

# **Two Essays on the Economics of Global Food Demand**

**A Thesis Presented for the  
Master of Science  
Degree  
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## **DEDICATION**

This thesis is dedicated to my parents, Luc Nkundirema Gatungo and Aimee Mutanegurwa. Your sacrifices for my siblings and me have not gone unnoticed and are deeply appreciated. To my beloved brothers and sisters, Valery, Etienne, Nadia, Joyce, Peace, and Teta, I hope this makes you proud! Lastly, I extend this dedication to my grandparents Levis (late) & Neema, and Vedaste & Leonille.

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## **ABSTRACT**

This study provides an understanding of global consumption patterns across major spending and food categories using data from the 2017 International Comparison Program (ICP). The first chapter examines the demand for food and non-food items across 162 countries using the Quadratic Almost Ideal Demand System (QUAIDS) to estimate demand for nine spending categories: food, clothing, furnishings, transport, housing, health, recreation, education, and miscellaneous. We calculated expenditure, own-price, cross-price elasticities, and marginal shares across these spending categories and performed a welfare analysis to determine the compensation required to maintain the same utility following inflationary periods. The findings indicate that food is the least responsive to changes in income, with an expenditure elasticity of 0.58, while education is the least responsive to price change, with an own-price elasticity of -0.991. The second chapter uses the Almost Ideal Demand Model (AIDS) to derive expenditure, own-price, cross-price elasticities, and marginal shares across eight food products, including bread, meat, fish, dairy, oils, fruits & vegetables, beverages, and other food. Expenditure and price elasticities vary across food categories, where bread is the least responsive to income and price change, with an expenditure elasticity of 0.760 and own-price elasticity of -1.784. Our results show that the allocation of additional income varied across products and countries.

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**CHAPTER I**  
**ECONOMICS OF GLOBAL FOOD DEMAND: ANALYSIS OF FOOD AND**  
**NON-FOOD SPENDING ACROSS 162 COUNTRIES**

# 1. ABSTRACT

This paper examines food and non-food demand across 162 countries using the 2017 International Comparison Program (ICP) data from the World Bank, providing an understanding of global consumption patterns and how income is allocated across major spending categories. We estimated demand using the Quadratic Almost Ideal Demand System (QUAIDS), which offers additional flexibility and accuracy, especially in capturing how income or total expenditures affect spending across categories. Based on the model estimates, we calculated expenditure, own-price, and cross-price elasticities across nine broad spending categories, such as food, health, and education, among others. We also conduct a welfare analysis to determine the compensation required to maintain the same utility (or welfare) following inflationary periods. The findings indicate that income spending varies across countries and categories, with over 50% of additional income allocated globally to housing, health, and education. The income elasticity for food is 0.580, which is the least responsive to a change in income when compared to other broad categories. Welfare analysis reveals that North America has the highest compensating variation (CV) at \$1,600 when food prices increase by 50%, while Sub-Saharan Africa and South Asia have the lowest CV.

## 2. INTRODUCTION

The United Nations has projected that the world population will reach 9.8 billion by 2050 (Islam & Karim, 2019). This poses significant challenges for governments and policymakers globally on how to feed the world with high-quality and nutritious food. As the global population increases, it is crucial to understand the relationship between income, prices, and spending across products and countries. Such insights are valuable for projecting global food demand patterns, which are important to designing policies and programs to address poverty and food insecurity on national, regional, and global levels (Engel, 1895; Hertel, 1998).

Factors determining food spending include income, price, government social programs, economic stability, cultural preferences, gender, and education level (Axelson, 1986). Among these factors, income is an important driving force in determining global food consumption (Seale et al., 2003). However, food spending also depends on the cost and allocation of income across other essential categories such as clothing, housing, and other goods and services. In regions where essential products and services are expensive, a smaller portion of income is allocated to food. Individuals with lower income rely on cheaper and more affordable food products. For countries offering free education or affordable housing, this enables individuals to allocate more income towards food or other categories (Lazear & Michael, 1988; Southworth, 1945; Seale et al., 2003).

Food spending varies significantly across countries, with prices affecting individuals in low- and high-income countries differently. Individuals in low-income countries allocate a larger portion of their income to food, making prices even more important for spending decisions (Mellow, 1978; Pinstrup-Andersen, 1985). However, price increases in high-income countries have a smaller impact on consumption (Seale et al., 2003; Muhammad et al., 2011; Green et al., 2013). Engel's law, which states that the share of income spent on food declines as income

increases, illustrates this relationship between income and food consumption (Engel, 1895; Stigler, 1954). Given the significant portion of income spent on food, low-income individuals are particularly vulnerable to rising food prices (Dessus, 2008). Food price inflation is caused by supply chain disruptions, higher farming input, and energy prices, among other factors (Baek & Koo, 2010). Price increases could reduce overall food intake or shift food consumption towards cheaper and less nutritious alternatives (Cornelsen et al., 2015).

Important to studying food demand is deriving and estimating food demand elasticities. Income and price elasticities measure demand responsiveness to changes in income and price, respectively (Blundell et al., 2012). High-income countries exhibit lower food expenditure elasticities as food constitutes a smaller share of their total income than low-income countries (Gao, 2012). A better understanding of income and price elasticities enables meaningful comparisons across countries and products.

This study examines the impact of income and prices on food demand across countries while accounting for both food and non-food expenditures, explores income allocation across food and other essential spending categories such as health care, housing, clothing, etc., derives expenditure and price elasticities, and examines cross-price relationships among these broad expenditure categories. We estimate demand using the Quadratic Almost Ideal Demand System (QUAIDS) (Banks et al., 1997) using expenditure and price data from the World Bank's International Comparison Program (ICP). We examine cross-price effects to assess the relationship between a price change in one category on the demand for another category, with a particular focus on food spending and prices, and offer updated insights into global and regional consumption, revealing global patterns in the latest 2017 ICP data. Using estimates from the demand analysis, we address how spending patterns differ across countries based on prices and income and compare how countries allocate extra income across broad categories. Lastly, we

evaluate welfare effects of a price spike on broad categories by calculating global and regional compensating variation.

Food spikes are attributed to higher energy and fertilizer prices, growing food demand globally, and declining currency values (Vos, 2015; Arndt et al., 2023). These spikes significantly affect availability and affordability, particularly impacting low-income households due to their limited financial flexibility to cope with rising costs. An increase in food prices intensifies food insecurity, especially in poor countries, reducing food access (Akter & Basher, 2014). Countries that are dependent on food imports are heavily impacted by price shocks, international conflicts, and supply chain related issues. In 1972, the prices of corn, wheat, and soybean climbed to a record high, and the World Bank predicted that 130 million people were driven into poverty due to their inability to afford food (Headey, 2011). More recently, during the COVID-19 pandemic, many individuals experienced income loss and job disruptions, posing a threat to global food security and availability despite various governments' efforts to provide stimulus checks (Laborde et al., 2021). Supply chain issues contributed to a 39% increase in food prices between January 2020 and February 2022, and increased by another 10% due to Russia's war in Ukraine, affecting mostly cereals, energy, and fertilizers (Rother et al., 2023).

It is important to provide a foundation for understanding the shifts and changes in global consumption patterns to income and price changes and offer insights into consumption patterns across products, countries, and regions. With an evolving global demand for food, understanding demand shifts is vital for developing policies to address food insecurity and structuring the food industry to accommodate changes in global food demand (Regmi & Meade, 2013). Furthermore, insights into food consumption and demand can be used by policymakers and researchers seeking to eradicate hunger, poverty, and malnutrition.

Understanding global food consumption patterns across countries is important to addressing global nutritional and health-related needs. The global food system fails to meet

nutritional needs, and there are growing concerns for health related to both under- and over-consumption, which differ across countries and regions (Graham et al., 2007). For example, Africa faces unprecedented population growth, and 44% of the Sub-Saharan African population has food insecurity problems (Gu et al., 2021). According to Kearney (2010), excessive production of energy-dense and nutrient-poor food such as sugars contributes to over-consumption, negatively impacting overall health and leading to diseases such as obesity and diabetes.

Assessing global food demand and spending is critical for addressing global food security. By analyzing food demand and spending across countries, we identify trends, variations, and vulnerable countries. Policymakers can use these insights to anticipate shortages or surpluses and take timely actions to prevent food crises. Additionally, this understanding helps plan for adequate supply to meet demand and ensure access to nutritious food despite a rise in non-food demand for agricultural products, such as biofuels (Regmi, 2013).

The rest of the paper is organized as follows. The background section provides the context and a foundational understanding of food consumption, particularly emphasizing how food shares vary across countries and regions. The literature review examines relevant existing studies. The data section details the source and data types we used in this analysis. The results section presents a comprehensive discussion of our findings. Lastly, we close the paper with a summary, research implications, and concluding remarks.

### **3. LITERATURE REVIEW**

Studying global food demand is complex and requires an understanding of how income, prices, and other variables affect spending across countries. Income and price elasticities of demand serve as indicators of understanding food dynamics (Muhammad et al., 2011). Price and

income sensitivity knowledge is important for effective policymaking (Goodwin, 1992), and is key to comprehending the complexities of global consumption.

Different studies have explored global consumption patterns, examining the impact of income growth and price fluctuations on spending across products and countries. Broad categories respond to income and price changes differently. Food, a necessity, has lower income elasticity than other products, indicating a smaller increase in food consumption with increase in income than in other categories (Engler, 1857). In contrast, luxury items or categories demonstrate higher income elasticities.

Houthakker (1957) used large cross-sectional data to estimate the double-log Engel curve. This study considered four broad categories: food, clothing, housing, and miscellaneous. The study found that food expenditure elasticities range from 0.731 in Poland to 0.344 for the British middle class. They found no pattern for clothing elasticities, where other factors aside from price could influence buying decisions. Expenditure elasticities in the United States were 0.692 for food, 1.280 for clothing, 0.895 for housing, and 1.248 for miscellaneous. This paved the way for similar studies to be conducted, and this study is considered the start of more recent studies using International Comparison Program data (Selvanathan & Selvanathan, 2003).

Blandford (1984) focused on regional demand analysis by examining trends in food consumption patterns across the Organization for Economic Cooperation and Development (OECD) countries. The study found that per capita income became less responsive to changes in income. For 8 out of 21 countries, an increase in per capita income was less likely to increase per capita food consumption. This study also highlighted that most countries had a large share of meat products, and a lower share of cereals in the diet.

Selvanathan and Selvanathan (1993) studied international consumption patterns across 18 OECD countries. Food, housing, and medical care were classified as necessities, while clothing, durables, transportation, and recreation were luxuries. This analysis was later expanded by Chen

(1999), who included countries such as Hong Kong, Israel, Singapore, and Mexico, among others. The consumption data included nine broad categories: food, beverages, clothing, and others. In the less developed countries, food and housing categories had a higher consumption share with 34.25% and 11.40%, respectively.

Seale and Regmi (2003) applied the Florida-Preference Independence model and Florida-Slutsky demand models to 1996 ICP data from 114 countries. This study analyzed consumption across nine broad categories and eight food sub-categories using a multistage demand system. The findings indicate that low-income countries are more responsive to price and income changes than high-income countries. Specifically, they observed that food share declines by 10% when income doubles. Food, clothing & footwear were identified as necessities, while other categories were luxuries. The study reported income or expenditure elasticities for food ranging from 0.740 in Vietnam to 0.090 in the United States.

Clements et al. (2006) analyzed a time-series database published by Selvanathan and Selvanathan (2003). They found that high-income countries spend less than 20% of their income on food, whereas lower-income countries spend more than 50%. The study highlights that as income increases, the budget share allocated to necessities such as food decreases, while spending on luxury increases. High-income countries and households have a diversified and specialized consumption basket. According to Selvanathan & Selvanathan (2006), developed countries allocate 24.70% of their income to food, while developing countries allocate 38.45%.

Muhammad et al. (2011) conducted a study using a two-stage demand system for nine broad consumption categories and eight food sub-categories based on 2005 ICP data. This research revealed that low-income countries are more responsive to changes in income and prices. The income elasticity of demand in low-income countries was 1.5 times higher than in high-income countries. The study found that lower-income countries allocate a higher portion of extra

income on food, with a marginal share ranging from 0.63 in the Democratic Republic of Congo to 0.06 in the United States.

Meade et al. (2014) published a report on food consumption focusing on cross-price effects, utilizing 2005 ICP data. This study considered a 2-good system (food and non-food) and nine major consumption categories. The findings indicate that the poorest countries respond differently to price and income changes, and exhibit a lower non-food share than higher-income countries. For example, uncompensated non-food cross-price elasticities were six times larger in magnitude than food cross-price elasticities in low-income countries, and 2.7 and 2.4 times in middle- and high-income countries, respectively.

Demand models offer a powerful tool to analyze and predict consumer behavior, such as choice and preferences (Andreyev et al., 2010). Model selection is important in establishing an empirical framework for global food demand studies. Choosing the right model is essential to accurately identify patterns and understand the relationships between factors influencing global food demand. Research on global food demand has incorporated a range of models, including Working's model (Working, 1943), Almost Ideal Demand System (AIDS) (Deaton & Muellbauer, 1980), Quadratic Almost Ideal Demand System (QUAIDS) (Banks et al., 1997), Exact Affine Stone Index (EASI) demand model (Pendakur, 2009), Florida Model (Regmi & Seale, 2010), among others.

Working's model states that budget shares are a linear function of the logarithm of total expenditure or income (Working, 1943; Gao, 2012). Working (1943) analyzed household expenditures collected by the U.S. Bureau of Labor Statistics to investigate the relationship between expenditures and income for five categories: food, home maintenance, clothing, recreation, transportation, and miscellaneous. Working found that an average family spent 1/3 of their expenditure on food and 1/3 on home maintenance; the three other categories had equal parts of the remaining 1/3 (Working, 1943).

