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Abstract

Price and income elasticities are key to understanding how changes in prices and income affect food demand. The U.S. Department of Agriculture's International Food Security Assessment and Baseline models rely on price and income elasticity estimates from previous studies (Seale et al., 2003; Muhammad et al., 2011). This study derives new elasticities using an Almost Ideal Demand System (AIDS) approach and relies on data from the 2017 International Comparison Program (ICP) of the World Bank. The ICP data, covering 176 economies, are categorized by geographic regions and income groups. Results indicate that consumers in low-income economies allocate a higher proportion of their income to necessities like food, while those in high-income economies spend more on luxury goods. Marginal shares demonstrate changes in food spending distribution across subcategories based on income levels. The study also identifies the price elasticity of various food items, distinguishing between relatively price inelastic (e.g., "bread and cereals," "oils and fats," "fruit," "vegetables," and "sugar, jam, honey, chocolate, and confectionery") and price elastic (e.g., "meat," "fish and seafood," and "nonalcoholic beverages") subcategories.

Keywords: income elasticity, price elasticity, agricultural trade, demand system analysis, food insecurity

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International Income and Price Elasticity Estimates: An Update

Introduction and Background

Estimates of income and price elasticities measure the responsiveness of food demand to changes in prices and income for various food items, reflecting economic conditions and consumer preferences (Muhammad et al., 2011). This information is crucial when anticipating and modeling consumer and producer responses to shocks to incomes, prices, or both.

USDA, Economic Research Service's (ERS) income and price elasticity estimates by Muhammad et al. (2011) serve as foundational data for economic models, including the USDA, ERS's Baseline model and the International Food Security Assessment model. These use cases highlight the need for accurate and timely demand estimates that shift according to consumer demands reflected in expenditures across different income groups (e.g., low-income, middle-income, and high-income countries).

This study makes two key contributions: First, we replaced the Florida-Slutsky model with the Almost Ideal Demand System (AIDS) to incorporate a nonlinear price index,[1] which more accurately reflects consumer demand for food (Deaton & Muellbauer, 1980a). This is a departure from previous USDA, ERS reports (e.g., Muhammad et al., 2011; Seale et al., 2003). The new approach offered the advantage of including the use of a more accurate price index, allowing for more robust and precise elasticity estimates. While other models, like the Florida-Preference Independence (PI) and Florida-Slutsky models (e.g., Muhammad et al., 2011; Seale et al., 2003) were used in previous research, the AIDS model and its quadratic extension (Quadratic Almost Ideal Demand System (QUAIDS)) have gained popularity due to their flexibility and ease of estimation. The Trigonometric Demand System (TDS) (Matsuda, 2009) was another potential demand model, although its use in empirical studies has been limited due to its complex form that does not nest traditional Engel curves (Matsuda, 2009).

Second, the study presents updated estimates of price and income elasticities for aggregate and food consumption categories, utilizing the 2017 International Comparison Program (ICP) data managed by the World Bank.[2] These estimates supersede those published in 2011 by USDA, ERS (Muhammed et al., 2011), which were based on the 2005 ICP data.

The 2017 ICP data[3] offered expanded geographical coverage and a more detailed food category breakdown compared with its 2005 predecessor. By leveraging this enhanced dataset, this report provides more contemporary income and price elasticity estimates across different countries and income groups.

[1] The price index used here is nonlinear, distinguishing it from the simpler linear Stone price index often used in empirical studies. While the linear index is straightforward, recent advancements in computing and statistical methods have made nonlinear indices more easily applicable.

[2] The World Bank is an international development organization owned by 187 countries. Its role is to reduce poverty by lending money to the governments of its poorer members to improve their economies and to improve the standard of living of their people. The bank is also one of the world's largest research centers in development. It has specialized departments that use this knowledge to advise countries in areas such as health, education, nutrition, finance, justice, law, and the environment. Another part of the bank, the World Bank Institute, offers training to government and other officials in the world through local research and teaching institutions (World Bank, 2012).

[3] The World Bank recently released new International Comparison Program (ICP) data from 2021. However, due to time constraints, we were unable to incorporate this updated information into our analysis in a timely manner.

Our results are a set of elasticities for an aggregate demand system of 12 broad consumption categories and a demand system of 10 food subcategories. Consistent with economic theory, results from the current estimation indicate that consumers in low-income economies allocated a larger proportion of their income to necessities, such as food, while consumers in high-income economies spent more on luxury goods[4] and services like health and recreation. Relative to low-income economies, a higher proportion of additional income in middle- and high-income economies was allocated to luxuries than necessities (e.g., food and clothing). For instance, a $1 increase in income led to a 26-cent increase in food spending in low-income economies compared with 7 cents for middle income, with minimal change for high-income economies. Income elasticities of food consumption generally declined as income increased, indicating reduced responsiveness of food consumption to income changes. This was particularly evident in 7 out of 10 food subcategories. Staple foods, such as bread and cereals, oils and fats, and vegetables, were relatively price inelastic, implying that changes in price had a relatively small impact on consumption. In contrast, luxury food items, such as meat, fish, and nonalcoholic beverages, exhibited higher price elasticity, demonstrating greater sensitivity to price changes. The allocation of food spending across subcategories shifted with income levels. The differences in the quality of goods of the food subcategories of economies with different income levels may have also played a role in the changes in food spending allocation.

Data

The International Comparison Program (ICP) provided the price and expenditure data used in this analysis. The ICP is a joint initiative by the United Nations Statistics Division (UNSD) and the International Comparisons Unit of the University of Pennsylvania and managed by the ICP Development Data Group of the World Bank.

The number of participating economies[5] has grown significantly, from 10 in Phase I (1970) to 176 in the ICP 2017 cycle. Building on this extensive data, multiple studies, including those by Theil et al. (1989), Seale et al. (2003), and Muhammad et al. (2011), have used ICP data from previous years to conduct demand analysis and estimate elasticities. The ICP dataset of a specific year includes cross-sectional variation in prices, expenditure, and demand across countries around the world.

Significant efforts have been made to standardize the criteria and procedures used to select and measure specific goods and services across different countries. For example, the ICP 2005 round introduced a methodology to improve the accuracy and consistency of data collection and analysis among participating countries (Diewert, 2010).

The ICP collects comparative price and expenditure data in participating economies to produce purchasing power parities (PPPs) and price level indexes (PLIs) for each economy. PPPs are used to convert volume and per capita measures of Gross Domestic Product (GDP) and its expenditure components into a common currency. The ICP is primarily designed to enable cross-country comparisons of economic levels using a common currency in a particular reference year (World Bank, 2023).

[4] In economics, luxury goods are described as those whose income elasticity of demand is greater than one (Deaton & Muellbauer, 1980b). This implies that the proportion of budget spent on luxury good rises as the income rises.

