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PRICE ELASTICITIES OF FOOD DEMAND: COMPENSATED VS UNCOMPENSATED*

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Abstract

Cornelsen et al. (2014) and Green et al. (2013) provide a comprehensive review/summary of a large number of recent estimates of the price elasticity of food consumption using a meta-regression approach. In this letter, we introduce a way of removing the income effect from these elasticities to recover the compensated elasticities. Although the income effect is small, the compensated elasticities vary by income group. Both types of elasticity should possibly be considered when assessing the impact of policy changes on food consumption.

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1. Introduction

In two recent papers, Cornelsen et al. (2014) and Green et al. (2013) summarise 78 studies of food demand carried out since 1990 using a meta-regression approach. These two papers represent a major contribution in synthesising such a large body of research by providing centre-of-gravity uncompensated price elasticities for seven food items in three groups of countries, distinguished by income per capita.[1] These elasticities answer the question, what is the impact of a price rise on consumption when consumers' money income is held constant? But for some purposes it is useful to know the response when consumers' real income remains unchanged.[2] In this letter, we show how compensated elasticities can be recovered from the uncompensated elasticities reported by Cornelsen et al. (2014).

2. Consumption Theory

Let p_i and q_i be the price and quantity demand of good i $(i = 1,\ldots,n)$, so that $M = \Sigma_{i=1}^{n} p_i q_i$ is total expenditure ("income" for short) and $w_i = p_i q_i / M$ is the i^{th} budget share. The Slutsky equation links the compensated and uncompensated elasticities as follows:

(1) $$\eta_{ij}^{*} = \eta_{ij} + w_j \eta_i$$

Here,

$$\eta_{ij}^{*} = \left. \frac{\partial(\log q_i)}{\partial(\log p_j)} \right|_{\substack{\text{utility}\\ \text{constant}}}$$

is the $(i, j)^{th}$ compensated price elasticity (the substitution effect), η_{ij} the uncompensated elasticity, $w_j \eta_i$ the income effect with $\eta_i = \partial(\log q_i)/\partial(\log M)$ the income elasticity of good i. In the spirit of "want-independence" of Frisch (1959, propositions 56 and 56a, p. 185), we make the simplifying assumption that the marginal utility of consumption of each good is

[1] Cornelsen et al. (2014) draw upon the estimated own-price elasticities from Green et al. (2013), which is based on 136 studies over the same time period.

[2] For example, suppose a tax is imposed on consumption of good j and the revenue from the tax is redistributed back to consumers as a lump sum. This keeps real income unchanged and the impact of a one-percent rise in the price of j on the consumption of i is given by the $(i, j)^{th}$ compensated elasticity. But note that lump-sum transfers mean there can be no distributional effects. That is, with lump-sum transfers, intensive consumers of good j do not receive full compensation for the price rise, so there is an income transfer from intensive to non-intensive consumers. The overall effect of this depends on differences across groups in marginal propensities to spend. Note also the case in which tax revenues are earmarked for health programs: If these programs are valued at their cost by consumers, then, effectively, real income remains unchanged and the compensated elasticity is the relevant concept to use. If the programs are wasteful, however, real income falls and in the extreme when the programs are valueless, the uncompensated elasticity is to be used. For intermediate cases, a weighted average of the two elasticities can be used.

independent of the consumption of the others ("preference independence"). Under preference independence, the consumer's utility function is (some increasing function of) the sum of n sub-utility functions, one for each good: $u(q_1,...,q_n)=\Sigma_{i=1}^n u_i(q_i)$, with $u_i(\cdot)$ the i^{th} sub-utility function that depends only on the consumption of good i.

Given the prices, the consumer chooses the consumption basket to maximise utility, $\Sigma_{i=1}^n u_i(q_i)$, subject to the budget constraint, $M=\Sigma_{i=1}^n p_i q_i$. Differentiating the budget constraint with respect to income and p_j yields $\Sigma_{i=1}^n \partial(p_i q_i)/\partial M = 1$ and $\Sigma_{i=1}^n p_i(\partial q_i/\partial p_j)+q_j=0,$ which can be expressed as

$$(2)\qquad \sum_{i=1}^n w_i\eta_i = 1, \qquad \sum_{i=1}^n w_i\eta_{ij} + w_j = 0.$$

Denoting by λ the marginal utility of income, the i^{th} first-order condition for a budget-constrained utility maximum is $\log u_i' = \log\lambda + \log p_i$, where the prime denotes a first derivative. Using $\Sigma_{i=1}^n u_i(q_i)$, we differentiate the first-order condition with respect to $\log M$ and $\log p_j$ to yield

$$\frac{\partial \log u_i'}{\partial \log q_i}\eta_i = \phi^{-1}, \qquad \frac{\partial \log u_i'}{\partial \log q_i}\eta_{ij} = \frac{\partial \log\lambda}{\partial \log p_j} + \delta_{ij},$$

where $\phi^{-1} = \partial(\log\lambda)/\partial(\log M)$ is the income elasticity of λ (the reciprocal of the "income flexibility") and δ_{ij} is the Kronecker delta ($\delta_{ij}=1$ if $i=j$, 0 otherwise).[3] Combining the above two equations gives

$$(3)\qquad \eta_{ij} = \phi\frac{\partial\log\lambda}{\partial\log p_j}\eta_i + \delta_{ij}\phi\eta_i,$$

which we multiply by the budget share of i, w_i, and then sum both sides over $i=1,\ldots,n$ to give

$$\sum_{i=1}^n w_i\eta_{ij} = \phi\frac{\partial\log\lambda}{\partial\log p_j}\sum_{i=1}^n w_i\eta_i + \phi\sum_{i=1}^n \delta_{ij}w_i\eta_i = \phi\frac{\partial\log\lambda}{\partial\log p_j} + \phi w_j\eta_j,$$