The Almost Ideal Demand System (AIDS) model developed by Deaton and Muellbauer (1980) has been a fundamental tool for analyzing consumer demand and deriving demand elasticities. The AIDS model is easy to estimate while enabling homogeneity and symmetry to be imposed and tested. Other AIDS-related models include The Inverse AIDS (Eales and Unnevehr, 1994), Additive Demand System (AIDADS) (Cranfield et al., 1998), and Exact Affine Stone Index (EASI) demand system (Pendakur, 2009), among others.

The Quadratic Almost Ideal Demand System (QUAIDS) model is an extension of the AIDS model by adding a quadratic term, which captures the curvature in the Engel curves. This allows for accurately analyzing how consumption varies with income while accounting for non-linear income effects on demand. QUAIDS offers a more robust framework for understanding global demand and is more versatile in modeling food and non-food consumption patterns (Matsuda, 2006; Mittal, 2010).

Few studies have applied multiple demand models. Gao (2012) used the 2005 International Comparison Project (ICP) data to estimate income elasticities, marginal shares, and budget share for food using Working's, Generalized Working's, logistic, and Multiplicative Variable Elasticity (MVE) models. Gao noted that the MVE model has the advantage of fitting data well and that the budget share is always positive. However, it is important to acknowledge that previous studies that used old data do not reflect current global consumption trends due to various political and socio-economic shifts that have influenced global food markets in more recent years.

## **4. BACKGROUND**

An examination of global food consumption involves comparing countries with different per capita income levels, including developing and developed countries. In 2017, China, the United States, and India emerged as the biggest economies, with Gross Domestic Product (GDP)

of \$19.6 trillion, \$19.5 trillion, and \$8 trillion, respectively, as measured on purchasing power parity (PPP) basis. However, when considering GDP per capita, there are huge disparities due to population. China and India had approximately 1.3 billion people, while the United States had 325 million. The GDP per capita of countries included in this study ranges from \$112,701 in Luxembourg to \$784 in Burundi, with a global average of \$21,661. Overall, Sub-Saharan Africa has the lowest average GDP per capita at \$5,365, while North America has the highest average GDP per capita at \$54,320—approximately ten times that of Sub-Saharan Africa (World Bank, 2020).

We used Actual Individual Consumption (AIC) for the analysis as defined by the World Bank, reflecting the total per capita consumption. AIC is a sum of nine broad consumption categories: food, clothing, furnishing, transport, housing, health, recreation, education, and miscellaneous or ‘other.’ Since consumption is part of the Gross Domestic Product, AIC is smaller than GDP per capita for all net exporting countries. AIC ranges from \$44,734 in the United States to \$575 in Niger, with a global average of \$13,924.

The World Bank uses market exchange rate (MER) and purchasing power parity (PPP) rates to derive expenditure estimates that are comparable across countries. Taylor & Taylor (2002) defines PPP as a currency conversion rate at which a currency of one country can be converted into another to purchase the same basket of goods or services in another country. Market exchange rates compare economies using the exchange rate at a given time or an average over a specified period (Callen, 2012). In 2017, the global economy was estimated to be \$119.0 trillion using PPPs and only \$79.7 trillion using MERs (World Bank, 2020).

The choice of using either PPPs or MERs data significantly affects the outcome of the analysis. MERs data is preferred when the analysis involves financial flows. MER fails to account for the lower cost of services in developing countries, is subjected to volatility due to market conditions or political instability, and is only relevant for internationally traded goods, leading to

biased estimates (Nordhaus, 2007). PPPs involve locally produced goods and services and are stable over time (Callen, 2012). The biggest concern is the difference in measures of prices of goods and services across countries and that PPPs are hard to measure since they require large datasets, non-linear econometric models, and sophisticated statistical procedures (Taylor & Taylor, 2002; Nordhaus, 2007).

Figure 1 presents a comparative analysis of food share across countries using PPPs and MERs, with countries arranged from lowest to highest GDP per capita. Food share is higher using market exchange rates, with a global average of 29.3%, compared to 17.4% using PPPs. Non-traded goods are cheaper in low-income countries, making PPPs lower than MERs in low-income countries (Deaton & Aten, 2017). Guinea Bissau had the highest food share using both measures, with 75.6% using MERs and 49.5% using PPPs. Differences in food shares are attributed to currency market fluctuations or inflation and changes in the cost of imported goods. Other countries with higher food share using PPPs include Chad (44.2%) and the Democratic Republic of Congo (40.6%). Singapore (4.9%) and South Korea (5.6%) had the lowest PPP-based food share. We conducted our study using Purchasing Power Parity (PPP) data. All tables and figures are in the appendix section at the end of each chapter.

Spending allocation is not uniform across countries and broad categories. Due to differences in preferences and prices, countries allocate income differently across categories (Selvanathan & Selvanathan, 2006). The global average food budget is \$1,751, ranging from \$6,533 in Luxemburg to \$131 in Liberia. On average, a global consumer allocates 17.4% of their income on food, 3.4% on clothing, 3.3% on furnishing, 9.2% on transportation and communication, 21.0% on housing, 11.2% on health, 3.9% on recreation, 17.8% on education, and 12.7% on miscellaneous.

Figure 2 shows that Sub-Saharan Africa allocated 25% of their income to food, while North America allocated only 8%. Food share for the rest of the regions is the following: 20% in

South Asia, 15% in East Asia, 14% in Latin America, 14% in the Middle East, and 14% in Europe. This observation that low-income regions spend a larger portion of their income on food than high-income regions aligns with Engel's law (Stigler, 1954). It is worth noting that the regional population (in billions) also varied from 2.27 in East Asia, 1.72 in South Asia, 0.98 in Sub-Saharan Africa, 0.83 in Europe, 0.53 in Latin America, 0.42 in the Middle East, and 0.36 in North America.

Working with ICP data enables cross-country and regional analysis, allowing comparison of estimates and expenditures. However, some uncertainty issues arise when modeling international consumption patterns that use cross-country and cross-product data (Deaton & Aten, 2017). Data issues such as outliers, heteroskedasticity, and missing data can lead to inaccurate estimates that do not correspond to economic theory (Seale & Regmi, 2006). Additionally, regionalization of data collection efforts, where agencies express country data relative to the United States or express expenditures in U.S. dollars, can lead to unreliable results. For example, Asian countries might have data relative to Hong Kong, while Latin American countries have data relative to Mexico (Seale & Regmi, 2006). In addition, developing countries often produce inferior-quality data (Clements et al., 2006), characterized by issues such as constant shares over time or unexplained jumps, which might be omitted or treated as outliers (Chen, 1999). Also, variations in global food consumption can be attributed to differences in real income and relative prices, while non-economic factors are relegated to a random error term (Gao, 2012).

## **5. DATA**

We used data collected by the World Bank through the 2017 International Comparison Program (ICP) round, a project initiated in 1968 by the United Nations and the University of Pennsylvania (World Bank, 2020). The purpose of the ICP is to generate statistical data that enables economic comparisons across almost all countries. ICP data was collected by seven

regional agencies: the African Development Bank (AfDB), the Asian Development Bank (ADB), Interstate Statistical Committee of the Commonwealth of Independent States (CIS-STAT), the United Nations Economic Commission for Latin America and the Caribbean (UN-ECLAC), the United Nations Economic and Social Commission for Western Asia (UN-ESCWA), the Statistics Department of the European Union (Eurostat), and the Organization for Economic Co-operation and Development (OECD).

This study includes 162 countries from which we had complete data to conduct the analysis. We used expenditure data in USD and the Price Level Index (PLI) based on the global average (world=100) across nine broad categories. Table 1 (appendix) provides information and details on broad expenditure categories, including sub-categories.

### **5.1 Descriptive Statistics**

This study includes countries across different regions: 2 from North America (USA & Canada), 7 from South Asia, 16 from the Middle East and North Africa, 19 from East Asia and Pacific, 29 from Latin America and the Caribbean, 44 from Sub-Saharan Africa (SS Africa), and 45 from Europe and Central Asia. Table 2 presents a summary of expenditure and price data on broad categories. Total expenditures range from \$575 in Niger to \$44,733 in the United States. In fact, 94 out of 162 countries have expenditures below the global average of \$13,923. Countries with higher global expenditure include Hong Kong, Luxembourg, and Iceland, while countries with lower total expenditure include Central Africa, Burundi, and the Democratic Republic of Congo. The housing category accounted for the highest expenditure across categories, with a global average of \$2,914.10, representing 21% of the total expenditure. There are instances of notably low expenditure on certain categories in some countries. For example, the reported data indicate that Chad spent \$1.36 on clothing, Burundi spent \$4.29 on furnishing, and the Democratic Republic of Congo spent \$6.14 on recreation.

There is a huge variance in prices of different categories, as indicated by the standard deviation. Overall, global prices vary between 26 and 214, indicating that living costs differ significantly across countries. Education and housing show the most deviation, with max values reaching 403 and 267, respectively. This indicates that the cost of education can be extremely low or free in some countries and high in others. Housing variance also shows that some countries have affordable housing, while it is expensive in others compared to the world average of 100.

Regions had different prices and income allocations across the broad expenditure categories. The average total expenditure is \$4,190 in Sub-Saharan Africa, \$5,6756 in South Asia, \$12,481 in Latin America, \$12,146 in the Middle East, \$16,885 in East Asia, \$23,218 in Europe, and \$38,828 in North America. Sub-Saharan Africa and South Asia have similar consumption patterns, with high food shares of 25% and 20%, respectively. In contrast, North America has an average food share of 8%. These shares are relative to their total expenditures, where the average food expenditure is \$3,048 in North America and \$816 in Sub-Saharan Africa.

Prices across most categories are higher in North America than in other regions. The overall price in North America is 146, which is 46% higher than the global average. South Asia has the lowest average prices at 51. Food prices are higher in North America and Latin America at 119, lower in South Asia at 75, and in Sub-Saharan Africa at 91. Disparities between expenditure allocation and prices show how spending differs across countries, regions, and products.

## **6. MODEL AND ESTIMATION METHOD**

We considered several demand models, including Working's (Working, 1943) model, the Almost Ideal Demand System (AIDS) (Deaton & Muellbauer, 1980), and the Quadratic Almost Ideal Demand System (QUAIDS) (Banks et al., 1997). The QUAIDS model was chosen for its

ability to capture non-linear income effects on demand, making it particularly suited for our analysis.

Banks et al. (1997) suggested an extension of the AIDS Model with a quadratic term, which is non-linear in parameters called the QUAIDS model. This implies that the relationship between income and consumption is not linear. As income increases, it can have a lesser or no impact on consumption since the effect of income varies depending on the income level.

Assuming  $k$  product categories, the QUAIDS model can be expressed as follows:

$$w_i = \alpha_i + \sum_{j=1}^k \gamma_{ij} \ln p_j + \beta_i \ln \left\{ \frac{m}{a(p)} \right\} + \frac{\lambda_i}{b(p)} \left[ \ln \left\{ \frac{m}{a(p)} \right\} \right]^2$$

Where,  $i$  represents the spending category such as food and beverages, housing, health, and others.  $k$  denotes the total number of spending categories.  $\ln(a(p))$  is a logarithmic function of the price vector  $p$ , and  $b(p)$  is a simple Cobb-Douglas price aggregator. The expenditure share ( $w_i$ ) is calculated as  $w_i = \frac{p_i q_i}{m}$ , where  $p_i$  represents the price of category  $i$ ,  $q_i$  is the quantity consumed. Where  $w_i$  is the portion of total expenditure that is spent on good  $i$ ,  $m$  is the total expenditure  $\sum_{i=1}^k p_i q_i$ ,  $\ln(m)$  is the log of total expenditure, and  $\alpha, \beta, \gamma$ , and  $\lambda$  are parameters to be estimated. Below are the equations for  $\ln(a(p))$  and  $b(p)$ :

$$\ln(a(p)) = \alpha_0 + \sum_{i=1}^k \alpha_i \ln p_i + \frac{1}{2} \sum_{i=1}^k \sum_{j=1}^k \gamma_{ij} \ln p_i \ln p_j$$

$$b(p) = \prod_{i=1}^k p_i^{\beta_i}$$

We can impose restrictions on the model based on demand theory: adding up, homogeneity, and symmetry to ensure consistency with utility maximization. Adding up suggests that the budget shares for all broad consumption categories sum to 1 and implies the following:

$$\sum_{i=1}^k \alpha_i = 1, \quad \sum_{i=1}^k \beta_i = 0, \quad \sum_{i=1}^k \lambda_i = 0, \quad \sum_{i=1}^k \gamma_{ij} = 0$$

The homogeneity restriction implies that prices are homogeneous of degree zero. In other words, the quantity demanded remains consistent if income and prices change proportionally.

Homogeneity implies the following:

$$\sum_{j=1}^k \gamma_{ij} = 0$$

Symmetry implies that ensures that the cross-price coefficients between two goods are symmetrical, reflecting a mutual substitute or complementary relationship:

$$\gamma_{ij} = \gamma_{ji}$$

Estimated parameters in the QUAIDS model are difficult to interpret directly, but they are useful for calculating elasticities. We used Banks et al. (1997) to derive the elasticities. Differentiating the QUAIDS equation with respect to  $m$  or  $p$  yields the following:

$$\begin{aligned} \mu_i &= \frac{\partial \omega_i}{\partial \ln m} = \beta_i + \frac{2\lambda_i}{b(p)} \left\{ \ln \left[ \frac{m}{a(p)} \right] \right\} \\ \mu_{ij} &= \frac{\partial w_i}{\partial \ln p_j} = \gamma_{ij} - \mu_i \left( \alpha_j + \sum_k \gamma_{jk} \ln p_k \right) - \frac{\lambda \beta_i}{b(p)} \left\{ \ln \left[ \frac{m}{a(p)} \right] \right\}^2 \end{aligned}$$

Using these terms, the expenditure or income elasticity, which measures the demand responsiveness to changes in income is as follows:

$$e_i = \left( \frac{\mu_i}{w_i} \right) + 1$$

The Marshallian or uncompensated price elasticities measure the change in quantity demanded due to changes in price, including the substitution and income effect of a price change. We can derive the uncompensated price elasticities as follows:

$$e_{ij}^u = \left( \frac{\mu_{ij}}{w_i} \right) - \delta_{ij}$$

$\delta_{ij}$  is Kronecker delta, which takes the value of 1 for own-price elasticity and 0 otherwise.