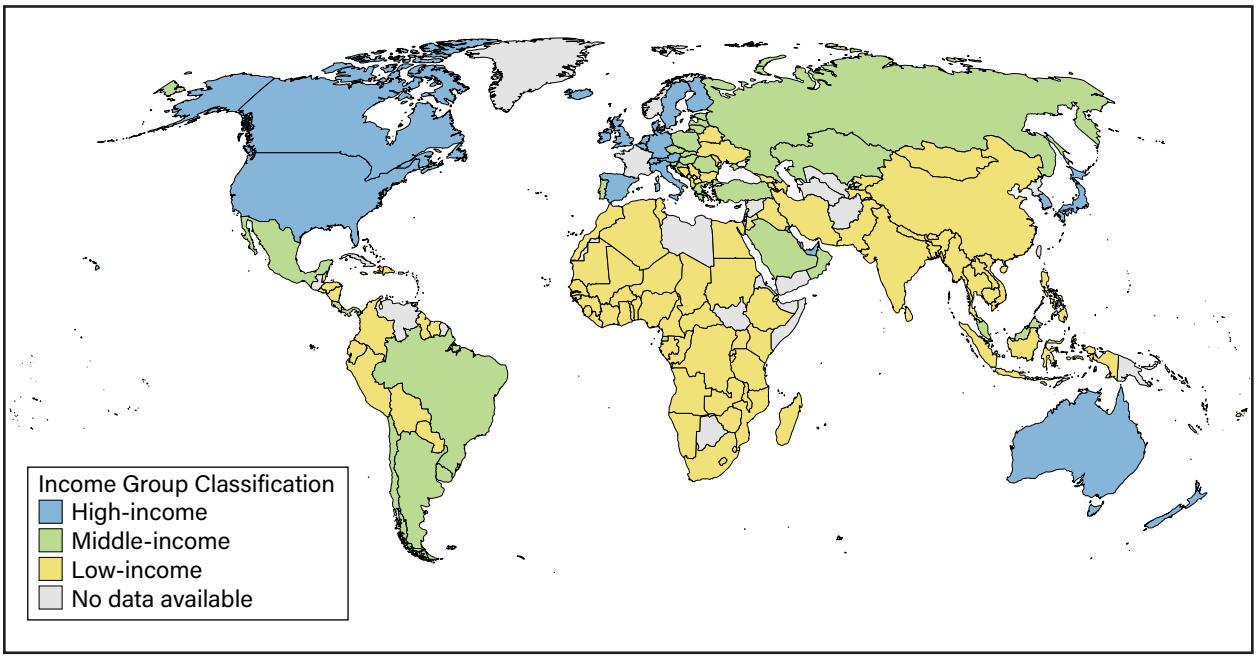
[5] In the World Bank's International Comparison Program (ICP) dataset, the term "economies" is used to refer to individual regions or entities that are part of a country or geographic area. These entities could be individual countries or subnational regions within a country.

The ICP methodology consists of three primary components. The first, ICP Classification of Expenditures, uses the System of National Accounts (SNA) definition of final expenditures on GDP to categorize expenditures. The second component is the basket of goods and services from which items are selected for pricing. To ensure the representativeness of household consumption baskets across the regions and participating economies, each region within the ICP comparison selects a set of global and regional items to be priced. Global items ensure sufficient overlap across the regions, while regional items, identified as items typically consumed by households of economies within a region, ensure that the baskets are locally representative. The third component is the estimation of PPPs for each participating economy (World Bank, 2023).

This analysis utilizes the 2017 ICP data, covering 176 economies categorized into 7 regions: East Asia and Pacific (19 economies), Europe and Central Asia (46 economies), Latin America and the Caribbean (39 economies), Middle East and North Africa (17 economies), North America (3 economies), South Asia (7 economies), and Sub-Saharan Africa (45 economies). The 2017 ICP data provided a further disaggregation of food categories relative to the ICP 2005 data.

The 2017 ICP data divides the 176 economies into 3 income groups based on their per capita income relative to the United States in 2011 (Muhammad et al., 2011). The low-income group comprises economies with per capita income less than 15 percent of the U.S. level; the middle-income group includes economies with per capita income between 15 and 45 percent of the U.S. level; and the high-income group encompasses economies exceeding 45 percent of the U.S. level (figure 1).

Figure 1
Economies in the 2017 ICP data classified by income group



Source: USDA, Economic Research Service using the World Bank's 2017 International Comparison Program (ICP) data.

The low-income group primarily consists of Sub-Saharan African economies, along with several countries in Central and South Asia, the Middle East, and Central America. Eastern European, Latin American, and North African economies predominantly fall into the middle-income category. High-income economies largely encompass Western European and North American nations, oil-producing states in the Middle East, Australia, Japan, South Korea, and New Zealand (figure 1). For more information and a list of the economies, see the World Bank's International Comparison Program.

Tables 1a and 1b present the average budget shares for aggregate categories and the average conditional budget shares for food subcategories across three income groups of economies. The average shares are a simple unweighted average, with each economy in a group given equal weight. The budget share allocated to food exhibits a substantial decline across income groups, from an average of 35.5 percent in low-income economies to 9.5 percent in high-income economies. A comparable though less pronounced trend was observed for the alcoholic beverages, tobacco, and narcotics, and the "clothing and footwear" categories. The budget shares in "housing," "health," "recreation," and "restaurants and hotels" all increased in income, indicating that these goods and services are luxuries for consumers. Middle-income economies allocated a higher share of their budget to "furnishings and household maintenance," "transport," and "communications" than both high-income and low-income economies.

Ten subcategories fall under the food category in the 2017 ICP data. Table 1b presents the conditional budget shares for these subcategories. Consumers in low-income economies allocated a significantly larger portion of their budgets to "bread and cereals" and "oils and fats" compared with those consumers in middle- and high-income economies. This pattern suggests that these food items are essential staples for low-income populations. The budget shares for "bread and cereals" were 23.2, 16.3, and 14.7 percent for low-income, middle-income, and high-income economies, respectively. The budget share for "oils and fats" in low-income economies (5.4 percent) was more than double that of high-income economies (2.5 percent). In contrast, the subcategories of "meat," "fish and seafood," and "milk, cheese, and eggs" showed relatively higher budget shares for middle-income groups compared with both high-income and low-income groups, confirming the findings of Muhammad et al. (2011). The budget shares increased as incomes rose for the remaining four subcategories: "fruit," "other food products," "nonalcoholic beverages," and "sugar, jam, honey, chocolate, and confectionery." For example, the nonalcoholic beverages' share was 6.0, 10.0, and 10.5 percent for low-income, middle-income, and high-income economies, respectively. Similarly, the budget share for fruit increased from 6.6 percent in low-income economies to 8.5 percent in high-income economies.

Table 1a
Budget shares for aggregate categories vary by income groups

Aggregate categories	Income group		
	Low	Middle	High
Food and nonalcoholic beverages	0.355	0.162	0.095
Alcoholic beverages, tobacco, and narcotics	0.036	0.033	0.024
Clothing and footwear	0.045	0.039	0.034
Housing	0.129	0.189	0.196
Furnishings and household maintenance	0.044	0.047	0.043
Health	0.060	0.091	0.114
Transport	0.089	0.116	0.099
Communication	0.032	0.039	0.025
Recreation	0.032	0.057	0.081
Education	0.071	0.073	0.084
Restaurants and hotels	0.038	0.056	0.070
Miscellaneous goods and services	0.069	0.097	0.133

Source: USDA, Economic Research Service using the World Bank's 2017 International Comparison Program (ICP) data.