[3] In the general case in which there is preference dependence, the marginal utility of good i, $\partial u/\partial q_i$, depends on the consumption of all goods and

$$\frac{\partial(\log\partial u/\partial q_i)}{\partial(\log x)} = \sum_{j=1}^n \frac{\partial(\log\partial u/\partial q_i)}{\partial(\log q_j)}\frac{\partial(\log q_j)}{\partial(\log x)}, \quad x = M, p_j, \quad j=1,\ldots,n.$$

Under preference independence, the cross derivatives vanish and only the ith term in the summation on the right of this equation remains.

which follows from the first member of (2). Combining this with the second member of (2) gives $\partial \log \lambda / \partial \log p_j = -w_j \left(\eta_j + \phi^{-1} \right)$, which when substituted back into (3), yields

(4) $$\eta_{ij} = \phi \eta_i \left(\delta_{ij} - w_j \eta_j \right) - w_j \eta_i .^4$$

3. Application to Food

We use equations (1) and (4) to derive the compensated price elasticities. The uncompensated elasticities for seven food items are from Cornelsen et al. (2014) and the budget shares w_j are from the 2005 International Comparison Program (World Bank, unpublished). We treat the values of the seven income elasticities $\eta_1,...,\eta_7$ and the income flexibility as unknown. The income elasticities of the food items are a weighted average of the income elasticity of all food $\left(\eta_F \right)$, available from Gao (2012):

(5) $$\sum_{i=1}^{7} \left(\frac{w_i}{W_F} \right) \eta_i = \eta_F ,$$

where $W_F = \Sigma_{i=1}^{7} w_i$ is the budget share of all food. Equation (4) for $i, j = 1,...7$ is a system of 49 equations which is overdetermined and has no exact unique solution. Thus, we add an error term $\left(\varepsilon_{ij} \right)$ to give $\eta_{ij} = \phi \eta_i \left(\delta_{ij} - w_j \eta_j \right) - w_j \eta_i + \varepsilon_{ij}$ and then minimise the sum of squared errors:

(6) $$\mathrm{Min}_{\eta_1,...,\eta_7,\phi} \sum_{i=1}^{7} \sum_{j=1}^{7} \left[\eta_{ij} - \phi \eta_i \left(\delta_{ij} - w_j \eta_j \right) + w_j \eta_i \right]^2 ,$$

subject to constraint (5) for a given value of η_F and the constraint that all income elasticities are positive.

Table 1 gives the budget shares for the food items and the total, as well as the food income elasticity. Two comments can be made. First, column 9 reveals that low-income countries on average spend 35 percent of their income on food, while this falls to 9 percent for the high-income countries, which reflects Engel's law. Second, cereals are clearly the single most important item in low-income countries (column 6) with a budget share of 11 percent. For the high-income countries, there is more diversification of food spending, with no single commodity clearly dominating.

[4] Under preference independence, income elasticities are positive.

The solution to problem (6) yields estimates of seven income elasticities and the income flexibility, to be denoted by $\hat{\eta}_1, ..., \hat{\eta}_7$ and $\hat{\phi}$. There are then two ways of deriving the compensated elasticities:

- *Approach I*: Combine equations (1) and (4) and then substitute the estimated income elasticities and the income flexibility, together with the budget shares. This gives the estimated compensated elasticities, $\hat{\eta}^*_{ij} = \hat{\phi}\hat{\eta}_i \left(\delta_{ij} - w_j \hat{\eta}_j\right)$, $i, j = 1, ..., 7$.
- *Approach II*: *S*ubstitute into Slutsky equation (1) the uncompensated elasticities from Cornelsen et al. (2014), the budget shares and the estimates of the income elasticities. This gives an alternative set of estimated compensated elasticities, $\tilde{\eta}^*_{ij} = \eta_{ij} + w_j \hat{\eta}_i$, $i, j = 1, ..., 7$.

The difference between the two approaches is that the second does not rely so much on the assumption of preference independence as equation (4) is bypassed. Thus, this approach might possibly be preferred as it is somewhat more general. However, as minimisation problem (6) is based on preference independence, that assumption still plays a role in determining the estimated income elasticities. A further difference is that the estimates from Approach I satisfy demand homogeneity and Slutsky symmetry, while this is not the case for Approach II.[5] In what follows, we present the results from Approach I, although these are not too different from those of Approach II (see Appendix).

4. Results

The estimated income elasticities and income flexibility are given in Table 2 and as can be seen, all the food income elasticities are less than unity, so the goods are necessities. For each of the three income groups, the item "Fish" has the highest income elasticity, whilst "Cereals" and "Fats and oils" have the lowest and are thus viewed as more of necessities by consumers. The absolute value of the income flexibility increases with income, which supports the famous conjecture by Frisch (1959, p. 189), but the values are somewhat larger in absolute value than previous estimates (Clements and Zhao, 2009, pp. 227-29).

The estimated compensated price elasticities are given in Table 3. Thus, for example, for low income countries the compensated own-price elasticity for Fruit and Vegetables is -0.669 (first element of column 2), while the corresponding uncompensated version is -0.720

[5] A set of sufficient conditions for the two approaches to give identical results this is when the income flexibility equals –1, each income elasticity is unity, each uncompensated own-price elasticity –1 and each uncompensated cross-price elasticity zero. These conditions are satisfied by a Cobb-Douglas utility function, but are restrictive.

(Cornelsen et al., 2014). Table 4 reports the compensated/uncompensated differences, which are the income effects. Three comments can be made. First, as indicated by equation (1), the size of the income effect depends on the relative importance of the good in the budget (its budget share) and the income elasticity. As both these concepts take only modest values in the case of the seven food items, the income effects will also be modest, as Table 4 reveals. Second, the largest income effect is for meat in low-income countries, which reflects the combined effect of this good's relatively high budget share and income elasticity. Third, all income effects decline as we move from low- to medium- to high-income countries. The reason is that as income rises, the budget share and the income elasticity of each food item declines.[6] The decline in the compensated elasticities is consistent with Timmer's (1980) hypothesis of a "curvature" in the Slutsky matrix.