Hicksian or compensated price elasticities measure the response of demand to price changes, holding real income constant. We derived compensated price elasticities as follows:

$$e_{ij}^c = e_{ij}^u + e_i w_j$$

The marginal share ( $\theta_i$ ) measures how an additional income (unit of expenditure) is allocated to spending category  $i$ . It is subject to change with an increase or decrease in income and is calculated as follows:

$$\theta_i = \frac{\partial(p_i q_i)}{\partial m} = \frac{e_i}{w_i}$$

### 6.1 Welfare Effects from Price Spikes

Following Azzam and Rettab (2012) and Roosen et al. (2022), we calculate the welfare effects of recent price spikes as the compensating variation (CV) of a price change. In this context, CV can be interpreted as the income loss for consumers from an increase in prices, the tax equivalent of a price increase, or what consumers would need to be just as well off as before (Azzam and Rettab, 2012). The CV can be calculated as follows:

$$CV = \sum_{i=1}^9 p_i^0 q_i^0 \left( \frac{dp_i}{p_i^0} + \frac{dq_i^*}{q_i^0} + \frac{dp_i}{p_i^0} \frac{dq_i^*}{q_i^0} \right)$$

Note that  $p_i^0$  and  $q_i^0$  denote the price and quantity before the price increase, which is equivalent to the total expenditure,  $dq_i^*$  is the compensated change in quantity from the price increase, and  $dp_i$  is the price change. Note that compensated change in quantity from a price increase can be derived from the compensated price elasticities as follows:  $dq_i^* = \left[ \sum_{j=1}^9 e_{ij}^c \frac{dp_i}{p_i^0} \right] q_i^0$ .

### 6.2 Modeling with STATA

We used Stata 18.0 to estimate the model (“*demandsys*” command) (Stata, 2023). This command facilitates the estimation of different demand systems: QUAIDS, Almost Ideal Demand System, the Cobb-Douglas system, the translog indirect utility demand system, and others. This command allows for adjusting various options including expenditure shares (weights), prices, total expenditure, demographics, elasticity type, and other variables. We estimated the QUAIDS

model using the 2017 ICP data, incorporating budget shares for weights, price level indices for prices, and total expenditures. This provided estimation results, which allowed the extraction of estimates using post-estimation commands. Then, we calculate different elasticities by specifying the type of model between “expenditure,” “compensated,” or “uncompensated price” elasticities. Stata was also used to calculate marginal shares across countries using model estimates and budget shares across categories.

## 7. RESULTS

The estimation results, expenditure and own-price elasticities, cross-price elasticities, marginal shares, and welfare effects of a price increase are discussed in this section.

### 7.1 Estimation Results

Table 3 shows the QUAIDS model estimation results. The majority of parameters are significant. However, parameters have no direct economic interpretation. Beta ( $\beta$ ) estimators are used to derive expenditure elasticities, and  $\gamma_{ij}$  are used to calculate price elasticities. The parameter  $\lambda$  captures the curvature of Engel’s curve, allowing for non-linearity in income responsiveness. Note that  $\lambda$  is significant for food, recreation, and education, highlighting the importance of the quadratic term for these categories.

A negative  $\beta$  estimate for food and education implies that as income increases, the expenditure share allocated to food and education decreases, while the expenditure share for health and recreation increases with income. The magnitude of  $\beta$  for food (-0.038) is much lower than those obtained by Muhammad et al. (2017) (-0.108) and Theil et al. (1989) (-0.134), who used an earlier version of ICP data. Comparisons of these estimates, however, must be approached with caution due to potential disparities in model selection, time periods, ICP data collection methods, and the range of countries covered. The difference in estimates can be

attributed to a decrease in food share as income increases across countries and different countries that participate in ICP rounds.

## **7.2 Expenditure and Price Elasticities**

We computed expenditure and price elasticities to measure responsiveness to changes in income and price. Global estimates for the expenditure, uncompensated, and compensated price elasticities derived from the QUAIDS model are reported in Table 4. All are derived at mean expenditure shares. All expenditure elasticities were significant and positive, indicating that all categories are normal goods. Categories with expenditure elasticities less than 1 are necessities (Liu et al., 1999; Hertel et al., 2008), including food (0.584), clothing (0.873), furnishing (0.972), and education (0.862). Other categories including transport, housing, health, recreation, and miscellaneous were luxuries. Food was most income inelastic or least sensitive to income changes among other categories, with an income elasticity of 0.584, while recreation was the most elastic with 1.381. Seale and Regmi (2006) found food and clothing to be necessities, while other broad categories were luxuries. Selvanathan and Selvanathan (1993) identified food, housing, and medical care as necessities.

Own-price elasticities for all broad categories are negative and significant, indicating that an increase in price leads to a decrease in demand. Uncompensated own-price elasticities show the total effect of a price change on demand, including both substitution and income effects. In contrast, compensated price elasticity measures substitution effect only, holding utility constant. We primarily focus our discussion on uncompensated elasticities. The findings of uncompensated price elasticities show that education (-0.991) was the only inelastic category. Food with a price elasticity of -1.086 was close to unitary and the second least responsive to price changes. Food and education elasticities are almost unitary across countries.

### 7.3 Cross-Price Elasticities

Cross-price elasticities assess the impact of price change in one category on the demand for another. Table 5 presents a 9x9 matrix of uncompensated cross-price elasticities for nine broad categories. Generally, food is a necessity and exhibits smaller changes in demand in response to changes in the price of other goods (Meade et al., 2014). A positive cross-price elasticity implies that two categories are substitutes, whereas negative value indicates complementary spending categories. For instance, clothing (0.766) is a substitute for food, suggesting that a one percent increase in the price of food corresponds to an increase in demand for clothing of 0.766%. Transport and ‘other’ are also substitute, with elasticities of 0.394, and 0.155 respectively. Health and recreation are complementary to food, indicated by negative elasticities of -0.427 and -0.324, respectively; thus, a price increase in food leads to a decreased demand for these categories. However, due to low significance levels, there are no definitive conclusions regarding the effects of food price changes on demand for other broad categories.

Price increases in other broad categories affect food demand. Cross-price elasticities of clothing, transport, and “other” categories are 0.180, 0.327, and 0.256, respectively, indicating that food demand increases when prices in these categories increase. In contrast, health has a complementary relationship, with a negative cross-price elasticity of -0.284, suggesting that food demand decreases as health costs increase. This can be attributed to spending a higher portion of income on health, leaving a smaller portion for food expenditure. Moreover, the cross-price elasticity of furnishing with respect to housing (0.019), and vice versa (0.041) are very small in magnitude, indicating a complementary relationship between these two categories.

### 7.4 Marginal Shares

Marginal shares indicate a distribution of an additional \$1 of income across categories. Figure 3 shows the difference between income spending across categories and the allocation of

additional income. The food spending share is 0.17, but the marginal share of food is 0.11, meaning that for an additional dollar, 11 cents are allocated to food. This shows that with an increase in income, consumers spend less on food. Housing has the highest portion of the extra income with 23 cents, followed by education with 16 cents, other/miscellaneous with 15 cents, health with 15 cents, transport with 10 cents, and furnishing and clothing with both 3 cents. Housing, health, recreation, and “other” had a marginal share greater than the average share, indicating that they allocated a higher portion of additional income to these categories.

Figure 4 shows how the distribution of extra income varies across different countries, sorted from low-income to high-income countries. The marginal share of food varies from 0.31 in Central Africa to 0.16 in Panama. Low-income countries allocate a higher percentage of their income to food than high-income countries. The marginal share of income spent on food declines from low to high-income countries (Muhammad et al., 2011). In lower-income countries, a smaller portion of their income is allocated to “other” or miscellaneous and recreation, with the majoring of income distributed among essential goods and services such as food, housing, and education.

## **7.5 Welfare Effects from Price Spikes**

According to the World Bank commodity price data (pink sheet), from 2020 to 2022, the overall price of critical commodities such as energy, agriculture, food, fertilizers, and metals & minerals has surged by 95%, 48%, 65%, 190%, and 47% respectively (World Bank, 2024). Our study explores the welfare impact of a hypothetical 50% price increase in broad categories, assuming an increase in one category while maintaining constant prices in others. Table 7 presents the compensating variation of a price change for four broad categories including food, clothing, health, and education globally and across different regions. Compensating variation represents the additional amount of money needed to maintain the same level of welfare after a

price increase, also serving as a key metric in understanding income loss for consumers due to price increases.

North America shows the highest compensating variation for food at \$1,600, followed by East Asia at \$711. This indicates that consumers in North America would require a higher amount of additional income to maintain their welfare level with an increase in food prices. Sub-Saharan Africa and South Asia had the lowest compensating variation for food with \$51 and \$66, respectively, which is very low compared to the global average of \$464. This can be attributed to lower food prices in these regions and the share of total expenditure allocated to food. Clothing had the highest global compensating variation at \$1,201. This varies from \$2,815 in North America to \$458 in Sub-Saharan Africa. Europe had the second-highest CV with \$2,177. Health had an average global compensating variation of \$440. Regions with higher health CVs include the Middle East, and Latin America with \$805 and \$778, respectively, while South Asia has \$34, the lowest CV. An increase in education prices results in a global compensation of \$469, varying from \$1942 in North America to \$66 in Sub-Saharan Africa.

Overall, North America requires the highest compensation across all categories except for health, which reflects a high welfare sensitivity to price increases. Sub-Saharan Africa and South Asia had the lowest compensating variations. On average, clothing required the highest compensation, mostly due to the higher compensation required for Europe and North America. Health had the lowest compensating variations, which can partially be attributed to lower out-of-pocket health spending or insurance mechanisms that may cover extra expenses in case of price increase.

## 8. CONCLUSION

This paper provides an understanding of global food demand and consumption across countries using the 2017 ICP data. We highlight that food spending is determined by several factors including income, price, spending on other essential categories, agricultural practices, among many other factors. This spending varies across countries, and products affecting low- and high-income countries and households differently, where low-income countries and regions allocate a higher percentage of their income on food, which is consistent with the demand theory. Specifically, Sub-Saharan Africa, and South Asia spent a higher portion of their income on food than other regions.

We used the Quadratic Almost Ideal Demand System model for elasticities estimation, which are important in understanding the consumption behaviors across broad categories and countries. We found that food was the least responsive to changes in income. Cross-price elasticity results revealed the relationship between different consumption categories as complements or substitutes. Welfare analysis findings revealed significant regional and global different in welfare impacts due to price increases across broad categories, with high compensating variation in North America, and low compensating variation in Sub-Saharan Africa and South Asia. Our results can be used in policymaking, providing a foundation to predict the shifts in global food consumption.

Further research is needed to understand how the COVID-19 pandemic and global conflicts such as the Russia-Ukraine war impacted food demand consumption across countries. While accessing up-to-date and reliable data may be challenging, using regional or more localized data could offer preliminary insights into global or regional consumption trends. This research would provide recent and valuable estimates for policy design, ensuring that global food systems are resilient to future pandemics and conflicts.

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## APPENDIX

**Table 1. Classification of expenditure broad categories, based on ICP 2017.**

| Aggregate Category          | Sub-categories                                                                             |
|-----------------------------|--------------------------------------------------------------------------------------------|
| Food                        | Food, non-alcoholic and alcoholic beverages, tobacco and narcotics.                        |
| Clothing and Footwear       | Clothing materials, garments, shoes, and other footwear.                                   |
| Furnishing                  | Furniture, carpets, other floor coverings, household textiles, and appliances.             |
| Transport and Communication | Purchase and operation of vehicles, transport, postal services, telephone and telefax      |
| Housing                     | Rentals, water, electricity, gas, other fuels.                                             |
| Health                      | Medical products, appliances, equipment, outpatient, and hospital services.                |
| Recreation and Culture      | Audiovisual, photographic equipment, recreational and cultural services.                   |
| Education                   | Pre-primary, primary, secondary, post-secondary, tertiary, education not defined by level. |
| Other                       | Restaurants and hotels, personal care, social protection, insurance, etc.                  |

Source: 2017 International Comparison Program (ICP) data, World Bank.

**Table 2. Descriptive statistics, broad categories.**

| Category          | Expenditure (\$) |           |        |           | Price (World=100) |          |     |     |
|-------------------|------------------|-----------|--------|-----------|-------------------|----------|-----|-----|
|                   | Mean             | Std. dev. | Min    | Max       | Mean              | Std. dev | Min | Max |
| Total Expenditure | 13,923.97        | 11,112.52 | 574.53 | 44,733.82 | 80                | 38       | 26  | 214 |
| Food              | 1,751.53         | 1,110.60  | 130.95 | 6,532.94  | 102               | 32       | 52  | 203 |
| Clothing          | 425.7            | 389.28    | 1.36   | 2,126.92  | 90                | 38       | 29  | 207 |
| Furnishing        | 470.76           | 432.55    | 4.29   | 1,732.54  | 82                | 31       | 36  | 208 |
| Transport         | 1,409.26         | 1,245.58  | 32.1   | 5,448.33  | 94                | 32       | 28  | 189 |
| Housing           | 2,914.10         | 2,457.99  | 80.72  | 13,784.16 | 75                | 57       | 10  | 267 |
| Health            | 1,843.64         | 1,836.61  | 33.97  | 9,365.04  | 70                | 45       | 17  | 242 |
| Recreation        | 764              | 1,017.58  | 6.14   | 5,668.57  | 77                | 32       | 28  | 191 |
| Education         | 2,149.80         | 1,538.37  | 47.1   | 6,777.09  | 75                | 64       | 8   | 403 |
| Other             | 2,195.19         | 2,483.78  | 40.21  | 13,579.97 | 82                | 50       | 24  | 327 |

Source: Author's calculations using 2017 International Comparison Program (ICP) data, World Bank.