Table 1b
Conditional budget shares for food subcategories vary by income groups

Food subcategories	Income group		
	Low	Middle	High
Bread and cereals	0.232	0.163	0.147
Meat	0.166	0.205	0.201
Fish and seafood	0.060	0.072	0.071
Milk, cheese, and eggs	0.097	0.127	0.111
Oils and fats	0.054	0.037	0.025
Fruit	0.066	0.076	0.085
Vegetables	0.160	0.111	0.111
Sugar, jam, honey, chocolate, and confectionery	0.048	0.053	0.066
Other food products	0.057	0.057	0.077
Nonalcoholic beverages	0.060	0.100	0.105

Source: USDA, Economic Research Service using the World Bank's 2017 International Comparison Program (ICP) data.

Estimation Strategy

Previous USDA, Economic Research Service (ERS) reports applied both the Florida-Preference Independence (PI) model (Seale et al., 1991) and the Florida-Slutsky model (Seale et al., 2003; Muhammad et al., 2011) to study cross-country consumption patterns.

Seale et al. (2003) used 1996 data from the International Comparison Program (ICP) to examine global food consumption. Their two-stage budgeting model allocated income across spending categories and within those categories on specific goods, employing the Florida-Preference and Florida-Slutsky models to estimate expenditure and price elasticities. The USDA, ERS study by Muhammad et al. (2011) followed the same approach to update global food consumption estimates using the more comprehensive 2005 ICP data covering 144 countries.

This study relies on the Almost Ideal Demand System (AIDS) and its extensions, such as the Quadratic Almost Ideal Demand System (QUAIDS) or Exact Affine Stone Index (EASI). The change in methodology aims to better account for potential nonlinearities in the unknown relationship between budget shares, expenditure logarithms, and price logarithms to a first order approximation (Banks et al., 1997; Lewbel & Pendakur, 2009). In addition, the AIDS model "satisfies the axioms of choice exactly; it aggregates perfectly over consumers without invoking parallel linear Engel curves; it has a functional form which is consistent with known household budget data" (Deaton & Muellbauer, 1980a).

Both the AIDS and QUAIDS model have limitations, and alternative models may perform better under specific situations. Matsuda (2009) provided a comprehensive discussion on six classes of exactly aggregable demand systems. A Trigonometric Demand System (TDS), which is a rank-three demand system as the QUAIDS model, was proposed and used by Matsuda (2009) and was shown to have unique values for specific demand issues. It can capture expenditure variations in the Engel curves that can oscillate when other demand systems are not able to, and a TDS can possess large regular regions among the known demand systems (Matsuda, 2009). The TDS has not been widely used in empirical studies, partly because the trigonometric form does not nest either traditional linear/linear-logarithmic or quadratic/quadratic-logarithmic Engel curves (Matsuda, 2009).

The Almost Ideal Demand System (AIDS), developed by Deaton and Muellbauer (1980a), was employed for the demand analysis in this study using 2017 ICP data. The model was applied in two separate demand system estimations. The first estimation focused on an aggregate demand system of 12 broad consumption categories: food, alcoholic beverages, clothing and footwear, housing, furnishings and maintenance, health, transport, communication, recreation, education, restaurants and hotels, and miscellaneous goods and services. The second estimation delved deeper, analyzing a demand system composed of 10 food subcategories: bread and cereals; meat; fish and seafood; milk; oils and fats; fruit; vegetables; sugar, jam, honey, chocolate, and confectionery; other food products; and nonalcoholic beverages. The estimation strategy was based on two-stage budgeting and the weak separability among aggregate consumption categories. The assumption that food constitutes a strongly separable block within the consumer's utility function is commonly employed in economic analysis. Given the broad nature of the food category, this assumption is generally considered reasonable and supported by empirical findings (Selvanathan, 1993).

The Almost Ideal Demand System (AIDS) Model

The AIDS model preserves the generality of both the Rotterdam (Theil, 1965) and Translog models (Christensen et al., 1975). It can be considered as a first-order approximation to any unknown demand relation (Deaton & Muellbauer, 1980b). The demand equations of the AIDS model are budget share equations econometrically specified as

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln(x/P) + u_i, \quad (1)$$

where p_j is the price of good j (j = 1, 2, ..., n), x = $\sum_{i=1}^{n} p_i q_i$ is the total expenditure spent on n goods, q_i is the quantity demanded of good i (i = 1, 2, ..., n), $w_i = p_i q_i / x$ is the budget share of good i, and the α_i, γ_{ij} and β_i are parameters, and u_i is the error term. The P is a price index defined by

$$\ln P = \alpha_0 + \sum_{k=1}^{n} \alpha_k \ln p_k + \frac{1}{2} \sum_{j=1}^{n} \sum_{k=1}^{n} \gamma_{kj} \ln p_k \ln p_j, \quad (2)$$

Based on the consumer theory, α_i, β_i, and γ_{ij} are subject to the following conditions:

Adding up conditions: $\sum_{i=1}^{n} \alpha_i = 1$, $\sum_{i=1}^{n} \beta_i = 0$, $\sum_{i=1}^{n} \gamma_{ij} = 0$ for all j,

Homogeneity conditions: $\sum_{j=1}^{n} \gamma_{ij} = 0$ for all i, and

Symmetry conditions: $\gamma_{ij} = \gamma_{ji}$ for all i,j.

After the econometric estimation, the parameter estimates and the values of variables are used to calculate the expenditure (income) elasticities (e_i), uncompensated (Marshallian) price elasticities (e_{ij}), and compensated (Hicksian) price elasticities (e^*_{ij}) according to the following formulae:

Expenditure (income) elasticities: $e_i = \frac{\partial q_i}{\partial x} \frac{x}{q_i} = 1 + \beta_i / w_i$ and (3)

Uncompensated (Marshallian) price elasticities:

$$e_{ij} = \frac{\partial q_i}{\partial p_j} \frac{p_j}{q_i} = -\delta_{ij} + \gamma_{ij} / w_i - (\beta_i / w_i)(\alpha_j + \sum_{k=1}^{n} \gamma_{kj} \ln p_k), \quad (4)$$

where δ_{ij} is Kronecker delta with $\delta_{ij} = 0$ for $i \neq j$ and $\delta_{ij} = 1$ for $i = j$, and

Compensated (Hicksian) price elasticities: $e^*_{ij} = e_{ij} + e_i w_j$. (5)

The expenditure (income) elasticity measures the percentage change in the quantity demanded of a good in response to a 1-percent increase in the total expenditure. The uncompensated price elasticity represents the percent change in the quantity demanded of a good in response to a 1-percent increase in the good's price or another good's price. The compensated price elasticity shows the percent change in the quantity demanded of a good in response to a 1-percent increase in the good's price or another good's price with the real expenditure unchanged.

Another relevant measure is the marginal share (φ_i), which shows the share of one more unit of the expenditure that is distributed to a specific good. For the AIDS model, this is given by

$$\varphi_i = \frac{\partial w_i}{\partial x} = w_i e_i = w_i + \beta_i. \quad (6)$$

The value of the marginal share of a good depends on the good's budget share and expenditure elasticity. The marginal share is smaller than the corresponding budget share for a necessity ($e_i < 1$) and larger than the budget share for a luxury good ($e_i > 1$).