5. Concluding Comments

When the objective is to use a tax instrument to limit consumption of a certain item by raising its price to consumers, the value of the price elasticity of demand is key. The rule is

$$\text{Required price increase} = \frac{\text{Requred reduction in consumption}}{\text{Price elasticity}}.$$

For example, a 25-percent reduction in consumption requires a 50-percent price increase if the elasticity is -1/2. There are two types of price elasticity, (i) the uncompensated version that holds constant consumers' money (or nominal) income; and (ii) the compensated version in which real income is constant. Both the uncompensated and compensated elasticities contain information that is of considerable value to policy makers in understanding consumer response to price changes that result from policy changes.

Cornelsen et al. (2014) and Green et al. (2013) made a major contribution in reviewing a large number of recent studies of food demand and summarising the price elasticities for seven important food items with a meta-regression approach. In this letter, we showed how to covert these uncompensated elasticities into their compensated counterparts. The difference between the two elasticities depends on the relative importance of the good in consumers' budgets and the income elasticity. In the case of the seven food items, these differences are not large, but still the compensated elasticities could be of some use. To reflect the underlying uncertainty of behaviour, the two elasticities could be used together to

[6] Using the estimates of the compensated elasticities from Approach I, together with the budget shares and the estimated income elasticities, in equation (1) gives estimates of the uncompensated elasticities, $\hat{\eta}_{ij}$. As shown in the Appendix, the estimated own-price uncompensated elasticities are very close to their actual counterparts. However, the estimated cross-price elasticities are a good distance away from the actuals.

provide a range of possible consumer responses when modelling the impact of food taxes/subsidies.

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Table 1 Food budget shares and income elasticities

Income group	Budget shares w_i, W_F								Food income elasticity η_F
	Fruits & vegs	Meat	Fish	Dairy	Cereals	Fats and oils	Sweets	Total food	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Low	0.089	0.068	0.030	0.030	0.112	0.024	0.021	0.353	0.819
Medium	0.042	0.051	0.010	0.025	0.036	0.009	0.013	0.186	0.517
High	0.020	0.023	0.008	0.012	0.016	0.003	0.008	0.089	0.313

Notes:

1. Budget shares are calculated using the disaggregated expenditure data from the International Comparison Program (ICP) dataset supplied by the World Bank (unpublished). See the Appendix for details.
2. Food income elasticities from Gao (2012) are averaged across countries by income group.

Table 2 Estimated income elasticities and income flexibility

Income group	Income elasticities η_i								Income flexibility ϕ
	Fruits & vegs	Meat	Fish	Dairy	Cereals	Fats and oils	Sweets	Non-food	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Low	0.827	0.888	0.902	0.886	0.756	0.681	0.851	1.108	-0.873
Medium	0.508	0.560	0.573	0.564	0.432	0.426	0.537	1.110	-1.265
High	0.304	0.344	0.351	0.345	0.248	0.242	0.322	1.067	-1.736

Table 3 Compensated price elasticities

Group (1)	Fruits & vegetables (2)	Meat (3)	Fish (4)	Dairy (5)	Cereals (6)	Fats and oils (7)	Sweets (8)	Non-Food (9)
				A. Low Income				
Fruits & vegetables	-0.669	0.043	0.019	0.019	0.061	0.012	0.013	0.500
Meat	0.057	-0.728	0.021	0.021	0.066	0.013	0.014	0.537
Fish	0.058	0.047	-0.766	0.021	0.067	0.013	0.014	0.546
Dairy	0.057	0.047	0.021	-0.753	0.065	0.013	0.014	0.536
Cereals	0.048	0.040	0.018	0.018	-0.604	0.011	0.012	0.458
Fats and oils	0.044	0.036	0.016	0.016	0.050	-0.585	0.011	0.413
Sweets	0.055	0.045	0.020	0.020	0.063	0.012	-0.729	0.515
Non-Food	0.071	0.058	0.026	0.026	0.082	0.016	0.018	-0.296
				B. Medium Income				
Fruits & vegetables	-0.629	0.018	0.004	0.009	0.010	0.002	0.004	0.581
Meat	0.015	-0.688	0.004	0.010	0.011	0.003	0.005	0.641
Fish	0.015	0.021	-0.721	0.010	0.011	0.003	0.005	0.656
Dairy	0.015	0.020	0.004	-0.703	0.011	0.003	0.005	0.645
Cereals	0.012	0.016	0.003	0.008	-0.538	0.002	0.004	0.495
Fats and oils	0.011	0.015	0.003	0.007	0.008	-0.537	0.004	0.487
Sweets	0.014	0.019	0.004	0.009	0.011	0.003	-0.674	0.614
Non-Food	0.030	0.040	0.008	0.019	0.022	0.005	0.010	-0.135
				C. High Income				
Fruits & vegetables	-0.524	0.004	0.001	0.002	0.002	0.000	0.001	0.512
Meat	0.004	-0.593	0.002	0.002	0.002	0.000	0.002	0.581
Fish	0.004	0.005	-0.607	0.002	0.002	0.000	0.002	0.592
Dairy	0.004	0.005	0.002	-0.596	0.002	0.000	0.002	0.581
Cereals	0.003	0.003	0.001	0.002	-0.428	0.000	0.001	0.418
Fats and oils	0.002	0.003	0.001	0.002	0.002	-0.419	0.001	0.408
Sweets	0.003	0.004	0.002	0.002	0.002	0.000	-0.558	0.544
Non-Food	0.011	0.014	0.005	0.008	0.007	0.001	0.005	-0.052

Note:
To complete the demand system, a "non-food" group is added so there are $n = 7+1 = 8$ goods. The non-food income elasticity is derived from the requirement that $\Sigma_{i=1}^{8} w_i \eta_i = 1$, where w_i and η_i are the budget share and income elasticity of good i, with $w_8 = 1 - \Sigma_{i=1}^{7} w_i$ the non-food budget share.