**Table 3. QAIDS estimates based on broad categories.**

|            | <b>Food</b>         | <b>Clothing</b>      | <b>Furnishing</b>    | <b>Transport</b>     | <b>Housing</b>       | <b>Health</b>        | <b>Recreation</b>    | <b>Education</b>     | <b>Other</b>         |
|------------|---------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| $\alpha$   | 0.074***<br>(0.015) | 0.028***<br>(0.005)  | 0.035***<br>(0.004)  | 0.108***<br>(0.008)  | 0.211***<br>(0.019)  | 0.159***<br>(0.010)  | 0.072***<br>(0.005)  | 0.132***<br>(0.018)  | 0.181***<br>(0.012)  |
| $\beta$    | -0.038**<br>(0.018) | -0.004<br>(0.006)    | -0.002<br>(0.004)    | -0.002<br>(0.010)    | 0.006<br>(0.023)     | 0.031***<br>(0.012)  | 0.030***<br>(0.006)  | -0.055**<br>(0.022)  | 0.033**<br>(0.014)   |
| $\gamma_1$ | -0.018<br>(0.020)   | 0.024***<br>(0.006)  | -0.005<br>(0.005)    | 0.040***<br>(0.010)  | 0.002<br>(0.010)     | -0.049***<br>(0.010) | -0.013*<br>(0.007)   | -0.008<br>(0.007)    | 0.026*<br>(0.014)    |
| $\gamma_2$ |                     | -0.024***<br>(0.005) | 0.005<br>(0.004)     | -0.017***<br>(0.005) | 0.000<br>(0.004)     | 0.006<br>(0.004)     | 0.006<br>(0.005)     | -0.001<br>(0.003)    | 0.000<br>(0.006)     |
| $\gamma_3$ |                     |                      | -0.031***<br>(0.006) | 0.009**<br>(0.004)   | 0.000<br>(0.003)     | 0.009***<br>(0.003)  | 0.015***<br>(0.005)  | -0.000<br>(0.002)    | -0.002<br>(0.004)    |
| $\gamma_4$ |                     |                      |                      | -0.060***<br>(0.010) | 0.006<br>(0.006)     | 0.017***<br>(0.007)  | 0.013**<br>(0.006)   | 0.003<br>(0.004)     | -0.012<br>(0.009)    |
| $\gamma_5$ |                     |                      |                      |                      | -0.092***<br>(0.013) | 0.042***<br>(0.008)  | 0.022***<br>(0.004)  | -0.028***<br>(0.007) | 0.047***<br>(0.009)  |
| $\gamma_6$ |                     |                      |                      |                      |                      | -0.048***<br>(0.009) | 0.011**<br>(0.004)   | -0.003<br>(0.005)    | 0.017*<br>(0.009)    |
| $\gamma_7$ |                     |                      |                      |                      |                      |                      | -0.040***<br>(0.009) | 0.002<br>(0.003)     | -0.017***<br>(0.006) |
| $\gamma_8$ |                     |                      |                      |                      |                      |                      |                      | -0.001<br>(0.008)    | 0.035***<br>(0.007)  |
| $\gamma_9$ |                     |                      |                      |                      |                      |                      |                      |                      | -0.094<br>(0.157)    |
| $\lambda$  | 0.009*<br>(0.004)   | 0.000<br>(0.001)     | -0.000<br>(0.001)    | -0.003<br>(0.002)    | -0.003<br>(0.006)    | 0.003<br>(0.003)     | 0.006***<br>(0.001)  | -0.013**<br>(0.005)  | 0.003<br>(0.004)     |

Note: Standard errors are in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Source: Author's calculations using 2017 International Comparison Program (ICP) data, World Bank.

**Table 4. Expenditure, own price uncompensated and compensated elasticities.**

|                            | <b>Food</b>          | <b>Clothing</b>      | <b>Furnishing</b>    | <b>Transport</b>     | <b>Housing</b>       | <b>Health</b>        | <b>Recreation</b>    | <b>Education</b>     | <b>Other</b>         |
|----------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| Expenditure                | 0.584***<br>(0.058)  | 0.873***<br>(0.086)  | 0.972***<br>(0.057)  | 1.064***<br>(0.046)  | 1.068***<br>(0.054)  | 1.208***<br>(0.047)  | 1.381***<br>(0.063)  | 0.862***<br>(0.057)  | 1.180***<br>(0.045)  |
| Own-price<br>Uncompensated | -1.086***<br>(0.137) | -1.740***<br>(0.160) | -1.882***<br>(0.162) | -1.607***<br>(0.102) | -1.478***<br>(0.070) | -1.437***<br>(0.080) | -1.941***<br>(0.201) | -0.991***<br>(0.042) | -1.656***<br>(0.105) |
| Own-price<br>Compensated   | -1.003***<br>(0.138) | -1.712***<br>(0.159) | -1.882<br>(0.162)    | -1.500***<br>(0.103) | -1.266***<br>(0.066) | -1.293***<br>(0.080) | -1.881***<br>(0.201) | -0.837***<br>(0.044) | -1.478***<br>(0.105) |

Note: Standard errors are in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Source: Author's calculations using 2017 International Comparison Program (ICP) data, World Bank.

**Table 5. Uncompensated cross-price elasticities.**

|            | <b>Food</b>          | <b>Clothing</b>      | <b>Furnishing</b>   | <b>Transport</b>     | <b>Housing</b>       | <b>Health</b>        | <b>Recreation</b>    | <b>Education</b>     | <b>Other</b>         |
|------------|----------------------|----------------------|---------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| Food       |                      | 0.766***<br>(0.197)  | -0.132<br>(0.150)   | 0.394***<br>(0.103)  | 0.003<br>(0.052)     | -0.427***<br>(0.082) | -0.324**<br>(0.162)  | -0.035<br>(0.041)    | 0.155*<br>(0.091)    |
| Clothing   | 0.183***<br>(0.045)  |                      | 0.133<br>(0.108)    | -0.168***<br>(0.051) | 0.000<br>(0.019)     | 0.041<br>(0.035)     | 0.131<br>(0.107)     | 0.000<br>(0.015)     | -0.003<br>(0.039)    |
| Furnishing | -0.019<br>(0.037)    | 0.146<br>(0.116)     |                     | 0.085**<br>(0.042)   | 0.000<br>(0.014)     | 0.068**<br>(0.027)   | 0.330***<br>(0.114)  | 0.004<br>(0.011)     | -0.022<br>(0.030)    |
| Transport  | 0.327***<br>(0.072)  | -0.506***<br>(0.156) | 0.255**<br>(0.121)  |                      | 0.023<br>(0.031)     | 0.121**<br>(0.055)   | 0.260**<br>(0.128)   | 0.033<br>(0.025)     | -0.095*<br>(0.057)   |
| Housing    | 0.100<br>(0.076)     | 0.041<br>(0.117)     | 0.019<br>(0.080)    | 0.047<br>(0.063)     |                      | 0.305***<br>(0.065)  | 0.427***<br>(0.092)  | -0.128***<br>(0.044) | 0.277***<br>(0.062)  |
| Health     | -0.284***<br>(0.071) | 0.191<br>(0.130)     | 0.262***<br>(0.093) | 0.161**<br>(0.067)   | 0.200***<br>(0.039)  |                      | 0.184*<br>(0.102)    | 0.005<br>(0.029)     | 0.082<br>(0.058)     |
| Recreation | -0.065<br>(0.051)    | 0.202<br>(0.145)     | 0.437***<br>(0.145) | 0.128**<br>(0.057)   | 0.109***<br>(0.020)  | 0.075**<br>(0.037)   |                      | 0.026<br>(0.016)     | -0.125***<br>(0.041) |
| Education  | 0.006<br>(0.049)     | -0.004<br>(0.079)    | 0.002<br>(0.055)    | 0.023<br>(0.042)     | -0.151***<br>(0.035) | -0.054<br>(0.040)    | 0.011<br>(0.062)     |                      | 0.207***<br>(0.047)  |
| Other      | 0.254***<br>(0.098)  | 0.031<br>(0.178)     | -0.065<br>(0.128)   | -0.125<br>(0.087)    | 0.227***<br>(0.045)  | 0.100***<br>(0.072)  | -0.458***<br>(0.139) | 0.223***<br>(0.042)  |                      |

Note: Standard errors are in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Source: Author's calculations using 2017 International Comparison Program (ICP) data, World Bank.

**Table 6. Compensated Cross-Price Elasticities for Broad Consumption Categories.**

|            | Food                 | Clothing             | Furnishing          | Transport            | Housing             | Health               | Recreation          | Education           | Other               |
|------------|----------------------|----------------------|---------------------|----------------------|---------------------|----------------------|---------------------|---------------------|---------------------|
| Food       |                      | 0.890***<br>(0.198)  | 0.006<br>(0.151)    | 0.545***<br>(0.103)  | 0.155***<br>(0.053) | -0.255***<br>(0.083) | -0.128<br>(0.163)   | 0.088**<br>(0.041)  | 0.323***<br>(0.091) |
| Clothing   | 0.202***<br>(0.045)  |                      | 0.164<br>(0.107)    | -0.134***<br>(0.051) | 0.035*<br>(0.018)   | 0.080**<br>(0.035)   | 0.176*<br>(0.106)   | 0.027*<br>(0.015)   | 0.035<br>(0.038)    |
| Furnishing | -0.019<br>(0.037)    | 0.146<br>(0.116)     |                     | 0.085**<br>(0.042)   | 0.000<br>(0.014)    | 0.068**<br>(0.027)   | 0.330***<br>(0.114) | 0.004<br>(0.011)    | -0.022<br>(0.030)   |
| Transport  | 0.385***<br>(0.073)  | -0.418***<br>(0.158) | 0.353***<br>(0.122) |                      | 0.131***<br>(0.031) | 0.243***<br>(0.055)  | 0.398***<br>(0.129) | 0.120***<br>(0.025) | 0.023<br>(0.058)    |
| Housing    | 0.216***<br>(0.073)  | 0.214*<br>(0.114)    | 0.212***<br>(0.078) | 0.258***<br>(0.061)  |                     | 0.545***<br>(0.063)  | 0.702***<br>(0.089) | 0.044<br>(0.041)    | 0.511***<br>(0.059) |
| Health     | -0.214***<br>(0.070) | 0.295**<br>(0.129)   | 0.378***<br>(0.093) | 0.288***<br>(0.066)  | 0.327***<br>(0.038) |                      | 0.348***<br>(0.101) | 0.108***<br>(0.028) | 0.223***<br>(0.057) |
| Recreation | -0.040<br>(0.051)    | 0.241*<br>(0.145)    | 0.480***<br>(0.145) | 0.175***<br>(0.056)  | 0.156***<br>(0.020) | 0.129***<br>(0.037)  |                     | 0.064***<br>(0.016) | -0.073*<br>(0.041)  |
| Education  | 0.110**<br>(0.051)   | 0.151***<br>(0.082)  | 0.175***<br>(0.056) | 0.212***<br>(0.043)  | 0.039***<br>(0.036) | 0.161***<br>(0.041)  | 0.257***<br>(0.064) |                     | 0.417***<br>(0.048) |
| Other      | 0.342***<br>(0.097)  | 0.162<br>(0.178)     | 0.081<br>(0.128)    | 0.035<br>(0.086)     | 0.387<br>(0.045)    | 0.281***<br>(0.072)  | -0.250*<br>(0.139)  | 0.353***<br>(0.041) |                     |

Note: Standard errors are in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Source: Author's calculations using 2017 International Comparison Program (ICP) data, World Bank.

**Table 7. CV estimates for selected broad categories.**

|           | <b>Global</b> | <b>East Asia</b> | <b>Europe</b> | <b>Latin America</b> | <b>Middle East</b> | <b>North America</b> | <b>SS Africa</b> | <b>South Asia</b> |
|-----------|---------------|------------------|---------------|----------------------|--------------------|----------------------|------------------|-------------------|
| Food      | 464           | 711              | 658           | 555                  | 625                | 1,606                | 51               | 66                |
| Clothing  | 1,201         | 1,315            | 2,127         | 995                  | 968                | 2,815                | 458              | 547               |
| Health    | 440           | 530              | 398           | 778                  | 805                | 215                  | 162              | 34                |
| Education | 469           | 699              | 861           | 361                  | 343                | 1,942                | 69               | 154               |

Source: Author's calculations using 2017 International Comparison Program (ICP) data, World Bank.