Results and Discussion

This section initially presents the estimation results of the AIDS model for both the aggregate categories and food subcategories. Subsequently, income and price elasticities were computed using the derived parameter estimates and the data values. These calculated elasticities are then reported and discussed.[6] The theoretical restrictions of adding up were automatically satisfied if the data added up. Homogeneity and symmetry restrictions were checked through hypothesis testing with likelihood ratio tests. All these restrictions were not rejected for the AIDS model for the 12 aggregate consumption categories and the 10 food subcategories with the 2017 ICP data.

Parameter Estimates and Elasticities of Aggregate Categories

The parameter estimates for the 12 aggregate consumption categories are included in table 2. The values of beta (β) estimates showed that "food and nonalcoholic beverages" and "clothing and footwear" were necessities ($\beta < 0$ and significant), in line with the findings of Muhammad et al. (2011). In contrast, "housing," "health," "transport," "communication," "recreation and culture," "restaurants and hotels," and "miscellaneous goods and services" were luxuries ($\beta > 0$ and significant). The largest absolute value β estimate was found for "food and nonalcoholic beverages" at 0.096. The estimated coefficient (β) for food indicates that a 1-percent increase in real expenditure is associated with a 0.1-percent decrease in the average food budget share. Furthermore, a doubling of real income leads to a decline in food budget share by 6.6 percentage points (i.e., -0.096*0.69). Although lower than the standard 10-percentage point reduction reported in previous studies (Clements & Chen, 1996), this finding aligns with the strong form of Engel's law: A doubling of income leads to approximately a 10-percentage point reduction in the food budget share (Clements & Chen, 1996; Reimer & Hertel, 2004; Seale & Regmi, 2006).

[6] We also applied the QUAIDS model for estimation using the 2017 ICP data. The estimation results and elasticities of the AIDS model and the QUAIDS model were very similar in terms of both the values and significance levels. The only exception is that the income elasticity of the aggregate category of food and nonalcoholic beverages is lower in the QUAIDS model (0.411) than in the AIDS model (0.621), and the price elasticity is insignificant for the aggregate category of food and nonalcoholic beverages in the QUAIDS model estimation. In addition, most of the coefficients of the quadratic-logarithmic expenditure terms in both aggregate categories and food subcategories were insignificant. Eight out of the 12 aggregate categories were statistically insignificant at a 5-percent level. Nine out of the 10 food subcategories were statistically insignificant at a 5-percent level. Results from the QUAIDS model are available on the USDA, ERS website.

The corresponding income elasticity estimates for these aggregate consumption categories are in table 3a. Among the necessity categories (income elasticity $e_i < 1$), the "food and nonalcoholic beverages" category had the lowest income elasticity (0.621). The "recreation and culture" category had the highest income elasticity (1.270) among the luxury categories ($e_i > 1$), which is in line with the findings of Seale and Regmi (2006).

Compared with the income elasticity estimates of the most recent study (Muhammad et al., 2011) using the 2005 ICP data, this study using the 2017 ICP data yielded relatively smaller income elasticity estimates for "food and nonalcoholic beverages" (partly because alcoholic beverages, tobacco, and narcotics are separated from the food category in the 2017 ICP data), "clothing and footwear," "health," "recreation," (especially for the lower-income economies), and "miscellaneous items." Larger income elasticity estimates were found for "housing," "transport," and "communication," while similar estimates were attributed to "furnishing" and "education."

Income elasticity estimates were calculated for individual economies and are available on the USDA, ERS website. Generally, as the income level increased, the income elasticity values changed for some consumption categories (table 3b). For "food and nonalcoholic beverages," the income elasticity estimates decreased as the income level rose, confirming previous findings (Seale & Regmi, 2006; Muhammad et al., 2011). Low-income economies had the highest income elasticities for both "food and nonalcoholic beverages" (0.689) and "alcoholic beverages, tobacco, and narcotics" (0.763). In contrast, high-income economies had the lowest income elasticities for these categories. Middle-income economies fell between these two extremes. The income elasticities of the three groups of economies for "clothing and footwear" (0.758, 0.823, 0.801) and those for "education" (0.943, 0.957, 0.964) were relatively similar.

For four of the seven luxury categories, "health," "recreation and culture," "restaurants and hotels," and "miscellaneous goods and services," the income elasticities decreased as we moved from lower to higher income economies. The "recreation and culture" category showed the most luxury consumption, which is consistent with other studies that used the ICP data (Muhammad et al., 2011; Seale & Regmi, 2006). The income elasticity was 1.666 for low-income economies, 1.266 for middle-income economies, and 1.169 for high-income economies. Seale and Regmi (2006) reported the income elasticity of demand for "recreation" in Vietnam at 2.20 and in the United States at 1.28. The three groups of economies had very close income elasticity estimates for one luxury category, "home furnishing." For the two remaining luxury categories, "transport" and "communication," low-income economies had the highest income elasticities (1.304 and 1.361), while middle-income economies had the lowest (1.206 and 1.205). The income elasticity for education was close to unity for the three income groups. This indicates a similar budget share of "education" across income levels. This is supported by a similar proportion of income spent on education and smaller beta (β) estimates among the three income categories (Muhammad et al., 2011; Seale & Regmi, 2006).

Table 2
Parameter (α and β) estimates for aggregate categories using ICP 2017 data

Aggregate categories	α		β	
	Parameter estimate	Standard error	Parameter estimate	Standard error
Food and nonalcoholic beverages	0.594***	0.043	-0.096***	0.008
Alcoholic beverages, tobacco, and narcotics	0.058**	0.018	-0.005	0.003
Clothing and footwear	0.066***	0.019	-0.006†	0.004
Housing, water, electricity, gas, and other fuels	0.079**	0.029	0.023***	0.006
Furnishings, household equipment, and routine household maintenance	0.040*	0.018	0.001	0.003
Health	0.031	0.019	0.016***	0.004
Transport	0.005	0.023	0.021***	0.004
Communication	-0.007	0.016	0.007*	0.003
Recreation and culture	0.002	0.018	0.013***	0.003
Education	0.097***	0.018	-0.003	0.004
Restaurants and hotels	0.022	0.022	0.009*	0.004
Miscellaneous goods and services	0.013	0.053	0.020*	0.009

Note: Superscript ***, **, *, and † indicate the significance level at the 0.001, 0.01, 0.05, and 0.1 level, respectively.

Source: USDA, Economic Research Service using the World Bank's 2017 International Comparison Program (ICP) data.

Table 3a
Income elasticity estimates for aggregate categories, 2017 ICP data

Aggregate categories	Income elasticities	Standard errors
Food and nonalcoholic beverages	0.621***	0.032
Alcoholic beverages, tobacco, and narcotics	0.849***	0.101
Clothing and footwear	0.851***	0.085
Housing, water, electricity, gas, and other fuels	1.148***	0.037
Furnishings, household equipment, and routine household maintenance	1.026***	0.073
Health	1.200***	0.046
Transport	1.218***	0.045
Communication	1.203***	0.092
Recreation and culture	1.270***	0.069
Education	0.963***	0.048
Restaurants and hotels	1.181***	0.085
Miscellaneous goods and services	1.223***	0.105

Note: Superscript ***, **, *, and † indicate the significance level at 0.001, 0.01, 0.05, and 0.1 level, respectively.

