).$$

We divide the n goods into $G < n$ groups, written $\mathbf{S}_1, \dots, \mathbf{S}_G$, where each good belongs to one group only. As established in the last section of this appendix, equation (A9.1) can be decomposed into between- and within-group components:

$$(A9.2) \quad \sum_{i=1}^n w_i^{cd} (\eta_i^{cd} - 1) \log \left(\frac{q_i^{cd}}{Q^{cd}} \right) = \sum_{g=1}^G W_g^{cd} (\eta_g^{cd} - 1) \log \left(\frac{Q_g^{cd}}{Q^{cd}} \right) + \sum_{g=1}^G W_g^{cd} \eta_g^{cd} \left[\sum_{i \in \mathbf{S}_g} w_i'^{cd} (\eta_i'^{cd} - 1) \log \left(\frac{q_i^{cd}}{Q_g^{cd}} \right) \right].$$

Here, for countries c and d , $W_g^{cd} = \sum_{i \in \mathbf{S}_g} w_i^{ab}$ is the budget share of group g ; $\eta_g^{cd} = \sum_{i \in \mathbf{S}_g} w_i'^{cd} \eta_i^{cd}$ is the income elasticity of g , with $w_i'^{ab} = w_i^{ab} / W_g^{cd}$ the conditional budget share of good $i \in \mathbf{S}_g$; $\log Q_g^{cd} = \sum_{i \in \mathbf{S}_g} w_i'^{cd} \log q_i^{cd}$ is the volume index for group g ; and $\eta_i'^{cd} = \eta_i^{cd} / \eta_g^{cd}$ is the conditional income elasticity of $i \in \mathbf{S}_g$.

The first term on the right of equation (A9.2) is a group-budget-share weighted-average of the terms $(\eta_g^{cd} - 1) \log(Q_g^{cd} / Q^{cd}) = (\eta_g^{cd} - 1) (\log Q_g^{cd} - \log Q^{cd})$, $g = 1, \dots, G$. This is the group-wise version of (A9.1) and is the between-group component of the quality index. The term in square brackets on the right of equation (A9.2) is $\sum_{i \in \mathbf{S}_g} w_i'^{cd} (\eta_i'^{cd} - 1) \log(q_i^{cd} / Q_g^{cd})$, which is the quality index within group g . Thus, the entire last term on the right, $\sum_{g=1}^G W_g^{cd} \eta_g^{cd} \left[\sum_{i \in \mathbf{S}_g} w_i'^{cd} (\eta_i'^{cd} - 1) \log(q_i^{cd} / Q_g^{cd}) \right]$, is a weighted average of the quality indexes of the G groups. The weights here are $W_g^{cd} \eta_g^{cd} = 1/2 (\partial M_g^c / \partial M^c + \partial M_g^d / \partial M^d)$, where, for country c , $M_g^c = \sum_{i \in \mathbf{S}_g} p_i^c q_i^c$ is expenditure on group g and $M^c = \sum_{g=1}^G M_g^c = \sum_{i=1}^n p_i^c q_i^c$ is total expenditure. These weights are group marginal shares, which have a unit sum. Accordingly, the last term on the right of

(A9.2) is the within-group component of quality. Decompositions similar to (A9.2) also apply to the quality of spending and the price of quality.

Application to Food

We divide the $n=31$ food items into the same $G=7$ groups, as before, and use equation (A9.2) to decompose total quality. table A9.1 gives background information on budget shares and income elasticities, and table A9.2 contains the results. The results differ from those for diet diversity where the between-group component clearly dominates. For the quality of consumption (panel A of table A9.2), it is true that the between-group component exceeds the within component for countries within the first quartile (first row of columns 3 and 4). But for the three other comparisons, the reverse is true and the component difference grows with the income gap. That is, the ratio of within to between for countries in the first quartile is $3.54/4.00 = 0.89$; for quartile 1 compared to quartile 2, the ratio is 2.1; 2.3 for the comparison between quartiles 1 and 3; and 2.6 for quartile 1 vs quartile 4. As items within the same group are likely to be closer substitutes to one another than items in different groups, the importance of within-group quality means that greater variety in consumption of close substitutes is the main driver of higher quality of food consumption.

Panels B and C of table A9.2 contain analogous decompositions for the price of and spending on food quality. For prices, the between component dominates, while the spending results reflect those for consumption. Table A9.3 considers the effect of income on the contribution of each group to the within component of the quality of consumption. As can be seen, income plays a significant role in all cases. Income differences have the largest negative effect in the case of fruit and vegetables, and the largest positive effect on dairy.

Quality and Diversity

As quality and diversity both increase with income, the two elements are themselves positively related. This is made explicit in the bivariate histogram of figure A9.1. While the dependence is visually clear, surprisingly, the relationship is only moderately strong. As shown in panel E of table A9.4, the correlation across the whole income distribution between quality and dispersion (an inverse measure of diversity) is -0.68. This table also makes clear that much of the correlation between quality and income operates between quartiles; this is evidenced by the value of this correlation for all countries (0.82, from panel E) being considerably larger than any of the within-quartile correlations (0.40, 0.28, 0.49 and 0.62). The same pattern also holds for the relation between dispersion and income.

Derivations

To derive (A9.2), first rewrite equation (A9.1) as

$$\begin{aligned}
(A9.3) \quad \sum_{i=1}^n w_i^{cd} (\eta_i^{cd} - 1) (\log q_i^{cd} - \log Q^{cd}) &= \sum_{i=1}^n w_i^{cd} (\eta_i^{cd} - 1) (\log q_i^{cd} - \log Q_g^{cd} + \log Q_g^{cd} - \log Q^{cd}) \\
&= \sum_{i=1}^n w_i^{cd} (\eta_i^{cd} - 1) (\log Q_g^{cd} - \log Q^{cd}) + \sum_{i=1}^n w_i^{cd} (\eta_i^{cd} - 1) (\log q_i^{cd} - \log Q_g^{cd}).
\end{aligned}$$

The first component of the second line of (A9.3) can be expressed as

$$\begin{aligned}
\sum_{i=1}^n w_i^{cd} (\eta_i^{cd} - 1) (\log Q_g^{cd} - \log Q^{cd}) &= \sum_{g=1}^G \sum_{i \in g} w_i^{cd} (\eta_i^{cd} - 1) (\log Q_g^{cd} - \log Q^{cd}) \\
&= \sum_{g=1}^G (\log Q_g^{cd} - \log Q^{cd}) \left[\sum_{i \in g} w_i^{cd} \eta_i^{cd} - \sum_{i \in g} w_i^{cd} \right] \\
&= \sum_{g=1}^G (\log Q_g^{cd} - \log Q^{cd}) (W_g^{cd} \eta_g^{cd} - W_g^{cd}) \\
&= \sum_{g=1}^G W_g^{cd} (\eta_g^{cd} - 1) \log \left(\frac{Q_g^{cd}}{Q^{cd}} \right).
\end{aligned}$$

This is the between-group component, which is the first term on the right in (A9.2)

Next, use $w_i^{cd} = w_i'^{cd} W_g^{cd}$ and $\eta_i^{cd} = \eta_i'^{cd} \eta_g^{cd}$ to express the second component of the second line of (A9.3) as

$$\begin{aligned}
\sum_{i=1}^n w_i^{cd} (\eta_i^{cd} - 1) (\log q_i^{cd} - \log Q_g^{cd}) &= \sum_{g=1}^G \sum_{i \in g} w_i^{cd} \eta_i^{cd} (\log q_i^{cd} - \log Q_g^{cd}) - \sum_{g=1}^G \sum_{i \in g} w_i^{cd} (\log q_i^{cd} - \log Q_g^{cd}) \\
&= \sum_{g=1}^G \sum_{i \in g} w_i'^{cd} W_g^{cd} \eta_i'^{cd} \eta_g^{cd} (\log q_i^{cd} - \log Q_g^{cd}) - \sum_{g=1}^G \sum_{i \in g} w_i'^{cd} W_g^{cd} (\log q_i^{cd} - \log Q_g^{cd}) \\
&= \sum_{g=1}^G W_g^{cd} \eta_g^{cd} \sum_{i \in g} w_i'^{cd} \eta_i'^{cd} (\log q_i^{cd} - \log Q_g^{cd}) - \sum_{g=1}^G W_g^{cd} \sum_{i \in g} w_i'^{cd} (\log q_i^{cd} - \log Q_g^{cd}).
\end{aligned}$$

Since $\sum_{i \in g} w_i'^{cd} (\log q_i^{cd} - \log Q_g^{cd}) = 0$, it is convenient to write the final term in the last line above as

$$\sum_{g=1}^G W_g^{cd} \sum_{i \in g} w_i' (\log q_i - \log Q_g) = \sum_{g=1}^G W_g^{cd} \eta_g^{cd} \sum_{i \in g} w_i'^{cd} (\log q_i^{cd} - \log Q_g^{cd}),$$

so that

$$\begin{aligned}
\sum_{i=1}^n w_i^{cd} (\eta_i^{cd} - 1) (\log q_i^{cd} - \log Q_g^{cd}) &= \sum_{g=1}^G W_g^{cd} \eta_g^{cd} \sum_{i \in g} w_i'^{cd} \eta_i'^{cd} (\log q_i^{cd} - \log Q_g^{cd}) - \sum_{g=1}^G W_g^{cd} \eta_g^{cd} \sum_{i \in g} w_i'^{cd} (\log q_i^{cd} - \log Q_g^{cd}) \\
&= \sum_{g=1}^G W_g^{cd} \eta_g^{cd} \left[\sum_{i \in g} w_i'^{cd} \eta_i'^{cd} (\log q_i^{cd} - \log Q_g^{cd}) - \sum_{i \in g} w_i'^{cd} (\log q_i^{cd} - \log Q_g^{cd}) \right] \\
&= \sum_{g=1}^G W_g^{cd} \eta_g^{cd} \left[\sum_{i \in g} w_i'^{cd} (\eta_i'^{cd} - 1) (\log q_i^{cd} - \log Q_g^{cd}) \right].
\end{aligned}$$

This is the within-group component, the second term on the right of (A9.2)

The above approach formulates the quality index in terms of a comparison of one country with another. Theil (1975/76, Chaps. 11 and 14) considers quality with quantities expressed in terms of changes over time. The above decomposition is analogous to his.

A10. Prices and Policies

Government intervention in agricultural markets to protect food security and domestic producers can have distortionary effects on consumer prices of food. For example, Japan has had a long-standing policy of keeping rice prices high in order to protect the interests of its rice producers. Historically, higher-income advanced countries have favoured pro-agriculture policies whilst lower-income developing countries have taxed their agriculture sector in order to subsidise the manufacturing sector (Anderson, Rausser and Swinnen, 2013).

The relative rate of assistance (RRA) to agriculture, from Anderson, Rausser and Swinnen (2013), provides a measure of whether a country's policies are pro- or anti-agriculture; a positive (negative) value indicates pro-(anti-) agriculture policies. Using the average RRAs over the period 2007 to 2011 and matching these with the ICP data, we obtain a sample of 59 countries. With these data, figure A10.1 shows a positive relationship between the RRA and income, agreeing with Anderson, Rausser and Swinnen (2013). The right panel of figure A10.2 contains plots of the price variance, price of quality and the relative price of food against the RRA. It is somewhat of a puzzle that all three of these variables decline with the RRA. However, the left panel shows that the three variables are also negatively related to income. As the RRA is positively correlated with income, the negative effect of the RRA on prices could just reflect the role of income as the key driver. The correlations, reported in table A10.1, show in all three cases the price measures are more closely related to the country's income than to its RRA.

To investigate this issue further, we regress each of the price measures on income and the RRA and table A10.2 contains the results. The income coefficients are negative and statistically significant in the three cases (row 1). For the price variance (column 2), countries with a higher RRA -- pro-agriculture policies -- tend to have marginally higher price dispersion. This could be interpreted as saying that the policy causes some food prices to rise relative to others, that is, the policy has a selective effect. However, this effect is not significant. That more pro-agriculture policies are associated with a lower price of quality (column 3) could mean these policies operate to increase the prices of foods with lower income elasticities and vice versa for those with higher elasticities; however, this effect is small. Lastly, pro-agriculture policies have an effect of increasing the relative price of food, as is to be expected (column 4). This effect is only marginally significant. Thus, after controlling for income, agriculture policies, as measured by the RRA, cause food prices to change in a manner that can be understood. But in view of the size of the coefficients of the RRAs, and their relatively high standard errors, the main conclusion is the minor impact on prices of government policy as compared to that of income.

A11. Consumer Demand for Food

This appendix provides further details and derivations of the applications of our diversity and quality measures on the demand for food.

Index Numbers

The indexes in equation (2) of the article are budget-share weighted averages of the Divisia (1925) form. In more conventional differential form, these are

$$(A11.1) \quad d(\log P) = \sum_{i=1}^n w_i d(\log p_i), \quad d(\log Q) = \sum_{i=1}^n w_i d(\log q_i).$$

A less well-known index number is when the weights are marginal shares, defined as $\theta_i = \partial(p_i q_i) / \partial M$, with $\sum_{i=1}^n \theta_i = 1$. As the use of marginal shares was advocated by Frisch (1932), we shall call the following “Frisch indexes”:

$$d(\log P') = \sum_{i=1}^n \theta_i d(\log p_i), \quad d(\log Q') = \sum_{i=1}^n \theta_i d(\log q_i).$$

The Frisch second-order moments are:

$$(A11.2) \quad \Pi'_p = \sum_{i=1}^n \theta_i [d(\log p_i) - d(\log P')]^2, \quad \Pi'_q = \sum_{i=1}^n \theta_i [d(\log q_i) - d(\log Q')]^2.$$

The quality of consumption is a budget-share weighted covariance between the income elasticities (η_i) and the quantities consumed, that is, $y_q = \sum_{i=1}^n w_i [\eta_i - 1] [d(\log q_i) - d(\log Q)]$, while the price of quality is $y_p = \sum_{i=1}^n w_i [\eta_i - 1] [d(\log p_i) - d(\log P)]$. Using $\eta_i = \theta_i / w_i$, these become the excess of the Frisch index over the Divisia counterpart:

$$(A11.3) \quad y_q = d(\log Q') - d(\log Q), \quad y_p = d(\log P') - d(\log P).$$

For luxuries, $\eta_i = \theta_i / w_i > 1$, so that relative to the Divisia index, Frisch accords higher weights to luxuries; and vice versa for necessities. Thus, when, on average, the consumption of luxuries grows faster than necessities, $d(\log Q') > d(\log Q)$, or $y_q > 0$; that is, quality of consumption improves. Similarly for prices: When, on average, the prices of luxuries increase and those of necessities fall, the price of quality rises.

The consumer's budget constraint is $M = \sum_{i=1}^n p_i q_i$ and its logarithmic differential is $d(\log M) = \sum_{i=1}^n w_i d(\log q_i) + \sum_{i=1}^n w_i d(\log p_i)$, or, after substituting in equation (A11.1), $d(\log M) = d(\log P) + d(\log Q)$. To interpret the Divisia quantity index $d(\log Q)$ further, consider the differential of the utility function, $du = \sum_{i=1}^n u_i dq_i$, where $u_i = \partial u / \partial q_i$ is the

marginal utility of i . Using the first-order conditions, $u_i = \lambda p_i$, $i = 1, \dots, n$, where $\lambda > 0$ is the marginal utility of income, $du = \lambda M \cdot \sum_{i=1}^n w_i d(\log q_i) = \lambda M \cdot d(\log Q)$. Thus, $d(\log Q)$ has the dual interpretation as (i) proportional to the change in utility; and (ii) the excess of the change in money income over the change in the cost-of-living index. Therefore, setting $d(\log Q) = 0$ in a demand equation holds real income constant. A similar property also holds for relative price change formed by deflating by the Frisch index, $d(\log p_i) - d(\log P')$; this holds constant the marginal utility of income (Frisch, 1932, Theil, 1967).

Demand Equations

Under general conditions, a demand equation for good i can be expressed in terms of $d(\log Q)$ and the Frisch relative price changes $d(\log p_j) - d(\log P')$, $j = 1, \dots, n$, as

$$(A11.4) \quad d(\log q_i) = \eta_i d(\log Q) + \sum_{j=1}^n \eta'_{ij} [d(\log p_j) - d(\log P')].$$

Here, η'_{ij} is the $(i, j)^{th}$ Frisch price elasticity that holds constant the marginal utility of income. The Frisch elasticity is related to the corresponding Slutsky elasticity (η_{ij}) according to $\eta_{ij} = \eta'_{ij} - \phi \eta_i \theta_j$, where $\phi = [\partial(\log \lambda) / \partial(\log M)]^{-1} < 0$ is the inverse of the income elasticity of the marginal utility of income λ , known as the income flexibility. The link with the Cournot counterpart (η_{ij}^*) is $\eta_{ij}^* = \eta'_{ij} - \phi \eta_i \theta_j - w_j \eta_i$.

When the marginal utility of each good is independent of the consumption of all others (known as “want-independence”), $\eta'_{ij} = 0$, $i \neq j$, and $\eta'_{ii} = \phi \eta_i$, $i = 1, \dots, n$. Here, the income flexibility is the average own-price elasticity, $\phi = \sum_{i=1}^n w_i \eta'_{ii}$. Want-independence means that equation (A11.4) simplifies by (i) having only the own-relative price on the right, rather than all n ; and (ii) the own-price elasticity η'_{ii} becoming $\phi \eta_i$:

$$(A11.5) \quad d(\log q_i) = \eta_i d(\log Q) + \phi \eta_i [d(\log p_i) - d(\log P')].$$

A Cross-Commodity Regression

If the income elasticities are known, the income flexibility ϕ is the only unknown parameter in the system of equations comprising (A11.5) for $i = 1, \dots, n$. This parameter can be estimated by regressing $d(\log q_i) - \eta_i d(\log Q)$ on $\eta_i [d(\log p_i) - d(\log P')]$ for $i = 1, \dots, n$. We shall use a weighted least-squares approach that uses as weights the budget shares. As shown below, this involves some of our previous measures of dispersion of the budget, as well as the price of quality.

We multiply both sides of equation (A11.5) by $[d(\log p_i) - d(\log P')]$, weight by w_i and then sum over $i = 1, \dots, n$. On the left, in view of the second member of (A11.3), this gives

$$(A11.6) \quad \sum_{i=1}^n w_i d(\log q_i) [d(\log p_i) - d(\log P')] = \Pi'_{p,q} - y_p d(\log Q),$$

where $\Pi'_{p,q} = \sum_{i=1}^n w_i [d(\log p_i) - d(\log P')] [d(\log q_i) - d(\log Q)]$ is a weighted price-quantity covariance; and y_p is the price of quality. After multiplying the right of equation (A11.5) by $[d(\log p_i) - d(\log P')]$ and then taking the weighted sum, we obtain a real income term and a substitution term. The income term vanishes and in view of equation (A11.2), the substitution term becomes $\phi \Pi'_p$. Combining this with (A11.6), we obtain $\Pi'_{p,q} - y_p d(\log Q) = \phi \Pi'_p$. The weighted least-squares estimator of ϕ is then the ratio of the right side of equation (A11.6) to Π'_p :

$$\hat{\phi} = \frac{\Pi'_{p,q} - y_p d(\log Q)}{\Pi'_p}.$$

This is equation (10) of the article.

Food and Non-food

Consider again equation (A11.4), the demand equation for good i ($i = 1, \dots, n$):

$$(A11.7) \quad d(\log q_i) = \eta_i d(\log Q) + \sum_{j=1}^n \eta'_{ij} [d(\log p_j) - d(\log P')].$$

Here, η_i is the income elasticity of i and η'_{ij} is the $(i, j)^{th}$ Frisch price elasticity. These elasticities satisfy a symmetry condition

$$(A11.8) \quad w_i \eta'_{ij} = w_j \eta'_{ji} \quad i, j = 1, \dots, n,$$

and

$$(A11.9) \quad \sum_{j=1}^n \eta'_{ij} = \phi \eta_i \quad i = 1, \dots, n,$$

where $\phi = [\partial(\log \lambda) / \partial(\log M)]^{-1}$ is the income flexibility. Let the n goods be divided into two groups, food (F) and non-food (N), written S^F , S^N . If these blocks are want-independent in the sense of Frisch (1959), then

$$\eta'_{ij} = 0, \quad i \in S^F, \quad j \in S^N \quad \text{and} \quad \sum_{j \in S^F} \eta'_{ij} = \phi \eta_i, \quad i \in S^F.$$

In this case, the substitution term in equation (A11.7) for $i \in S^F$ is confined to the relative prices within S^F , rather than all n such prices:

$$(A11.10) \quad d(\log q_i) = \eta_i d(\log Q) + \sum_{j \in S^F} \eta'_{ij} [d(\log p_j) - d(\log P')].$$

Equation (A11.10) can be used to derive a demand equation for food as a whole. For this purpose, three basic concepts are needed. First, the budget shares

$$w_i^F = \frac{w_i}{W^F}, i \in S^F, W^F = \sum_{i \in S^F} w_i.$$

This w_i^F is the proportion of food expenditure devoted to the i^{th} type of food, known as the conditional budget share, and W^F is the budget share of food. Second, the income elasticities

$$\eta_i^F = \frac{\eta_i}{\eta^F}, i \in S^F, \eta^F = \sum_{i \in S^F} w_i^F \eta_i.$$

Here, η_i^F is the conditional income elasticity of $i \in S^F$ and η^F is the income elasticity of food. Third, the Divisia volume index of food and the corresponding Frisch price index

$$d(\log Q^F) = \sum_{i \in S^F} w_i^F d(\log q_i), d(\log P'^F) = \sum_{i \in S^F} w_i^F \eta_i^F d(\log p_i).$$

In the Frisch index, the weight attached to the i^{th} food price is $w_i^F \eta_i^F$. This is equal to the conditional marginal share of $i \in S^F$, which is $\partial(p_i q_i) / \partial M^F$, where $M^F = \sum_{i \in S^F} p_i q_i$ is expenditure on food.