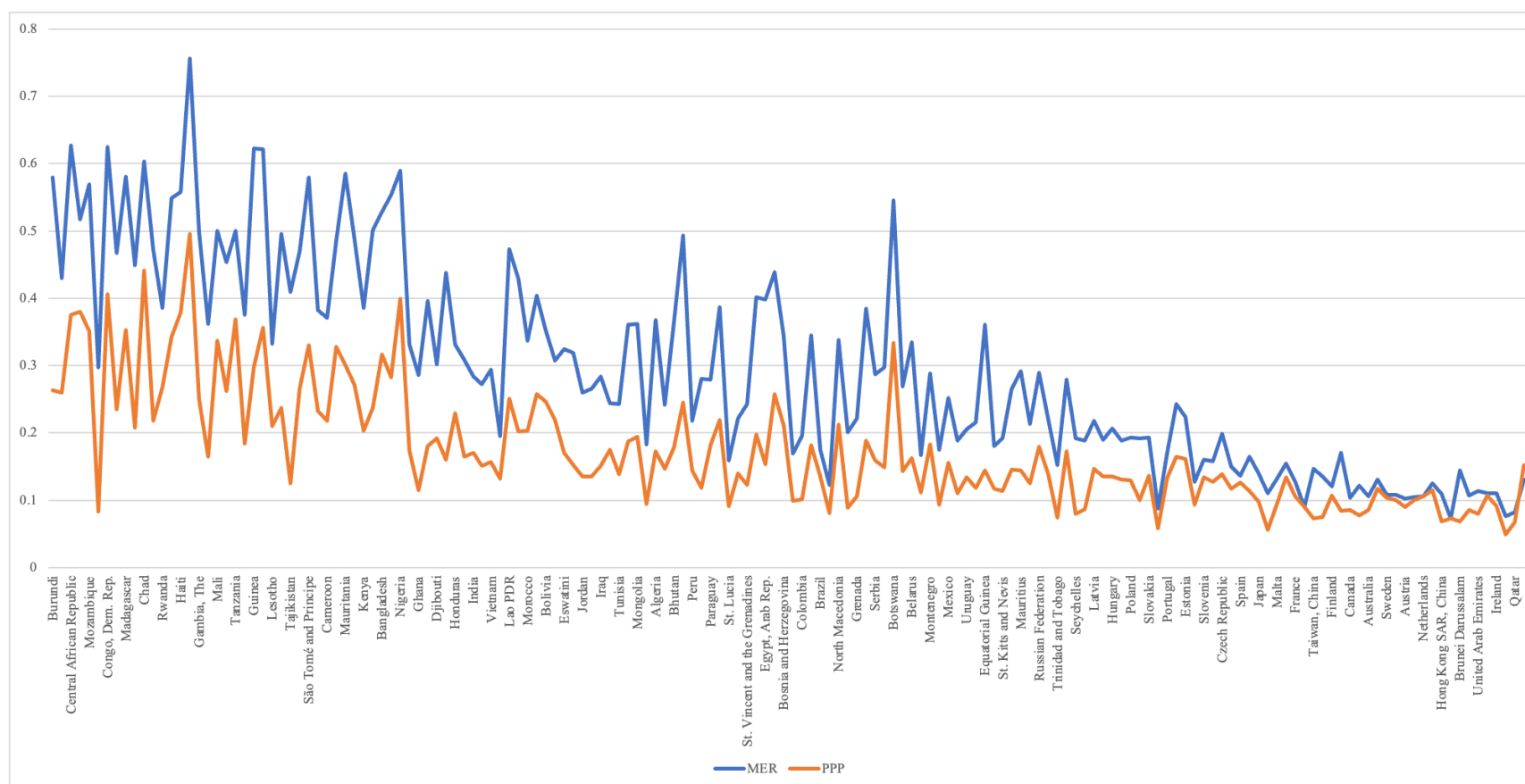


**Figure 1. Purchasing Power Parity vs. Market Exchange Rate food share across countries.**

Source: Author's calculations using 2017 International Comparison Program (ICP) data, World Bank.

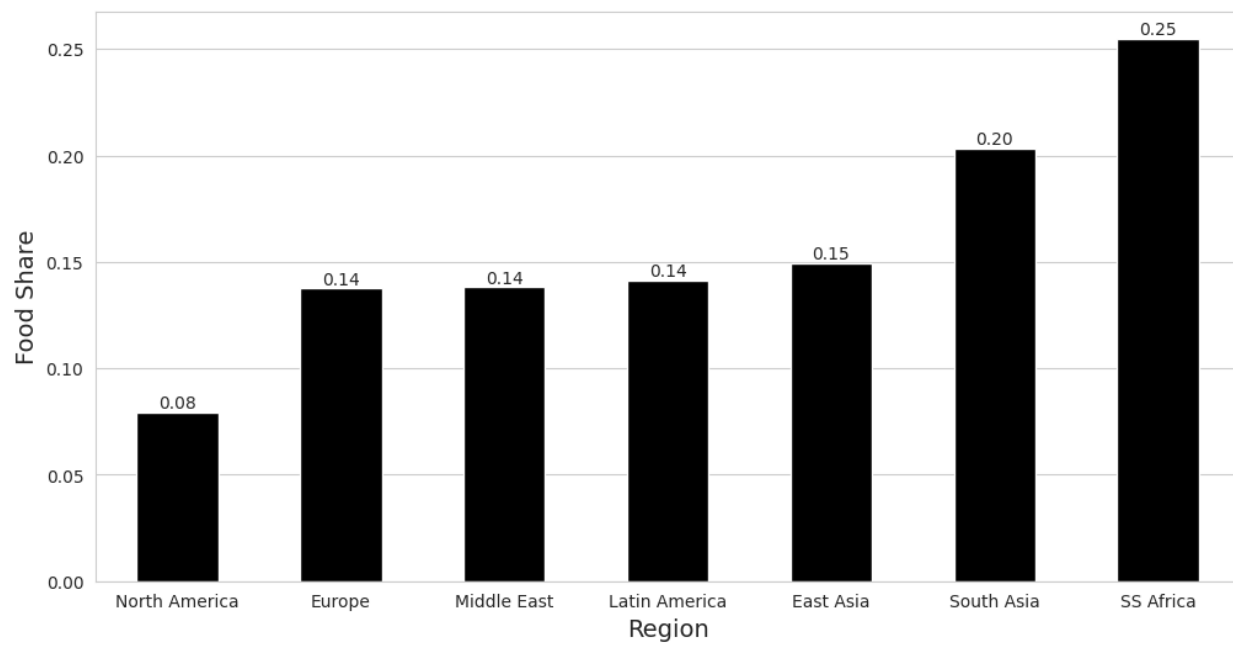


**Figure 2. Average food share across regions.**

Source: Author's calculations using 2017 International Comparison Program (ICP) data, World Bank.

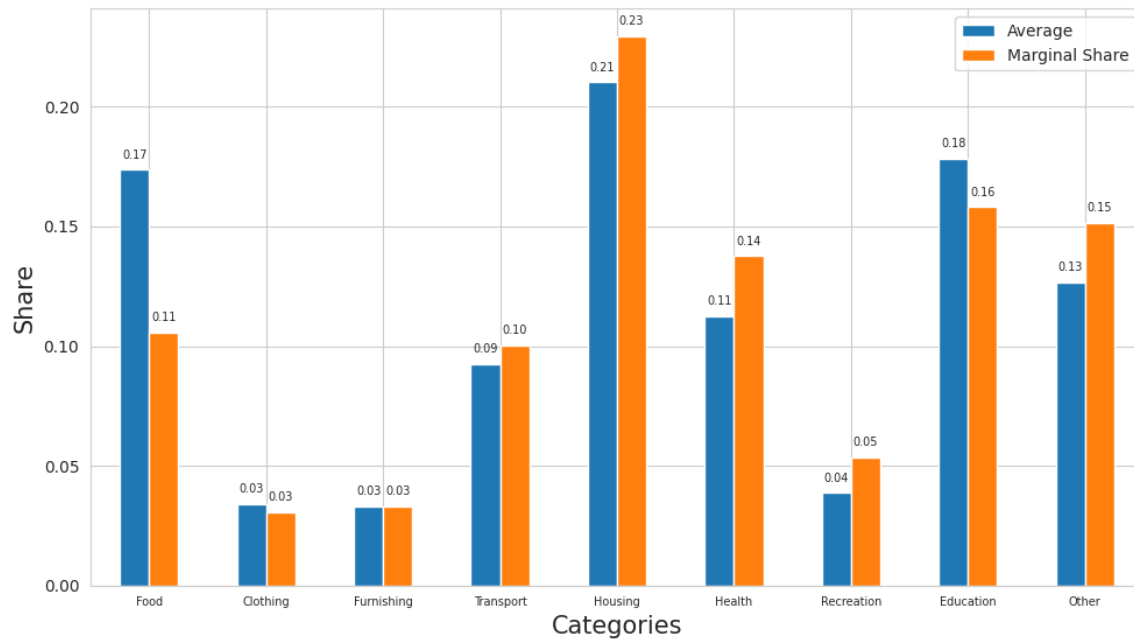


**Figure 3. Average share vs marginal share, broad consumption categories.**

Source: Author's calculations using 2017 International Comparison Program (ICP) data, World Bank.

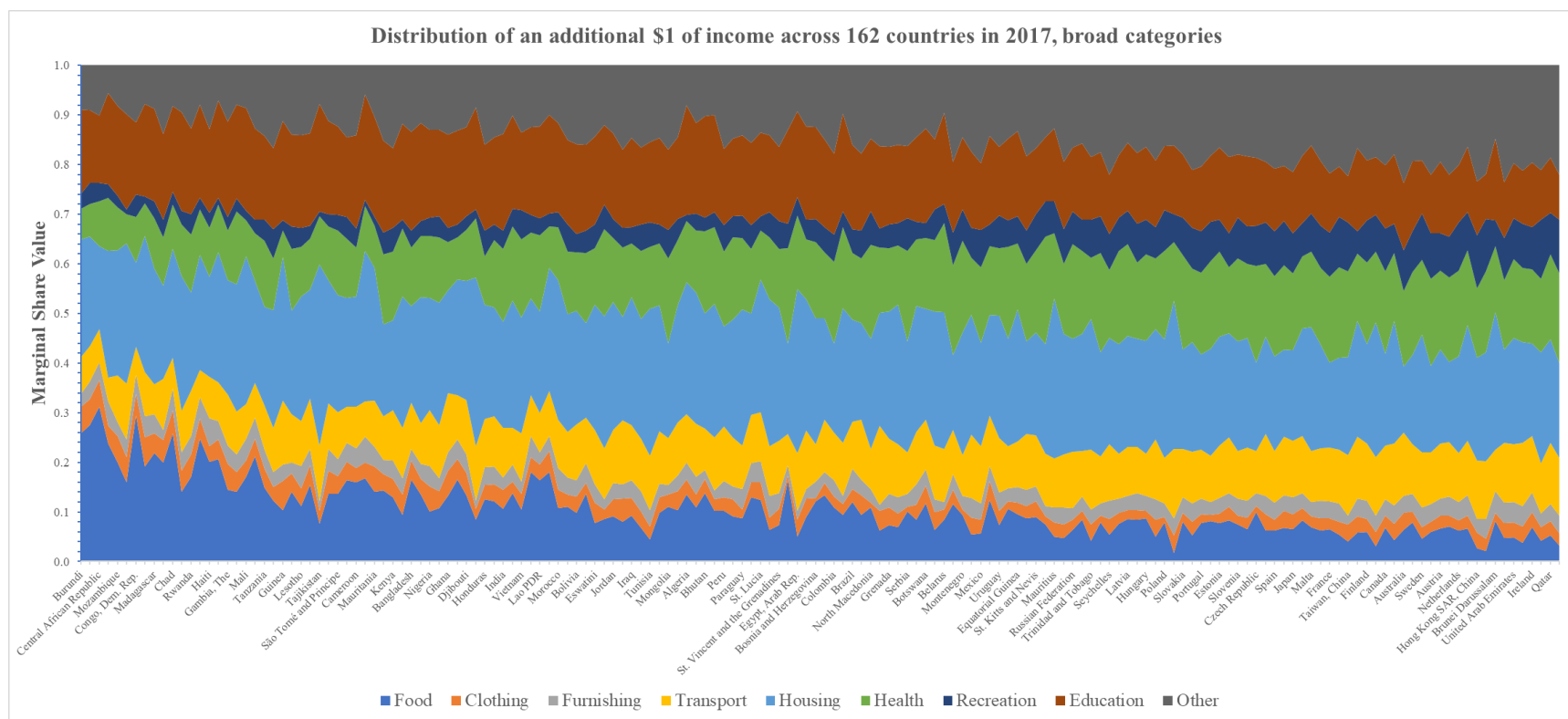


**Figure 4. Distribution of an extra dollar across countries, broad consumption categories.**

Note: Countries are arranged from low to high GDP Per Capita.

Source: Author's calculations using 2017 International Comparison Program (ICP) data, World Bank.

**CHAPTER II**  
**GLOBAL FOOD DEMAND TRENDS: A DISAGGREGATED ANALYSIS**  
**ACROSS 162 COUNTRIES**

## **1. ABSTRACT**

This study analyzes expenditures across food products and countries. We used the Almost Ideal Demand System (AIDS) model to estimate demand and calculate expenditure and price elasticities. Food categories covered in this study include bread & cereals, meat, fish & seafood, dairy, oils & fats, fruits & vegetables, and beverages. Our findings show that bread & cereals make up a large share of consumption in low-income countries, with Sub-Saharan Africa and South Asia allocating 24% and 28% of their income to bread & cereals, respectively. Bread was the least responsive to income changes, with a global income elasticity of 0.760, while meat had the highest income elasticity at 1.237. Bread showed the lowest price sensitivity with a global uncompensated own-price elasticity of -1.784, whereas fish had the highest price elasticity at -2.909. Cross-price analysis reveals a strong substitute relationship between meat and fish. Lastly, marginal share results show significant differences in how an extra food dollar is allocated across food categories and countries.

## 2. INTRODUCTION

The Food and Agricultural Organization (FAO) estimated that 691 to 783 million people were hungry in 2022 (FAO, 2023). This issue was attributed to the COVID-19 pandemic and the increase in global political conflicts and economic crises, such as food price fluctuations that left millions of individuals without access to sufficient food (Erokhin & Gao, 2020; Laborde et al., 2021). In the battle to feed the world with limited food resources, food consumption is affected by a growing need for food products in other sectors, such as biofuel production, agricultural land lost to urbanization, soil erosion, and other factors (Godfray et al., 2010). Without adequate and nutritious food, there is an increase in the risk of chronic diseases, which might lead to death or inability to work. It is important to note that food sufficiency, availability, preferences, and spending vary across countries and individuals. Understanding the impact of income and price changes on the demand for individual food products is important in implementing national, regional, and global policies and strategies to fight against hunger and malnutrition.