Source: USDA, Economic Research Service using the World Bank, 2017 International Comparison Program (ICP) data.

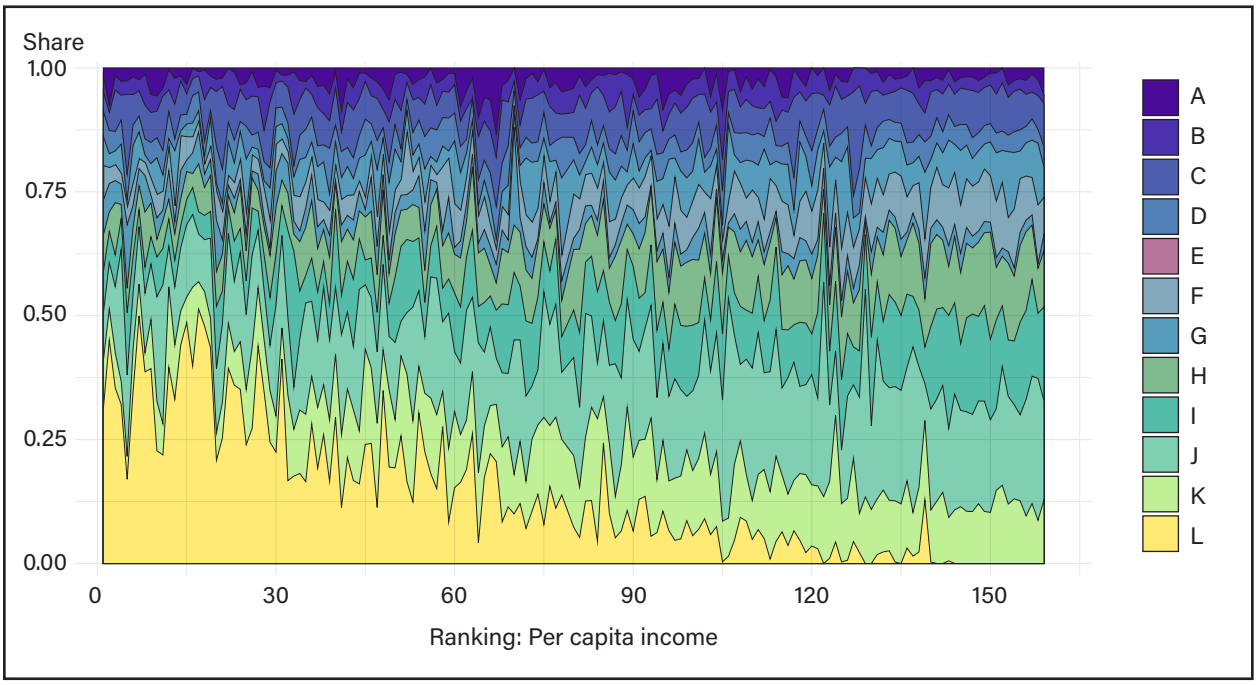
Table 3b
Average income elasticities for aggregate categories by income groups, 2017 ICP data

Aggregate categories	Income group		
	Low	Middle	High
Food and nonalcoholic beverages	0.689	0.366	-0.089
Alcoholic beverages, tobacco, and narcotics	0.763	0.627	0.620
Clothing and footwear	0.758	0.823	0.801
Housing, water, electricity, gas, and other fuels	1.214	1.137	1.135
Furnishings, household equipment, and routine household maintenance	1.032	1.026	1.028
Health	1.338	1.194	1.189
Transport	1.304	1.206	1.226
Communication	1.361	1.205	1.307
Recreation and culture	1.666	1.266	1.169
Education	0.943	0.957	0.964
Restaurants and hotels	1.514	1.277	1.152
Miscellaneous goods and services	1.398	1.225	1.170

Source: USDA, Economic Research Service using the World Bank's 2017 International Comparison Program (ICP) data.

Marginal shares provide a different way to measure the allocation of higher income, i.e., an additional $1 among consumption of various categories. The marginal share estimates for 12 aggregate consumption categories for all 3 economy groups are plotted in figure 2. The income levels of economies are ordered by their magnitudes on the x-axis, and the scale is linear. In general, relative to low-income groups, the proportions of the additional income allocated by higher income groups to necessities (e.g., food, labeled as E) became smaller, while the proportions of the additional income allocated to luxury goods (e.g., health), labeled as G, and recreation, labeled as J, became larger. For example, a $1 increase in total income will cause the "food and nonalcoholic beverage" consumption to increase by 26 cents in low-income economies and 7 cents in middle-income economies and change slightly in high-income economies. The consumption category of "recreation and culture" was a luxury. A $1 increase in total real income will result in an increase of 4.5 cents on "recreation and culture" consumption in low-income economies, an increase of 7 cents in middle-income economies, and an increase of 7 cents in high-income economies.

Figure 2
Marginal shares: Allocations of an additional $1 among aggregate consumption categories across economies



Note: The per capita income in the x-axis is ranked from the lowest to the highest. The letters stand for the following: A: Alcoholic beverages, tobacco, and narcotics (top); B: Communication; C: Education; D: Furnishing, household equipment, and routine household maintenance; E: Restaurants and hotels; F: Recreation and culture; G: Clothing and footwear; H: Health; I: Miscellaneous goods and services; J: Housing, water, electricity, gas, and other fuels; K: Transport; and L: Food and nonalcoholic beverages (bottom).

Source: USDA, Economic Research Service using the World Bank's 2017 International Comparison Program (ICP) data.

Own-price elasticities measure the percentage change in the quantity demanded of a consumption category in response to a 1-percent increase in its own price. The estimated Marshallian (uncompensated) price elasticities and Hicksian (compensated) price elasticities for 12 aggregate consumption categories are reported in tables 5a and 6a, respectively. Generally, uncompensated own-price elasticities (table 5a) are more responsive to price changes than compensated own-price elasticities (table 6a) because they account for both the substitution and income effects. The consumption of "food and nonalcoholic beverages" was the least price sensitive (-0.511), and "restaurants and hotels" was the most price sensitive (-1.541). The demands for 3 out of the 12 aggregate consumption categories, "recreation and culture," "restaurants and hotels," and "miscellaneous goods and services," were price elastic, which means the own price elasticities of these 3 categories had absolute values greater than 1. The own-price elasticities of the other nine categories had absolute values lower than 1, i.e., their demand was price inelastic.

With respect to "food and nonalcoholic beverages," the own-price elasticities of demand were larger in absolute value for low-income countries than for high-income countries. The demand for some categories also became less price sensitive with income. For example, the uncompensated and compensated price elasticity of the consumption of "restaurants and hotels" were -2.532 and -2.485 for low-income economies, -1.826 and -1.721 for middle-income economies, and -1.455 and -1.375 for high-income economies, respectively (tables 5b and 6b). For many other aggregate consumption categories, such as "housing," "alcoholic beverages," "furnishings," "health," "transport," and "education," price elasticities were relatively similar for the three income groups.