As shown in the next section, the group demand equation for food as a group takes the form

$$(A11.11) \quad d(\log Q^F) = \eta^F d(\log Q) + \phi \eta^F [d(\log P'^F) - d(\log P')].$$

Thus, under want-independence the demand for food as a whole depends on real income and the relative price of food, $d(\log P'^F) - d(\log P')$.

Derivations I

To derive equation (A11.11), we multiply both sides of equation (A11.10) for $i \in S^F$ by w_i^F and then sum over $i \in S^F$:

$$\sum_{i \in S^F} w_i^F d(\log q_i) = \sum_{i \in S^F} w_i^F \eta_i d(\log Q) + \sum_{i \in S^F} w_i^F \sum_{j \in S^F} \eta'_{ij} [d(\log p_j) - d(\log P')].$$

On the left, we have $d(\log Q^F)$. The first term on the right is $\eta^F d(\log Q)$. This confirms the first and second terms of equation (A11.11).

The substitution term is

$$(A11.12) \quad \sum_{i \in S^F} w_i^F \sum_{j \in S^F} \eta'_{ij} [d(\log p_j) - d(\log P')] = \sum_{i \in S^F} \sum_{j \in S^F} w_i^F \eta'_{ij} d(\log p_j) - \sum_{i \in S^F} \sum_{j \in S^F} w_i^F \eta'_{ij} d(\log P').$$

The first term on the right of the above as

$$\begin{aligned}
\sum_{i \in S^F} \sum_{j \in S^F} w_i^F \eta'_{ij} d(\log p_j) &= \sum_{j \in S^F} \sum_{i \in S^F} w_i^F \eta'_{ij} d(\log p_j) \\
(A11.13) \quad &= \sum_{j \in S^F} w_j^F \sum_{i \in S^F} \eta'_{ji} d(\log p_j) \\
&= \phi \sum_{j \in S^F} w_j^F \eta_j d(\log p_j).
\end{aligned}$$

The second line in the above is based on equation (A11.8), since $w_i \eta'_{ij} = w_j \eta'_{ji}, i, j \in S^F$, implies $w_i^F \eta'_{ij} = w_j^F \eta'_{ji}$, where $w_i^F = w_i / W^F, i \in S^F$. The third line is based on constraint (A11.9), which becomes $\sum_{j \in S^F} \eta'_{ij} = \phi \eta_i, i \in S^F$, under want-independence. As $\eta_i^F = \eta_i / \eta^F, i \in S^F$, the last line of equation (A11.13) can be written as

$$\phi \sum_{j \in S^F} w_j^F \eta_j d(\log p_j) = \phi \eta^F \sum_{j \in S^F} w_j^F \eta_j^F d(\log p_j) = \phi \eta^F d(\log P'^F),$$

where $d(\log P'^F)$ is the Frisch price index of food defined above.

$$\text{As } \sum_{j \in S^F} \eta'_{ij} = \phi \eta_i, i \in S^F,$$

$$\sum_{i \in S^F} \sum_{j \in S^F} w_i^F \eta'_{ij} = \phi \sum_{i \in S^F} w_i^F \eta_i = \phi \eta^F,$$

the last term on the far right of equation (A11.12) becomes

$$\sum_{i \in S^F} \sum_{j \in S^F} w_i^F \eta'_{ij} d(\log P') = \phi \eta^F d(\log P').$$

Collecting terms, the whole substitution term simplifies to

$$\sum_{i \in S^F} w_i^F \sum_{j \in S^F} \eta'_{ij} [d(\log p_j) - d(\log P')] = \phi \eta^F [d(\log P'^F) - d(\log P')],$$

which confirms the final term of equation (A11.11).

Conditional Demand for Food

Equation (A11.7), the demand for good i , depends on income and the n relative prices. Instead of income, the conditional demand equation for $i \in S^F$ depends on total food, while the relative prices of all goods are replaced by those of goods within the food group. This holds under the condition of want-independence of food and non-food. This section sets out these conditional demands.

Under block independence, the unconditional demand for $i \in S^F$ is given by equation (A11.10), while equation (A11.11) is the corresponding group demand. The right-hand sides of these two equations both contain income $d(\log Q)$. The combination of those equations to eliminate this variable gives the conditional demand equation for $i \in S^F$:

$$(A11.14) \quad d(\log q_i) = \eta_i^F d(\log Q^F) + \sum_{j \in S^F} \eta'_{ij} [d(\log p_j) - d(\log P'^F)],$$

where, as before, $\eta_i^F = \eta_i / \eta^F$ is the conditional income elasticity, $d(\log Q^F)$ is the Divisia food volume index and $d(\log P'^F)$ is the Frisch food price index. The detailed derivation of the above equation is in the next section.

Derivations II

From equation (A11.11), we have $d(\log Q) = 1/\eta^F \cdot d(\log Q^F) - \phi [d(\log P'^F) - d(\log P')]$.

Substituting the right of this equation for $d(\log Q)$ in (A11.10) gives

$$d(\log q_i) = \eta_i^F d(\log Q^F) - \eta_i \phi [d(\log P'^F) - d(\log P')] + \sum_{j \in S^F} \eta'_{ij} [d(\log p_j) - d(\log P')].$$

As $\sum_{j \in S^F} \eta'_{ij} = \phi \eta_i, i \in S^F$, the terms involving prices become

$$\begin{aligned} & -\eta_i \phi [d(\log P'^F) - d(\log P')] + \sum_{j \in S^F} \eta'_{ij} [d(\log p_j) - d(\log P')] \\ &= -\sum_{j \in S^F} \eta'_{ij} [d(\log P'^F) - d(\log P')] + \sum_{j \in S^F} \eta'_{ij} [d(\log p_j) - d(\log P')] \\ &= \sum_{j \in S^F} \eta'_{ij} [d(\log p_j) - d(\log P')]. \end{aligned}$$

This yields the conditional demand equation (A11.14).

Disaggregating Food

Suppose there are n^F items that make up the food group S^F . Now let these items be divided into $G < n^F$ food sub-groups, such that each item belongs to one sub-group only. Bread and cereals is an example of such a sub-group, with members rice, cereals, bread, bakery and pasta. Denote the G sub-groups by $S_1^F, \dots, S_G^F$. It is assumed that each sub-group of food is want-independent, so that

$$\eta'_{ij} = 0 \quad i \in S_g^F, j \in S_h^F, g \neq h, g, h = 1, \dots, G.$$

We continue to take the food and non-food groups to be want-independent, so that

$$\eta'_{ij} = 0, \quad i \in S^F, j \in S^N \quad \text{and} \quad \sum_{j \in S^F} \eta'_{ij} = \phi \eta_i, \quad i \in S^F.$$

As the food sub-groups are also want-independent, the constraint immediately above now becomes

$$(A11.15) \quad \sum_{j \in S_g^F} \eta'_{ij} = \phi \eta_i, \quad i \in S_g^F, g = 1, \dots, G.$$

The objective is to obtain a demand equation for the sub-group S_g^F that depends on total food consumption and the relative price of the sub-group. Accordingly, we need " S_g^F -versions" of the three concepts introduced previously. First, the budget shares

$$w_{ig}^F = \frac{w_i^F}{W_g^F}, \quad i \in S_g^F, \quad W_g^F = \sum_{i \in S_g^F} w_i^F.$$

Thus, w_{ig}^F is the share of i in total expenditure on food sub-group g and W_g^F is the share of g in total food expenditure. Second, the income elasticities

$$(A11.16) \quad \eta_{ig}^F = \frac{\eta_i^F}{\eta_g^F}, \quad i \in S_g^F, \quad \eta_g^F = \sum_{i \in S_g^F} w_{ig}^F \eta_i^F.$$

The term η_{ig}^F is the conditional income elasticity of $i \in S_g^F$, while η_g^F is the income elasticity of S_g^F . Third, the volume index of sub-group g and the Frisch index of the prices of this sub-group

$$d(\log Q_g^F) = \sum_{i \in S_g^F} w_{ig}^F d(\log q_i), \quad d(\log P_g'^F) = \sum_{i \in S_g^F} w_{ig}^F \eta_{ig}^F d(\log p_i).$$

The weight attached to the price of i in this price index is the conditional marginal share of $i \in S_g^F$, that is, $w_{ig}^F \eta_{ig}^F = \partial(p_i q_i) / \partial M_g^F$, where $M_g^F = \sum_{i \in S_g^F} p_i q_i$ is expenditure on S_g^F .

It is shown in the next section that the conditional demand for S_g^F is

$$(A11.17) \quad d(\log Q_g^F) = \eta_g^F d(\log Q^F) + \phi \eta^F \eta_g^F [d(\log P_g'^F) - d(\log P'^F)].$$

This equation has exactly the same form as that of (A11.5), the demand equation for good i under the assumption that all goods are want-independent. Now with sub-groups want-independent, the substitution involves the relative price of the sub-group, rather than that of an individual good, as in equation (A11.5). It follows from (A11.17) that $\eta'_{gg} = \phi \eta^F \eta_g^F$ is the Frisch own-price elasticity of group g . Additionally, $\phi \eta^F$ is (i) a weighted average of the Frisch own-price elasticities, $\sum_{g=1}^G W_g^F \eta'_{gg}$, which follows from $\sum_{g=1}^G W_g^F \eta_g^F = 1$, where W_g^F is the group budget share; and (ii) the Frisch own-price elasticity of demand for food as a whole [see equation (A11.11)].

Derivations III

Equation (A11.14) refers to the demand for $i \in S^F$:

$$d(\log q_i) = \eta_i^F d(\log Q^F) + \sum_{j \in S^F} \eta'_{ij} [d(\log p_j) - d(\log P'^F)].$$

This has on the right the relative prices of all items of food. But as noted above, when the sub-groups are all want-independent $\eta'_{ij} = 0$, $i \in S_g^F$, $j \in S_h^F$, $g \neq h$. This means that only the prices of food items within the sub-group S_g^F remain. Thus,

$$(A11.18) \quad d(\log q_i) = \eta_i^F d(\log Q^F) + \sum_{j \in S_g^F} \eta'_{ij} \left[d(\log p_j) - d(\log P'^F) \right], \quad i \in S_g^F.$$

We multiply both sides of equation (A11.18) by w_{ig}^F and then sum over $i \in S_g^F$. On the left, we obtain $d(\log Q_g^F)$, the Divisia volume index of S_g^F . The first term on the right is $\eta_g^F d(\log Q^F)$. The weighted sum of the price term is

$$(A11.19) \quad \sum_{i \in S_g^F} w_{ig}^F \sum_{j \in S_g^F} \eta'_{ij} \left[d(\log p_j) - d(\log P'^F) \right]$$

The first term is

$$\begin{aligned} \sum_{i \in S_g^F} w_{ig}^F \sum_{j \in S_g^F} \eta'_{ij} d(\log p_j) &= \sum_{i \in S_g^F} \sum_{j \in S_g^F} w_{jg}^F \eta'_{ji} d(\log p_j) \\ &= \sum_{j \in S_g^F} w_{jg}^F \phi \eta_j d(\log p_j) \\ &= \phi \eta^F \eta_g^F \sum_{j \in S_g^F} w_{jg}^F \eta_{jg}^F d(\log p_j) \\ &= \phi \eta^F \eta_g^F d(\log P_g'^F). \end{aligned}$$

The first step of the above follows from the symmetry relation (A11.8); the second line from (A11.15); and the third from (A11.16) and $\eta_i^F = \eta_i / \eta^F$.

The second term of (A11.19) is

$$\begin{aligned} - \sum_{i \in S_g^F} w_{ig}^F \sum_{j \in S_g^F} \eta'_{ij} d(\log P'^F) &= - \sum_{i \in S_g^F} w_{ig}^F \phi \eta_i d(\log P'^F) \\ &= - \phi \eta^F \sum_{i \in S_g^F} w_{ig}^F \eta_i^F d(\log P'^F) \\ &= - \phi \eta^F \eta_g^F d(\log P'^F). \end{aligned}$$

The first step above is based on (A11.9), while the subsequent ones use the definitions of the income elasticities.

Combining the previous steps, the price term (A11.19) is

$$\sum_{i \in S_g^F} w_{ig}^F \sum_{j \in S_g^F} \eta'_{ij} \left[d(\log p_j) - d(\log P'^F) \right] = \phi \eta^F \eta_g^F \left[d(\log P_g'^F) - d(\log P'^F) \right],$$

so the conditional demand for S_g^F is

$$d(\log Q_g^F) = \eta_g^F d(\log Q^F) + \phi \eta^F \eta_g^F \left[d(\log P_g'^F) - d(\log P'^F) \right],$$

which is equation (A11.17).

A Cross-Group Regression

Write equation (A11.17) as

$$(A11.20) \quad d(\log Q_g^F) = \eta_g^F d(\log Q^F) + \phi^F \eta_g^F [d(\log P_g'^F) - d(\log P'^F)],$$

where $\phi^F = \phi \eta^F$ is the food flexibility. When the income elasticities are known, the parameter ϕ^F can be estimated by regressing $d(\log Q_g^F) - \eta_g^F d(\log Q^F)$ on $\eta_g^F [d(\log P_g'^F) - d(\log P'^F)]$ for $g = 1, \dots, G$ using a weighted least-squares (WLS) approach with W_g^F as weights (Theil, 1967).

The WLS estimator can be obtained by multiplying both sides of equation (A11.20) by $[d(\log P_g'^F) - d(\log P'^F)]$ and then taking the weighted sum over $g = 1, \dots, G$ using the W_g^F as weights. After rearrangements, this yields

$$\hat{\phi}^F = \frac{\Pi'_{P^F, Q^F} - y_{P^F} d(\log Q^F)}{\Pi'_{P^F}},$$

where

$$\Pi'_{P^F, Q^F} = \sum_{g=1}^G W_g^F [d(\log P_g'^F) - d(\log P'^F)] [d(\log Q_g^F) - d(\log Q^F)]$$

is a weighted price-quantity covariance involving the G sub-groups of food; and

$$y_{P^F} = \sum_{g=1}^G W_g^F [\eta_g^F - 1] [d(\log P_g'^F) - d(\log P'^F)]$$

is the price of quality of the groups; and

$$\Pi'_{P^F} = \sum_{g=1}^G W_g^F \eta_g^F [d(\log P_g'^F) - d(\log P'^F)]^2$$

is the variance of the group prices.

Implementation

As many of the 31 ICP food items are quite narrowly defined, it would not be reasonable to suppose that all are want-independent. We thus invoke the weaker assumption of want-independence with respect to the seven broader groups of the food items of table 2, rather than the individual elements. As Frisch (1959, p. 186) put it:

If the goods are specified in all concrete detail (say, margarine with one technical specification as distinguished from margarine with another technical specification), it will hardly ever be realistic to assume want-independence for any of the goods. But if the goods are aggregated in a

reasonable way ... one will in practice get goods about which we can say a priori with considerable confidence that they are want independent.

Group want-independence amounts to the goods within a group being weakly separable from goods outside of the group.

To apply the above concepts to the food groups in the 155 countries, we interpret differentials as “moves” from one country to another, an approach that is similar to that used by Clements and Theil (1979). To ease the notation, we shall now confine attention to food only, so we define w_i^c as the share of food expenditure devoted to i in country c and θ_i^c the corresponding marginal share. The food subgroup g was previously denoted by S_g^F , $g=1,...,G$; this now simply becomes group g , denoted by S_g . There are $g=1,...,7$ food groups that are identified in table 2.

The budget and marginal shares of group g in country c are $W_g^c = \sum_{i \in S_g} w_i^c$ and $\Theta_g^c = \sum_{i \in S_g} \theta_i^c$, with $\theta_i^c = w_i^c \eta_i^c$. For the comparison of country c with country d , as it is desirable to treat both countries symmetrically, we use the averages of the budget and marginal shares in the two countries, $W_g^{cd} = \frac{1}{2}(W_g^c + W_g^d) = \sum_{i \in S_g} w_i^{cd}$ and $\Theta_g^{cd} = \frac{1}{2}(\Theta_g^c + \Theta_g^d) = \sum_{i \in S_g} \theta_i^{cd}$, where $w_i^{cd} = \frac{1}{2}(w_i^c + w_i^d)$ and $\theta_i^{cd} = \frac{1}{2}(\theta_i^c + \theta_i^d)$. For country c as compared to d , define the Divisia price and volume indexes for group g as

$$\log P_g^{cd} = \sum_{i \in S_g} \left(\frac{w_i^{cd}}{W_g^{cd}} \right) \log \left(\frac{p_i^c}{p_i^d} \right), \quad \log Q_g^{cd} = \sum_{i \in S_g} \left(\frac{w_i^{cd}}{W_g^{cd}} \right) \log \left(\frac{q_i^c}{q_i^d} \right),$$

where p_i^c and q_i^c are the price and quantity of i in country c . The corresponding indexes for all goods are

$$\log P^{cd} = \sum_{g=1}^G W_g^{cd} \log P_g^{cd}, \quad \log Q^{cd} = \sum_{g=1}^G W_g^{cd} \log Q_g^{cd}.$$

The Frisch price indexes are

$$\log P_g'^{cd} = \sum_{i \in S_g} \left(\frac{\theta_i^{cd}}{\Theta_g^{cd}} \right) \log \frac{p_i^c}{p_i^d}, \quad \log P'^{cd} = \sum_{g=1}^G \Theta_g^{cd} \log P_g'^{cd}.$$

The “groupwise” price-quantity covariance is

$$\Pi_{P,Q}'^{cd} = \sum_{g=1}^7 W_g^{cd} [\log P_g'^{cd} - \log P'^{cd}] [\log Q_g^{cd} - \log Q^{cd}].$$

The groupwise price of quality and the Frisch price variance are

$$y_P^{cd} = \sum_{g=1}^7 W_g^{cd} (\eta_g^{cd} - 1) (\log P_g'^{cd} - \log P'^{cd}), \quad \Pi_P'^{cd} = \sum_{g=1}^7 \Theta_g^{cd} [\log P_g'^{cd} - \log P'^{cd}]^2.$$

Here, $\eta_g^{cd} = \Theta_g^{cd} / W_g^{cd}$ is the income elasticity of g .

With these definitions, the estimate of the food flexibility for countries c and d is

$$(A11.21) \quad \hat{\phi}_{cd}^F = \frac{\Pi_{P,Q}^{cd} - y_P^{cd} \cdot \log Q^{cd}}{\Pi_P^{cd}}.$$

This estimator has the desirable property that it is invariant to the direction of the “journey” from one country to another; that is, $\hat{\phi}_{cd}^F = \hat{\phi}_{dc}^F$. This property follows from (i) $\Pi_{P,Q}^{cd} = \Pi_{P,Q}^{dc}$; (ii) $y_P^{cd} = -y_P^{dc}$; (iii) $\log Q^{cd} = -\log Q^{dc}$; (iv) $y_P^{cd} \cdot \log Q^{cd} = y_P^{dc} \cdot \log Q^{dc}$; and (v) $\Pi_P^{cd} = \Pi_P^{dc}$. Accordingly, the 155×155 matrix of estimates $\left[\hat{\phi}_{cd}^F \right]$ is symmetric.

As there are 155 countries, equation (A11.21) gives an estimate of the food flexibility ϕ^F for each of the 11,858 distinct country pairs, that is, $\hat{\phi}_{cd}^F$ $c, d = 1, \dots, 155$, $c < d$. Panel A of figure A11.1 gives a histogram of these estimates. As in the quality index section of the article, the results can be compressed into multilateral form by averaging to give one value for each country, $\hat{\phi}_c^F = 1/155 \cdot \sum_{d=1}^{155} \hat{\phi}_{cd}^F$. These estimates are given in table A11.1 and are plotted in panel B of figure A11.1. Panel C of this figure is a histogram of the medians of each row of the matrix $\left[\hat{\phi}_{cd}^F \right]$. In these three cases, the overall mean is about -1.6.

A12. More on Sensitivities

This appendix provides the details underlying the material in the limitations and sensitivities section of the article.

Geography

The United Nations Statistics Division (UNSD, 2016) allocates all countries to regions and sub-regions. We consolidate the sub-regions into five main groups based on the geographical proximity and the similarity in their cultures and diets: (i) Europe, North America and ANZ, which contains all European countries as well as the United States, Canada, Australia and New Zealand; (ii) East/South Asia and the Pacific Islands, which consists of East, South and South-East Asia as well as the Pacific Islands off Australia and New Zealand; (iii) Middle East, North Africa and Central Asia, which includes West Asia (more commonly known as the Middle East) and the portion of Africa north of the Sahara Desert; (iv) Latin America and the Caribbean, which includes Mexico; and (v) Sub-Sahara Africa. The countries in these groups are listed in table A12.1.

The regional budget shares and income statistics are given in Table A12.2. The Europe-N. America-ANZ region has the highest total consumption per capita, whilst Sub-Sahara Africa has the lowest by a large margin. The remaining three regions have fairly similar

consumption per capita, although GDP of Latin America and the Caribbean is noticeably lower than that of the other two.³² On the basis of the conditional budget shares, rice, other cereals and fresh and chilled vegetables and potatoes dominate the diet of the Sub-Sahara region, whilst diets in Europe, North America and ANZ are more diverse. This parallels the consumption patterns of the poorest and richest income quartiles in table 2 of the text.