Table 4 Income effects of price changes

Group (1)	Fruits & vegetables (2)	Meat (3)	Fish (4)	Dairy (5)	Cereals (6)	Fats and oils (7)	Sweets (8)
			A. Low Income				
Uncompensated elasticity η_{ii}	-0.720	-0.780	-0.800	-0.780	-0.610	-0.600	-0.740
Compensated elasticity $\hat{\eta}_{ii}^{*}$	-0.669	-0.728	-0.766	-0.753	-0.604	-0.585	-0.729
Income effect	0.051	0.052	0.034	0.027	0.006	0.015	0.011
			B. Medium Income				
Uncompensated elasticity η_{ii}	-0.650	-0.720	-0.730	-0.720	-0.550	-0.540	-0.680
Compensated elasticity $\hat{\eta}_{ii}^{*}$	-0.629	-0.688	-0.721	-0.703	-0.538	-0.537	-0.674
Income effect	0.021	0.032	0.009	0.017	0.012	0.003	0.006
			C. High Income				
Uncompensated elasticity η_{ii}	-0.530	-0.600	-0.610	-0.600	-0.430	-0.420	-0.560
Compensated elasticity $\hat{\eta}_{ii}^{*}$	-0.524	-0.593	-0.607	-0.596	-0.428	-0.419	-0.558
Income effect	0.006	0.007	0.003	0.004	0.002	0.001	0.002

Note:
Uncompensated elasticities are from Cornelsen et al. (2014) and compensated elasticities from Table 3.

Appendix

The Data

Uncompensated price elasticities from Cornelsen et al. (2014) are reproduced in Table A1. Purchasing power parities and nominal expenditures on 129 disaggregated components of GDP in 146 countries are from the 2005 International Comparison Program (ICP) data (World Bank, unpublished). The 29 food categories and their broad group classifications are given in Table A2. The commodities in the last four rows of Table A2 would typically be considered as part of food consumption; however, Cornelsen et al. (2014) omit price elasticities for “Eggs” and “Other foods” due to the low number of observations for the former and the majority of observations coming from one study for the latter. Therefore, we omit these groups.

Of the 146 countries in the ICP data, 16 countries were dropped as they had little or no expenditure on certain food items, be it for income, geographical, religious or other reasons. Two more countries were also dropped as they did not submit national accounts data to the ICP. Lastly, four remaining countries were omitted as they did not appear in the Gao (2012), the source of the income elasticity for food. The number of countries is thus $146-16-2-4=124$ countries.

Income Groups

Countries are grouped by income using the approach of Cornelsen et al. (2014), which is based on Muhammad et al. (2011). They divide countries into low-, middle-, and high-income countries on the basis of their real income per capita relative to that of the United States, using the 2005 ICP data. Low-income countries are those with 15 percent or less income relative to the United States, middle-income are those between 15 and 45 percent, while high-income countries have income equal to or greater than 45 percent the United States. We cross-checked our 124 countries with those reported Muhammad et al. (2011) to ensure income groups are properly assigned and they agree with the dataset that Cornelsen et al. (2014) sent us. The 124 countries, and the income groupings, are listed in Table A3 along with our own calculations of real income per capita. While this allocation of countries to income groups agrees with Cornelsen et al. (2014) and Muhammad et al. (2011), there are some minor inconsistencies with income. Our measure of real income per capita that is presented in Table A3 differs slightly from Muhammad et al. (2011). It is for this reason why some low-income countries have higher incomes than middle income countries. Take the case of country 58, Tajikistan, which has an income of $7,010 and is classified as a low-income country. But this income is higher than that of countries 59-66, all of which are classified as middle-income countries. A similar problem occurs with countries near the high-income "border". We judge this issue to be of relatively minor importance that is unlikely to have a substantial impact on the results.

More on Preference Independence

Combining equations (1) and (4), under preference independence the compensated elasticities are related to the income elasticities according to

$$\eta_{ij}^{*} = \phi\eta_i\left(\delta_{ij} - w_j\eta_j\right), \; i, j = 1, \ldots, n.$$

Preference independence also implies that the income elasticities are positive, which, as $\phi < 0$, means that $\eta_{ij}^{*} > 0, \; i \neq j.$

Approach II for Compensated Elasticities

Compensated elasticities estimated from Approach II are given in Table A4. Note the similarities in estimated values compared to Approach I in Table 3 of the text. When Approach II is used, there is a tendency for the absolute values of the elasticities to be lower compared to Approach I, but most of the differences are small. Figure A1 confirms the closeness of the two sets of results for the own-price elasticities. The only item some distance away from the 45-degree line is cereals, especially for the low-income countries, reflecting the large budget share of this good. As the compensated elasticity estimates are similar for both approaches, they also yield broadly similar income effects.

Note that the two approaches give identical results when $\hat{\phi}\hat{\eta}_i\left(\delta_{ij} - w_j\hat{\eta}_j\right) = \eta_{ij} + w_j\hat{\eta}_i$. A set of sufficient conditions for this is when the income flexibility equals –1, each income elasticity is unity, each uncompensated own-price elasticity –1 and each uncompensated cross-price elasticity zero. These are restrictive conditions.

The Implied Uncompensated Elasticities

Table A5 contains the estimated uncompensated elasticities using Approach I. These are obtained from equation (1) by substituting into the right-hand side the estimated compensated elasticities of Table 3 and the budget shares and income elasticities of Tables 1 and 2, respectively. Figure A2 demonstrates that for the own-price uncompensated elasticities, the estimates from Approach I and actual values are in close agreement, with the possible exception of cereals. As for Approach II actual and estimated coincide, a similar comparison is not meaningful.