Table 5a

Marshallian (uncompensated) price elasticities for aggregate categories, 2017 ICP data

Aggregate categories	Uncompensated price elasticities	Standard errors
Food and nonalcoholic beverages	-0.511***	0.143
Alcoholic beverages, tobacco, and narcotics	-0.962***	0.196
Clothing and footwear	-0.761***	0.189
Housing, water, electricity, gas, and other fuels	-0.828***	0.099
Furnishings, household equipment, and routine household maintenance	-0.836***	0.237
Health	-0.874***	0.117
Transport	-0.838***	0.158
Communication	-0.751***	0.132
Recreation and culture	-1.245***	0.253
Education	-0.796***	0.086
Restaurants and hotels	-1.541***	0.262
Miscellaneous goods and services	-1.239**	0.414

Note: Superscript ***, **, *, and † indicate the significance level at the 0.001, 0.01, 0.05, and 0.1 level, respectively.

Source: USDA, Economic Research Service using the World Bank's 2017 International Comparison Program (ICP) data.

Table 5b

Average Marshallian (uncompensated) price elasticities for aggregate categories, 2017 ICP data

	Income group		
Aggregate categories	Low	Middle	High
Food and nonalcoholic beverages	-0.591	-0.181	0.368
Alcoholic beverages, tobacco, and narcotics	-0.941	-0.909	-0.906
Clothing and footwear	-0.613	-0.716	-0.681
Housing, water, electricity, gas, and other fuels	-0.750	-0.840	-0.845
Furnishings, household equipment, and routine household maintenance	-0.793	-0.831	-0.822
Health	-0.783	-0.877	-0.882
Transport	-0.779	-0.847	-0.830
Communication	-0.560	-0.748	-0.620
Recreation and culture	-1.595	-1.240	-1.154
Education	-0.686	-0.764	-0.804
Restaurants and hotels	-2.532	-1.826	-1.455
Miscellaneous goods and services	-1.411	-1.234	-1.179

Source: USDA, Economic Research Service using the World Bank's 2017 International Comparison Program (ICP) data.

Table 6a
Hicksian (compensated) price elasticities for aggregate categories, 2017 ICP data

Aggregate categories	Compensated price elasticities	Standard errors
Food and nonalcoholic beverages	-0.354*	0.147
Alcoholic beverages, tobacco, and narcotics	-0.934***	0.195
Clothing and footwear	-0.726***	0.187
Housing, water, electricity, gas, and other fuels	-0.647***	0.096
Furnishings, household equipment, and routine household maintenance	-0.790***	0.235
Health	-0.780***	0.117
Transport	-0.719***	0.158
Communication	-0.711***	0.132
Recreation and culture	-1.184***	0.253
Education	-0.725***	0.085
Restaurants and hotels	-1.483***	0.261
Miscellaneous goods and services	-1.130***	0.413

Note: Superscript ***, **, *, and † indicate the significance level at the 0.001, 0.01, 0.05, and 0.1 level, respectively.

Source: USDA, Economic Research Service using the World Bank, 2017 International Comparison Program (ICP) data.

Table 6b
Average Hicksian (compensated) price elasticities for aggregate categories by income group, 2017 ICP data

	Income group		
Aggregate categories	Low	Middle	High
Food and nonalcoholic beverages	-0.334	-0.115	0.367
Alcoholic beverages, tobacco, and narcotics	-0.910	-0.881	-0.887
Clothing and footwear	-0.574	-0.683	-0.654
Housing, water, electricity, gas, and other fuels	-0.597	-0.628	-0.625
Furnishings, household equipment, and routine household maintenance	-0.748	-0.783	-0.777
Health	-0.708	-0.770	-0.752
Transport	-0.668	-0.710	-0.709
Communication	-0.521	-0.703	-0.588
Recreation and culture	-1.550	-1.169	-1.060
Education	-0.618	-0.694	-0.722
Restaurants and hotels	-2.485	-1.761	-1.375
Miscellaneous goods and services	-1.323	-1.116	-1.025

Source: USDA, Economic Research Service using the World Bank's 2017 International Comparison Program (ICP) data.

Parameter Estimates and Elasticities of Food Subcategories

Table 7 includes the parameter estimates for 10 food subcategories. The values of the beta estimates (table 7) and the calculated income elasticities (tables 8a and 8b) indicate whether a food subcategory is a necessity or a luxury good. The estimated results in table 8a show that, conditional on a certain budget by food category, three food subcategories, "bread and cereals," "oils and fats," and "vegetables," were necessities ($e_i < 1$) and significantly different from 1. Muhammad et al. (2011) found similar results for these food subcat-

egories but also identified "meat" and "fish" as necessities. Our analysis reveals that three subcategories, "fish and seafood," "sugar, jam, honey, chocolate, and confectionery," and "other food products," have statistically unit income elasticity. Meanwhile, four subcategories, "meat," "milk, cheese, and eggs," "fruit," and "nonalcoholic beverages" were classified as luxury goods ($e_i > 1$) and significantly different from 1. "Bread and cereals" was the subcategory with the lowest income elasticity, indicating that they are considered necessities. "Nonalcoholic beverages" with the highest income elasticity suggests that they are more luxury goods.

Income elasticity estimates were calculated for individual economies and are available on the USDA, ERS website. As we moved from lower income to higher income economies, income elasticities decreased for 7 out of 10 food subcategories. For example, the income elasticity of "bread and cereals" decreased from 0.687 for low-income economies, 0.605 for middle-income economies, and 0.565 for high-income economies (table 8b). The income elasticities of the fruit subcategory for low-, middle-, and high-income economies were 1.461, 1.263, and 1.204, respectively. For two food subcategories, "milk, cheese, and eggs" and "vegetables," the income elasticity for low-income economies was higher than those of middle- and high-income economies. The income elasticities of the subcategory of "other food products" were very similar for all three groups of economies. The overall results were consistent with the observation that the consumption of food subcategories is less responsive to an income change when an economy is wealthier.

Table 7
Parameter (α and β) estimates for food subcategories, 2017 ICP data

	α		β	
Food subcategories	**Parameter estimate**	**Standard error**	**Parameter estimate**	**Standard error**
Bread and cereals	0.338***	0.022	-0.062***	0.009
Meat	0.101***	0.020	0.037***	0.009
Fish and seafood	0.055***	0.016	0.003	0.007
Milk, cheese, and eggs	0.065***	0.016	0.020**	0.007
Oils and fats	0.068***	0.009	-0.009*	0.004
Fruit	0.040**	0.013	0.016**	0.006
Vegetables	0.207***	0.021	-0.029**	0.009
Sugar, jam, honey, chocolate, and confectionery	0.042***	0.011	0.006	0.004
Other food products	0.067***	0.019	-0.004	0.008
Nonalcoholic beverages	0.017	0.018	0.022**	0.008

Note: Superscript ***, **, *, and † indicate the significance level at the 0.001, 0.01, 0.05, and 0.1 level, respectively.

Source: USDA, Economic Research Service using the World Bank's 2017 International Comparison Program (ICP) data.