Tables A12.3 and A12.4 give the food diversity measures when countries are grouped by income and region, respectively. Columns 2-4 of table A12.4 decompose diet diversity using an unweighted average of countries within each group. From column 2, for each of the three types of variances (the budget shares, prices and quantities), the smallest total variance is in Europe/North America/Australia and New Zealand, while the largest is in Sub-Sahara Africa. As the former group contains the richest countries and the latter the poorest, this result agrees in broad terms with the previous findings of the article, that is, when countries were grouped by income quartile, the variances fell as income rose. These results were summarised in table 7 in the form of a comparison of diet diversity of the rich vis-a-vis the poor, a measure we call “diversity inequality”.

A further way to investigate the sensitivity of inequality with respect to countries is to omit certain large ones. Thus, table A12.5 reports the inequality measures when the USA, China, India and Japan are omitted, the countries with the four largest GDPs. These results are to be compared to those of table 7, when all countries are included. Panel A of table A12.5 reveals that when the “big four” are excluded, the effect of weighting is for diet inequality to increase in most cases – it is only when GDP per capita weights are used that inequality decreases (and even then the fall is modest). In all cases, inequality is again higher when the between component of the total variance is used. When countries are grouped by region and the big four continue to be excluded (panel B of table A12.5), the results are the same as those of panel B of table 7. This is because (i) the inequality measure pertains to the ratio of Europe/NA/ANZ to Sub-Sahara Africa, which does not involve China, India nor Japan; and (ii) the USA is excluded from all variance calculations as it is the reference country.

Columns 2-4 of table A12.4 contain the unweighted variances for each region. These are disaggregated into the seven food groups in table A12.6. In a number of instances the bread and cereals group has the highest variance.

There are three basic measures of dispersion – the variance of the budget shares, prices and quantities. These variances are cross-commodity and weighted by the relative size of each commodity. For each of the five regions, figure A12.1 plots the three variances

³² The lower food share of this region only adds to the puzzle.

against income. In each case, a negative relationship between the variance and income is evident, so reduced dispersion comes with higher affluence. This is consistent with the grouping-by-income results of the article, so controlling for regional effects, we continue to observe dispersion falling (or diets becoming more diverse) as income rises.³³ There is also a tendency for there to be more dispersion around the regression line for Sub-Sahara Africa (the poorest region), while there is less dispersion for Europe, N. America and ANZ (the richest).

Quality

Next, we investigate the sensitivities of the quality of consumption regarding which commodities and countries are included. The results, for the unweighted and the weighted cases, are given in table A12.7. In both cases, there is only a modest reduction in the gap between the rich and poor when the five goods in the bread and cereals group are omitted; and an even smaller change when the big four countries are omitted. On this basis, it can be concluded that the results are relatively insensitive to the commodities and countries that are included in the quality index.

Commodities

In moving from a high-income country to a poorer one, it is entirely possible that the nature of some items changes. For example, rice in the US would mostly likely be purchased in packaged form in a supermarket, while in a poor country it may be purchased in a much less elaborate form of package (if at all) in an outside market, possibly in larger amounts also. Thus, even if the physical attributes of the item are the same, in a certain sense, the nature of the commodity differs across countries. Suppose that income differences drive much of the differences in the nature of the individual items of food. Then, one way to control for some of this influence is to restrict the comparison to countries with similar incomes. We previously considered the difference in quality between countries c and d , y_q^{cd} , for all pairs $c, d = 1, \dots, 155$, together with the bilateral index for c , $1/155 \sum_{d=1}^{155} y_q^{cd}$. As countries are ranked according to decreasing income per capita, to compare quality between countries in the first income quartile, we use y_q^{cd} , $c, d = 1, \dots, 39$, and $1/39 \sum_{d=1}^{39} y_q^{cd}$. In table A12.8, we redo table A8.1, but now the multilateral indexes are restricted to countries within the relevant quartile. That is, for countries 1 to 39 which belong to the first quartile, column 2 gives the

³³ Interestingly, while East/South Asia has about the same mean income as the Middle East, its total variances are noticeably larger (see column 2 of table A12.4). This is mostly due to the dominance of rice in Asian diets, but it needs to be kept in mind that there is also more dispersion of incomes in Asia.

multilateral index of consumption $y_q^{c\bullet} = \frac{1}{39} \sum_{d=1}^{39} y_q^{cd}$, where c and d are both restricted to the first quartile and $y_q^{cd} = \sum_{i=1}^{31} w_i^{cd} (\eta_i^{cd} - 1) (\log q_i^{cd} - \log Q^{cd})$ is the bilateral quality index. Similarly, the values for countries numbered 40 to 78 are for comparisons within the second quartile and so on. The indexes for prices and spending are defined analogously. The results here lead to three findings. (i) Within each quartile, the relationship between the quality indexes and income is similar to the all countries case in table A8.1, where both the quantity and spending indexes tend to increase with income, while the price of quality tends to fall with income. The plots of the within-quartile index of the quality of consumption against income, in figure A12.2, confirm this. (ii) Comparing this figure with Panel A of figure 3 (all countries combined), it can be seen that while the coefficient on log income is significantly positive for each quartile, the standard errors are now considerably higher than before. (iii) The responsiveness of quality to income is roughly the same in the first three quartiles with an average elasticity of about 0.3; but this elasticity is considerably smaller in the fourth quartile. This could be interpreted as saying that as long as they stay in the fourth quartile, very poor consumers are more concerned with food for survival than switching to higher-quality items as their income rises. In summary, while these results not as strong as those of the article, they are not contradictory. The more general point is that caution is called for when comparing countries with very different incomes -- the more different are countries, the less reliance can be placed in the measures.

Even when the budget is split into as many as 31 food items, a case can easily be made that this is insufficient, with some commodities still too broadly defined so that some interesting aspects of diet diversity are missed. For example, “beef and veal” encompasses both cheap and prime cuts. As the data we use is the ICP in its most disaggregated form, we are unable to observe quality differences within food items. We shed light on the likely impact of this issue by combining the $n = 31$ goods into new broader ones, such that n falls from 31 to 28, 26, 23 and 21 successively. Table A12.9 recomputes the variances of the budget shares and quantities for various values of n ; the precise details of the aggregations are contained in the notes to the table. In general, the total variance and the within-group component decline as n declines, as expected since the part of the variability is contained in the now larger, new commodities. The corresponding measures of inequality of diet diversity (the ratio of the quantity variance for the poorest countries to that of the richest ones) are contained in table A12.10. These show that (i) inequality based on the total variance and the between-group component both tend to increase as n falls; (ii) the between measure is always larger than its total counterpart; and (iii) for all values of n , the between-total difference for the quantity variance is larger than that for the budget share variance. As mentioned in the

text, data limitations do not allow us to go in the opposite direction and split the commodities to increase n beyond 31 goods. But on the basis of the above results, it is reasonable to conclude that this process would tend to decrease the inequality of diet diversity; and in all probability the between-group measure of inequality would remain larger than that based on the total variance.

Finally, there are two related points to note. The first concerns the identification of high- and low-quality goods on the basis of their income elasticities. For some food items such as rice there is a wide variety of quality, but the ICP data does not reflect this detail as it comprises more aggregated items (rice as a whole, for example). As the data do not permit any finer disaggregation of commodities, we have to settle for a centre-of-gravity measure of the quality spectrum and classify a good on the basis of its overall income elasticity. Such a classification is to be interpreted as reflecting the “average” quality of the good. The implication for the quality gap between poor and rich countries is similar to the above discussion regarding the effects on the inequality of diet diversity of increasing the number of commodities n . That is, on the basis of the argument above that an increase in n would be likely to decrease inequality, as neglecting within-good differences in quality is equivalent to a decrease in n , measured inequality is possibly overstated.

A second related point is the question, does the quality of goods change with income? As we use the income elasticities to identify quality, this amounts to asking if the elasticities change with income? The answer is yes, the elasticities change with income. But it should be acknowledged that while the underlying demand model allows the elasticities to change with income, they cannot change so much that a good can switch from being a luxury to a necessity. This restriction of the flexibility of the income responses is a limitation of our approach.

Other Issues

Food consumed away from home (FAFH) is excluded from the 31 ICP food items.³⁴ This is likely to be an important issue in some countries; in the US, for example, FAFH is more than 40 percent of the food budget in 2014 and is likely to be substantial in other high-income countries as well.³⁵ Suppose FAFH has an above-average income elasticity and its consumption is more important in country c than in country d . Then, according to our measure, it would contribute to higher quality of food consumption in c relative to d . Consequently, excluding FAFH would have the effect of lowering measured quality in

³⁴ FAFH is included in the ICP data as part of the basic heading “Catering services”. This item is not included in our analysis as it is not possible to determine the composition of food types consumed.

³⁵ Of course, much of this expenditure represents the services embodied in FAFH, rather than just the food itself. The source of the US figure is United States Department of Agriculture Economic Research Service (2016).

countries where it is important; and in countries where consumption of FAFH is limited, its exclusion would not have much impact on the quality index. This probably means that quality is understated in high-income countries.

Finally, the use of per capita averages for each country is an appealing way to proceed, but it neglects within-country variation in diet diversity and quality, and so our measures understate the total variability. Nonetheless, there is some reason to believe these measures still account for a sizable part. As diversity and quality are substantially related to income, and as it has been found that the dispersion of income between countries is substantially greater than that within countries, it would seem the same pattern would likely hold for diversity and quality.³⁶

A13. Wellbeing

As nutritionists recommend a balanced diet for good health, it is easy to imagine how the nature of the diet could affect wellbeing and income, as well as being influenced by income. Moreover, similar mechanisms are likely to be at play with the quality of food consumption – higher income leads to a diet of better quality food, with this feeding back into enhanced productivity and income. To demonstrate further the potential usefulness of our measures of diversity and quality, we briefly sketch the essential elements of a theory that links diet diversity, nutrition, income and wellbeing.

The northeast quadrant of figure A13.1 shows a positive relationship between wellbeing and diet diversity for an individual; this reflects the greater nutritional value of a diversified diet, as well as the psychological benefits of eating more satisfying food. Diminishing marginal returns to diversity is reflected in the way the relationship is drawn. When diet diversity increases from d to d' , wellbeing increases from w to w' . This higher wellbeing, in turn, leads to the individual being happier, more productive and earning an enhanced income, which increases to y' from y (as in the northwest quadrant). The two southern quadrants of the figure show how higher income then feeds back into greater

³⁶ As a cautionary note, it needs to be acknowledged that there is considerable debate regarding the nature of global income inequality and the relative importance of within- and between-country components. See the studies cited in Anand and Segal (2008, Sec. 6). Anand and Segal are critical of many of these studies and the interpretation of their methods (the Gini coefficient, the Theil H index and the Theil L index). Anand and Segal argue that most prior studies tend to underestimate the within-country component. Nevertheless, they seem to prefer the Theil L measure (the mean logarithmic deviation) because only it admits a consistent within- and between-country interpretation; see Anand (1983, pp. 198–202). For more recent evidence with the Theil L index, see Chotikapanich et al. (2012, table 7), who find between-country inequality accounts for more than 60 percent of the total; Milanovic (2013), where this share is about two-thirds in the year 2000; and Milanovic (2015, table 3), who reports it to be 70 percent in 2008.

diversity. The value of diversity associated with the higher income is d' , the value consistent with overall equilibrium for the individual.

To investigate the empirical content of the above links, we proxy wellbeing with life expectancy (LE).³⁷ The left graph in panel A of figure A13.2 is a scatter of LE in the 155 countries against the inverse of the food budget share, a measure advocated by Clements and Chen (2010) as an index of “true” income.³⁸ For convenience, the labels on the horizontal axis refer to the percentage food share, rather than its reciprocal. The graph shows that LE rises as the food share falls, that is, as income rises. But there is a diminishing marginal effect of income as LE approaches the vicinity of 80 years. As can be seen, a logistic curve seems to fit the data reasonably well. From the equation in the figure, life expectancy is approximately equal to $\frac{81}{1+\exp\left(\frac{-49}{\text{food share}}\right)}$. This equation implies that for very poor countries, where the food share is about 50 percent, LE is about 59 years, while for the richest, with a food share of about 10 percent, this increases to 80 years, close to the upper asymptote of the logistic of 81 years. Interestingly, this more-than-20-year-life-expectancy gap across countries exceeds that found by Chetty et al (2016). They find the gap between the richest 1 percent of males in the US and the poorest 1 percent for the period 2001 and 2014 to be about 15 years; for females, the gap is 10 years. For comparison, the right graph in the panel of the figure plots LE against the logarithm of per capita GDP. This shows that LE increases with income, as before, but now the logistic seems to provide a less appealing description of the data.

Next, panel B of figure A13.2 plots LE against two measures of diversity. The first is the weighted standard deviation (SD) of the budget shares. As the SD is logarithmic and a higher value means less diet diversity, in the left of the panel, we use the negative of the SD. The graph on the right of panel B contains the second measure of diversity, viz., the negative SD of the logarithmic quantities. It is clear that for the two measures there is a positive association between LE and diet diversity. While there is not a substantial difference visually, the SD of the budget shares (on the left) seems to be somewhat better in explaining LE. If good nutrition leads to higher life expectancy, this result is contrary to the argument in the article that the SD of the quantities -- as opposed to the SD of budget shares -- provides better

³⁷ A recent prominent paper on income and life expectancy is Chetty et al. (2016), which contains extensive references to the literature. Jones and Klenow (2016) use a broader measure of wellbeing, viz., a combination of consumption, leisure, life expectancy and inequality, which they find to be highly correlated with GDP per capita across countries.

³⁸ Life expectancy is for the years 2011 and 2015 and is from the CIA World Factbook (<https://www.cia.gov/library/publications/the-world-factbook/rankorder/2102rank.html>) and the World Bank World Development Indicators (<http://databank.worldbank.org/data/reports.aspx?source=2&series=SP.DYN.LE00.IN&country>). GDP per capita, which is used subsequently, is in PPP terms for 2011; this is from the International Comparisons Program (<http://siteresources.worldbank.org/ICPINT/Resources/270056-1183395201801/2011-International-Comparison-Program-results.xlsx>).

guidance to the nutritional value of a diversified diet. Finally, panel C of the figure is a similar scatter with the index of the quality of consumption replacing diversity. This clearly reveals that LE increases with higher quality, again with diminishing returns to quality.

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Table A1.1 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, photographic and information processing equipment
22.	Fresh or chilled potatoes	84.	Recording media
23.	Frozen, preserved or processed vegetables and vegetable-based products	85.	Repair of audio-visual, photographic and information processing equipment
24.	Sugar	86.	Major durables for outdoor and indoor recreation
25.	Jams, marmalades and honey	87.	Maintenance and repair of other major durables for recreation and 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 materials, other articles of clothing and 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 consumption expenditure of resident households in the rest of the world
48.	Carpets and other floor coverings	110.	Final consumption expenditure of non-resident households in the economic 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 A1.1 ICP Categories (continued)

No.	ICP Category	No.	ICP Category
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.	Fabricated metal products, except machinery and 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 A1.2 Composition of Food Items

Food class	ICP Basic Headings	
	Name	Description
(1)	(2)	(3)
1. <u>BREAD AND CEREALS</u>		
Bread and cereals <i>Includes</i> farinaceous-based products prepared with meat, fish, seafood, cheese, vegetables or fruit.	Rice	Rice in all forms except flour
	Other cereals and flour	Maize, wheat, barley, oats, rye and other cereals in the form of grain, meal or flour; cereal preparations (cornflakes, oat flakes, etc.) and other cereal products (malt, malt flour, malt extract, potato starch, tapioca, sago and other starches); <i>includes</i> couscous; rice flour; <i>excludes</i> sweetcorn.
	Bread	Fresh bread and special bread.
	Other bakery products	Bakery products such as crispbread, rusks, toasted bread, biscuits, gingerbread, wafers, waffles, crumpets, muffins, croissants, cakes, tarts, pies, quiches and pizzas; <i>includes</i> mixes and doughs for the preparation of bakery products; <i>excludes</i> meat pies; fish pies.
	Pasta products	Pasta products in all forms.
2. <u>MEAT AND SEAFOOD</u>		
Meat <i>Includes</i> animals and poultry purchased live for consumption as food.	Beef and veal	Fresh, chilled or frozen meat of bovine animals, <i>excludes</i> edible offal.
	Pork	Fresh, chilled or frozen meat of swine; <i>excludes</i> edible offal.
	Lamb, mutton and goat	Fresh, chilled or frozen meat of sheep and goat; <i>excludes</i> edible offal.
	Poultry	Fresh, chilled or frozen meat or poultry (chicken, duck, goose, turkey, guinea fowl); <i>includes</i> edible poultry offal.
	*Other meats and preparations	Fresh, chilled or frozen meat of hare, rabbit, game (antelope, deer, boar, pheasant, grouse, pigeon, quail, etc.), marine mammals (seal, walrus, whale, etc.), horse, mule, donkey, camel, ostrich, kangaroo, alligator, etc.; fresh, chilled or frozen edible offal; <i>excludes</i> edible poultry offal. Dried, salted or smoked meat and edible offal (sausages, salami, bacon, ham, pâté, etc.); other preserved or processed meat and meat-based preparations (canned meat, meat extracts, meat juices, meat pies, etc.); <i>excludes</i> frogs, land and sea snails; lard and other edible animal fats; soups, broths and stocks containing meat.

(continued on next page)

Table A1.2 Composition of Food Items (continued)

Food class (1)	ICP Basic Headings	
	Name (2)	Description (3)
Seafood	Fresh or frozen fish and seafood	Fresh, chilled or frozen fish and seafood (crustaceans, molluscs and other shellfish, sea snails); <i>includes</i> land crabs, land snails and frogs; fish and seafood purchased live for consumption as food.
	Preserved fish and seafood	Dried, smoked or salted fish and seafood; other preserved or processed fish and seafood and fish and seafood based preparations (canned fish and seafood, caviar and other hard roes, fish pies, etc.); <i>excludes</i> soups, broths and stocks containing fish or seafood.
3. <u>DAIRY</u>		
Milk, cheese and eggs <i>Includes</i> non-dairy milk substitutes such as soya milk; <i>excludes</i> butter and butter products.	Fresh milk	Raw milk; pasteurised or sterilised milk; <i>includes</i> whole and low fat milk; recombined or reconstituted milk; soya milk.
	Preserved milk and milk products	Condensed, evaporated or powdered milk; yoghurt, cream, milk-based desserts, milk-based beverages and other similar milk-based products; <i>includes</i> milk, cream and yoghurt containing sugar, cocoa, fruit or flavourings.
	Cheese	Cheese and curd.
	Eggs and egg-based products	Eggs and egg products made wholly from eggs.
Oils and fats	*Butter and margarine	Butter and butter products (butter, oil, ghee, etc.). Margarine; <i>includes</i> “diet” margarine.
	Other edible oils and fats	Edible oils (olive oil, corn oil, sunflower-seed oil, cotton-seed oil, soybean oil, groundnut oil, walnut oil, etc.); edible animal fats (lard, etc.); edible vegetable fats (peanut butter, etc.); <i>excludes</i> cod or halibut liver oil
4. <u>FRUIT AND VEGETABLES</u>		
Fruit	Fresh or chilled fruit	Fresh or chilled fruit; <i>includes</i> melons and water melons; <i>excludes</i> vegetables grown for their fruit such as aubergines, cucumbers and tomatoes.
	Frozen, preserved or processed fruits	Frozen fruit; dried fruit, fruit peel, fruit kernels, nuts and edible seeds; other preserved fruit; processed fruit; fruit-based products; <i>excludes</i> jams, marmalades, compotes, jellies, fruit purees and pastes; parts of plants preserved in sugar; fruit juices.

(continued on next page)

Table A1.2 Composition of Food Items (continued)

Food class	ICP Basic Headings	
	Name	Description
(1)	(2)	(3)
Vegetables	Fresh or chilled vegetables	Fresh or chilled vegetables cultivated for their leaves or stalks (asparagus, broccoli, cauliflower, endives, fennel, spinach, etc.), for their fruit (aubergines, cucumbers, courgettes, green peppers, pumpkins, tomatoes, etc.), and for their roots (beetroot, carrots, onions, parsnips, radishes, turnips, etc.); <i>includes</i> olives; garlic; pulses; sweetcorn; sea fennel and other edible seaweed; mushrooms and other edible fungi; <i>excludes</i> lentils; culinary herbs (parsley, rosemary, thyme, etc.) and spices (pepper, pimento, ginger, etc.).
	Fresh or chilled potatoes	Fresh or chilled potatoes; <i>includes</i> other tuber vegetables (manioc, arrowroot, cassava, sweet potatoes, etc.).
	Frozen or preserved vegetables	Frozen vegetables; dried vegetables; other preserved vegetables; processed vegetables; vegetable-based products; <i>includes</i> frozen preparations such as chipped potatoes; lentils; products of potatoes and other tuber vegetables such as flours, meals, flakes, purees, chips, crisps, etc.; <i>excludes</i> potato starch, tapioca, sago and other starches; soups, broths and stocks containing vegetables; vegetable juices.
5. SWEET THINGS		
Sugar, jam, honey, chocolate and confectionery	Sugar	Cane or beet sugar, unrefined or refined, powdered, crystallised or in lumps; <i>includes</i> artificial sugar substitutes.
	Jams, marmalades and honey	Jams, marmalades, compotes, jellies, fruit purees and pastes, natural and artificial honey, maple syrup, molasses and parts of plants preserved in sugar.
	*Confectionery, chocolate and ice cream	Chocolate in bars and slabs, chewing gum, sweets, toffees, pastilles and other confectionery products; cocoa-based foods and cocoa-based dessert preparations; <i>excludes</i> cocoa and chocolate-based powder. Edible ice, ice cream and sorbet.
6. OTHER FOODS		
Food products n.e.c.	Food products n.e.c.	Salt, spices (pepper, pimento, ginger, etc.), culinary herbs (parsley, rosemary, thyme, etc.), sauces, condiments, seasonings (mustard, mayonnaise, ketchup, soy sauce, etc.), vinegar; prepared baking powders, baker's yeast, dessert preparations, soups, broths, stocks, culinary ingredients, etc.; homogenised baby food and dietary preparations irrespective of the composition; <i>excludes</i> soya milk; milk-based desserts; artificial sugar substitutes; cocoa-based dessert preparations.