Cross Price Elasticities

For the estimated uncompensated cross-price elasticities (unreported), they are a good distance away from the actuals from in Cornelsen et al. (2014). This reflects the nature of problem (6): The own-price elasticities from Cornelsen et al. (2014) are large relative to the own-price elasticities, so the squared errors of the former also tend to be relatively large. As all the squared errors (the own- and cross-price ones) are summed, the solution to the minimisation problem emphasises accurate prediction the own-price elasticities at the expense of the cross-price elasticities. Such an implication is not unreasonable as the own-price elasticities are more economically important than the cross-price ones.

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Table A1 Uncompensated price elasticities from Cornelsen et al. (2014)

Commodity	Fruits & vegetables	Meat	Fish	Dairy	Cereals	Fats and oils	Sweets	Non-Food
				A. Low Income				
Fruits & vegetables	-0.720	0.005	-0.014	-0.001	0.065	-0.014	0.112	-
Meat	0.020	-0.780	-0.008	0.011	0.062	0.016	0.101	-
Fish	0.014	0.045	-0.800	-0.003	0.092	0.031	0.098	-
Dairy	-0.001	0.003	-0.020	-0.780	0.117	0.042	0.108	-
Cereals	0.009	0.003	-0.010	0.068	-0.610	0.006	0.100	-
Fats and oils	0.012	-0.043	-0.061	0.022	0.071	-0.600	0.094	-
Sweets	0.022	0.003	-0.004	0.033	0.074	0.022	-0.740	-
Non-Food	-	-	-	-	-	-	-	-
				B. Medium Income				
Fruits & vegetables	-0.650	-0.026	-0.079	-0.058	0.007	-0.039	0.034	-
Meat	0.001	-0.720	-0.073	-0.045	0.005	-0.010	0.024	-
Fish	-0.004	0.014	-0.730	-0.059	0.035	0.005	0.021	-
Dairy	-0.020	-0.028	-0.085	-0.720	0.060	0.016	0.031	-
Cereals	-0.010	-0.028	-0.076	0.012	-0.550	-0.020	0.023	-
Fats and oils	-0.006	-0.074	-0.126	-0.035	0.014	-0.540	0.017	-
Sweets	0.003	-0.028	-0.069	-0.024	0.017	-0.003	-0.680	-
Non-Food	-	-	-	-	-	-	-	-
				C. High Income				
Fruits & vegetables	-0.530	0.002	0.010	-0.030	0.048	-0.033	0.060	-
Meat	-0.009	-0.600	0.016	-0.018	0.045	-0.003	0.049	-
Fish	-0.015	0.042	-0.610	-0.032	0.075	0.012	0.046	-
Dairy	-0.030	0.001	0.004	-0.600	0.100	0.023	0.057	-
Cereals	-0.020	0.000	0.013	0.039	-0.430	-0.013	0.048	-
Fats and oils	-0.017	-0.046	-0.037	-0.007	0.054	-0.420	0.043	-
Sweets	-0.007	0.000	0.020	0.004	0.057	0.003	-0.560	-
Non-Food	-	-	-	-	-	-	-	-

Note:
Two typographic errors regarding signs in Table 3 of Cornelsen et al. (2014) have been corrected (the own-price elasticities for “Meat” and “Fish”). These errors were confirmed in correspondence with Rosemary Green, one of the authors of that study.

Table A2 ICP Basic Headings

No. (1)	ICP Category (2)	Assigned Group (3)
1.	1101111 Rice	Cereals
2.	1101112 Other cereals and flour	Cereals
3.	1101113 Bread	Cereals
4.	1101114 Other bakery products	Cereals
5.	1101115 Pasta products	Cereals
6.	1101121 Beef and veal	Meat
7.	1101122 Pork	Meat
8.	1101123 Lamb, mutton and goat	Meat
9.	1101124 Poultry	Meat
10.	1101125 Other meats and preparations	Meat
11.	1101131 Fresh or frozen fish and seafood	Fish
12.	1101132 Preserved fish and seafood	Fish
13.	1101141 Fresh milk	Dairy
14.	1101142 Preserved milk and milk products	Dairy
15.	1101143 Cheese	Dairy
16.	1101151 Butter and margarine	Fats and oils
17.	1101153 Other edible oils and fats	Fats and oils
18.	1101161 Fresh or chilled fruit	Fruits and vegetables
19.	1101162 Frozen, preserved or processed fruits	Fruits and vegetables
20.	1101171 Fresh or chilled vegetables	Fruits and vegetables
21.	1101172 Fresh or chilled potatoes	Fruits and vegetables
22.	1101173 Frozen or preserved vegetables	Fruits and vegetables
23.	1101181 Sugar	Sweets
24.	1101182 Jams, marmalades and honey	Sweets
25.	1101183 Confectionery, chocolate and ice cream	Sweets
26.	1101144 Eggs and egg-based products	Omitted
27.	110119 Food products n.e.c.	Omitted
28.	110121 Coffee, tea and cocoa	Omitted
29.	110122 Mineral waters, soft drinks, fruit and vegetable juices	Omitted

Source: World Bank (unpublished).