Income is a primary factor affecting dietary choices, preferences, and demand for individual food products (Houthakker, 1957; Muhammad et al., 2017; Seale et al., 2003). As income increases, individuals shift their food expenditure by decreasing spending on starches and staples such as bread, rice, and cereals and increasing spending on fruits, vegetables, and animal products such as milk and meat (Bennett, 1941; Gehlhar & Coyle, 2001). For example, Huang & Bouis (2011) showed that per capita consumption of cereals declined rapidly in Japan, Korea, and Taiwan due to increased income, while meat, fish, and dairy consumption increased.

The pattern of food spending for individuals can also be observed at the country level. Spending on food products varies significantly across countries, with low-income countries spending a higher portion of their food budget on staple foods such as cereals (Meade & Rosen, 1886; Muhammad et al., 2011). In contrast, developed countries have a more diversified consumption basket, with more food options available relative to poor countries (Clements et al., 2006; Rathnayaka et al., 2022). Food choice

differences are also attributed to different cultures and religions that influence or limit food choices and intake (Seleshe et al., 2014). This results in different preferences across food products and countries.

Understanding consumption patterns across food categories is crucial to developing policy aimed at ensuring healthy food choices. Low-income countries rely on affordable food products such as bread and cereals. Sometimes, low-income countries consume meat, fish, or dairy on special occasions. Inadequate dietary intake and undernutrition lead to micronutrient deficiency disorders and diseases, which can alter growth in children (Caulfield et al., 2006), high medical costs within countries, and millions of deaths annually around the world (Ahmed et al., 2013).

Food availability and affordability are affected by supply-chain related issues. Unprecedented situations such as the COVID-19 pandemic caused a rise in commodity and labor pricing, impacted food transportation & logistics, and led to higher prices that affected food demand globally (Allam, 2022). Regional and global conflicts affect countries and regions that heavily rely on food imports through shipping disruptions. An increase in food prices affects many countries, but things are even worse for poor countries where a high percentage of the population already struggle with affordability issues.

The reduction of available food in the global market due to economic sanctions against Russia and Belarus, and poor harvest in some countries, and supply chain disruptions increased food prices (Hassen & Bilali, 2022). For example, the Russia-Ukraine war resulted in higher global food prices, affecting food transportation and availability, especially for cereals-importing countries since Ukraine was the fourth largest exporter of cereals, with 6% of the global market (Jagtap et al., 2022). Farmers, among many others, are affected by global insecurity, resulting in changes in prices in the local and international markets, creating uncertainty in the long-term nature of their returns (Godfray et al., 2010). As the world depends on a few countries to produce key commodities for the rest of the world, a shock in any of these countries, such as climate change, conflicts, poor harvest, or export bans affects the whole world (D'odorico et al., 2014). Ensuring global security and implementing global trade policies are crucial in stabilizing food prices and diversification to meet an increasing demand for ethnic foods that include specific ingredients and dishes (Lee et al., 2014).

This study aims to understand the impact of price changes and per capita income on the demand for food products across countries. We examined the food-product shares and prices and estimated demand across several food categories. We derive global expenditure and price elasticities across countries, which is crucial in understanding the responsiveness of food expenditures to prices and income using the Almost Ideal Demand System (AIDS) model and 2017 ICP data. Elasticities can be a tool to explain changes in income and prices (Hertel et al., 1998). We derive and examine the own and cross-price elasticities, to understand how price changes in one food category affect demand for other food categories. Lastly, we use the model to estimate marginal shares across countries, which is a measure of how an extra food dollar is allocated across all food categories.

The rest of the paper is organized as follows: the literature review examines relevant existing studies and models used to study global food consumption. The data section describes the dataset used for our analysis and presents summary statistics. The model and estimation method section details the demand model used in this study. The results section presents our findings. The conclusion section includes a summary of our findings and concluding remarks.

### **3. LITERATURE REVIEW**

Numerous studies have investigated how income is allocated across food products. These studies differ in terms of types and number of food products included in their study. Some studies explore income and price sensitivity across products within specific countries, regions, or on a global scale.

Jurén (1956) is among the first studies to examine demand in a multi-country framework. This study discussed differences in calorie intake and consumption, per capita consumption across countries, and the demand for products over time. For example, the United States consumption of bread and potatoes decreased from 1916 to 1952 by 39% and 45%, respectively, while the consumption of sugar, fruits and vegetables, eggs, and dairy products increased. Although, the consumption of meat and oils slightly changed over the years.

Seale et al. (2003) conducted a study using ICP 1996 data across eight food categories. Cereals, oils and fats, and fruits and vegetables had the largest food share in developing countries. The findings show that cereals had the smallest responses to changes in income and prices compared to other valued food products such as meat, fish, and dairy.

Seale & Regmi (2006) used a two-stage demand system to fit 1996 ICP data across 114 countries, where the first stage fit nine aggregate consumption categories. The second stage fits seven different food categories, including bread & cereals, meat, fish, dairy, fruits and vegetables, oils and fats, and beverages and tobacco. Bread and cereals, oils and fats, and fruits and vegetables were price inelastic, while the rest were price elastic. Elasticities also varied across countries. Vietnam had the largest elasticity in terms of magnitude, while the United States had the smallest. For example, meat's income (expenditure) elasticity ranges from 0.79 to 0.10, and price elasticity ranges from -0.66 to -0.07 in Vietnam and the United States, respectively.

Muhammad et al. (2011) studied food budget allocation across eight food categories, including cereals, meats, fish, dairy, oils and fats, fruits and vegetables, beverages, and other foods. The study found low-income countries allocate a higher portion of income on cereals and fruits & vegetables. As income increases, the portion of income allocated to cereals and fruits decreases while increasing the portion allocated to other foods, including dining out in restaurants and high-end food expenditures.

Chen et al. (2016) used a meta-regression technique to conduct a meta-analysis of food and agricultural demand elasticities in China. This study also found some contrary results, where the own-price elasticities of food products became more price elastic, with an increase in per capita income. This analysis covered 16 food products. This resulted in varying expenditure and price elasticities. Aquatic products (0.695), poultry (0.669), and dairy (0.654) had higher expenditure (income) elasticities compared to other products. Food products that are less responsive to changes in income include wheat, coarse grains, and edible oil. Wheat and dairy products were highly sensitive to price changes.

Muhammad et al. (2017) studied how income and food prices influence global dietary intakes for 11 food categories by age and sex across 164 countries. They identified income and price elasticities

across food categories and regions. The key findings indicate that income and food prices significantly impact dietary choices. This study also indicates that an increase in income might lead to an increase in fruit and meat consumption but a declining intake of goods such as beans/legumes and nuts/seeds.

Colen et al. (2018) conducted a meta-analysis on income (expenditure) elasticities for different types of food in 48 African countries. This study highlighted how African countries have diverse food choices and preferences, unlike regions such as Asia. They highlighted how the increase in income in Africa has increased food expenditure. An increase in consumption does not necessarily mean shifting to healthier diets. Income elasticities varied across products from 1.24 for beverages, 0.81 for dairy, 0.79 for meat, fish, and eggs, 0.62 for fruits and vegetables, 0.58 for fats & oils, 0.42 for tubers, 0.40 for legumes & nuts, 0.40 for cereals.

The Almost Ideal Demand System (AIDS) is one of the most popular models, widely used in food demand analysis globally, regionally, or within a specific country (Deaton & Muellbauer, 1980). The AIDS model was used to study food demand in several countries, including Spain (Molina, 1994), the United Kingdom/Great Britain (Chesher & Rees, 1987; Tiffin & Tiffin, 1999), Greece (Mergos & Donatos, 1989), Lithuania (Hossain & Jensen, 2000), Malaysia (Tey et al., 2007), and Caribbean countries (Forgenie et al., 2024). Some studies used the AIDS model to study the demand for specific food products. The AIDS model was also used to study the demand for meat by Moschini and Meilke (1989) in the United States, and Jabarin (2005) in Jordan. This model is not only used for food demand but can also be used in analyzing housing demand (Parsons, 1986) and other cases.

## **4. DATA**

We used the World Bank's International Comparison Program (ICP) data for this analysis (World Bank, 2020). The data include expenditures and prices for eight food categories. Our analysis includes 162 countries for which we had complete data. We used the purchasing power parities data, where expenditure is expressed in USD, and the Price Level Index is based on the global average (world=100). The food categories included in this analysis are the following: bread & cereals, meat, fish and seafood,

dairy (milk, cheese, and eggs), oils and fats, fruits and vegetables, other foods, and non-alcoholic beverages (beverages). It is worth noting that the beverages category only accounts for non-alcoholic beverages, including soft drinks, juice, mineral water, coffee, and tea. ‘Other foods’ includes other products not included in the food category. For simplicity, throughout the study, bread is used instead of bread & cereals, fish instead of ‘fish and seafood’, oils instead of ‘oils and fats’, and dairy instead of ‘milk, cheese, and eggs. Table 8 (located in the appendix section) provides details about each food category.

#### **4.1 Descriptive Statistics**

Table 9 presents summary statistics. The average food expenditure globally is \$1,445.38 per capita, which varies from \$112.99 in Liberia to \$3,373.62 in Iceland. Bread and Cereals have an average food share of 19%. The Bahamas has the lowest bread & cereals share with 7.4%, while Haiti has 49.7%. Low-income countries had the highest bread & cereals share. Apart from Haiti, other countries with the highest bread & cereals shares include Niger, Lesotho, Bangladesh, Eswatini, and Mozambique. Meat had an average food share of 19%, indicating that it is a significant part of the diet globally. Some countries reported lower meat shares, such as Malawi, which had only 1%, while Mauritania reported 51.7%. Fruits and Vegetables have the highest average food share with 24%, varying from 4% in Mongolia to 80% in Rwanda. Overall, oils and fats had the lowest global average at 3%.

The price level indexes used for the analysis are price series where the global average (world) equals 100. While these indexes do not allow for comparisons across products, they provide insights into how products are more or less expensive across countries. For example, the price level index for bread and cereals varies from 47 in Tunisia to 232 in St. Kitts and Nevis. Also, meat prices vary from 46 in Mongolia to 309 in South Korea.

#### **4.2. Spending Allocation Across Regions**

As countries differ in spending across food categories, there is a variance in income allocation across regions. Fig 5 shows that, on average, fruits and vegetables had the highest share, accounting for

24% of the total food budget. Bread and meat each had 19%, while oil had the lowest budget share, with only 3%. Table 8 reflects the regional differences in the allocation of food budget. Bread and cereals have a higher budget share in South Asia and Saharan Africa than in other regions. Europe and North America have the lowest shares of bread. Latin America allocates about 25% of food income on meat, and while South Asia only allocates 7% on meat due to higher income allocation on bread and fruits & vegetables.

East Asia allocates 14% of their food income to fish and seafood, while other regions allocate less than 10%. This is not surprising since 61% of the world's supply of fish comes from Asia. Also, the annual per capita consumption of fish is 27 kg in Asia, compared to 18 kg globally (Dey et al., 2008). Fruits and vegetables have the highest allocation across different categories. The lowest share is only 18% in North America, while Sub-Saharan Africa allocates 30% of their food budget to fruits & vegetables. North America has a higher budget share for ‘other foods,’ which reflects a greater variety of other food items.

## 5. MODEL AND ESTIMATION METHOD

The Almost Ideal Demand System (AIDS) model was developed by Deaton and Muellbauer (1980) and represents a significant advancement in consumer demand analysis. This model is easy to estimate and linear in parameters, providing a framework for estimating how individuals allocate their spending across goods and services. The AIDS model is based on utility-maximization, where expenditure functions are consistent with consumer theory. It incorporates a price level index, addressing the issue of how price change relative to a consumer’s purchasing power affects demand. This model is known as “almost” due to its ability to generate estimates that align with real-world consumer behaviors. In addition, the AIDS model assumes and allows testing of symmetry and homogeneity restrictions. We used Stata 18.0 to estimate the model (“*demandsys*” command) (Stata, 2023) and calculate elasticities and marginal shares. Assuming  $k$  product categories, the AIDS model can be expressed as follows:

$$w_i = \alpha_i + \sum_{j=1}^k \gamma_{ij} \ln p_j + \beta_i \ln \left\{ \frac{m}{a(p)} \right\}$$

Where,  $i$  represents the food categories such as bread, meat, fish, etc.  $k$  denotes the total number of food categories. The expenditure share ( $w_i$ ) is calculated as  $w_i = \frac{p_i q_i}{m}$ , where  $p_i$  represents the price of food product  $i$ ,  $q_i$  is the quantity consumed. Where  $w_i$  is the portion of total food expenditure that is spent on food product  $i$ ,  $m$  is the total food expenditure, and  $\ln(m)$  is the log of total food expenditure  $\sum_{i=1}^k p_i q_i$ .  $\alpha, \beta$ , and  $\gamma$  are parameters to be estimated, and  $\ln(a(p))$  is a logarithmic function of the price vector  $p$ . Below is the equation for  $\ln(a(p))$ :

$$\ln(a(p)) = \alpha_0 + \sum_{i=1}^k \alpha_i \ln p_i + \frac{1}{2} \sum_{i=1}^k \sum_{j=1}^k \gamma_{ij} \ln p_i \ln p_j$$

We can impose restrictions on the model based on demand theory: adding up, homogeneity, and symmetry to ensure consistency with utility maximization. Adding up implies that the budget shares for all broad consumption categories sum to 1 and implies the following:

$$\sum_{i=1}^k \alpha_i = 1, \quad \sum_{i=1}^k \beta_i = 0, \quad \sum_{i=1}^k \gamma_{ij} = 0$$

The homogeneity restriction implies that prices are homogeneous of degree zero. In other words, the quantity demanded remains consistent if income and prices change proportionally. Homogeneity implies the following:

$$\sum_{j=1}^k \gamma_{ij} = 0$$

Symmetry implies that the cross-price coefficients between two goods are symmetric, reflecting a mutual substitute or complementary relationship:

$$\gamma_{ij} = \gamma_{ji}$$

We used Green & Alston (1990) to derive elasticities. Expenditure elasticities, which measures the demand responsiveness to changes in income is derived as follows:

$$e_i = \left( \frac{\beta_i}{w_i} \right) + 1$$

The Marshallian or uncompensated price elasticities measure the change in quantity demanded due to changes in price, including the substitution and income effect of a price change. We derived the uncompensated price elasticities as follows:

$$e_{ij}^u = -\delta_{ij} + \left(\frac{\gamma_{ij}}{w_i}\right) - \beta_i \left(\frac{w_j}{w_i}\right)$$

$\delta_{ij}$  is Kronecker delta, which takes the value of 1 for own-price elasticity and 0 otherwise.