(continued on next page)

Table A1.2 Composition of Food Items (continued)

Food class	ICP Basic Headings	
	Name	Description
(1)	(2)	(3)
Coffee, tea and cocoa	Coffee, tea and cocoa	Coffee, whether or not decaffeinated, roasted or ground; tea, maté and other plant products for infusions; cocoa, whether or not sweetened, and chocolate-based powder; <i>includes</i> instant coffee; coffee substitutes; extracts and essences of coffee; tea substitutes; extracts and essences of tea; cocoa-based beverage preparations; <i>excludes</i> chocolate in bars or slabs; cocoa-based foods and cocoa-based dessert preparations.
Mineral waters, soft drinks, fruit and vegetable juices	*Mineral waters, soft drinks, fruit and vegetable juices	Mineral or spring waters; all drinking water sold in containers. Soft drinks such as sodas, lemonades and colas; syrups and concentrates for the preparation of beverages; <i>excludes</i> non-alcoholic beverages which are generally alcoholic such as non-alcoholic beer. Fruit and vegetable juices.
7. <u>ALCOHOL</u>		
Spirits	Spirits	Eaux-de-vie, liqueurs and other spirits; <i>includes</i> mead; aperitifs and other wine-based aperitifs
Food products n.e.c.	Wine	Wine, cider and perry, including sake; champagne and other sparkling wines; fortified wines and wine-based aperitifs
Coffee, tea and cocoa	Beer	All kinds of beer, such as ale, lager and porter; <i>includes</i> non-alcoholic beer; shandy

Note: The ICP Basic Headings are based on OECD Basic Headings. As some were considered too detailed by the ICP, they were combined as denoted by “*”. Basic headings are reported as they appear in the confidential spreadsheet supplied by the World Bank and refer to consumption expenditure by households on food and non-alcoholic beverages. The food products and alcoholic beverages considered here are those purchased for consumption at home. The data exclude food products sold for immediate consumption away from the home by hotels, restaurants, cafés, bars, kiosks, street vendors, automatic vending machines, etc.; cooked dishes prepared by restaurants for consumption off their premises; cooked dishes prepared by catering contractors whether collected by the customer or delivered to the customer’s home; and products sold specifically as pet foods. The seven panels represent the seven food groups as defined in this paper.

Source: World Bank (2003).

Table A1.3 Instances of Low Consumption

ICP Category		Cut-off (per capita real expenditure)							
		A. Original data				B. Pork and Lamb combined			
		= \$0	≤ \$0.01	≤ \$0.1	≤ \$1	= \$0	≤ \$0.01	≤ \$0.1	≤ \$1
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1.	1101111 Rice	0	0	0	1	0	0	0	1
2.	1101112 Other cereals and flour	0	0	1	4	0	0	1	4
3.	1101113 Bread	0	0	0	1	0	0	0	1
4.	1101114 Other bakery products	0	0	1	9	0	0	1	9
5.	1101115 Pasta products	0	1	5	21	0	1	5	21
6.	1101121 Beef and veal	0	0	0	3	0	0	0	3
7.	1101122 Pork	6	12	13	22	1	1	1	3
8.	1101123 Lamb, mutton and goat	3	3	5	20				
9.	1101124 Poultry	0	0	0	8	0	0	0	8
10.	1101125 Other meats and preparations	0	0	2	15	0	0	2	15
11.	1101131 Fresh/frozen fish and seafood	0	1	1	4	0	1	1	4
12.	1101132 Preserved fish and seafood	0	1	3	13	0	1	3	13
13.	1101141 Fresh milk	0	1	6	20	0	1	6	20
14.	1101142 Preserved milk and milk products	0	0	1	7	0	0	1	7
15.	1101143 Cheese	0	3	14	41	0	3	14	41
16.	1101144 Eggs and egg-based products	0	0	4	20	0	0	4	20
17.	1101151 Butter and margarine	1	2	6	20	1	2	6	20
18.	1101161 Fresh or chilled fruit	0	1	1	4	0	1	1	4
19.	1101162 Frozen, preserved or processed fruits	0	0	0	1	0	0	0	1
20.	1101171 Fresh or chilled vegetables	1	4	8	35	1	4	8	35
21.	1101172 Fresh or chilled potatoes	0	0	0	0	0	0	0	0
22.	1101173 Frozen or preserved vegetables	0	1	1	4	0	1	1	4
23.	1101181 Sugar	1	1	5	16	1	1	5	16
24.	1101182 Jams, marmalades and honey	0	0	0	1	0	0	0	1
25.	1101183 Confectionery, chocolate and ice cream	0	3	14	51	0	3	14	51
26.	1101153 Other edible oils and fats	0	2	4	22	0	2	4	22
27.	110119 Food products n.e.c.	0	0	0	3	0	0	0	3
28.	110121 Coffee, tea and cocoa	0	0	0	12	0	0	0	12
29.	110122 Min. waters, sft drinks, fruit & veg. juices	0	0	0	5	0	0	0	5
30.	1102111 Spirits	5	5	11	24	5	5	11	24
31.	1102121 Wine	6	8	14	37	6	8	14	37
32.	1102131 Beer	5	5	5	13	5	5	5	13
Countries affected		18	34	57	111	11	22	49	103

Note: Entries indicate the number of instances where a low reading occurs. The last row is the number of countries affected.

Table A3.1 Decomposition of Price-Quantity Covariances

Income quartile	Total covariance	Components		Group term						
		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	-10.56	-4.09	-6.47	39.03	-4.31	-8.00	-5.24	-5.71	-4.26	-2.90
2	-15.47	-5.85	-9.62	43.14	-20.92	-5.13	-4.39	-12.93	-12.02	-4.29
3	-23.61	-9.47	-14.14	49.44	-26.09	-14.98	-4.73	-16.35	-15.16	-2.46
4	-37.71	-19.32	-18.39	68.02	-21.82	-28.54	-4.03	-19.94	-5.00	-0.63
All	-21.88	-9.68	-12.19	50.11	-18.38	-14.16	-4.63	-13.78	-9.19	-2.60

Note: All entries are $\times 100$. See notes to table 4 of the article for calculation details.

Table A4.1 Who Eats What Bread and Cereals?

Characteristic	Type of country			
	Rice eaters	Other cereal eaters	Bread eaters	Diversified
(1)	(2)	(3)	(4)	(5)
Number of countries	37	38	63	17
Income (\$ p. c.)	6,463	4,888	15,547	22,487
SD of income (% of income)	103.96	87.35	58.50	39.61
Budget shares (%)				
Rice	54.42	17.11	10.41	6.70
Other cereals	14.38	51.68	15.56	14.35
Bread	15.97	17.04	46.09	27.71
Other bakery products	8.99	9.07	21.08	41.55
Pasta products	6.24	5.11	6.86	9.69
Bread and cereals group	22.79	24.17	15.63	14.09

Note: A country is a rice eater if its expenditure on rice is the largest within the bread and cereals group. The same rule applies for other cereals and bread eaters, while a country is classified as diversified if it does not belong to any of the other three groups. The budget shares for rice, cereals, bread, other bakery and pasta are shares within bread and cereals. The “bread and cereals share” (in the last row) is the budget share within food. Shares are averaged over countries and are $\times 100$.

Table A4.2 Income and Bread and Cereals Consumption (Number of countries)

Income quartile	Type of country				Total
	Rice eaters	Cereal eater	Bread eaters	Diversified	
A. <u>Observed</u>					
First	3	0	24	12	39
Second	7	6	22	4	39
Third	10	14	14	1	39
Fourth	17	18	3	0	38
Total	37	38	63	17	155
B. <u>Expected</u>					
First	9.31	9.56	15.85	4.28	39
Second	9.31	9.56	15.85	4.28	39
Third	9.31	9.56	15.85	4.28	39
Fourth	9.07	9.32	15.45	4.17	38
Total	37	38	63	17	155

Note: Panel A gives the number of countries in each income/consumption category. Panel B gives the expected number under independence.

Table A5.1 A Demand System for Food and Non-food

$$w_{ic} = \alpha_i + \beta_i \log Q_c + \delta_i \log \frac{P_{ic}}{P_c^*} + \varepsilon_{ic}, i = 1, \dots, 32 \text{ goods}; c = 1, \dots, 155 \text{ countries}$$

Item	Intercept $\alpha_i \times 100$	Income coefficient $\beta_i \times 100$	Price coefficient $\delta_i \times 100$	Normalised price coefficient $\gamma_i = \delta_i / \sum_{j=1}^{32} \delta_j \times 100$
(1)	(2)	(3)	(4)	(5)
<i>Food</i>				
1. Rice	15.19 (1.53)	-1.60 (0.17)	-1.43 (0.10)	16.51 (0.14)
2. Other cereals and flour	20.92 (1.62)	-2.12 (0.18)	-1.54 (0.10)	17.80 (0.17)
3. Bread	3.52 (0.70)	-0.27 (0.08)	-0.36 (0.03)	4.15 (0.13)
4. Other bakery products	0.22 (0.22)	0.04 (0.02)	-0.06 (0.02)	0.71 (0.21)
5. Pasta products	1.32 (0.19)	-0.12 (0.02)	-0.27 (0.02)	3.11 (0.16)
6. Beef and veal	7.08 (0.71)	-0.66 (0.08)	0.01 (0.01)	-0.12 (0.16)
7. Pork, Lamb, mutton and goat	3.72 (0.57)	-0.32 (0.06)	-0.26 (0.02)	2.95 (0.14)
8. Poultry	2.95 (0.49)	-0.21 (0.06)	-0.61 (0.04)	7.06 (0.17)
9. Other meats and preparations	0.82 (0.57)	0.02 (0.06)	0.07 (0.02)	-0.83 (0.18)
10. Fresh or frozen fish and seafood	3.53 (0.82)	-0.35 (0.09)	-1.02 (0.07)	11.79 (0.13)
11. Preserved fish and seafood	3.95 (0.51)	-0.39 (0.06)	-0.28 (0.02)	3.21 (0.17)
12. Fresh milk	3.03 (0.50)	-0.26 (0.06)	-0.48 (0.03)	5.60 (0.16)
13. Preserved milk and milk products	1.81 (0.38)	-0.11 (0.04)	-0.72 (0.05)	8.33 (0.20)
14. Cheese	-0.06 (0.35)	0.06 (0.04)	-0.34 (0.03)	3.97 (0.19)
15. Eggs and egg-based products	1.37 (0.27)	-0.10 (0.03)	-0.21 (0.02)	2.43 (0.14)
16. Butter and margarine	1.64 (0.31)	-0.16 (0.03)	-0.20 (0.02)	2.28 (0.15)
17. Other edible oils and fats	6.22 (0.40)	-0.60 (0.04)	-0.06 (0.02)	0.70 (0.20)
18. Fresh or chilled fruit	2.07 (0.53)	-0.13 (0.06)	-0.71 (0.05)	8.20 (0.18)
19. Frozen, preserved or processed fruits	1.21 (0.17)	-0.11 (0.02)	-0.21 (0.02)	2.38 (0.18)
20. Fresh or chilled vegetables	6.75 (0.72)	-0.60 (0.08)	-0.98 (0.07)	11.32 (0.19)
21. Fresh or chilled potatoes	6.89 (1.05)	-0.69 (0.12)	-1.03 (0.07)	11.86 (0.12)
22. Frozen or preserved vegetables	3.17 (0.53)	-0.29 (0.06)	-0.16 (0.03)	1.82 (0.28)
23. Sugar	4.30 (0.31)	-0.41 (0.03)	-0.03 (0.01)	0.30 (0.12)
24. Jams, marmalades and honey	0.20 (0.09)	-0.01 (0.01)	-0.07 (0.01)	0.79 (0.13)
25. Confectionery, chocolate and ice cream	-0.36 (0.24)	0.09 (0.03)	-0.23 (0.02)	2.60 (0.16)
26. Food products n.e.c.	5.99 (0.74)	-0.53 (0.08)	-0.02 (0.02)	0.23 (0.25)
27. Coffee, tea and cocoa	1.13 (0.22)	-0.08 (0.02)	-0.01 (0.01)	0.17 (0.17)
28. Min. waters, sft drnks, frit & veg. juices	1.84 (0.45)	-0.08 (0.05)	-0.40 (0.03)	4.57 (0.21)
29. Spirits	0.22 (0.35)	0.03 (0.04)	-0.27 (0.02)	3.17 (0.12)
30. Wine	0.35 (0.20)	0.00 (0.02)	-0.26 (0.02)	3.02 (0.10)
31. Beer	2.72 (0.54)	-0.21 (0.06)	-0.15 (0.02)	1.69 (0.13)
<i>Non-food</i>	-13.72 (4.26)	10.17 (0.47)	3.61 (0.24)	-41.76 (0.00)
Sum	100	0	-8.66 (0.58)	0

Note: Standard errors are in parentheses.

Table A5.2 Income Elasticities of Demand

Food item (1)	Income quartile				
	First (2)	Second (3)	Third (4)	Fourth (5)	All (6)
<i>Food</i>					
1. Rice	-9.010	-1.739	0.031	0.704	0.170
2. Other cereals and flour	-9.110	-2.960	-0.296	0.635	-0.049
3. Bread	0.549	0.779	0.842	0.841	0.793
4. Other bakery products	1.073	1.056	1.054	1.083	1.064
5. Pasta products	0.134	0.519	0.651	0.770	0.615
6. Beef and veal	-0.654	0.126	0.562	0.716	0.467
7. Pork, Lamb, mutton and goat	0.272	0.643	0.700	0.809	0.685
8. Poultry	0.503	0.838	0.874	0.835	0.820
9. Other meats and preparations	1.021	1.012	1.017	1.019	1.017
10. Fresh or frozen fish and seafood	0.248	0.535	0.758	0.836	0.707
11. Preserved fish and seafood	-0.503	-0.165	-0.019	0.744	0.370
12. Fresh milk	0.114	0.528	0.711	0.755	0.628
13. Preserved milk and milk products	0.721	0.894	0.911	0.872	0.876
14. Cheese	1.156	1.095	1.084	1.309	1.124
15. Eggs and egg-based products	0.033	0.722	0.848	0.809	0.756
16. Butter and margarine	-0.320	0.430	0.598	0.742	0.547
17. Fresh or chilled fruit	-2.853	-0.066	0.400	0.690	0.338
18. Frozen/ preserved/processed fruits	0.803	0.888	0.918	0.920	0.897
19. Fresh or chilled vegetables	0.197	0.472	0.515	0.759	0.570
20. Fresh or chilled potatoes	0.008	0.606	0.781	0.809	0.699
21. Frozen or preserved vegetables	-3.839	-0.482	0.159	0.765	0.361
22. Sugar	-0.128	0.342	0.566	0.716	0.512
23. Jams, marmalades and honey	-6.303	0.014	0.458	0.696	0.360
24. Confec., chocolate and ice cream	0.870	0.936	0.958	0.931	0.935
25. Other edible oils and fats	1.172	1.160	1.155	1.266	1.179
26. Food products n.e.c.	0.200	0.375	0.658	0.757	0.594
27. Coffee, tea and cocoa	0.687	0.851	0.858	0.844	0.828
28. Min. wtrs, sft drnks, f. & veg. juice	0.888	0.935	0.941	0.929	0.928
29. Spirits	1.104	1.037	1.053	1.069	1.057
30. Wine	1.011	1.011	1.016	1.013	1.012
31. Beer	0.483	0.752	0.809	0.815	0.759
<i>Non-food</i>	1.114	1.130	1.148	1.187	1.140

Table A5.3 Food Budget Shares and Income Elasticities

Source (1)	Income quartile				
	First (2)	Second (3)	Third (4)	Fourth (5)	All (6)
A. <u>Budget share</u> $W_F \times 100$					
Table 2	11	22	31	46	27
Gao (2012)	11	21	35	46	28
B. <u>Income elasticity</u> N_F					
Implied by table A5.2	0.09	0.53	0.68	0.78	0.68
Gao (2012)	0.31	0.53	0.74	0.90	0.62

Source: Gao (2012, table 7), who uses the 2005 ICP data (World Bank, 2008).

Table A5.4 Modified Income Elasticities

Food item (1)	Income quartile				
	First (2)	Second (3)	Third (4)	Fourth (5)	All (6)
<i>Food</i>					
1. Rice	0.095	0.097	0.031	0.704	0.170
2. Other cereals and flour	0.095	0.097	0.099	0.635	0.100
3. Bread	0.521	0.755	0.836	0.841	0.791
4. Other bakery products	1.019	1.023	1.047	1.083	1.061
5. Pasta products	0.127	0.503	0.647	0.770	0.614
6. Beef and veal	0.095	0.122	0.558	0.716	0.466
7. Pork, Lamb, mutton and goat	0.258	0.624	0.695	0.809	0.683
8. Poultry	0.477	0.813	0.868	0.835	0.817
9. Other meats and preparations	0.970	0.981	1.010	1.019	1.014
10. Fresh or frozen fish and seafood	0.236	0.518	0.753	0.836	0.705
11. Preserved fish and seafood	0.095	0.097	0.099	0.744	0.369
12. Fresh milk	0.108	0.512	0.706	0.755	0.626
13. Preserved milk and milk products	0.685	0.867	0.905	0.872	0.873
14. Cheese	1.097	1.062	1.076	1.309	1.121
15. Eggs and egg-based products	0.031	0.700	0.842	0.809	0.754
16. Butter and margarine	0.095	0.416	0.594	0.742	0.545
17. Other edible oils and fats	0.095	0.097	0.397	0.690	0.337
18. Fresh or chilled fruit	0.763	0.861	0.912	0.920	0.894
19. Frozen/ preserved/processed fruits	0.187	0.457	0.512	0.759	0.569
20. Fresh or chilled vegetables	0.008	0.587	0.776	0.809	0.697
21. Fresh or chilled potatoes	0.095	0.097	0.158	0.765	0.360
22. Frozen or preserved vegetables	0.095	0.332	0.562	0.716	0.511
23. Sugar	0.095	0.013	0.455	0.696	0.358
24. Jams, marmalades and honey	0.826	0.907	0.951	0.931	0.932
25. Confec., chocolate and ice cream	1.113	1.124	1.147	1.266	1.176
26. Food products n.e.c.	0.190	0.363	0.654	0.757	0.592
27. Coffee, tea and cocoa	0.652	0.824	0.852	0.844	0.826
28. Min. wtrs, sft drnks, f. & veg. juice	0.843	0.906	0.935	0.929	0.925
29. Spirits	1.048	1.006	1.045	1.069	1.054
30. Wine	0.960	0.980	1.009	1.013	1.009
31. Beer	0.458	0.729	0.803	0.815	0.756
All Food	0.535	0.657	0.695	0.779	0.684
<i>Non-food</i>					
	1.058	1.095	1.140	1.187	1.136

Table A5.5 Conditional Budget Shares and Income Elasticities of Food

Food item (1)	Income quartile							
	First		Second		Third		Fourth	
	Budget share (2)	Income elasticity (3)	Budget share (4)	Income elasticity (5)	Budget share (6)	Income elasticity (7)	Budget share (8)	Income elasticity (9)
1. Rice	1.42	0.18	2.50	0.15	5.09	0.04	11.64	0.90
2. Other cereals and flour	1.91	0.18	2.52	0.15	5.14	0.14	12.06	0.82
3. Bread	5.42	0.99	5.65	1.16	5.19	1.21	3.70	1.08
4. Other bakery products	4.35	1.94	3.01	1.57	2.23	1.52	0.95	1.39
5. Pasta products	1.17	0.24	1.13	0.77	1.11	0.94	1.12	0.99
6. Beef and veal	3.55	0.18	3.47	0.19	4.73	0.81	4.96	0.92
7. Pork, lamb, mutton and goat	3.90	0.49	4.07	0.96	3.56	1.01	3.73	1.04
8. Poultry	3.75	0.91	5.99	1.25	5.33	1.26	2.74	1.07
9. Other meats and preparations	6.72	1.85	5.72	1.51	3.01	1.47	1.76	1.31
10. Fresh or frozen fish and seafood	4.13	0.45	3.66	0.80	4.58	1.09	4.54	1.07
11. Preserved fish and seafood	2.32	0.18	1.60	0.15	1.21	0.14	3.37	0.96
12. Fresh milk	2.59	0.21	2.54	0.79	2.86	1.02	2.42	0.97
13. Preserved milk and milk products	3.61	1.30	4.86	1.33	4.06	1.31	2.04	1.12
14. Cheese	3.60	2.09	2.96	1.63	2.37	1.56	0.46	1.68
15. Eggs and egg-based products	0.98	0.06	1.71	1.08	2.11	1.22	1.23	1.04
16. Butter and margarine	1.05	0.18	1.27	0.64	1.21	0.86	1.29	0.95
17. Other edible oils and fats	1.32	0.18	2.54	0.15	3.15	0.58	4.19	0.89
18. Fresh or chilled fruit	5.90	1.45	5.30	1.32	5.24	1.32	3.77	1.18
19. Frozen, preserved or processed fruits	1.23	0.36	0.99	0.70	0.71	0.74	0.97	0.98
20. Fresh or chilled vegetables	5.47	0.01	6.83	0.90	8.59	1.13	7.28	1.04
21. Fresh or chilled potatoes	1.27	0.18	1.97	0.15	2.51	0.23	6.43	0.98
22. Frozen or preserved vegetables	2.38	0.18	2.16	0.51	2.08	0.82	2.11	0.92
23. Sugar	5.90	1.45	5.30	1.32	5.24	1.32	3.77	1.18
24. Jams, marmalades and honey	1.23	0.36	0.99	0.70	0.71	0.74	0.97	0.98
25. Confectionery, chocolate and ice cream	5.47	0.01	6.83	0.90	8.59	1.13	7.28	1.04
26. Food products n.e.c.	6.19	0.36	4.06	0.56	5.45	0.95	4.91	0.97
27. Coffee, tea and cocoa	2.26	1.24	2.31	1.27	1.68	1.24	1.11	1.08
28. Min. water, soft drink, fruit & veg juice	7.06	1.60	6.41	1.39	4.93	1.36	2.82	1.19
29. Spirits	2.58	2.00	3.52	1.55	1.81	1.52	0.96	1.37
30. Wine	3.98	1.83	2.08	1.51	1.01	1.46	0.79	1.30
31. Beer	3.92	0.87	3.99	1.12	4.14	1.17	2.60	1.05

Note: For food item i , the conditional budget share is the proportion of total food expenditure devoted to i . These shares are averaged over countries and are $\times 100$. The conditional income elasticity is conditional on total food expenditure and is defined as η_i/η_g , where $\eta_i = \partial \log q_i / \partial \log M$ is the conventional income elasticity and $\eta_g = \sum_{i \in S_g} w'_i \eta_i$ is the income elasticity of demand for the food group S_g , with w'_i the conditional budget share of $i \in S_g$. The elasticities are averaged over countries. For details, see Appendices A5-A7.