Table A3 Countries by income group

#	Country	Real income per capita. ($US, PPP)	#	Country	Real income per capita ($US, PPP)
(1)	(2)	(3)	(4)	(5)	(6)
	A. Low Income		63.	Uruguay	6,477
1.	Guinea-Bissau	338	64.	South Africa	6,720
2.	Niger	362	65.	Montenegro	6,893
3.	Liberia	420	66.	Bosnia and Herzegovina	6,921
4.	Mozambique	458	67.	Chile	7,160
5.	Central African Republic	473	68.	Macedonia, FYR	7,171
6.	Rwanda	669	69.	Argentina	7,175
7.	Malawi	696	70.	Oman	7,302
8.	Burkina Faso	704	71.	Saudi Arabia	7,834
9.	Nepal	704	72.	Ukraine	8,195
10.	Côte d'Ivoire	803	73.	Romania	8,678
11.	Madagascar	844	74.	Serbia	9,128
12.	Sierra Leone	905	75.	Iran, Islamic Rep.	9,137
13.	Senegal	928	76.	Bulgaria	9,204
14.	Guinea	928	77.	Mauritius	9,428
15.	Benin	955	78.	Mexico	9,649
16.	Ghana	984	79.	Croatia	10,223
17.	Mauritania	993	80.	Russian Federation	10,414
18.	Cameroon	1,158	81.	Kazakhstan	10,996
19.	Sudan	1,242	82.	Macao, China	11,235
20.	São Tomé and Principe	1,260	83.	Latvia	11,711
21.	Nigeria	1,276	84.	Bahrain	12,171
22.	Kenya	1,454	85.	Poland	12,212
23.	India	1,488	86.	Slovak Republic	12,230
24.	Cambodia	1,649	87.	Belarus	12,309
25.	Yemen, Rep.	1,710	88.	Lithuania	12,709
26.	Indonesia	1,844	89.	Estonia	12,764
27.	Congo, Rep.	1,870	90.	Korea, Rep.	13,533
28.	China	1,923	91.	Czech Republic	13,944
29.	Morocco	1,964	92.	Hungary	13,974
30.	Pakistan	1,975	93.	Slovenia	14,956
31.	Philippines	2,071	94.	Brunei Darussalam	15,380
32.	Vietnam	2,223	95.	Israel	17,537
33.	Iraq	2,271		C. High Income	
34.	Cape Verde	2,456	96.	Portugal	14,528
35.	Mongolia	2,663	97.	Kuwait	15,838
36.	Lesotho	2,715	98.	Cyprus	16,087
37.	Sri Lanka	2,781	99.	Singapore	16,471
38.	Paraguay	2,948	100.	Malta	16,911
39.	Syrian Arab Republic	3,330	101.	Greece	17,510
40.	Equatorial Guinea	3,636	102.	New Zealand	17,988
41.	Swaziland	3,709	103.	Qatar	18,230
42.	Fiji	3,785	104.	Spain	18,275
43.	Namibia	3,842	105.	Italy	18,433
44.	Peru	4,161	106.	Finland	20,322
45.	Ecuador	4,472	107.	Taiwan, China	20,430
46.	Bolivia	4,562	108.	Hong Kong, China	20,658
47.	Tunisia	4,616	109.	Germany	20,799
48.	Egypt, Arab Rep.	4,691	110.	Ireland	21,391
49.	Jordan	4,713	111.	Belgium	21,563
50.	Georgia	4,715	112.	France	21,966
51.	Gabon	4,870	113.	Japan	22,088
52.	Botswana	4,955	114.	Denmark	22,345
53.	Kyrgyz Republic	4,998	115.	Austria	22,471
54.	Azerbaijan	5,251	116.	Australia	22,519
55.	Albania	5,398	117.	Switzerland	22,828
56.	Armenia	5,584	118.	Canada	23,439
57.	Moldova	5,661	119.	Sweden	23,866
58.	Tajikistan	7,010	120.	United Kingdom	25,389
	B. Middle Income		121.	Norway	26,728
59.	Venezuela, RB	5,362	122.	Iceland	28,308
60.	Malaysia	5,794	123.	United States	29,999
61.	Turkey	6,139	124.	Luxembourg	33,057
62.	Brazil	6,201			

Note: Real income per capita in columns 3 and 6 is real total consumption, based on our own calculations using 2005 ICP data from the World Bank (unpublished). This is the sum over expenditures of the 116 consumption categories, each deflated by the population and the respective PPP.

Table A4 Compensated price elasticities, Approach II

Group	Fruits & vegetables	Meat	Fish	Dairy	Cereals	Fats and oils	Sweets	Non-Food
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
				A. Low Income				
Fruits & vegetables	-0.647	0.061	0.011	0.024	0.158	0.006	0.130	-
Meat	0.099	-0.720	0.018	0.038	0.161	0.038	0.120	-
Fish	0.094	0.106	-0.773	0.024	0.193	0.053	0.117	-
Dairy	0.078	0.063	0.006	-0.753	0.216	0.064	0.127	-
Cereals	0.076	0.054	0.013	0.091	-0.525	0.024	0.116	-
Fats and oils	0.073	0.003	-0.041	0.042	0.147	-0.583	0.109	-
Sweets	0.098	0.061	0.021	0.058	0.169	0.043	-0.722	-
Non-Food	-	-	-	-	-	-	-	-
				B. Medium Income				
Fruits & vegetables	-0.629	0.000	-0.074	-0.045	0.025	-0.035	0.041	-
Meat	0.024	-0.691	-0.067	-0.031	0.025	-0.005	0.031	-
Fish	0.020	0.043	-0.724	-0.045	0.056	0.010	0.028	-
Dairy	0.004	0.001	-0.079	-0.706	0.080	0.021	0.038	-
Cereals	0.008	-0.006	-0.072	0.023	-0.534	-0.016	0.029	-
Fats and oils	0.012	-0.052	-0.122	-0.025	0.029	-0.536	0.023	-
Sweets	0.026	-0.001	-0.064	-0.011	0.036	0.002	-0.673	-
Non-Food	-	-	-	-	-	-	-	-
				C. High Income				
Fruits & vegetables	-0.524	0.009	0.012	-0.026	0.053	-0.032	0.062	-
Meat	-0.002	-0.592	0.019	-0.014	0.051	-0.002	0.052	-
Fish	-0.008	0.050	-0.607	-0.028	0.081	0.013	0.049	-
Dairy	-0.023	0.009	0.007	-0.596	0.106	0.024	0.060	-
Cereals	-0.015	0.006	0.015	0.042	-0.426	-0.012	0.050	-
Fats and oils	-0.012	-0.041	-0.035	-0.004	0.058	-0.419	0.045	-
Sweets	-0.001	0.007	0.023	0.008	0.062	0.004	-0.557	-
Non-Food	-	-	-	-	-	-	-	-