Hicksian or compensated price elasticities measure the response of demand to price changes, holding real income constant. We derived compensated price elasticities as follows:

$$e_{ij}^c = e_{ij}^u + e_i w_j$$

The marginal share ( $\theta_i$ ) measures how an additional income (unit of expenditure) is allocated to spending category  $i$ . It is subject to change with an increase or decrease in income and is calculated as follows:

$$\theta_i = \frac{\partial(p_i q_i)}{\partial m} = \frac{e_i}{w_i}$$

## 6. RESULTS

### 6.1 Estimation Results

Estimated parameters and significance levels for food categories are reported in Table 11. Alpha coefficients ( $\alpha_i$ ) show a basic level of demand when income and prices are constant. Bread, oils, and ‘other food’ had negative beta coefficients ( $\beta_i$ ), indicating that an increase in the food budget decreases the demand for these products. Meat, dairy, and beverages had a positive beta coefficient, which shows that demand increases with an increase in the food budget. Gamma coefficients ( $\gamma_{ij}$ ) are related to cross-price elasticities, indicating how the demand of a given food category changes with the price change of the other. Since six of the eight categories have  $\beta_i < 0$ , their expenditure elasticity is less than 1, indicating an inelastic response to expenditures for these food categories (Seale et al., 2003). The Almost Ideal Demand System allows us to conclude whether goods are luxuries or necessities, where negative beta estimates indicate necessities and positive estimates indicate luxuries (Deaton & Muellbauer, 1980). Beta

estimates classify bread, oils, and ‘other food’ as necessities, while meat, dairy, and beverages are luxuries. Beverages as a necessity are consistent with the findings of Seale et al. (2003), noting that beverages can be considered a luxury due to low food budget share, especially in low-income countries.

## 6.2 Expenditure and Own-Price Elasticities

Elasticity results and marginal share are conditional to total food expenditure. Three elasticities estimated include expenditure or income, uncompensated (Marshallian), and compensated (Hicksian) price elasticities. Table 12 shows expenditure and own-price elasticities for eight food products. The global expenditure elasticities for food products are 0.760 for bread & cereals, 1.237 for meat, 0.967 for fish, 1.225 for dairy, 0.866 for oils, 0.921 for fruits and vegetables, 0.887 for other food, and 1.179 for beverages. Since  $w_i$  is positive, a negative  $\beta_i$  implies that expenditure elasticity is less than one, while a positive  $\beta_i$  implies that expenditure elasticity is greater than one (Blancifortini & Green, 1983). Among all food categories, bread was the least responsive (less elastic) to income, while dairy & beverages had the highest elasticity. Fish and fruits & beverages had close to a unitary elasticity.

The price elasticity reflects a change in quantity demanded with price change. Uncompensated own-price elasticities vary from -1.784 for bread & cereals to -2.909 for fish. Oil was also less responsive to price change, with a price elasticity of -1.841. The rest had the following elasticities: -2.105 for meat, -2.069 for dairy, -2.111 for fruits & vegetables, -2.096 for other food, and -2.184 for beverages. Compensated price elasticities are also reported in Table 14, which are smaller than uncompensated price elasticities in absolute terms since they only account for the substitution effect of a price change, holding real income changes constant.

## 6.3 Cross-Price Elasticities

Tables 13 and 14 present a matrix of uncompensated and compensated cross-price elasticities, respectively. Cross-price elasticity reflects a change in quantity demanded due to a change in the price of the other food category. We calculated cross-price elasticities to evaluate the demand change as the price

of other food products change. A positive price cross-price elasticity indicates that two goods are substitutes, while a negative elasticity indicates complements. Bread & cereals show a substitutable relationship with meat (0.219), dairy (0.307), and beverages (0.886). Conclusions can be drawn about the relationship between bread and other goods, but these relationships have low significance.

Meat has a strong substitute relationship with fish, with a cross-price elasticity of 0.511, which is the highest compared to other food categories. This indicates that as prices of meat or fish increase, the demand for other products increases, with the difference being magnitude. A one percent increase in the price of meat results in a 0.511 percent increase in demand for fish, while a one percent increase in price of fish results in a 0.187 percent increase in demand for meat. Fruits and vegetables have a substitute relationship with all categories except oils and fats. Beverages, fish, and 'other food' have the strongest substitute relationship with cross-price elasticities of 0.674, 0.643, and 0.586, respectively.

Most of the complementary relationships between products have low significance. Beverages show a complementary relationship with dairy and other food. This can be explained by the fact that some food products are consumed with a beverage. Beverages include coffee, tea, mineral water, soft drinks, juice, and others, sometimes consumed with or without other food products.

## **6.4 Marginal Shares**

Figure 5 shows the differences between the average allocation of the food budget and the allocation of an additional dollar. The results indicate that meat, dairy, and beverages have a higher marginal share compared to their average shares. This suggests that as income increases, consumers allocate a smaller portion of their income to bread (decreased from 0.19 to 0.15) and fruits and vegetables (0.24 to 0.22), while other categories have no significant changes. Figure 7 shows the variability in marginal shares differs across regions. This shows both the mean and variability of marginal share across regions. There is no significant difference within North America, as it consists of only the United States and Canada.

Figure 6 shows the allocation of an extra food dollar (marginal share) to food categories across 162 countries. This Marginal Share measures the allocation of extra food dollars across different food categories. Bread has a relatively stable budget share across countries, with a few countries such as Niger (0.26), Mozambique (0.24), and Ethiopia (0.23) allocating higher income shares. The marginal share for fish is higher in Maldives, Liberia, Namibia, and South Korea, while Rwanda, Burundi, and Uganda had the lowest marginal share for fish. This shows that coastal countries have a higher budget share for fish, while landlocked countries have limited fishery resources since they have no access to sea or ocean but rely on fish imports. Cultural preferences play a part in fish consumption, where some countries, especially in Asia, consume fish regularly. Higher-income countries, including South Korea (0.15), Switzerland (0.14), Japan (0.13), Singapore (0.13), and the United States (0.11), have a higher marginal share for other food (sugar, jams, etc.), reflecting a variation in diets. Table 15 in the appendix shows marginal share for each food category across countries.

## **7. CONCLUSION**

The analysis in this study shows variance in price and income elasticities across food categories, indicating differences in choice and preferences of food products. Regarding average shares, most countries allocated a high percentage of their income to fruits and vegetables. Elasticities from this study show a change in consumer dependence with respect to changes in price and income. Globally, meat is the most sensitive to price change, while bread is the least responsive. The marginal share results show that with an increase in income, consumers allocate their largest portion of the extra food budget on meat and fruits & vegetables, while decreasing their consumption on bread and other foods.

Policymakers can use the results from this study to develop policies to regulate the prices of selected food products through tax or subsidy programs. These policies can target an increase in the consumption and affordability of healthy foods while limiting the consumption of unhealthy food products. Additionally, it is worth noting that factors other than price and income, including cultural influences and preferences, affect food consumption but were not included in the model.

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## APPENDIX

**Table 8. Classification of expenditure food categories, based on ICP 2017.**

| Food category                  | Details                                                                           |
|--------------------------------|-----------------------------------------------------------------------------------|
| Bread and Cereals              | Rice, bread, pasta products, and other cereals.                                   |
| Meat                           | Fresh, chilled or frozen meat of beef and veal, pork, lamb, poultry, other meats. |
| Fish and Seafood               | Fresh, chilled or frozen, preserved or processed seafood.                         |
| Dairy (Milk, Cheese, and Eggs) | Fresh and preserved milk, cheese, eggs                                            |
| Oils and fats                  | Butter, margarine, other edible oils and fats                                     |
| Fruits and vegetables          | Fresh, chilled, frozen fruits and vegetables, potatoes                            |
| Other foods                    | Sugar, jams, homely, and other food products.                                     |
| Beverages                      | Coffee, tea, mineral water, soft drinks, juices, etc.                             |

Source: Author's calculations using 2017 International Comparison Program (ICP) data, World Bank.

**Table 9. Descriptive statistics, food categories.**

| Variable                 | Mean      | Std. dev. | Min    | Max        |
|--------------------------|-----------|-----------|--------|------------|
| GDP (\$)                 | 21,661.45 | 21,108.22 | 784.48 | 112,700.70 |
| Food Exp (\$)            | 1,445.38  | 790.78    | 112.99 | 3,373.62   |
| Bread share              | 0.19      | 0.08      | 0.07   | 0.50       |
| Meat share               | 0.19      | 0.08      | 0.01   | 0.52       |
| Fish share               | 0.08      | 0.07      | 0.00   | 0.41       |
| Dairy share              | 0.09      | 0.05      | 0.00   | 0.20       |
| Oils share               | 0.03      | 0.02      | 0.00   | 0.11       |
| Fruits & veg share       | 0.24      | 0.12      | 0.04   | 0.81       |
| Other food share         | 0.10      | 0.05      | 0.01   | 0.32       |
| Beverage share           | 0.07      | 0.04      | 0.00   | 0.21       |
| Bread price index        | 110.42    | 38.25     | 47.05  | 231.78     |
| Meat price index         | 99.67     | 38.97     | 45.72  | 309.16     |
| Fish price index         | 108.53    | 35.41     | 45.00  | 229.12     |
| Dairy price index        | 116.33    | 33.49     | 55.91  | 227.68     |
| Oils price index         | 108.44    | 28.90     | 59.68  | 225.89     |
| Fruits & veg price index | 120.20    | 50.52     | 33.19  | 322.73     |
| Other food price index   | 99.92     | 27.83     | 49.62  | 185.86     |
| Beverages price index    | 104.03    | 34.04     | 48.02  | 295.24     |

Source: Author's calculations using 2017 International Comparison Program (ICP) data, World Bank.

**Table 10. Food categories budget share across regions.**

| Food Product |        | Global | SS Africa | South Asia | Latin America | Middle East | East Asia | Europe & Central Asia | North America |
|--------------|--------|--------|-----------|------------|---------------|-------------|-----------|-----------------------|---------------|
|              | Obs.   | 162    | 44        | 7          | 29            | 16          | 19        | 45                    | 2             |
| Bread        | Median | 0.17   | 0.24      | 0.28       | 0.17          | 0.14        | 0.19      | 0.15                  | 0.16          |
|              | Mean   | 0.19   | 0.24      | 0.30       | 0.17          | 0.16        | 0.20      | 0.16                  | 0.16          |
| Meat         | Median | 0.19   | 0.14      | 0.06       | 0.24          | 0.20        | 0.17      | 0.21                  | 0.19          |
|              | Mean   | 0.19   | 0.15      | 0.07       | 0.25          | 0.21        | 0.20      | 0.21                  | 0.19          |
| Fish         | Median | 0.05   | 0.09      | 0.06       | 0.05          | 0.05        | 0.14      | 0.04                  | 0.03          |
|              | Mean   | 0.08   | 0.09      | 0.12       | 0.08          | 0.08        | 0.14      | 0.04                  | 0.03          |
| Dairy        | Median | 0.09   | 0.03      | 0.08       | 0.09          | 0.10        | 0.05      | 0.13                  | 0.10          |
|              | Mean   | 0.09   | 0.04      | 0.10       | 0.09          | 0.10        | 0.06      | 0.14                  | 0.10          |
| Oils         | Median | 0.03   | 0.04      | 0.03       | 0.03          | 0.03        | 0.02      | 0.03                  | 0.03          |
|              | Mean   | 0.03   | 0.04      | 0.04       | 0.03          | 0.04        | 0.02      | 0.03                  | 0.03          |
| Fruits & Veg | Median | 0.21   | 0.27      | 0.21       | 0.17          | 0.25        | 0.18      | 0.21                  | 0.18          |
|              | Mean   | 0.24   | 0.30      | 0.24       | 0.18          | 0.27        | 0.19      | 0.23                  | 0.18          |
| Other Food   | Median | 0.09   | 0.07      | 0.10       | 0.10          | 0.06        | 0.08      | 0.10                  | 0.20          |
|              | Mean   | 0.10   | 0.09      | 0.09       | 0.11          | 0.08        | 0.11      | 0.11                  | 0.20          |
| Beverages    | Median | 0.07   | 0.03      | 0.02       | 0.09          | 0.06        | 0.08      | 0.09                  | 0.11          |
|              | Mean   | 0.07   | 0.04      | 0.04       | 0.09          | 0.07        | 0.08      | 0.09                  | 0.11          |

Source: Author's calculations using 2017 International Comparison Program (ICP) data, World Bank.