Table A6.1 Previous Income Elasticities of Rice

Country (1)	Income elasticity (2)	Year (3)	Source (4)	Assigned income quartile (5)
Vietnam	0.761	2004	Cahn (2008)	Q4
Brazil	0.838	2003	Coelho et al. (2010)	Q3
Bhutan	0.330	2007	Minten and Dukpa (2010)	Q4
Africa, Other	0.100	2008	FAPRI (2008)	n/a
Argentina	0.110	2008	FAPRI (2008)	n/a
Australia	0.430	2008	FAPRI (2008)	Q1
Bangladesh	-0.040	2008	FAPRI (2008)	n/a
Brazil	-0.050	2008	FAPRI (2008)	Q2
Canada	0.470	2008	FAPRI (2008)	Q1
China	-0.070	2008	FAPRI (2008)	Q4
Egypt	0.300	2008	FAPRI (2008)	n/a
European Union	0.380	2008	FAPRI (2008)	n/a
Hong Kong	-0.190	2008	FAPRI (2008)	n/a
India	-0.040	2008	FAPRI (2008)	Q4
Indonesia	-0.120	2008	FAPRI (2008)	Q3
Iran	0.200	2008	FAPRI (2008)	n/a
Iraq	0.140	2008	FAPRI (2008)	Q3
Ivory Coast	0.140	2008	FAPRI (2008)	n/a
Japan	-0.260	2008	FAPRI (2008)	Q1
Malaysia	0.090	2008	FAPRI (2008)	Q2
Mexico	0.460	2008	FAPRI (2008)	Q2
Myanmar	0.130	2008	FAPRI (2008)	n/a
Nigeria	0.250	2008	FAPRI (2008)	Q4
Pakistan	0.100	2008	FAPRI (2008)	n/a
Philippines	0.150	2008	FAPRI (2008)	Q3
Saudi Arabia	0.100	2008	FAPRI (2008)	n/a
South Africa	0.470	2008	FAPRI (2008)	Q3
South Korea	-0.270	2008	FAPRI (2008)	Q1
Taiwan	-0.030	2008	FAPRI (2008)	n/a
Thailand	-0.160	2008	FAPRI (2008)	Q3
Turkey	0.400	2008	FAPRI (2008)	Q2
United States	0.340	2008	FAPRI (2008)	Q1
Uruguay	0.500	2008	FAPRI (2008)	Q2
Vietnam	-0.230	2008	FAPRI (2008)	Q4
Bangladesh	-0.016	1984	Ito et al. (1989)	n/a
Burma	0.028	1984	Ito et al. (1989)	n/a
China	0.133	1984	Ito et al. (1989)	n/a
India	0.125	1984	Ito et al. (1989)	Q4
Indonesia	0.108	1984	Ito et al. (1989)	Q4
Japan	-0.708	1984	Ito et al. (1989)	Q1
Malaysia	-0.671	1984	Ito et al. (1989)	Q3
Nepal	-0.346	1984	Ito et al. (1989)	Q4
Philippines	0.121	1984	Ito et al. (1989)	Q4
Singapore	-0.599	1984	Ito et al. (1989)	Q2
South Korea	0.046	1984	Ito et al. (1989)	Q3
Sri Lanka	0.032	1984	Ito et al. (1989)	Q4
Taiwan	-0.594	1984	Ito et al. (1989)	n/a
Thailand	-0.431	1984	Ito et al. (1989)	Q4
Argentina	0.106	2000	Lema et al. (2007)	n/a
Bolivia	0.074	2000	Lema et al. (2007)	Q4
Paraguay	0.067	2000	Lema et al. (2007)	Q3
Indonesia	0.450	1978	Tyers and Rachman (1982)	Q4
Australia	1.196	2002	Ulubasoglu et al. (2011)	Q1
China	0.370	1990	Wu et al. (1995)	Q4

Note: On the basis of correspondence with Karen Kovarik from FAPRI, the FAPRI estimates are taken to refer to the year 2008. The term “n/a” in column 5 indicates insufficient data from the WDI to assign the country to an income group.

Table A6.2 Summary of Previous Income Elasticities of Rice

Measure	Income quartile					Not cross classified by income
	First	Second	Third	Fourth	All	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Mean	0.171	0.134	0.084	0.100	0.115	0.097
Median	0.340	0.245	0.067	0.108	0.108	0.103
SD	0.584	0.384	0.394	0.300	0.405	0.355
Min	-0.708	-0.599	-0.671	-0.431	-0.708	-0.708
Max	1.196	0.500	0.838	0.761	1.196	1.196
No. of estimates	7	6	9	15	37	54

Table A7.1 Comparison of Income Elasticities of Food Groups

Commodity (1)	I. Current study Income quartile					II. Muhammad et al. (2011) Income group		
	First (2)	Second (3)	Third (4)	Fourth (5)	All (6)	High (7)	Middle (8)	Low (9)
A. <u>Income elasticities</u>								
1. Cereals	0.560	0.486	0.428	0.683	0.459	0.019	0.253	0.514
2. Meat	0.724	0.855	0.916	0.895	0.890	0.490	0.649	0.771
3. Fish	0.278	0.332	0.653	0.820	0.640	0.379	0.521	0.654
4. Dairy	0.665	0.854	0.899	0.891	0.880	0.506	0.671	0.798
5. Oils & Fats	0.085	0.209	0.659	0.758	0.528	0.097	0.297	0.531
6. Fruits & Vegetables	0.436	0.548	0.760	0.820	0.696	0.319	0.462	0.615
7. Other Food	0.665	0.749	0.909	1.030	0.870	0.636	0.882	1.420
8. Beverages & Tobacco	1.077	1.318	1.138	0.916	1.149	0.613	0.839	1.325
B. <u>Budget shares (×100)</u>								
1. Cereals	1.60	3.24	6.01	13.86	6.13	2.82	4.21	12.28
2. Meat	1.99	4.22	5.14	6.07	4.34	3.10	4.61	7.37
3. Fish	0.73	1.09	1.84	3.67	1.82	0.85	1.44	2.94
4. Dairy	1.21	2.65	3.61	2.70	2.54	1.82	2.62	4.03
5. Oils & Fats	0.27	0.83	1.38	2.53	1.25	0.44	0.84	2.36
6. Fruits & Vegetables	1.80	3.79	6.04	9.20	5.18	2.38	4.25	9.56
7. Other Food	1.31	1.97	3.09	4.00	2.58	6.70	8.18	6.07
8. Beverages & Tobacco	2.12	3.91	3.96	3.63	3.41	4.63	5.83	4.79
C. <u>Weighted income elasticities (×100)</u>								
1. Cereals	0.870	1.871	2.714	9.910	3.205	0.054	1.066	6.311
2. Meat	1.070	2.964	3.975	4.902	3.237	1.519	2.989	5.684
3. Fish	0.129	0.412	1.064	2.936	1.067	0.321	0.752	1.921
4. Dairy	0.738	2.167	3.173	2.306	2.141	0.920	1.756	3.214
5. Oils & Fats	0.026	0.174	0.626	1.773	0.505	0.043	0.251	1.254
6. Fruits & Vegetables	0.561	2.183	4.196	7.404	3.483	0.760	1.965	5.880
7. Other Food	0.816	1.076	2.239	3.142	1.829	4.259	7.211	8.624
8. Beverages & Tobacco	2.286	5.150	4.510	3.326	3.914	2.836	4.891	6.350
Total	6.49	16.00	22.50	35.70	19.38	10.71	20.88	39.24

Note:

1. The current study (columns 2-6): The 31 food items in table 2 are aggregated into the eight Muhammad et al. (2011) groups as follows: Cereals comprise items 1-5; meat, items 6-9; fish, 10-11; dairy, 12-15; oils and fats, 16-17; fruits and vegetables, 18-22; other food, 23-26; and beverages, 27-31. Tobacco is not included in our study. The income elasticities in panel A are conditional-budget-share weighted averages of the elasticities in table A5.4. The budget shares of panel B are derived from table 2.
2. Muhammad et al. (2011) (columns 7-9): The income elasticities of panel A are from their Appendix table 5. For details of the budget shares of panel B, see Table A7.2.
3. The weighted income elasticities in panel C are the income elasticities (panel A) multiplied by the budget shares (panel B).

Table A7.2 Intermediate Steps, Muhammad et al. (2011)

Item (1)	Income group		
	High (2)	Middle (3)	Low (4)
I. Unconditional marginal shares of total food (Muhammad et al., App. table 7)	0.107	0.209	0.392
II. Conditional marginal shares of food groups (Muhammad et al., App. table 8)			
Cereals	0.005	0.051	0.161
Meats	0.142	0.143	0.145
Fish	0.030	0.036	0.049
Dairy	0.086	0.084	0.082
Oils and Fats	0.004	0.012	0.032
Fruits and Vegetables	0.071	0.094	0.150
Food other	0.398	0.345	0.220
Beverages & Tobacco	0.265	0.234	0.162
III. Unconditional marginal shares of food groups (item I above $\times$ item II)			
Cereals [0.107 $\times$ 0.005; 0.209 $\times$ 0.051; 0.392 $\times$ 0.161]	0.001	0.011	0.063
Meats [0.107 $\times$ 0.142; 0.209 $\times$ 0.143; 0.392 $\times$ 0.145]	0.015	0.030	0.057
Fish	0.003	0.008	0.019
Dairy	0.009	0.018	0.032
Oils and Fats	0.000	0.003	0.013
Fruits and Vegetables	0.008	0.020	0.059
Food other	0.043	0.072	0.086
Beverages & Tobacco	0.028	0.049	0.064
IV. Unconditional income elasticities by food groups (Muhammad et al., App table 5)			
Cereals	0.019	0.253	0.514
Meats	0.490	0.649	0.771
Fish	0.379	0.521	0.654
Dairy	0.506	0.671	0.798
Oils and Fats	0.097	0.297	0.531
Fruits and Vegetables	0.319	0.462	0.615
Food other	0.636	0.882	1.42
Beverages & Tobacco	0.613	0.839	1.325
V. Implied unconditional budget shares (item III $\div$ item IV)			
Cereals	0.028	0.042	0.123
Meats	0.031	0.046	0.074
Fish	0.008	0.014	0.029
Dairy	0.018	0.026	0.040
Oils and Fats	0.004	0.008	0.024
Fruits and Vegetables	0.024	0.043	0.096
Food other	0.067	0.082	0.061
Beverages & Tobacco	0.046	0.058	0.048
VI. Weighted income elasticities (item IV $\times$ item V)			
Cereals	0.001	0.011	0.063
Meats	0.015	0.030	0.057
Fish	0.003	0.008	0.019
Dairy	0.009	0.018	0.032
Oils and Fats	0.000	0.003	0.013
Fruits and Vegetables	0.008	0.020	0.059
Food other	0.043	0.072	0.086
Beverages & Tobacco	0.028	0.049	0.064

Note: Items III and VI are conceptually and algebraically identical.

Table A8.1 Multilateral Food Quality Indexes by Country, 155 Countries in 2011

Country	Quality index of			Country	Quality index of			Country	Quality index of		
	Cons.	Prices	Spending		Cons.	Prices	Spending		Cons.	Prices	Spending
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1. Bermuda	22.5	-6.6	15.9	53. Russia	16.4	-1.5	14.9	105. Guatemala	-10.5	0.4	-10.1
2. United States	18.3	-0.9	17.4	54. Chile	10.9	-2.6	8.3	106. Swaziland	-29.1	-3.2	-32.3
3. Cayman Isnds	16.6	0.2	16.9	55. Estonia	24.8	-1.2	23.5	107. Fiji	-11.2	6.4	-4.8
4. Hong Kong	10.4	-4.0	6.4	56. Turkey	8.8	-2.0	6.8	108. Paraguay	0.9	0.3	1.2
5. Norway	26.6	1.3	27.9	57. Montserrat	4.8	2.4	7.3	109. Moldova	8.8	-1.8	7.0
6. Luxembourg	33.7	-4.9	28.8	58. Uruguay	2.4	2.5	4.8	110. Eq. Guinea	-12.1	-2.2	-14.4
7. Switzerland	33.3	-5.7	27.6	59. Seychelles	-23.9	7.3	-16.6	111. Suriname	-10.7	2.6	-8.1
8. UAE	1.0	0.3	1.3	60. Latvia	18.2	0.4	18.6	112. Indonesia	-28.9	4.9	-24.0
9. Sweden	27.0	-0.7	26.3	61. Antigua & Barb.	-3.0	-1.8	-4.8	113. Philippines	-24.3	3.2	-21.1
10. Germany	27.4	-3.0	24.4	62. Montenegro	11.9	-0.5	11.4	114. Cape Verde	-8.0	1.9	-6.1
11. Australia	20.9	0.1	20.9	63. Kazakhstan	8.2	-1.4	6.8	115. China	-15.7	4.4	-11.3
12. Austria	28.7	-2.9	25.8	64. Mexico	14.6	-1.0	13.7	116. Morocco	-15.1	-0.3	-15.5
13. Denmark	26.0	-0.8	25.3	65. Mauritius	-1.7	1.2	-0.5	117. Bhutan	-20.2	3.4	-16.8
14. Canada	20.0	0.1	20.0	66. Malaysia	-16.1	2.4	-13.7	118. Bolivia	-5.5	0.4	-5.1
15. Iceland	15.7	0.7	16.4	67. Virgin Islands	1.3	-3.0	-1.7	119. Honduras	-2.8	-0.2	-3.0
16. Finland	27.5	-0.1	27.3	68. Panama	-11.0	2.0	-9.0	120. Kyrgyzstan	-6.5	-2.5	-9.0
17. France	34.6	-6.3	28.2	69. Belarus	15.9	0.2	16.1	121. Vietnam	-13.2	1.3	-11.9
18. Belgium	30.1	-1.7	28.3	70. Romania	12.0	-0.5	11.5	122. India	-18.0	3.5	-14.5
19. United Kingdom	25.8	-1.2	24.6	71. Bulgaria	17.9	-2.1	15.9	123. S.Tomé & P.	-6.1	0.3	-5.7
20. Netherlands	24.3	-2.4	21.9	72. Serbia	14.1	-1.8	12.3	124. Cambodia	-16.7	2.6	-14.1
21. Singapore	7.2	0.6	7.8	73. Brazil	-10.0	2.3	-7.6	125. Ghana	-19.7	1.3	-18.5
22. Taiwan	7.4	-1.2	6.1	74. Costa Rica	1.9	0.1	2.0	126. Lesotho	-20.8	0.3	-20.4
23. Aruba	14.0	-3.7	10.3	75. Grenada	-2.3	0.4	-1.9	127. Tajikistan	-6.6	-1.1	-7.7
24. Macao	-6.9	0.8	-6.0	76. Jordan	3.6	-1.4	2.2	128. Nigeria	-19.0	0.5	-18.5
25. Japan	22.4	-10.1	12.3	77. Dominican Rep.	2.3	-0.8	1.5	129. Kenya	-17.9	1.2	-16.7
26. Ireland	24.3	-0.7	23.5	78. Dominica	-6.8	0.6	-6.2	130. Djibouti	-14.2	1.8	-12.4
27. Italy	20.7	-3.5	17.2	79. St. Vin. & Gren.	0.9	-2.3	-1.3	131. Cameroon	-20.6	1.5	-19.1
28. Cyprus	18.7	-0.3	18.5	80. Macedonia	6.8	-2.5	4.2	132. Côte d'Ivoire	-12.6	1.6	-11.0
29. New Zealand	16.5	-0.2	16.3	81. Thailand	-12.7	4.4	-8.3	133. Senegal	-23.3	1.5	-21.8
30. Spain	17.6	-1.0	16.7	82. South Africa	0.4	0.9	1.3	134. Nepal	-24.3	4.5	-19.8
31. Israel	14.8	2.2	17.0	83. Colombia	-3.3	1.8	-1.5	135. Zambia	-15.5	0.5	-15.0
32. Sint Maarten	-4.5	-1.5	-5.9	84. St. Lucia	1.6	1.3	2.9	136. Uganda	-21.1	1.9	-19.2
33. Greece	9.4	-1.5	8.0	85. Bosnia & Herz.	7.5	-1.0	6.5	137. Congo, Rep.	-8.7	0.5	-8.2
34. Curaçao	10.7	-3.7	7.0	86. Turks & Caicos	-0.1	-0.5	-0.6	138. Haiti	-29.8	0.1	-29.7
35. Malta	22.6	-2.1	20.6	87. Venezuela	-3.1	5.4	2.4	139. Gambia	-19.3	2.1	-17.2
36. Portugal	12.0	0.1	12.1	88. Ukraine	4.1	-0.9	3.1	140. Sierra Leone	-16.3	0.2	-16.2
37. Slovenia	24.4	-1.5	22.9	89. Tunisia	2.1	-2.0	0.1	141. Chad	-15.3	2.9	-12.4
38. South Korea	1.8	-1.6	0.2	90. Peru	-4.5	1.3	-3.1	142. Benin	-22.0	0.0	-22.0
39. Qatar	-6.4	1.8	-4.6	91. Azerbaijan	2.0	-3.1	-1.0	143. Rwanda	-24.9	2.9	-22.1
40. Anguilla	14.9	-2.3	12.6	92. Belize	-6.4	-0.3	-6.7	144. Zimbabwe	-22.7	0.9	-21.8
41. Bahrain	2.8	-1.1	1.7	93. El Salvador	2.5	-1.7	0.9	145. Madagascar	-12.4	1.1	-11.3
42. Czech	19.3	0.5	19.9	94. Ecuador	-10.2	1.3	-8.9	146. Guinea-B.	-20.3	2.0	-18.3
43. Bahamas	2.3	-0.2	2.1	95. Jamaica	0.5	-0.2	0.3	147. Mali	-34.6	3.0	-31.6
44. Trini. & Tob.	-3.7	1.5	-2.2	96. Sri Lanka	-31.5	4.9	-26.6	148. Mozambique	-19.6	1.0	-18.7
45. Poland	15.0	1.2	16.1	97. Albania	0.4	-1.5	-1.1	149. Liberia	-15.5	1.1	-14.4
46. Slovakia	18.2	-1.1	17.1	98. Namibia	-15.8	-2.2	-18.0	150. Burkina Faso	-22.0	1.6	-20.4
47. Barbados	-0.2	2.4	2.2	99. Botswana	-10.0	0.1	-9.9	151. Comoros	-20.6	1.2	-19.4
48. Lithuania	13.5	0.0	13.5	100. Armenia	6.9	-3.1	3.8	152. C. Africa	-19.2	2.3	-17.0
49. Oman	-3.0	-2.3	-5.3	101. Mongolia	2.7	2.4	5.1	153. Guinea	-26.6	0.5	-26.0
50. St. Kitts & Nevis	8.1	-0.5	7.6	102. Iraq	-11.9	0.0	-12.0	154. Niger	-28.0	1.3	-26.7
51. Croatia	13.4	-0.7	12.7	103. Georgia	8.0	-2.0	6.0	155. Congo, D.R.	-26.8	1.1	-25.7
52. Hungary	19.6	-1.5	18.1	104. Gabon	-4.7	2.2	-2.4				

Note: Columns 2, 6 and 10 contain the multilateral index of the quality of consumption of the 31 goods in the food basket in country c , defined as the average of that country's bilateral indexes, $1/155 \cdot \sum_{d=1}^{155} y_q^{cd}$, where $y_q^{cd} = \sum_{i=1}^{31} w_i^{cd} (\eta_i^{cd} - 1) (\log q_i^{cd} - \log Q^{cd})$ is the bilateral index of c relative to d ; $w_i^{cd} = (w_i^c + w_i^d)/2$ and $\eta_i^{ab} = w_i^a / (w_i^a + w_i^b) \cdot \eta_i^a + w_i^b / (w_i^a + w_i^b) \cdot \eta_i^b$ are the budget share and income elasticity of good i averaged over countries c and d ; $\log q_i^{cd} = \log(q_i^c / q_i^d)$ is relative consumption of good i ; and $\log Q^{cd} = \sum_{i=1}^{31} w_i^{cd} \log q_i^{cd}$ is the Divisia volume index in c relative to d . The quality indexes of prices and spending in the other columns are defined analogously (see the text for details). All entries are $\times 100$.