Note:

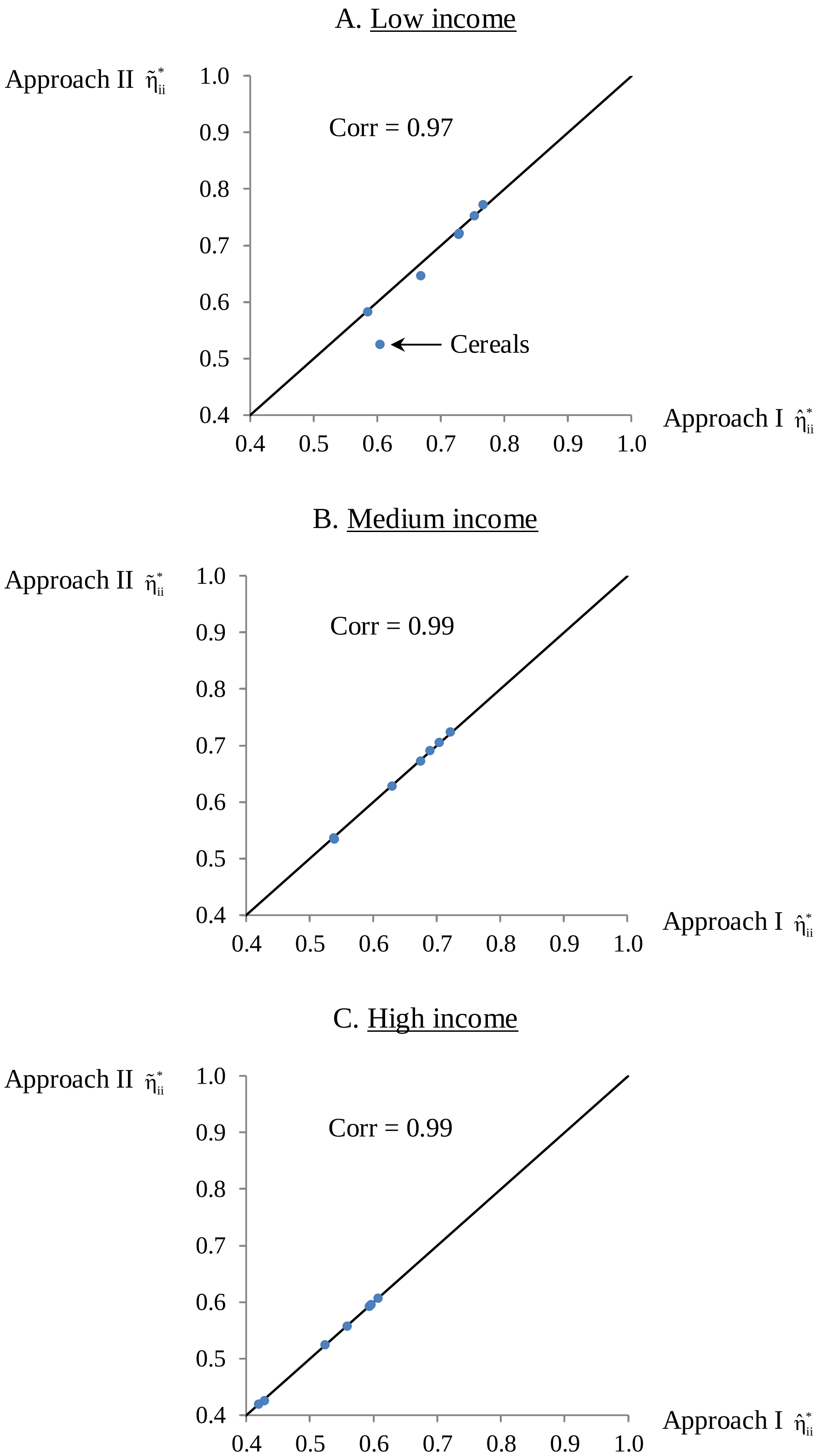
Denote by η_{ij} the $(i,j)^{th}$ uncompensated price elasticity from Cornelsen et al. (2014), w_j the budget share of j and $\hat{\eta}_i$ the estimated value of the i^{th} income elasticity. According to Approach II, the compensated price elasticities are derived from equation (1): $\tilde{\eta}^*_{ij} = \eta_{ij} + w_j \hat{\eta}_i$, $i, j = 1, \ldots, 7$.