Table 8a
Income elasticity estimates for food subcategories, 2017 ICP data

Food subcategories	Income elasticities	Standard errors
Bread and cereals	0.676***	0.047
Meat	1.202***	0.046
Fish and seafood	1.045***	0.102
Milk, cheese, and eggs	1.187***	0.061
Oils and fats	0.781***	0.091
Fruit	1.222***	0.076
Vegetables	0.786***	0.066
Sugar, jam, honey, chocolate, and confectionery	1.113***	0.083
Other food products	0.933***	0.121
Nonalcoholic beverages	1.264***	0.095

Note: Subscript ***, **, *, and † indicate the significance level at the 0.001, 0.01, 0.05, and 0.1 level, respectively.

Source: USDA, Economic Research Service, using the World Bank's 2017 International Comparison Program (ICP) data.

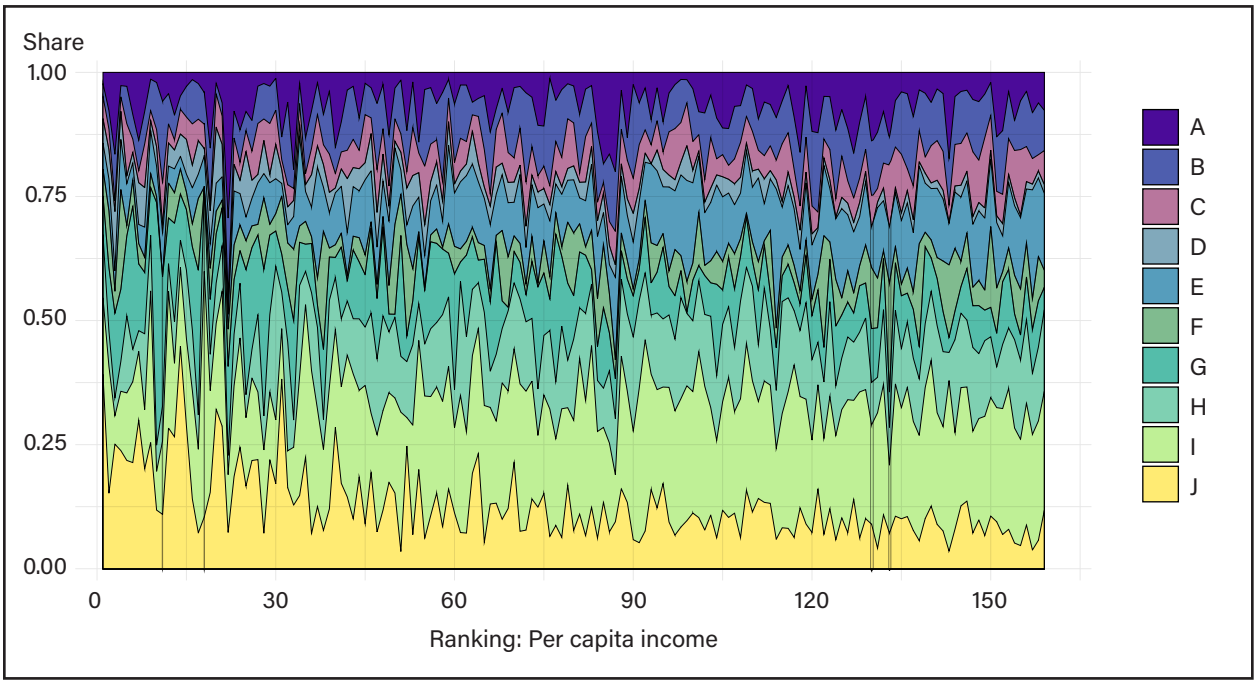
Table 8b
Average income elasticities for food sub-categories by income group, 2017 ICP data

	Income group		
Food subcategories	Low	Middle	High
Bread and cereals	0.687	0.605	0.565
Meat	1.305	1.200	1.192
Fish and seafood	1.089	1.068	1.055
Milk, cheese, and eggs	1.291	1.174	1.206
Oils and fats	0.784	0.698	0.550
Fruit	1.461	1.263	1.204
Vegetables	0.763	0.709	0.723
Sugar, jam, honey, chocolate, and confectionery	1.181	1.138	1.112
Other food products	0.863	0.893	0.922
Nonalcoholic beverages	1.643	1.248	1.221

Source: USDA, Economic Research Service using the World Bank's 2017 International Comparison Program (ICP) data.

Figure 3 shows the marginal share estimates for 10 food subcategories, conditional on a certain total food budget, for individual economies. Marginal share estimates show how 1 additional food expenditure unit was allocated across the 10 food subcategories. Consistent with the values of their income elasticities, the marginal shares of two necessities, "bread and cereals" (labeled A) and "vegetables" (J), decreased as the income level of an economy increased. For example, low-income economies had the largest marginal share (0.163) for "bread and cereals," high-income economies had the smallest marginal share (0.085), and middle-income economies had the medium marginal share (0.101). For most of the six luxury food subcategories, the marginal share estimates increased with an economy's income level. For instance, when the food expenditure increased by $1, fruit expenditure in Senegal increased by only 5.4 cents, while it increased by 11.1 cents in Switzerland.

Figure 3
Marginal shares: Allocations of an additional $1 among food subcategories across economies



Note: The per capita income in the x-axis is ranked from the lowest to the highest. The letters stand for the following: A: Fish and seafood (top); B: Fruit; C: Sugar, jam, honey, chocolate, and confectionery; D: Oils and fats; E: Nonalcoholic beverages; F: Other food products; G: Vegetables; H: Milk, cheese, and eggs; I: Meat; J: Bread and cereals (bottom).

Source: USDA, Economic Research Service using the World Bank's 2017 International Comparison Program (ICP) data.

The Marshallian (uncompensated) price elasticities of the 10 food subcategories are included in tables 10a and 10b. Similarly, the Hicksian (compensated) price elasticities of the 10 food subcategories are included in tables 11a and 11b. The consumption of a good is considered price inelastic if its own price elasticity is less than 1 in absolute value or price elastic if it is greater than 1 in absolute value. Based on both compensated (table 10a) and uncompensated (table 11a) own-price elasticities, the consumptions of "bread and cereals," "fruit," "oils and fats," "vegetables," and "sugar, jam, honey, chocolate, and confectionery" were relatively price inelastic, while the consumptions of "meat," "fish and seafood," "milk, cheese, and eggs," "other food products," and "nonalcoholic beverages" were relatively price elastic. Overall, two subcategories, "oil and fats" and "fruit," were the least price responsive, and the subcategory of "fish and seafood" was the most price responsive.

For "fish and seafood," "oils and fats," "other food products," and "nonalcoholic beverages," the own-price elasticities of demand were larger in absolute value for low-income countries than for high-income countries (Timmer, 1981). For example, low-income economies were the most price sensitive for "nonalcoholic beverages," with an uncompensated (table 10b) and compensated (table 11b) own-price elasticity of -1.99 and -1.91, respectively. High-income economies were the least price sensitive, with an uncompensated and compensated price elasticity of -1.34 and -1.22, respectively. Middle-income economies had medium own-price elasticities, with an uncompensated own-price elasticity of -1.385 and a compensated own-price elasticity of -1.264. For most of the remaining six food subcategories, the own-price elasticities were similar across the three income groups of economies.