Table A9.1 Budget Shares and Income Elasticities of Food Groups and Food Items

Food Group/Item (1)	First				Second				Third				Fourth			
	Group		Conditional		Group		Conditional		Group		Conditional		Group		Conditional	
	Budget share (2)	Income elast. (3)	Budget share (4)	Income elast. (5)	Budget share (6)	Income elast. (7)	Budget share (8)	Income elast. (9)	Budget share (10)	Income elast. (11)	Budget share (12)	Income elast. (13)	Budget share (14)	Income elast. (15)	Budget share (16)	Income elast. (17)
1. Bread and cereals	14.28	1.02			14.81	0.87			18.76	0.64			29.47	0.92		
1.1 Rice			9.87	0.18			15.86	0.18			25.05	0.08			38.24	0.99
1.2 Other cereals and flour			13.57	0.18			17.04	0.18			26.93	0.26			38.84	0.89
1.3 Bread			37.65	1.00			37.79	1.39			28.21	2.20			15.03	1.18
1.4 Other bakery products			30.80	1.95			21.57	1.89			13.40	2.76			3.85	1.52
1.5 Pasta products			8.11	0.24			7.75	0.93			6.40	1.70			4.04	1.08
2. Meat and seafood	24.36	0.84			24.53	0.97			22.41	1.06			21.10	1.03		
2.1 Beef and veal			15.18	0.22			13.98	0.20			21.16	0.77			25.08	0.89
2.2 Pork, Lamb, mutton and goat			15.67	0.60			16.63	1.01			15.14	0.96			17.44	1.01
2.3 Poultry			15.66	1.10			24.21	1.31			24.56	1.19			13.77	1.04
2.4 Other meats and preparations			28.62	2.25			24.09	1.59			13.74	1.39			7.93	1.27
2.5. Fresh or frozen fish and seafood			15.40	0.55			14.59	0.84			19.83	1.03			20.39	1.04
2.6 Preserved fish and seafood			9.48	0.22			6.51	0.16			5.57	0.14			15.41	0.93
3. Dairy	13.16	0.97			15.89	1.02			15.76	1.09			11.64	1.00		
3.1 Fresh milk			19.94	0.22			15.53	0.77			16.71	0.94			18.67	0.97
3.2 Preserved milk and milk products			28.16	1.38			30.82	1.31			27.70	1.21			17.59	1.12
3.3 Cheese			25.75	2.21			18.46	1.60			13.24	1.43			4.12	1.69
3.4 Eggs and egg-based products			8.28	0.06			10.97	1.06			13.57	1.12			10.24	1.04
3.5 Butter and margarine			7.65	0.19			8.08	0.63			7.88	0.79			10.58	0.96
3.6 Other edible oils and fats			10.22	0.19			16.14	0.15			20.89	0.53			38.80	0.89
4. Fruits and vegetables	16.25	0.59			17.25	0.88			19.12	1.01			20.56	1.03		
4.1 Fresh or chilled fruit			35.71	2.50			30.98	1.51			27.42	1.33			18.50	1.14
4.2 Frozen, preserved or processed fruits			7.64	0.61			5.43	0.80			3.78	0.75			4.85	0.94
4.3 Fresh or chilled vegetables			33.43	0.02			39.30	1.03			44.52	1.13			38.58	1.01
4.4 Fresh or chilled potatoes			8.11	0.31			11.74	0.17			14.00	0.23			26.61	0.95
4.5 Frozen or preserved vegetables			15.11	0.31			12.54	0.58			10.28	0.82			11.46	0.89
5. Sweet things	5.95	1.85			5.16	1.01			4.93	1.12			4.06	1.04		
5.1 Sugar			10.55	0.10			38.97	0.02			49.82	0.60			75.62	0.86
5.2 Jams, marmalades and honey			10.29	0.85			12.33	1.66			12.30	1.26			6.01	1.16
5.3 Confectionery, chocolate and ice cream			79.16	1.15			48.69	2.06			37.88	1.52			18.37	1.57
6. Other food	15.51	1.09			12.78	1.11			12.06	1.17			8.83	1.06		
6.1 Food products n.e.c.			35.65	0.34			30.74	0.51			40.67	0.81			50.97	0.92
6.2 Coffee, tea and cocoa			17.06	1.16			20.42	1.15			17.89	1.06			16.16	1.02
6.3 Min. water, soft drink, fruit & veg juice			47.29	1.50			48.83	1.26			41.44	1.16			32.87	1.12
7. Alcohol	10.48	1.51			9.59	1.35			6.96	1.31			4.34	1.18		
7.1 Spirits			25.02	1.33			35.62	1.14			28.31	1.16			23.66	1.16
7.2 Wine			37.34	1.22			21.65	1.11			16.50	1.12			23.43	1.10
7.3 Beer			37.64	0.58			42.73	0.83			55.19	0.89			52.91	0.89

Note: The budget share of group g ($g=1,...,7$) is $W_g = \sum_{i \in S_g} p_i q_i / M$, where S_g is the set of food items belonging to subgroup g , $p_i q_i$ = expenditure on i and M = total food expenditure. The conditional income elasticity of item i within S_g is $\eta'_i = \eta_i / \eta_g$, where $\eta_i = \partial \log q_i / \partial \log M$ is the conventional unconditional income elasticity and $\eta_g = \sum_{i \in S_g} w'_i \eta_i$ is the income elasticity of demand for the group as a whole, with $w'_i = p_i q_i / \sum_{i \in S_g} p_i q_i$ the conditional budget share of item i within S_g . The budget shares are averages over countries and are from table 2. For the source of the income elasticities η_i , see Appendix A5.

Table A9.2 Components of Food Quality

Quartile pair	Total	Components		Group quality						
		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)
A. Consumption										
1,1	7.54	4.00	3.54	0.61	2.11	0.61	-0.18	0.08	0.37	-0.07
1,2	9.96	3.25	6.71	2.03	-0.31	1.12	0.32	3.69	-0.81	0.68
1,3	25.32	7.62	17.70	7.95	1.51	2.20	0.05	3.73	0.39	1.88
1,4	36.71	10.13	26.58	6.84	5.85	6.01	-0.42	5.10	1.32	1.88
Average	21.59	6.55	15.03	4.90	2.29	2.74	-0.04	3.59	0.30	1.26
B. Prices										
1,1	-0.77	-0.52	-0.25	0.08	-0.40	-0.17	0.11	0.06	0.06	0.01
1,2	-1.33	-1.29	-0.04	0.76	-0.54	-0.02	0.39	-0.12	-0.26	-0.25
1,3	-1.95	-1.99	0.03	1.02	-0.84	0.02	0.61	-0.12	-0.19	-0.46
1,4	-3.50	-2.41	-1.09	0.56	-1.77	-0.20	0.69	0.06	-0.02	-0.40
Average	-2.04	-1.70	-0.34	0.68	-0.95	-0.08	0.50	-0.04	-0.13	-0.32
C. Spending										
1,1	6.77	3.48	3.29	0.69	1.72	0.44	-0.08	0.14	0.44	-0.06
1,2	8.63	1.96	6.67	2.79	-0.85	1.09	0.70	3.57	-1.06	0.42
1,3	23.37	5.63	17.74	8.97	0.67	2.22	0.66	3.61	0.19	1.42
1,4	33.22	7.72	25.49	7.40	4.08	5.81	0.26	5.16	1.30	1.48
Average	19.55	4.86	14.69	5.58	1.34	2.65	0.46	3.54	0.18	0.94

Notes:

1. This table compares elements of food quality in one country with that of another. For country c relative to d , the generic term is y^{cd} , $c < d$, $c \in \text{quartile } g$, $d \in \text{quartile } h$, $g \leq h$, $g, h = 1, \dots, 4$. Countries are ranked in terms of decreasing income, so country c is richer than d when $c < d$. These terms are then averaged over countries.
2. **Column 1:** This specifies the income quartiles to which countries belong. Thus, the first element of this column is 1,1, which means both countries in the pairwise comparison belong to the first quartile; the second element, 1,2, means c is from quartile 1 and d quartile 2; and so on.
3. **Column 2 of panel A:** This contains the index of the quality of food consumption for $n = 31$ items, $y_q^{cd} = \sum_{i=1}^{31} w_i^{cd} (\eta_i^{cd} - 1) (\log q_i^{cd} - \log Q^{cd})$, where, for countries c and d , w_i^{cd} is the proportion of food expenditure devoted to item i ; η_i^{cd} is the income elasticity of this good; $\log q_i^{cd} = \log(q_i^c / q_i^d)$ is relative consumption of good i ; and $\log Q^{cd} = \sum_{i=1}^{31} w_i^{cd} \log q_i^{cd}$ is the food volume index.
4. **Columns 3 and 4 of panel A:** Dividing food into $G=7$ groups and using equation (A9.2), total food quality can be decomposed into between- and within-group components:

$$(TA9.2.1) \quad y_q^{cd} = \underbrace{\sum_{g=1}^7 W_g^{cd} (\eta_g^{cd} - 1) \log \left(\frac{Q_g^{cd}}{Q^{cd}} \right)}_{\text{Between-group}} + \underbrace{\sum_{g=1}^7 W_g^{cd} \eta_g^{cd} \left[\sum_{i \in S_g} w_i^{cd} (\eta_i^{cd} - 1) \log \left(\frac{q_i^{cd}}{Q_g^{cd}} \right) \right]}_{\text{Within-group}}.$$

Here, for c and d , W_g^{cd} and η_g^{cd} are the budget share and income elasticity of group g , respectively; $\log Q_g^{cd} = \sum_{i \in S_g} w_i^{cd} \log q_i^{cd}$ and $\log Q^{cd} = \sum_{g=1}^7 W_g^{cd} \log Q_g^{cd} = \sum_{i=1}^{31} w_i^{cd} \log q_i^{cd}$ are the volume index of group g and of food as a whole; S_g is the set of goods in group g ; and w_i^{cd} and η_i^{cd} are the budget share and income elasticity of good i within group g . Columns 3 and 4 contain the above between- and within-components.

5. **Columns 5-11 of panel A:** These columns contain each of the seven elements of the within-group component of equation (TA9.2.1) above. These elements sum to the within component of column 4.
6. **Panels B and C:** The entries in these panels are defined analogously to those of panel A.
7. All entries are $\times 100$.

Table A9.3 Quality of Food Groups and Income

$$a_g^{cd} = \alpha_g + \beta_g \log(M/P)^{cd} + \varepsilon_g^{cd}, \quad g = 1, \dots, 7 \text{ groups}; c, d = 1, \dots, 155 \text{ countries}, c < d$$

Food group	Intercept $\alpha_g \times 100$	Slope $\beta_g \times 100$
(1)	(2)	(3)
1. Bread and cereals	25.60 (0.25)	-0.30 (0.15)
2. Meats and Seafood	20.49 (0.21)	-0.44 (0.13)
3. Dairy	13.00 (0.17)	2.12 (0.10)
4. Fruit and Vegetables	12.80 (0.14)	-1.65 (0.09)
5. Sweet things	10.84 (0.15)	1.38 (0.09)
6. Other Food	10.85 (0.14)	-0.92 (0.08)
7. Alcohol	6.40 (0.09)	-0.18 (0.06)

Note:

1. For country c as compared to d , a_g^{cd} is the proportionate contribution of group g to the within-group component of the quality of food consumption, with the sign disregarded:

$$a_g^{cd} = \frac{x_g^{cd}}{\sum_{g=1}^7 x_g^{cd}}, \quad \text{with } x_g^{cd} = \left| W_g^{cd} \eta_g^{cd} \left[\sum_{i \in S_g} w_i^{cd} (\eta_i^{cd} - 1) \log \left(\frac{q_i^{cd}}{Q_g^{cd}} \right) \right] \right|,$$

where the notation is defined in the notes to table A9.2. For details, see equation (TA9.2.1) in the notes to table A9.2.

2. The variable on the right of the regression is $\log(M/P)^{cd} = \log(M/P)^c - \log(M/P)^d$, the relative income difference between c and d , where income is real income (consumption) per capita, as defined in the note to table 1 of the article.

Table A9.4 Quality, Dispersion and Income Correlations

	Quality	Dispersion	Income
A. Quartile 1			
Quality	-	-0.69	0.40
Dispersion		-	-0.09
Income			-
B. Quartile 2			
Quality	-	-0.45	0.28
Dispersion		-	-0.08
Income			-
C. Quartile 3			
Quality	-	-0.66	0.49
Dispersion		-	-0.39
Income			-
D. Quartile 4			
Quality	-	-0.22	0.62
Dispersion		-	-0.21
Income			-
E. All			
Quality	-	-0.68	0.82
Dispersion		-	-0.66
Income			-

Table A10.1 Agricultural Assistance, Prices and Income Correlations

	RRA	Price variance	Index of price quality	Relative price of food	Log income
(1)	(2)	(3)	(4)	(5)	(6)
RRA		-0.23	-0.46	-0.12	0.46
Price variance			0.40	0.34	-0.78
Index of price quality				0.35	-0.52
Relative price of food					-0.63
Log income					

Note: The relative rate of assistance to agriculture (RRA) is measured in percent. See notes to figure A10.1. The index of price of quality is the multilateral version. The relative price of food is the difference between the budget-share weighted logarithmic mean of the prices of food items and the log of the index of the prices of all goods, $\log(P_F/P) = \log P_F - \log P$.

Table A10.2 Price Measures, Income and Agricultural Assistance

$$\text{Price measure}_c = \alpha + \beta \cdot (\log \text{income})_c + \gamma \cdot \text{RRA}_c + \varepsilon_c, \quad c = 1, \dots, 59 \text{ countries}$$

Independent variable	Dependent variable		
	Price variance	Index of price quality	Relative price of food
(1)	(2)	(3)	(4)
Log income	-6.80 (0.72)	-1.02 (0.32)	-16.71 (2.54)
Relative rate of assistance $\times 100$	0.05 (0.03)	-0.03 (0.01)	0.19 (0.10)
Constant	74.01 (6.66)	9.45 (2.93)	187.65 (23.41)

Note: See notes to table A10.1. Standard errors in parenthesis.

Table A11.1 Multilateral Estimates of Food Flexibility

Country (1)	Mean (2)	Median (3)	Country (4)	Mean (5)	Median (6)
1. Bermuda	-1.43	-1.32	40. Anguilla	-1.75	-1.57
2. United States	-1.81	-1.62	41. Bahrain	-2.28	-2.29
3. Cayman Isnds	-0.96	-0.85	42. Czech	-1.77	-1.58
4. Hong Kong	-2.36	-2.82	43. Bahamas	-1.36	-1.32
5. Norway	-1.06	-0.84	44. Trini. & Tob.	-1.58	-1.65
6. Luxembourg	-1.62	-1.51	45. Poland	-1.15	-1.03
7. Switzerland	-1.40	-1.30	46. Slovakia	-2.00	-1.91
8. UAE	-1.87	-1.89	47. Barbados	-1.29	-1.39
9. Sweden	-1.54	-1.36	48. Lithuania	-1.90	-1.69
10. Germany	-1.31	-1.27	49. Oman	-2.34	-2.35
11. Australia	-1.53	-1.42	50. St. Kitts & Nevis	-1.67	-1.61
12. Austria	-1.55	-1.47	51. Croatia	-1.63	-1.75
13. Denmark	-1.35	-1.36	52. Hungary	-2.40	-2.29
14. Canada	-2.21	-2.03	53. Russia	-1.23	-1.02
15. Iceland	-1.38	-1.09	54. Chile	-1.28	-1.05
16. Finland	-1.55	-1.31	55. Estonia	-2.20	-2.06
17. France	-0.86	-0.84	56. Turkey	-1.68	-1.48
18. Belgium	-0.90	-0.80	57. Montserrat	-1.71	-1.70
19. United Kingdom	-1.34	-1.15	58. Uruguay	-1.65	-1.51
20. Netherlands	-1.39	-1.33	59. Seychelles	-2.00	-1.85
21. Singapore	-0.71	-0.81	60. Latvia	-1.40	-1.11
22. Taiwan	-1.28	-1.46	61. Antigua & Barb.	-0.47	-0.56
23. Aruba	-1.44	-1.46	62. Montenegro	-2.23	-2.16
24. Macao	-1.08	-1.32	63. Kazakhstan	-0.96	-0.83
25. Japan	-2.40	-2.27	64. Mexico	-1.24	-0.99
26. Ireland	-1.50	-1.25	65. Mauritius	-1.42	-1.29
27. Italy	0.04	-0.04	66. Malaysia	-1.64	-1.61
28. Cyprus	-1.47	-1.35	67. Virgin Islands	-1.35	-1.29
29. New Zealand	-1.72	-1.68	68. Panama	-1.47	-1.75
30. Spain	-0.78	-0.78	69. Belarus	-1.85	-1.64
31. Israel	-1.35	-1.26	70. Romania	-1.24	-1.40
32. Sint Maarten	-2.16	-2.06	71. Bulgaria	-1.99	-1.71
33. Greece	-1.11	-1.19	72. Serbia	-1.82	-1.50
34. Curaçao	-1.39	-1.45	73. Brazil	-0.70	-0.46
35. Malta	-1.28	-1.34	74. Costa Rica	-1.19	-0.95
36. Portugal	-0.60	-0.64	75. Grenada	-1.65	-1.65
37. Slovenia	-1.61	-1.45	76. Jordan	-2.06	-2.18
38. South Korea	-1.29	-1.25	77. Dominican Rep.	-1.04	-0.78
39. Qatar	-1.42	-1.54	78. Dominica	-1.12	-1.21
Mean	-1.38	-1.34	Mean	-1.58	-1.49
Median	-1.39	-1.33	Median	-1.64	-1.57

(continued on next page)

Table A11.1 Multilateral Estimates of Food Flexibility (continued)

Country (1)	Mean (2)	Median (3)	Country (4)	Mean (5)	Median (6)
79. St. Vin. & Gren.	-1.22	-1.27	118. Bolivia	-1.65	-1.50
80. Macedonia	-1.73	-1.51	119. Honduras	-1.17	-0.91
81. Thailand	-1.53	-1.39	120. Kyrgyzstan	-1.28	-1.20
82. South Africa	-1.22	-0.97	121. Vietnam	-1.68	-1.27
83. Colombia	-1.48	-1.24	122. India	-1.93	-1.90
84. St. Lucia	-1.49	-1.58	123. S.Tomé & P.	-2.15	-2.25
85. Bosnia & Herz.	-1.49	-1.40	124. Cambodia	-2.05	-2.03
86. Turks & Caicos	-1.25	-1.06	125. Ghana	-2.20	-2.01
87. Venezuela	-1.00	-0.88	126. Lesotho	-1.88	-2.15
88. Ukraine	-0.64	-0.51	127. Tajikistan	-2.26	-2.36
89. Tunisia	-1.64	-1.55	128. Nigeria	-1.81	-1.74
90. Peru	-1.39	-1.23	129. Kenya	-1.25	-1.21
91. Azerbaijan	-1.59	-1.63	130. Djibouti	-2.01	-1.93
92. Belize	-0.90	-0.99	131. Cameroon	-2.78	-2.76
93. El Salvador	-1.42	-1.37	132. Côte d'Ivoire	-3.68	-3.61
94. Ecuador	-0.65	-0.41	133. Senegal	-1.29	-1.36
95. Jamaica	-0.79	-0.85	134. Nepal	-2.02	-1.91
96. Sri Lanka	-2.20	-2.15	135. Zambia	-2.45	-2.65
97. Albania	-1.64	-1.63	136. Uganda	-2.24	-2.18
98. Namibia	-1.78	-1.53	137. Congo, Rep.	-0.52	-0.37
99. Botswana	-0.39	0.03	138. Haiti	-1.70	-1.57
100. Armenia	-1.55	-1.44	139. Gambia	-2.14	-2.18
101. Mongolia	-1.53	-1.43	140. Sierra Leone	-2.48	-2.30
102. Iraq	-2.77	-2.76	141. Chad	-2.88	-2.67
103. Georgia	-1.49	-1.28	142. Benin	-1.51	-1.43
104. Gabon	-1.70	-1.59	143. Rwanda	-2.89	-2.83
105. Guatemala	-0.44	-0.78	144. Zimbabwe	-1.69	-1.63
106. Swaziland	-2.47	-2.29	145. Madagascar	-1.51	-1.50
107. Fiji	-1.28	-1.38	146. Guinea-B.	-3.22	-3.25
108. Paraguay	-1.96	-1.88	147. Mali	-2.86	-2.87
109. Moldova	-1.70	-1.44	148. Mozambique	-1.94	-1.84
110. Eq. Guinea	-1.32	-1.31	149. Liberia	-2.08	-1.95
111. Suriname	-1.58	-1.66	150. Burkina Faso	-1.36	-1.24
112. Indonesia	-2.97	-2.85	151. Comoros	-3.83	-3.82
113. Philippines	-1.85	-2.21	152. C. Africa	-1.66	-1.49
114. Cape Verde	-1.11	-1.05	153. Guinea	-2.08	-1.86
115. China	-0.98	-1.13	154. Niger	-1.14	-1.02
116. Morocco	-1.65	-1.67	155. Congo, D.R.	-2.28	-2.32
117. Bhutan	-1.23	-1.18			
Mean	-1.46	-1.40	Mean	-2.03	-1.96
Median	-1.49	-1.39	Median	-2.01	-1.91

Note: The food flexibility ϕ^F is the reciprocal of the elasticity of the marginal utility of income with respect to food expenditure. For the pair of countries $\{c,d\}$, $\hat{\phi}_{cd}^F$ is the estimate of ϕ^F . For all pairs $c, d = 1, \dots, 155$, the estimates form a symmetric 155×155 matrix $[\hat{\phi}_{cd}^F]$. Each country's entry in this table is the row mean of this matrix, $1/155 \cdot \sum_{d=1}^{155} \hat{\phi}_{cd}^F$, or the row median. The means and medians in the last two rows each of the four groups of countries are the quartile statistics.