Table A5 Estimated uncompensated price elasticities

Group	Fruits & vegetables	Meat	Fish	Dairy	Cereals	Fats and oils	Sweets	Non-Food
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
				A. Low Income				
Fruits & vegetables	-0.742	-0.013	-0.005	-0.006	-0.031	-0.008	-0.005	-0.017
Meat	-0.022	-0.788	-0.006	-0.006	-0.034	-0.009	-0.005	-0.018
Fish	-0.022	-0.014	-0.793	-0.006	-0.034	-0.009	-0.005	-0.019
Dairy	-0.022	-0.014	-0.006	-0.779	-0.034	-0.009	-0.005	-0.018
Cereals	-0.019	-0.012	-0.005	-0.005	-0.689	-0.007	-0.004	-0.016
Fats and oils	-0.017	-0.010	-0.004	-0.005	-0.026	-0.602	-0.004	-0.014
Sweets	-0.021	-0.013	-0.005	-0.006	-0.032	-0.008	-0.747	-0.017
Non-Food	-0.027	-0.017	-0.007	-0.008	-0.042	-0.011	-0.006	-0.990
				B. Medium Income				
Fruits & vegetables	-0.651	-0.008	-0.001	-0.004	-0.008	-0.002	-0.002	0.167
Meat	-0.008	-0.717	-0.002	-0.004	-0.009	-0.002	-0.002	0.185
Fish	-0.009	-0.009	-0.727	-0.004	-0.009	-0.002	-0.002	0.189
Dairy	-0.008	-0.008	-0.002	-0.717	-0.009	-0.002	-0.002	0.186
Cereals	-0.006	-0.006	-0.001	-0.003	-0.554	-0.002	-0.002	0.142
Fats and oils	-0.006	-0.006	-0.001	-0.003	-0.007	-0.541	-0.002	0.140
Sweets	-0.008	-0.008	-0.001	-0.004	-0.009	-0.002	-0.681	0.177
Non-Food	-0.017	-0.017	-0.003	-0.008	-0.018	-0.004	-0.005	-1.039
				C. High Income				
Fruits & vegetables	-0.530	-0.003	-0.001	-0.001	-0.003	-0.001	-0.001	0.236
Meat	-0.003	-0.601	-0.001	-0.002	-0.003	-0.001	-0.001	0.267
Fish	-0.003	-0.003	-0.610	-0.002	-0.003	-0.001	-0.001	0.272
Dairy	-0.003	-0.003	-0.001	-0.600	-0.003	-0.001	-0.001	0.267
Cereals	-0.002	-0.002	-0.001	-0.001	-0.432	0.000	-0.001	0.192
Fats and oils	-0.002	-0.002	-0.001	-0.001	-0.002	-0.420	-0.001	0.188
Sweets	-0.003	-0.003	-0.001	-0.002	-0.003	-0.001	-0.561	0.250
Non-Food	-0.010	-0.010	-0.003	-0.005	-0.010	-0.002	-0.004	-1.024

Source: Cornelsen et al. (2014).

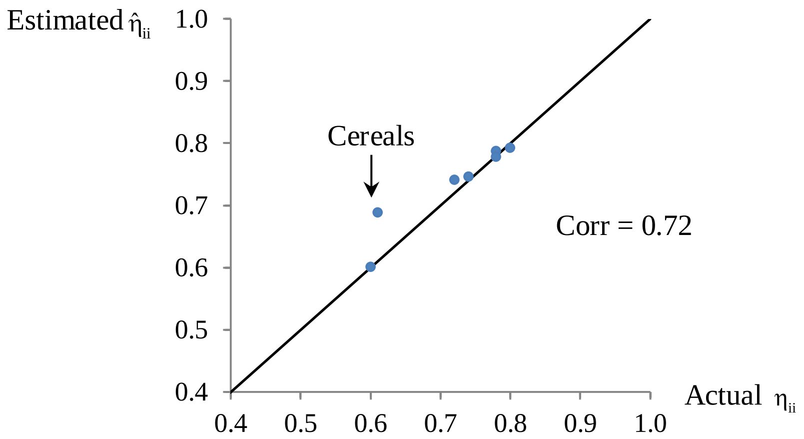
Figure A1 Compensated own-price elasticities,
Approach I vs. Approach II



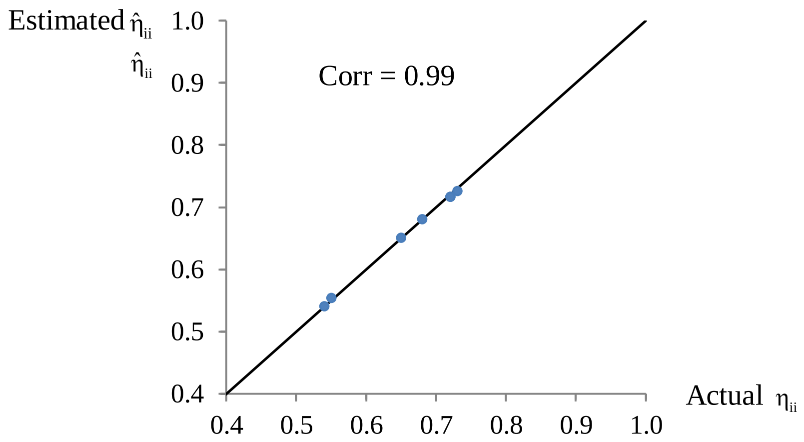
Notes: Along the solid lines, Approach I = Approach II. Approach I and II elasticities are the diagonal elements of Tables 3 and A4, respectively.

Figure A2 Estimated and actual uncompensated own-price elasticities, Approach I

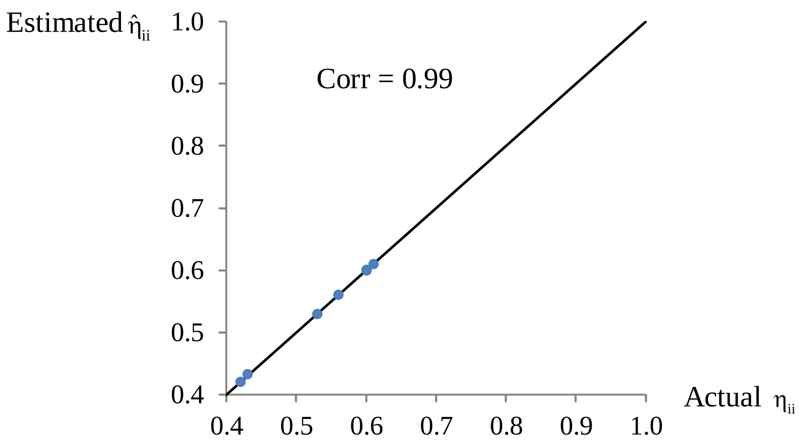
A. Low income



B. Medium income



C. High income



Note: Along the solid lines, estimated = actual. Actual and estimated uncompensated own-price elasticities are from Table A1 and Table A5, respectively.