Table 10a

Marshallian (uncompensated) price elasticities for food subcategories, 2017 ICP data

Food subcategories	Uncompensated price elasticities	Standard errors
Bread and cereals	-0.965***	0.160
Meat	-1.163***	0.126
Fish and seafood	-2.173***	0.237
Milk, cheese, and eggs	-1.206***	0.208
Oils and fats	-0.852***	0.212
Fruit	-0.833***	0.167
Vegetables	-0.982***	0.169
Sugar, jam, honey, chocolate, and confectionery	-0.927***	0.262
Other food products	-1.449***	0.425
Nonalcoholic beverages	-1.410***	0.254

Note: Superscript ***, **, *, and † indicate the significance level at the 0.001, 0.01, 0.05, and 0.1 level, respectively.

Source: USDA, Economic Research Service using the World Bank, 2017 International Comparison Program (ICP) data.

Table 10b

Average Marshallian (uncompensated) price elasticities for food subcategories, 2017 ICP data

	Income group		
Food subcategories	Low	Middle	High
Bread and cereals	-0.965	-0.957	-0.953
Meat	-1.246	-1.161	-1.155
Fish and seafood	-3.349	-2.797	-2.455
Milk, cheese, and eggs	-1.318	-1.191	-1.228
Oils and fats	-0.853	-0.796	-0.697
Fruit	-0.655	-0.802	-0.848
Vegetables	-0.979	-0.975	-0.979
Sugar, jam, honey, chocolate, and confectionery	-0.882	-0.911	-0.928
Other food products	-1.927	-1.723	-1.528
Nonalcoholic beverages	-1.990	-1.385	-1.343

Source: USDA, Economic Research Service using the World Bank's 2017 International Comparison Program (ICP) data.

Table 11a

Hicksian (compensated) price elasticities for food subcategories, 2017 ICP data

Food subcategories	Compensated price elasticities	Standard errors
Bread and cereals	-0.835***	0.160
Meat	-0.941***	0.125
Fish and seafood	-2.105***	0.234
Milk, cheese, and eggs	-1.076***	0.211
Oils and fats	-0.819***	0.212
Fruit	-0.744***	0.164
Vegetables	-0.876***	0.166
Sugar, jam, honey, chocolate, and confectionery	-0.868***	0.262
Other food products	-1.390**	0.425
Nonalcoholic beverages	-1.307***	0.255

Note: Superscript ***, **, *, and † indicate the significance level at the 0.001, 0.01, 0.05, and 0.1 level, respectively.

Source: USDA, Economic Research Service, using the World Bank, 2017 International Comparison Program (ICP) data.

Table 11b
Average Hicksian (compensated) price elasticities for food subcategories, 2017 ICP data

Food subcategories	Income group		
	Low	Middle	High
Bread and cereals	-0.802	-0.856	-0.868
Meat	-1.042	-0.919	-0.916
Fish and seafood	-3.286	-2.722	-2.381
Milk, cheese, and eggs	-1.197	-1.044	-1.096
Oils and fats	-0.809	-0.769	-0.681
Fruit	-0.573	-0.710	-0.746
Vegetables	-0.848	-0.893	-0.897
Sugar, jam, honey, chocolate, and confectionery	-0.829	-0.852	-0.856
Other food products	-1.872	-1.669	-1.456
Nonalcoholic beverages	-1.906	-1.264	-1.216

Source: USDA, Economic Research Service using the World Bank's 2017 International Comparison Program (ICP) data.

Conclusion

This study applied the Almost Ideal Demand System (AIDS) model to estimate income and price elasticities for aggregate consumption categories and food subcategories. Based on 2017 International Comparison Program (ICP) data and the AIDS demand model, the study reveals insights into international food consumption expenditure responses. Income and price elasticity estimates vary across consumption categories and income groups. The following is a summary of the key results:

Demand for Aggregate Categories

- Consumer spending behavior was influenced by income levels, with consumers in low-income economies allocating a larger proportion of their budget to necessities like food. High-income economies spent more on luxuries like health and recreation. Low-income, middle-income, and high-income groups spent 35.5, 19.5, and 9.5 percent of their budget on food, respectively. Conversely, low-income, middle-income, and high-income groups spent 3.8, 5.4, and 7.0 percent of their budget on restaurants and hotels, respectively.
- A doubling of income led to a decline in the average food budget share by 6.6 percentage points.
- The categories "food and nonalcoholic beverages" and "clothing and footwear" were identified as necessities, with negative and significant beta (β) estimates. "Housing," "health," "transport," "recreation," and "miscellaneous goods and services" were classified as luxuries.
- The lowest income elasticity was for "food and nonalcoholic beverages" (0.621), while the highest was for "recreation and culture" (1.270). Elasticities differed across income levels.
- High-income economies allocated a smaller proportion of additional income to necessities like food and clothing than low and middle-income economies while spending a larger share on luxury goods like recreation and health. For food, a $1 increase in income led to 26 cents more spending in low-income economies, 7 cents in middle income, and a minimal change in high income. For recreation, a $1 increase led to 4.5 cents more spending in low income, 7 cents in middle income, and 7 cents in high-income economies.

- "Food and nonalcoholic beverages" was the least price-sensitive category, while "restaurants and hotels" was the most price sensitive.
- The categories "recreation and culture," "restaurants and hotels," and "miscellaneous goods" exhibited price-elastic demand, indicating greater sensitivity to price changes.

Demand for Food Subcategories

- Three subcategories, "bread and cereals," "oils and fats," and "vegetables," were deemed necessities. Three subcategories, "fish and seafood," "sugar, jam, honey, chocolate, and confectionery," and "other food products," had statistically unit income elasticity. Four subcategories, "meat," "milk, cheese, and eggs," "fruit," and "nonalcoholic beverages," were classified as luxury goods.
- "Bread and cereals" had the lowest income elasticity (0.676), while "nonalcoholic beverages" was the most responsive to income changes (income elasticity of 1.264).
- Income elasticities decreased with higher income for 7 out of 10 food subcategories. However, for "milk, cheese, and eggs," and "vegetables," the income elasticity was higher in low-income economies compared with middle- and high-income economies.
- The marginal share of food spending across 10 subcategories changed with income level. The share for food subgroups, such as "bread and cereals," "oils and fats," and "vegetables," decreased, while others, such as "fruit," "sugar," and "nonalcoholic beverages," increased. For example, low-income economies spent 16.3 percent of their additional food budget on "bread and cereals," while high-income economies spent 8.5 percent. Conversely, the "fruit" expenditure increased from 5.4 cents in Senegal to 11.1 cents in Switzerland for each additional food budget.
- The subcategories "bread and cereals," "oils and fats," "fruit," and "vegetables" were price-inelastic, while "meat," "fish and seafood," and "nonalcoholic beverages" were price elastic. The subcategories "oils and fats" and "fruit" were the least price-responsive, while "fish and seafood" was the most price-responsive.
- Low-income economies exhibited the highest price sensitivity for nonalcoholic beverages, with uncompensated and compensated elasticities of -1.990 and -1.906, respectively. In contrast, high-income economies were the least price sensitive, with uncompensated and compensated elasticities of -1.343 and -1.216, respectively. Middle-income economies displayed intermediate price responsiveness across most food subcategories.

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