Table A12.1 Countries by Region

Country	Income quartile	Country	Income quartile	Country	Income quartile
(1)	(2)	(3)	(4)	(5)	(6)
A. Europe, N. America & ANZ		B. East/South Asia & Pacific Islands		D. Middle East, N. Africa & Central Asia	
1. Bermuda	Q1	1. Hong Kong	Q1	1. UAE	Q1
2. United States	Q1	2. Singapore	Q1	2. Cyprus	Q1
3. Norway	Q1	3. Taiwan	Q1	3. Israel	Q1
4. Luxembourg	Q1	4. Macao	Q1	4. Malta	Q1
5. Switzerland	Q1	5. Japan	Q1	5. Qatar	Q1
6. Sweden	Q1	6. South Korea	Q1	6. Bahrain	Q2
7. Germany	Q1	7. Malaysia	Q2	7. Oman	Q2
8. Australia	Q1	8. Thailand	Q3	8. Turkey	Q2
9. Austria	Q1	9. Sri Lanka	Q3	9. Kazakhstan	Q2
10. Denmark	Q1	10. Mongolia	Q3	10. Jordan	Q2
11. Canada	Q1	11. Fiji	Q3	11. Tunisia	Q3
12. Iceland	Q1	12. Indonesia	Q3	12. Azerbaijan	Q3
13. Finland	Q1	13. Philippines	Q3	13. Armenia	
14. France	Q1	14. China	Q3	14. Iraq	Q3
15. Belgium	Q1	15. Bhutan	Q3	15. Georgia	Q3
16. United Kingdom	Q1	16. Vietnam	Q4	16. Morocco	Q3
17. Netherlands	Q1	17. India	Q4	17. Kyrgyzstan	Q4
18. Ireland	Q1	18. Cambodia	Q4	18. Tajikistan	Q4
19. Italy	Q1	19. Nepal	Q4	19. Djibouti	Q4
20. New Zealand	Q1	C. Latin America & Caribbean		E. Sub-Saharan Africa	
21. Spain	Q1	1. Cayman Isnds	Q1	1. Seychelles	Q2
22. Greece	Q1	2. Aruba	Q1	2. Mauritius	Q2
23. Portugal	Q1	3. Sint Maarten	Q1	3. South Africa	Q3
24. Slovenia	Q1	4. Curaçao	Q1	4. Namibia	Q3
25. Czech	Q2	5. Anguilla	Q2	5. Botswana	Q3
26. Poland	Q2	6. Bahamas	Q2	6. Gabon	Q3
27. Slovakia	Q2	7. Trini. & Tob.	Q2	7. Swaziland	Q3
28. Lithuania	Q2	8. Barbados	Q2	8. Eq. Guinea	Q3
29. Croatia	Q2	9. St. Kitts & Nevis	Q2	9. Cape Verde	Q3
30. Hungary	Q2	10. Chile	Q2	10. São Tomé & P.	Q4
31. Russia	Q2	11. Montserrat	Q2	11. Ghana	Q4
32. Estonia	Q2	12. Uruguay	Q2	12. Lesotho	Q4
33. Latvia	Q2	13. Antigua & Barb.	Q2	13. Nigeria	Q4
34. Montenegro	Q2	14. Mexico	Q2	14. Kenya	Q4
35. Belarus	Q2	15. Virgin Islands	Q2	15. Cameroon	Q4
36. Romania	Q2	16. Panama	Q2	16. Côte d'Ivoire	Q4
37. Bulgaria	Q2	17. Brazil	Q2	17. Senegal	Q4
38. Serbia	Q2	18. Costa Rica	Q2	18. Zambia	Q4
39. Macedonia	Q3	19. Grenada	Q2	19. Uganda	Q4
40. Bosnia & Herz.	Q3	20. Dominican Rep.	Q2	20. Congo, Rep.	Q4
41. Ukraine	Q3	21. Dominica	Q2	21. Gambia	Q4
42. Albania	Q3	22. St. Vin. & Gren.	Q3	22. Sierra Leone	Q4
43. Moldova	Q3	23. Colombia	Q3	23. Chad	Q4
		24. St. Lucia	Q3	24. Benin	Q4
		25. Turks & Caicos	Q3	25. Rwanda	Q4
		26. Venezuela	Q3	26. Zimbabwe	Q4
		27. Peru	Q3	27. Madagascar	Q4
		28. Belize	Q3	28. Guinea-B.	Q4
		29. El Salvador	Q3	29. Mali	Q4
		30. Ecuador	Q3	30. Mozambique	Q4
		31. Jamaica	Q3	31. Liberia	Q4
		32. Guatemala	Q3	32. Burkina Faso	Q4
		33. Paraguay	Q3	33. Comoros	Q4
		34. Suriname	Q3	34. C. Africa	Q4
		35. Bolivia	Q4	35. Guinea	Q4
		36. Honduras	Q4	36. Niger	Q4
		37. Haiti	Q4	37. Congo, D.R.	Q4

Note: Income quartiles are from table 1. The source of regional classification of countries is UNSD (2016).

Table A12.2 Regional Food Consumption and Income

Food item	Europe, N. America & ANZ	E./S. Asia & Pacific Islands	Middle East, N. Africa & Central Asia	Latin America & Caribbean	Sub-Saharan Africa
(1)	(2)	(3)	(4)	(5)	(6)
<i>Conditional food budget shares × 100</i>					
1. Rice	0.55	10.98	2.77	3.58	10.17
2. Other cereals and flour	2.09	2.99	4.07	4.77	11.66
3. Bread	5.81	2.44	5.11	6.32	3.99
4. Other bakery products	4.18	2.23	2.75	2.60	1.07
5. Pasta products	1.05	1.53	1.58	1.10	0.83
6. Beef and veal	3.56	2.27	4.97	4.74	4.89
7. Pork, Lamb, mutton and goat	3.79	5.56	6.03	2.81	2.82
8. Poultry	3.35	3.82	4.85	7.10	3.25
9. Other meats and preparations	8.30	3.10	3.22	3.20	2.01
10. Fresh or frozen fish and seafood	2.36	8.64	3.58	3.57	5.11
11. Preserved fish and seafood	1.59	2.62	0.77	1.65	3.61
12. Fresh milk	3.50	3.14	3.47	1.62	1.84
13. Preserved milk and milk products	3.59	4.15	4.11	4.70	2.18
14. Cheese	4.44	0.65	2.87	2.52	0.41
15. Eggs and egg-based products	1.46	1.93	2.10	1.57	0.99
16. Butter and margarine	1.32	0.89	1.74	1.00	1.17
17. Other edible oils and fats	1.65	2.55	3.60	2.74	3.88
18. Fresh or chilled fruit	5.33	5.04	7.99	4.76	3.55
19. Frozen, preserved or processed fruits	1.02	0.95	1.54	0.72	0.89
20. Fresh or chilled vegetables	5.62	8.90	8.92	7.26	6.56
21. Fresh or chilled potatoes	1.85	1.31	2.43	1.94	6.65
22. Frozen or preserved vegetables	2.02	2.28	1.90	2.31	2.34
23. Sugar	1.06	1.44	2.46	2.32	2.66
24. Jams, marmalades and honey	0.73	0.37	0.78	0.37	0.35
25. Confectionery, chocolate and ice cream	4.69	2.51	3.49	1.57	0.61
26. Food products n.e.c.	4.06	6.22	2.98	6.04	6.10
27. Coffee, tea and cocoa	2.52	1.99	2.02	1.58	1.16
28. Min. water, soft drink, fruit & veg juice	5.63	4.25	4.25	8.28	3.10
29. Spirits	3.75	2.05	1.40	2.06	1.13
30. Wine	4.50	0.85	1.06	1.12	0.92
31. Beer	4.62	2.34	1.20	4.08	4.11
Number of countries	43	19	19	37	37
Food share of total consumption × 100	17.89	26.86	26.67	21.77	44.13
GDP p.c. (\$USPPP)	30,992	23,410	26,213	16,491	5,222
Consumption p.c. (\$USPPP)	20,032	11,214	11,341	10,825	2,599
SD of log (consumption p.c.) × 100	52.86	93.20	80.85	61.30	89.16

Note: The conditional food budget share is the proportion of total food expenditure devoted to the item.

Table A12.3 Food Diversity by Income Quartile, Unweighted and Weighted

Income quartile	Unweighted			Weighted								
	Total	Components		Population			GDP			GDP per capita		
		Between group	Within group	Total	Components		Total	Components		Total	Components	
					Between group	Within group		Between group	Within group		Between group	Within group
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
A. Budget shares												
First	50.86	16.90	33.96	52.42	17.70	34.73	51.99	17.33	34.66	52.68	18.56	34.11
Second	50.42	15.23	35.19	50.81	11.19	39.62	49.49	11.42	38.06	50.39	15.90	34.49
Third	66.28	23.96	42.32	67.27	25.27	42.00	66.64	25.16	41.47	66.59	24.07	42.52
Fourth	99.55	47.63	51.92	90.98	34.49	56.48	89.98	32.48	57.49	92.38	42.23	50.15
All	66.67	25.85	40.82	71.53	25.67	45.86	60.19	20.24	39.95	55.13	19.31	35.82
B. Prices												
First	7.95	3.24	4.72	8.31	3.67	4.64	8.41	3.77	4.64	8.92	3.44	5.48
Second	10.86	4.05	6.81	7.94	3.18	4.77	7.79	3.17	4.62	10.72	3.82	6.90
Third	15.38	6.25	9.13	19.73	7.21	12.53	19.64	7.14	12.50	15.79	6.30	9.49
Fourth	25.12	10.98	14.14	21.22	10.46	10.76	20.69	10.43	10.26	22.63	10.03	12.61
All	14.81	6.12	8.69	17.21	7.36	9.85	13.09	5.42	7.66	10.72	4.12	6.60
C. Quantities												
First	64.58	22.07	42.51	65.55	22.91	42.64	65.27	22.65	42.62	70.57	25.37	45.20
Second	70.50	22.87	47.62	66.03	16.01	50.02	64.04	16.05	48.00	71.18	23.88	47.30
Third	98.12	36.66	61.46	128.71	51.94	76.77	127.39	51.65	75.74	99.61	36.91	62.70
Fourth	149.85	75.29	74.56	140.21	59.69	80.52	142.19	58.20	83.99	137.95	66.20	71.75
All	95.61	39.10	56.51	116.26	46.13	70.13	92.57	34.16	58.41	76.64	27.74	48.90

Note: Columns 2-4 are from table 4 of the article. The entries in this table are averages over countries within each group. The population weight for a country is its share in the total population for all countries. The two other weighting schemes are analogous. All entries are $\times 100$.

Table A12.4 Food Diversity by Region, Unweighted and Weighted

Region	Unweighted			Weighted								
	Total	Components		Population			GDP			GDP per capita		
		Between group	Within group	Total	Components		Total	Components		Total	Components	
					Between group	Within group		Between group	Within group		Between group	Within group
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
A. Budget shares												
Eur/N. Am	44.88	11.08	33.80	41.87	9.24	32.62	42.31	8.48	33.83	44.85	10.56	34.29
E./S. Asia	79.03	33.44	45.59	78.40	29.71	48.70	74.19	30.97	43.22	69.09	31.42	37.67
M. East	52.81	16.15	36.66	52.65	15.70	36.94	51.44	15.84	35.60	53.22	19.51	33.70
L. Am	61.82	22.95	38.87	59.49	13.47	46.02	58.16	11.69	46.47	60.51	24.19	36.31
S-S Africa	97.01	46.61	50.41	89.39	38.78	50.61	78.75	31.89	46.85	79.19	33.51	45.68
All	66.67	25.85	40.82	71.53	25.67	45.86	60.19	20.24	39.95	55.13	19.31	35.82
B. Prices												
Eur/N. Am	7.27	3.31	3.96	6.89	3.74	3.15	6.89	3.85	3.04	7.28	3.52	3.76
E./S. Asia	18.91	8.02	10.88	20.38	8.61	11.77	18.57	7.17	11.40	13.44	4.70	8.74
M. East	14.84	6.34	8.50	14.40	6.21	8.18	12.93	4.93	8.00	13.51	4.08	9.43
L. Am	11.23	4.06	7.17	9.34	3.13	6.21	8.88	2.96	5.91	10.31	3.83	6.47
S-S Africa	24.81	10.26	14.55	21.06	9.26	11.80	16.62	6.72	9.89	21.32	7.65	13.67
All	14.81	6.12	8.69	17.21	7.36	9.85	13.09	5.42	7.66	10.72	4.12	6.60
C. Quantities												
Eur/N. Am	54.21	13.82	40.39	47.56	10.36	37.20	47.06	9.37	37.69	52.44	13.32	39.12
E./S. Asia	137.27	58.74	78.53	140.14	57.80	82.34	131.32	56.98	74.34	110.05	47.34	62.71
M. East	87.37	31.79	55.58	82.72	29.96	52.75	82.79	28.60	54.18	91.24	33.60	57.64
L. Am	79.72	30.83	48.89	78.27	19.34	58.93	76.58	17.32	59.26	78.39	32.82	45.56
S-S Africa	141.35	69.74	71.61	120.24	57.68	62.56	104.83	43.92	60.91	117.17	47.13	70.04
All	95.61	39.10	56.51	116.26	46.13	70.13	92.57	34.16	58.41	76.64	27.74	48.90

Note: The geographic regions are as follows: Eur/N. Am is Europe, North America, Australia and New Zealand; E./S. Asia is East/South Asia and the Pacific Islands; M. East is the Middle East, North Africa and Central Asia; L. Am is Latin America and the Caribbean; and S-S Africa is Sub-Saharan Africa. See notes to table A12.3. All entries are ×100.

Table A12.5 Diversity of Diets, Rich versus Poor Countries, USA, Japan, China and India Omitted

Type of variance	Weighted							
	Unweighted		Population		GDP		GDP per capita	
	Total variance	Between component	Total variance	Between component	Total variance	Between component	Total variance	Between component
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
<u>A. Income groups</u>								
Budget share	2.00	3.03	2.10	4.35	2.08	4.07	1.78	2.41
Quantity	2.38	3.67	2.54	5.59	2.59	5.16	1.98	2.74
<u>B. Regional groups</u>								
Budget share	2.16	4.21	2.13	4.20	1.86	3.76	1.77	3.17
Quantity	2.61	5.05	2.53	5.57	2.23	4.69	2.23	3.54

Note: The elements of this table give the diversity of diets of rich countries as compared to that of poor countries, using a cross-commodity variance as an inverse measure of diversity. These results pertain to (i) two types of variance (that of budget shares and quantities consumed); (ii) the total variance and the between-group component of that variance; (iii) the allocation of countries into regional and income groups; and (iv) various country-weighting schemes. See the article for details of the variances. This table is to be compared to table 7 of the article where all countries are included.

Table A12.6 Decomposition of Food Diversity by Region

Region	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)
A. Budget shares										
Eur/N. Am	44.88	11.08	33.80	45.93	42.84	31.45	35.02	49.36	17.67	15.03
E./S. Asia	79.03	33.44	45.59	56.28	40.61	39.69	50.77	45.49	29.81	25.87
M. East	52.81	16.15	36.66	41.57	42.22	32.54	42.40	31.25	18.17	27.84
L. Am	61.82	22.95	38.87	40.75	41.50	39.17	43.34	33.21	27.88	30.42
S-S Africa	97.01	46.61	50.41	65.44	42.52	55.38	41.62	48.49	36.59	32.66
All	66.67	25.85	40.82	50.11	42.09	40.21	41.46	42.56	26.23	25.88
B. Prices										
Eur/N. Am	7.27	3.31	3.96	4.07	4.46	3.76	3.56	1.56	1.28	6.86
E./S. Asia	18.91	8.02	10.88	19.03	17.05	3.76	4.04	4.83	2.06	20.18
M. East	14.84	6.34	8.50	15.93	9.43	3.74	9.27	2.93	2.41	4.09
L. Am	11.23	4.06	7.17	14.69	7.08	5.98	5.73	10.30	2.14	6.19
S-S Africa	24.81	10.26	14.55	23.39	21.13	5.18	9.48	2.43	1.37	3.71
All	14.81	6.12	8.69	14.57	11.26	4.63	6.26	4.44	1.74	7.24
C. Quantities										
Eur/N. Am	54.21	13.82	40.39	58.01	39.66	38.52	46.69	57.14	22.46	26.63
E./S. Asia	137.27	58.74	78.53	109.84	88.64	47.72	69.94	62.93	37.87	58.21
M. East	87.37	31.79	55.58	64.47	59.09	38.08	77.60	42.12	25.08	37.63
L. Am	79.72	30.83	48.89	60.33	41.48	38.39	65.95	61.22	31.44	48.91
S-S Africa	141.35	69.74	71.61	85.23	83.83	60.45	66.47	55.16	34.30	44.15
All	95.61	39.10	56.51	72.30	59.15	44.84	62.75	56.51	29.69	41.45

Note: The geographic regions are as follows: Eur/N. Am is Europe, North America, Australia and New Zealand; E./S. Asia is East/South Asia and the Pacific Islands; M. East is the Middle East, North Africa and Central Asia; L. Am is Latin America and the Caribbean; and S-S Africa is Sub-Saharan Africa. Columns 2-4 are from table A12.4. See notes to table 4 of the article. All entries are $\times 100$.

Table A12.7 Multilateral Indexes of Quality of Food Consumption, Unweighted and Weighted, Commodity and Country Sensitivities

Income quartile	Unweighted	Weighted		
		Population	GDP	GDP p.c.
(1)	(2)	(3)	(4)	(5)
A. All data (31 goods and 155 countries)				
First	17.88	21.29	26.70	22.69
Second	6.04	8.02	2.77	1.81
Third	-6.26	-10.83	-14.12	-10.03
Fourth	-18.13	-18.96	-15.76	-14.86
B. Bread and cereals group omitted (26 goods and 155 countries)				
First	15.72	18.16	22.19	19.66
Second	3.79	4.69	0.81	0.48
Third	-4.57	-6.97	-9.49	-7.33
Fourth	-15.33	-16.29	-13.86	-13.15
C. USA, China, India and Japan omitted (31 goods and 151 countries)				
First	17.71	20.23	25.24	22.65
Second	6.08	7.94	3.03	1.92
Third	-5.93	-9.90	-12.67	-9.68
Fourth	-18.04	-18.43	-15.42	-14.73

Note: The entries in this table are averages over countries within each group. The population-weighted quality index for country c is $\sum_{d=1}^{155} w^{cd} y_q^{cd}$, where $w^{cd} = (w^c + w^d)/2$, with w^c the share of c in total population; and y_q^{cd} is the quality index for country c compared to d . The two other weighting schemes are analogous. For convenience, column 2 of panel A reproduces column 2 of panel A of table 5. Panel B omits the 5 goods that make up the bread and cereals group. All entries are $\times 100$.

Table A12.8 Multilateral Food Quality Indexes and Income by Country, within Quartiles

Country	Quality index of			Country	Quality index of			Country	Quality index of		
	Cons.	Prices	Spending		Cons.	Prices	Spending		Cons.	Prices	Spending
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1. Bermuda	4.0	-2.3	8.2	53. Russia	10.2	-1.5	8.7	105. Guatemala	-4.7	0.8	-3.9
2. United States	1.0	-1.5	-3.2	54. Chile	4.6	-2.6	2.1	106. Swaziland	-22.8	-2.7	-25.5
3. Cayman Isnds	-1.0	0.4	16.5	55. Estonia	21.8	-1.7	20.2	107. Fiji	-5.7	5.8	0.1
4. Hong Kong	-14.1	-0.5	-3.4	56. Turkey	2.6	-2.5	0.1	108. Paraguay	6.0	0.7	6.7
5. Norway	13.8	1.7	-8.7	57. Montserrat	0.9	3.1	4.0	109. Moldova	13.0	-2.3	10.7
6. Luxembourg	23.8	0.7	11.9	58. Uruguay	-6.5	2.9	-3.6	110. Eq. Guinea	-5.8	-2.7	-8.5
7. Switzerland	18.7	-1.2	13.1	59. Seychelles	-34.7	8.4	-26.3	111. Suriname	-5.0	3.1	-1.9
8. UAE	-25.3	3.1	-2.4	60. Latvia	14.2	0.3	14.5	112. Indonesia	-21.7	3.3	-18.4
9. Sweden	13.5	0.0	8.2	61. Antigua & Barb.	-9.2	-1.4	-10.6	113. Philippines	-19.9	2.7	-17.3
10. Germany	15.2	-2.5	-12.7	62. Montenegro	6.2	-0.3	5.8	114. Cape Verde	-3.1	1.5	-1.6
11. Australia	4.0	0.1	3.4	63. Kazakhstan	0.2	-1.3	-1.2	115. China	-8.3	3.3	-5.0
12. Austria	17.5	-0.9	6.3	64. Mexico	11.1	-1.6	9.5	116. Morocco	-6.1	-1.5	-7.6
13. Denmark	9.6	-1.5	15.3	65. Mauritius	-8.4	1.4	-7.0	117. Bhutan	-15.9	2.4	-13.6
14. Canada	4.7	-1.5	8.7	66. Malaysia	-22.3	2.5	-19.8	118. Bolivia	5.8	-0.3	5.5
15. Iceland	-3.2	-2.6	2.1	67. Virgin Islands	-4.5	-3.3	-7.8	119. Honduras	7.9	-0.2	7.7
16. Finland	17.3	-1.7	20.2	68. Panama	-22.3	3.0	-19.4	120. Kyrgyzstan	4.6	-1.7	2.9
17. France	21.2	-2.5	0.1	69. Belarus	10.9	0.3	11.2	121. Vietnam	2.6	0.3	2.9
18. Belgium	15.4	3.1	4.0	70. Romania	7.5	-0.3	7.2	122. India	-0.5	1.2	0.7
19. United Kingdom	10.3	2.9	-3.6	71. Bulgaria	13.7	-1.9	11.8	123. S.Tomé & P.	6.7	-0.6	6.2
20. Netherlands	9.1	8.4	-26.3	72. Serbia	8.4	-2.0	6.4	124. Cambodia	1.1	0.8	1.9
21. Singapore	-12.9	0.3	14.5	73. Brazil	-19.5	2.3	-17.2	125. Ghana	0.1	-0.3	-0.2
22. Taiwan	-14.9	-1.4	-10.6	74. Costa Rica	-8.6	0.7	-7.9	126. Lesotho	-5.2	0.4	-4.8
23. Aruba	-6.7	-0.3	5.8	75. Grenada	-10.0	1.0	-9.1	127. Tajikistan	5.0	-0.9	4.1
24. Macao	-33.5	-1.3	-1.2	76. Jordan	-3.7	-2.0	-5.7	128. Nigeria	-0.1	-0.1	-0.2
25. Japan	1.6	-1.6	9.5	77. Dominican Rep.	-5.6	-0.5	-6.1	129. Kenya	-0.6	-0.2	-0.8
26. Ireland	8.3	1.4	-7.0	78. Dominica	-13.8	1.3	-12.4	130. Djibouti	2.9	0.2	3.1
27. Italy	4.1	2.5	-19.8	79. St. Vin. & Gren.	4.0	-2.4	1.6	131. Cameroon	0.3	-0.3	0.0
28. Cyprus	2.1	-3.3	-7.8	80. Macedonia	13.4	-2.8	10.6	132. Côte d'Ivoire	1.9	-0.2	1.7
29. New Zealand	-0.3	3.0	-19.4	81. Thailand	0.1	2.6	2.7	133. Senegal	-0.9	0.0	-0.9
30. Spain	-0.3	0.3	11.2	82. South Africa	6.8	0.5	7.3	134. Nepal	-3.7	1.6	-2.1
31. Israel	-2.2	-0.3	7.2	83. Colombia	2.5	0.8	3.3	135. Zambia	1.6	-0.3	1.3
32. Sint Maarten	-25.0	-1.9	11.8	84. St. Lucia	7.5	1.1	8.6	136. Uganda	1.1	-0.1	1.0
33. Greece	-14.1	-2.0	6.4	85. Bosnia & Herz.	16.5	-1.8	14.8	137. Congo, Rep.	3.9	-0.4	3.6
34. Curaçao	-9.9	2.3	-17.2	86. Turks & Caicos	7.1	-0.3	6.8	138. Haiti	-6.6	0.0	-6.6
35. Malta	7.5	0.7	-7.9	87. Venezuela	2.4	5.5	7.9	139. Gambia	-1.2	0.3	-0.9
36. Portugal	-7.2	1.0	-9.1	88. Ukraine	9.5	-1.2	8.3	140. Sierra Leone	0.5	-0.9	-0.3
37. Slovenia	11.5	-2.0	-5.7	89. Tunisia	11.9	-4.2	7.7	141. Chad	2.0	0.4	2.3
38. South Korea	-26.6	-0.5	-6.1	90. Peru	1.3	0.0	1.4	142. Benin	-1.4	-0.9	-2.3
39. Qatar	-36.9	1.3	-12.4	91. Azerbaijan	9.0	-4.4	4.6	143. Rwanda	-3.2	-0.2	-3.3
40. Anguilla	10.5	-2.3	8.2	92. Belize	-1.4	-1.2	-2.6	144. Zimbabwe	-3.9	0.6	-3.3
41. Bahrain	-1.8	-1.5	-3.2	93. El Salvador	8.8	-1.5	7.3	145. Madagascar	2.5	-0.4	2.0
42. Czech	16.2	0.4	16.5	94. Ecuador	-2.2	0.3	-1.9	146. Guinea-B.	1.5	0.3	1.8
43. Bahamas	-3.0	-0.5	-3.4	95. Jamaica	4.3	0.0	4.3	147. Mali	-7.3	1.4	-6.0
44. Trini. & Tob.	-10.4	1.7	-8.7	96. Sri Lanka	-24.2	3.6	-20.6	148. Mozambique	-1.4	-0.1	-1.6
45. Poland	11.1	0.7	11.9	97. Albania	6.8	-1.9	4.9	149. Liberia	1.6	0.3	1.9
46. Slovakia	14.3	-1.2	13.1	98. Namibia	-8.0	-2.2	-10.2	150. Burkina Faso	-1.9	0.2	-1.7
47. Barbados	-5.6	3.1	-2.4	99. Botswana	-5.1	-0.5	-5.6	151. Comoros	-1.8	0.1	-1.7
48. Lithuania	8.2	0.0	8.2	100. Armenia	13.4	-4.1	9.2	152. C. Africa	1.5	-0.1	1.4
49. Oman	-10.2	-2.5	-12.7	101. Mongolia	3.9	1.7	5.6	153. Guinea	-5.1	-0.8	-5.9
50. St. Kitts & Nevis	3.4	0.1	3.4	102. Iraq	-4.1	-1.1	-5.2	154. Niger	-5.9	0.4	-5.5
51. Croatia	7.2	-0.9	6.3	103. Georgia	15.4	-3.2	12.1	155. Congo, D.R.	-4.5	0.5	-3.9
52. Hungary	16.8	-1.5	15.3	104. Gabon	0.6	2.3	2.8				

Note: Rows 1 to 39 of column 2 contain the multilateral index of quality of consumption of the 31 goods in the food basket in the 39 countries in the first income quartile. That is, with countries ordered in terms of decreasing income, the quality index for country c in the first quartile is $y_q^{c*} = \frac{1}{39} \sum_{d=1}^{39} y_q^{cd}$, where

$y_q^{cd} = \sum_{i=1}^{31} w_i^{cd} (\eta_i^{cd} - 1) (\log q_i^{cd} - \log Q^{cd})$ is the bilateral index. The values of y_q^{c*} for countries in the other three quartiles are similarly defined and are contained in the remaining rows of columns 2, 6 and 10. The quality indexes of prices and spending in the other columns are defined analogously. All entries are $\times 100$.

Table A12.9 Diet Diversity, Various Commodity Aggregations

Income quartile (1)	Budget share variance			Quantity variance		
	Total (2)	Between (3)	Within (4)	Total (5)	Between (6)	Within (7)
A. $n = 31$						
1	50.89	16.90	33.96	64.58	22.07	42.51
2	50.42	15.23	35.19	70.50	22.87	47.62
3	66.28	23.96	42.32	98.12	36.66	61.46
4	99.55	47.63	51.92	149.85	75.29	74.56
All	66.67	25.85	40.82	95.61	39.10	56.51
B. $n = 28$						
1	56.39	22.83	33.56	64.18	27.06	37.12
2	61.39	26.38	35.01	79.80	35.72	44.08
3	74.09	31.71	42.38	104.55	47.50	57.05
4	98.60	48.46	50.15	147.77	81.24	66.53
All	72.56	32.30	40.26	98.98	47.80	51.19
C. $n = 26$						
1	52.31	18.48	33.83	59.24	22.10	37.14
2	59.10	22.93	36.17	75.84	31.73	44.11
3	73.27	30.31	42.96	100.50	45.37	55.13
4	110.96	59.78	51.18	155.69	92.85	62.84
All	73.81	32.79	41.02	97.69	47.89	49.80
D. $n = 23$						
1	49.91	20.01	29.90	57.11	23.39	33.72
2	53.97	24.09	29.88	72.92	34.29	38.63
3	66.32	31.64	34.68	94.56	46.87	47.69
4	102.38	61.72	40.65	149.85	96.59	53.26
All	68.04	34.28	33.76	93.48	50.16	43.32
E. $n = 21$						
1	43.36	18.59	24.77	50.23	22.09	28.14
2	48.54	22.86	25.68	66.48	32.48	34.00
3	62.33	31.16	31.17	89.98	46.39	43.59
4	99.51	59.09	40.43	149.50	94.94	54.56
All	63.33	32.85	30.48	88.91	48.85	40.06

Note:

1. **Panel A** (number of commodities $n = 31$): This panel is reproduced from columns 2-4 of panels A and C of table 4 of the article.
2. **Panel B** ($n = 28$): Combine “Beef and veal”, “Pork, Lamb, mutton and goat” and “Poultry” into one item in the Meat and seafood group; and combine “Fresh or chilled fruit” and “Frozen, preserved or processed fruit and fruit-based products” into one item in the Fruits and vegetables group.
3. **Panel C** ($n = 26$): Combine “Rice” and “Other cereals, flour and other products” into one item in the Bread and cereals group; and combine “Fresh milk” and “Preserved milk and other milk products” into one item in the Dairy group.
4. **Panel D** ($n = 23$): Combine “Bread” and “Other bakery products” into one item in Bread and cereals; combine “Fresh, chilled or frozen fish and seafood” and “Preserved or processed fish and seafood” into one item in Meat and seafood; and combine “Cheese” and “Eggs and egg-based products” into one item in Dairy.
5. **Panel E** ($n = 21$): Combine “Butter and margarine” and “Other edible oils and fats” into one item in Dairy; and combine “Fresh or chilled vegetables other than potatoes” and “Fresh or chilled potatoes” into one item in Fruit and vegetables.
6. These combinations are cumulative.

Table A12.10 Inequality of Diet Diversity, Various Commodity Aggregations

Number of food items	Budget share variance			Quantity variance		
	Total	Between	Within	Total	Between	Within
(1)	(2)	(3)	(4)	(5)	(6)	(7)
$n = 31$	1.96	2.82	1.53	2.32	3.41	1.75
$n = 28$	1.75	2.12	1.49	2.30	3.00	1.79
$n = 26$	2.12	3.24	1.51	2.63	4.20	1.69
$n = 23$	2.05	3.08	1.36	2.62	4.13	1.58
$n = 21$	2.30	3.18	1.63	2.98	4.30	1.94

Note: The elements of this table give the diversity of diets of rich countries as compared to that of poor countries, using a cross-commodity variance as an inverse measure of diversity. The first row contains the original set of $n = 31$ food items from table 2 and is calculated using the variances from table A12.9. In each subsequent row, we combine food items and recompute the ratios. These combinations are cumulative. Table A12.9 gives details of commodity aggregations.

Figure A2.1 Two measures of food consumption

Note: Average food in country c is $\sum_{i=1}^{31} q_{ic} / 31$, where q_{ic} is per capita consumption of good item i , measured in terms of \$US, in country c ($c = 1, \dots, 155$). The volume index is $\log Q_c = \sum_{i=1}^{31} w_{ic} \log q_{ic}$, where w_{ic} is the budget share of i within food in c . The equation is for the regression of the log of average food consumption on the volume index. The “x” (“y”) refers to the variable on the horizontal (vertical) axis. Standard errors in parentheses. The solid line is the regression line.

Figure A3.1 Food diversity and income

Note: The budget share variance for country c is $\Pi_{gc} = \sum_{i=1}^{31} w_{ic} (\log w_{ic} - \log W_c)^2$, where w_{ic} is the proportion of food expenditure devoted to food item i in country c and $\log W_c = \sum_{i=1}^{31} w_{ic} \log w_{ic}$ is a weighted geometric mean of budget shares. The variance of the prices and quantities are defined analogously. Income is real income (consumption) per capita, defined as $\log(M/P)$, as the note to table 1. The equation in each panel is for a regression of the logarithm of the variance $\times 100$ on the logarithm of income. The “x” (“y”) refers to the variable on the horizontal (vertical) axis. Standard errors in parentheses.

Percent of total

Figure A3.2 Summary of variance decompositions

Figure A7.1 Scatter plots of weighted income elasticities

Note: Weighted income elasticities are from panel C of table A7.1. As the low income group in Muhammad et al. (2011) encompasses 53 percent of their sample, the average of two lowest quartiles in the current study are used as a basis for comparison given in panel C of this figure.

Figure A8.1 Bilateral food quality indexes, 155 countries in 2011

Note: Panel A is a histogram of the bilateral index of the quality of consumption of the 31 goods in the food basket in country c relative to d , $y_q^{cd} = \sum_{i=1}^{31} w_i^{cd} (\eta_i^{cd} - 1) (\log q_i^{cd} - \log Q^{cd})$, $c = 1, \dots, 155$, $d = c + 1, \dots, 155$. Here, $w_i^{cd} = (w_i^c + w_i^d)/2$ and $\eta_i^{ab} = w_i^a / (w_i^a + w_i^b) \cdot \eta_i^a + w_i^b / (w_i^a + w_i^b) \cdot \eta_i^b$ are the budget shares and income elasticities of good i for c and d ; $\log q_i^{cd} = \log(q_i^c / q_i^d)$ is relative consumption of i ; and $\log Q^{cd} = \sum_{i=1}^{31} w_i^{cd} \log q_i^{cd}$ is the Divisia volume index in c relative to d . The quality indexes of prices and spending in panels B and C are defined analogously (see the text for details). Indexes are $\times 100$.

A. Perspective I B. Perspective II

Figure A9.1 Quality and dispersion of the food basket

Note: This figure contains bivariate histograms of the quality and dispersion of the food budget in one country as compared to another, for all pairs of countries $c, d = 1, \dots, 155, c \neq d$. The index of quality of consumption for $n=31$ food items is $y_q^{cd} = \sum_{i=1}^{31} w_i^{cd} (\eta_i^{cd} - 1) (\log q_i^{cd} - \log Q^{cd})$, where, for countries c and d , w_i^{cd} is the average proportion of food expenditure devoted to item i ; η_i^{cd} is the income elasticity of this good; $\log q_i^{cd} = \log(q_i^c / q_i^d)$ is relative consumption of good i ; and $\log Q^{cd} = \sum_{i=1}^{31} w_i^{cd} \log q_i^{cd}$ is the food volume index. The difference in diversity between the two countries is the difference in the weighted quantity variances. That is, $\Pi_q^c - \Pi_q^d$, where, for country c , $\Pi_q^c = \sum_{i=1}^{31} w_{ic} (\log q_{ic} - \log Q_c)^2$, with w_{ic} the proportion of food expenditure devoted to item i , q_{ic} the quantity of i and $\log Q_c = \sum_{i=1}^{31} w_{ic} \log q_{ic}$ the volume index of total food consumption. Both variables are $\times 100$.

Figure A10.1 Agricultural assistance and income

Note: The relative rates of assistance to agriculture (RRA), from Anderson, Rausser and Swinnen (2013), are 5-year averages from 2007-2011. Of the 81 countries in Anderson, Rausser and Swinnen (2013), 11 do not have RRA values and a further 11 are not in this paper; therefore, there are 59 countries matched to our ICP data. The “x” (“y”) refers to the variable on the horizontal (vertical) axis.

Figure A10.2 Price measures, income and agricultural assistance

Note: See notes to figure A10.1.

Figure A11.1 Estimates of the food flexibility for country pairs

Note: For the pair of countries $\{c,d\}$, $\hat{\phi}_{cd}^F$ is the estimate of the food flexibility ϕ^F , the reciprocal of the elasticity of the marginal utility of income with respect to food expenditure. For all pairs $c, d = 1, \dots, 155$, the estimates form a symmetric 155×155 matrix $[\hat{\phi}_{cd}^F]$. Panel A of this figure is a histogram of the elements in the upper triangle of this matrix (the distinct elements). Panel B refers to the row means of the matrix, $1/155 \cdot \sum_{d=1}^{155} \hat{\phi}_{cd}^F$. Panel C contains the row medians.

Figure A12.1 Food dispersion and income by region

Note: The budget-share variance for country c is $\Pi_{wc} = \sum_{i=1}^{31} w_{ic} (\log w_{ic} - \log \bar{W}_c)^2$, where w_{ic} is the proportion of food expenditure devoted to food item i in country c , and $\log \bar{W}_c = \sum_{i=1}^{31} w_{ic} \log w_{ic}$ is the logarithm of the weighted geometric mean of budget shares. The variance of the prices and quantities are defined analogously. Income is real income (consumption) per capita, defined as $\log(M/P)$, as in the notes to table 1. All variances are $\times 100$. The equation in each panel is for a regression of the logarithm of the variance $\times 100$ on the logarithm of income. The “x” (“y”) refers to the variable on the horizontal (vertical) axis. Standard errors in parentheses.

Figure A12.2 Multilateral food quality indexes and income, within quartiles

Note: Panel A is a scatter plot of the multilateral index of quality of consumption of the 31 goods in the food basket in the 39 countries in the first income quartile against income. That is, with countries ordered in terms of decreasing income, the quality index for country c here is $y_q^{c*} = \frac{1}{39} \sum_{d=1}^{39} y_q^{cd}$, where $y_q^{cd} = \sum_{i=1}^{31} w_i^{cd} (\eta_i^{cd} - 1) (\log q_i^{cd} - \log Q^{cd})$ is the bilateral index; and the income measure is $\log(M/P)^c = \log(M/P)^c - \frac{1}{39} \sum_{d=1}^{39} \log(M/P)^d$. The plots for the other three quartiles have a similar interpretation. Indexes are $\times 100$. The equation in each panel is for a regression of the quality index on the logarithm of income. The “x” (“y”) refers to the variable on the horizontal (vertical) axis. Standard errors in parentheses.

Figure A13.1 Diet diversity, income and wellbeing

A. Income

(i) Budget Share of Food

(ii) Log GDP Per Capita

B. Diet Diversity

(i) Negative SD of Budget Share (%)

(ii) Negative SD of Quantity (%)

(Continued next page)

Figure A13.2 Economic determinants of life expectancy

Figure A13.2 Economic determinants of life expectancy (continued)

Note:

1. There are 155 observations for the graphs in panels A and C. In the left part of panel B, there are 154 observations owing to the omission of the US, the base case country. In the right part of panel B, there are 153 observations owing to the omission of the base case country and an outlier country, the Comoros, whose inclusion causes convergence problems with the estimation algorithm. The “x” (“y”) refers to the variable on the horizontal (vertical) axis.
2. **Panel A:** The graph on the left of this panel involves the reciprocal of the food budget share, measured as a percentage. For convenience, the labels on the horizontal axis refer to the values of the share, not the reciprocals. The horizontal variable in the graph on the right of the panel involves the logarithm of GDP per capita, which is in \$US in PPP terms.
3. **Panel B:** The standard deviation (SD) of the 31 food budget shares for country c is the square root of $\sum_{i=1}^{31} w_{ic} (\log w_{ic} - \log \bar{W}_c)^2$, where w_{ic} is the proportion of food expenditure devoted to food item i ; and $\log \bar{W}_c = \sum_{i=1}^{31} w_{ic} \log w_{ic}$. The SD of the quantities is the square root of $\sum_{i=1}^{31} w_{ic} (\log q_{ic} - \log Q_c)^2$, where q_{ic} is the per capita quantity consumed of food item i ; and $\log Q_c = \sum_{i=1}^n w_{ic} \log q_{ic}$ is the Divisia volume index of food. As the SD is an inverse measure of diet diversity and as we use a logarithmic formulation, the negative of the SD is used in this panel.
4. **Panel C:** The index of food quality for country c in this panel is the multilateral index $(1/155) \sum_{d=1}^{155} y_q^{cd}$. This is an average of all pairs of the bilateral indexes involving c , $y_q^{cd} = \sum_{i=1}^{31} w_i^{cd} (\eta_i^{cd} - 1) (\log q_i^{cd} - \log Q^{cd})$. Here, $w_i^{cd} = (w_i^c + w_i^d)/2$, and $\eta_i^{cd} = \lambda_i \eta_i^c + (1 - \lambda_i) \eta_i^d$, with $\lambda_i = w_i^c / (w_i^c + w_i^d)$ and η_i^c the conditional income elasticity of food item i in c ; $\log q_i^{cd} = \log(q_i^c / q_i^d)$; and $\log Q^{cd} = \sum_{i=1}^n w_i^{cd} \log q_i^{cd}$.