**Table 11. AIDS estimates based on food categories.**

|            | <b>Bread</b>         | <b>Meat</b>          | <b>Fish</b>          | <b>Dairy</b>         | <b>Oils</b>          | <b>Fruits &amp; Vegetables</b> | <b>Other Food</b>    | <b>Beverages</b>     |
|------------|----------------------|----------------------|----------------------|----------------------|----------------------|--------------------------------|----------------------|----------------------|
| $\alpha$   | 0.101***<br>(0.022)  | 0.275***<br>(0.022)  | 0.073***<br>(0.018)  | 0.141***<br>(0.011)  | 0.026***<br>(0.006)  | 0.229***<br>(0.029)            | 0.063***<br>(0.016)  | 0.092***<br>(0.011)  |
| $\beta$    | -0.045***<br>(0.009) | 0.047***<br>(0.009)  | -0.003<br>(0.008)    | 0.021***<br>(0.005)  | -0.004*<br>(0.002)   | -0.018<br>(0.012)              | -0.011*<br>(0.007)   | 0.014***<br>(0.005)  |
| $\gamma_1$ | -0.152***<br>(0.033) | 0.048**<br>(0.021)   | 0.003<br>(0.017)     | 0.031**<br>(0.014)   | -0.011<br>(0.008)    | -0.005<br>(0.021)              | 0.018<br>(0.020)     | 0.069***<br>(0.014)  |
| $\gamma_2$ |                      | -0.206***<br>(0.026) | 0.041**<br>(0.016)   | 0.007<br>(0.011)     | 0.006<br>(0.006)     | 0.077***<br>(0.022)            | 0.038**<br>(0.016)   | -0.011<br>(0.011)    |
| $\gamma_3$ |                      |                      | -0.155***<br>(0.018) | 0.035***<br>(0.010)  | -0.000<br>(0.005)    | 0.052***<br>(0.016)            | 0.015<br>(0.014)     | 0.010<br>(0.009)     |
| $\gamma_4$ |                      |                      |                      | -0.097***<br>(0.015) | 0.006<br>(0.007)     | 0.029***<br>(0.011)            | 0.000<br>(0.014)     | -0.011<br>(0.010)    |
| $\gamma_5$ |                      |                      |                      |                      | -0.027***<br>(0.006) | -0.005<br>(0.006)              | 0.018**<br>(0.009)   | 0.013**<br>(0.006)   |
| $\gamma_6$ |                      |                      |                      |                      |                      | -0.258***<br>(0.032)           | 0.057***<br>(0.016)  | 0.054***<br>(0.011)  |
| $\gamma_7$ |                      |                      |                      |                      |                      |                                | -0.111***<br>(0.025) | -0.035***<br>(0.013) |
| $\gamma_8$ |                      |                      |                      |                      |                      |                                |                      | -0.089***<br>(0.013) |

Note: Standard errors are in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Source: Author's calculations using 2017 International Comparison Program (ICP) data, World Bank.

**Table 12. Expenditure, own price uncompensated and compensated elasticities.**

|                         | <b>Bread</b>         | <b>Meat</b>          | <b>Fish</b>          | <b>Dairy</b>         | <b>Oils</b>          | <b>Fruits &amp; Veg.</b> | <b>Other Food</b>    | <b>Beverages</b>     |
|-------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|--------------------------|----------------------|----------------------|
| Expenditure             | 0.760***<br>(0.049)  | 1.237***<br>(0.048)  | 0.967***<br>(0.095)  | 1.225***<br>(0.052)  | 0.866***<br>(0.077)  | 0.921***<br>(0.053)      | 0.887***<br>(0.067)  | 1.179***<br>(0.059)  |
| Own Price Uncompensated | -1.784***<br>(0.173) | -2.105***<br>(0.135) | -2.909***<br>(0.228) | -2.069***<br>(0.153) | -1.841***<br>(0.195) | -2.110***<br>(0.143)     | -2.096***<br>(0.248) | -2.184***<br>(0.170) |
| Own Price Compensated   | -1.641***<br>(0.175) | -1.859***<br>(0.133) | -2.830***<br>(0.225) | -1.955***<br>(0.154) | -1.813***<br>(0.194) | -1.898***<br>(0.140)     | -2.007***<br>(0.249) | -2.094***<br>(0.171) |

Note: Standard errors are in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Source: Author's calculations using 2017 International Comparison Program (ICP) data, World Bank.

**Table 13. Uncompensated cross-price elasticities.**

|                     | <b>Bread</b>        | <b>Meat</b>         | <b>Fish</b>         | <b>Dairy</b>        | <b>Oils</b>         | <b>Fruits &amp; Veg</b> | <b>Other Food</b>    | <b>Beverages</b>     |
|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|-------------------------|----------------------|----------------------|
| Bread               |                     | 0.219**<br>(0.104)  | 0.044<br>(0.211)    | 0.307**<br>(0.148)  | -0.342<br>(0.251)   | -0.017<br>(0.092)       | 0.190<br>(0.200)     | 0.886***<br>(0.146)  |
| Meat                | 0.326***<br>(0.113) |                     | 0.511**<br>(0.201)  | 0.004<br>(0.124)    | 0.243***<br>(0.201) | 0.359**<br>(0.096)      | 0.410***<br>(0.164)  | -0.196<br>(0.125)    |
| Fish                | 0.036<br>(0.093)    | 0.187**<br>(0.082)  |                     | 0.363***<br>(0.109) | 0.001<br>(0.172)    | 0.231***<br>(0.072)     | 0.154<br>(0.138)     | 0.114<br>(0.128)     |
| Dairy               | 0.195***<br>(0.072) | 0.001***<br>(0.056) | 0.440<br>(0.121)    |                     | 0.204***<br>(0.213) | 0.139<br>(0.048)        | 0.016***<br>(0.136)  | -0.173**<br>(0.083)  |
| Oils                | -0.055<br>(0.043)   | 0.027<br>(0.032)    | -0.003<br>(0.067)   | 0.059<br>(0.074)    |                     | -0.021<br>(0.025)       | 0.185**<br>(0.085)   | 0.168<br>(0.146)     |
| Fruits & Vegetables | 0.017<br>(0.117)    | 0.342***<br>(0.112) | 0.643***<br>(0.206) | 0.272**<br>(0.123)  | -0.138<br>(0.187)   |                         | 0.586***<br>(0.158)  | 0.674***<br>(0.169)  |
| Other food          | 0.114<br>(0.107)    | 0.172**<br>(0.081)  | 0.183<br>(0.168)    | -0.017**<br>(0.149) | 0.585<br>(0.266)    | 0.254***<br>(0.067)     |                      | -0.468***<br>(0.170) |
| Beverages           | 0.391***<br>(0.073) | -0.079<br>(0.055)   | 0.123<br>(0.115)    | -0.145<br>(0.106)   | 0.423***<br>(0.198) | 0.244***<br>(0.047)     | -0.332***<br>(0.128) |                      |

Note: Standard errors are in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Source: Author's calculations using 2017 International Comparison Program (ICP) data, World Bank.

**Table 14. Compensated cross-price elasticities.**

|                     | <b>Bread</b>        | <b>Meat</b>         | <b>Fish</b>         | <b>Dairy</b>        | <b>Oils</b>        | <b>Fruits &amp; Veg</b> | <b>Other Food</b>   | <b>Beverages</b>    |
|---------------------|---------------------|---------------------|---------------------|---------------------|--------------------|-------------------------|---------------------|---------------------|
| Bread               |                     | 0.452***<br>(0.105) | 0.227<br>(0.214)    | 0.538***<br>(0.148) | -0.179<br>(0.252)  | 0.157*<br>(0.093)       | 0.357*<br>(0.201)   | 1.108***<br>(0.143) |
| Meat                | 0.477***<br>(0.111) |                     | 0.703***<br>(0.200) | 0.248**<br>(0.122)  | 0.415**<br>(0.198) | 0.542***<br>(0.095)     | 0.586***<br>(0.161) | 0.039<br>(0.123)    |
| Fish                | 0.098<br>(0.092)    | 0.287***<br>(0.082) |                     | 0.463<br>(0.107)    | 0.071<br>(0.170)   | 0.306***<br>(0.071)     | 0.227*<br>(0.137)   | 0.209<br>(0.130)    |
| Dairy               | 0.266***<br>(0.073) | 0.116**<br>(0.057)  | 0.530***<br>(0.123) |                     | 0.284<br>(0.215)   | 0.224***<br>(0.049)     | 0.099<br>(0.138)    | -0.063<br>(0.083)   |
| Oils                | -0.030<br>(0.043)   | 0.067**<br>(0.032)  | 0.028<br>(0.067)    | 0.098<br>(0.074)    |                    | 0.009<br>(0.026)        | 0.214**<br>(0.085)  | 0.205<br>(0.142)    |
| Fruits & Vegetables | 0.191*<br>(0.114)   | 0.625***<br>(0.110) | 0.865***<br>(0.201) | 0.553<br>(0.120)    | 0.061<br>(0.183)   |                         | 0.790***<br>(0.154) | 0.945***<br>(0.170) |
| Other food          | 0.191*<br>(0.107)   | 0.297***<br>(0.082) | 0.281*<br>(0.169)   | 0.107<br>(0.149)    | 0.672**<br>(0.267) | 0.346***<br>(0.068)     |                     | -0.349**<br>(0.171) |
| Beverages           | 0.449***<br>(0.073) | 0.015<br>(0.055)    | 0.197*<br>(0.116)   | -0.051<br>(0.106)   | 0.489**<br>(0.198) | 0.314***<br>(0.047)     | -0.264**<br>(0.128) |                     |

Note: Standard errors are in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Source: Author's calculations using 2017 International Comparison Program (ICP) data, World Bank.

**Table 15. Marginal share across countries, food categories.**

| <b>Country</b>           | <b>Bread</b> | <b>Meat</b> | <b>Fish</b> | <b>Dairy</b> | <b>Oils</b> | <b>Fruits &amp; Veg</b> | <b>Other Food</b> | <b>Beverages</b> |
|--------------------------|--------------|-------------|-------------|--------------|-------------|-------------------------|-------------------|------------------|
| Burundi                  | 0.227        | 0.217       | 0           | 0.061        | 0.038       | 0.399                   | 0.045             | 0.021            |
| Niger                    | 0.264        | 0.158       | 0.052       | 0.036        | 0.051       | 0.387                   | 0.042             | 0.009            |
| Central African Republic | 0.233        | 0.208       | 0.105       | 0.028        | 0.036       | 0.278                   | 0.076             | 0.036            |
| Malawi                   | 0.209        | 0.217       | 0.037       | 0.063        | 0.038       | 0.357                   | 0.044             | 0.035            |
| Mozambique               | 0.241        | 0.149       | 0.102       | 0.057        | 0.032       | 0.292                   | 0.090             | 0.037            |
| Liberia                  | 0.178        | 0.166       | 0.213       | -            | 0.046       | 0.254                   | 0.068             | 0.076            |
| Congo, Dem. Rep.         | 0.227        | 0.162       | 0.070       | 0.045        | 0.042       | 0.361                   | 0.067             | 0.026            |
| Togo                     | 0.164        | 0.187       | 0.070       | 0.083        | 0.033       | 0.286                   | 0.100             | 0.077            |
| Madagascar               | 0.140        | 0.241       | 0.021       | 0.086        | 0.031       | 0.368                   | 0.039             | 0.075            |
| Ethiopia                 | 0.235        | 0.121       | 0.087       | 0.040        | 0.037       | 0.391                   | 0.055             | 0.034            |
| Chad                     | 0.200        | 0.305       | 0.069       | 0.071        | 0.039       | 0.260                   | 0.021             | 0.036            |
| Sierra Leone             | 0.179        | 0.198       | 0.098       | 0.066        | 0.037       | 0.331                   | 0.048             | 0.043            |
| Rwanda                   | 0.144        | 0.296       | 0           | 0.058        | 0.026       | 0.415                   | 0.022             | 0.041            |
| Burkina Faso             | 0.233        | 0.200       | 0.056       | 0.043        | 0.038       | 0.343                   | 0.055             | 0.032            |
| Haiti                    | 0.164        | 0.225       | 0.039       | 0.077        | 0.039       | 0.242                   | 0.106             | 0.108            |
| Guinea-Bissau            | 0.197        | 0.218       | 0.134       | 0.065        | 0.044       | 0.252                   | 0.052             | 0.039            |
| The Gambia               | 0.213        | 0.189       | 0.160       | 0.053        | 0.037       | 0.256                   | 0.049             | 0.044            |
| Uganda                   | 0.186        | 0.222       | 0           | 0.100        | 0.025       | 0.388                   | 0.046             | 0.053            |
| Mali                     | 0.209        | 0.233       | 0.115       | 0.038        | 0.038       | 0.293                   | 0.040             | 0.034            |
| Benin                    | 0.219        | 0.232       | 0.116       | 0.037        | 0.045       | 0.275                   | 0.040             | 0.036            |
| Tanzania                 | 0.133        | 0.284       | 0.047       | 0.074        | 0.030       | 0.303                   | 0.053             | 0.076            |
| Zimbabwe                 | 0.191        | 0.204       | 0.121       | 0.088        | 0.032       | 0.194                   | 0.102             | 0.067            |
| Guinea                   | 0.199        | 0.279       | 0.121       | 0.068        | 0.028       | 0.129                   | 0.092             | 0.084            |
| Nepal                    | 0.193        | 0.188       | 0.047       | 0.099        | 0.031       | 0.337                   | 0.063             | 0.041            |
| Lesotho                  | 0.190        | 0.240       | 0.099       | 0.089        | 0.032       | 0.189                   | 0.088             | 0.073            |
| Comoros                  | 0.185        | 0.210       | 0.078       | 0.063        | 0.029       | 0.304                   | 0.077             | 0.055            |
| Tajikistan               | 0.191        | 0.219       | 0.053       | 0.102        | 0.033       | 0.245                   | 0.081             | 0.075            |
| Senegal                  | 0.170        | 0.226       | 0.120       | 0.064        | 0.031       | 0.277                   | 0.056             | 0.055            |
| São Tomé and Príncipe    | 0.206        | 0.179       | 0.096       | 0.084        | 0.036       | 0.231                   | 0.096             | 0.072            |
| Zambia                   | 0.151        | 0.248       | 0.068       | 0.084        | 0.035       | 0.256                   | 0.077             | 0.081            |
| Cameroon                 | 0.162        | 0.233       | 0.102       | 0.050        | 0.028       | 0.313                   | 0.058             | 0.053            |
| Côte d'Ivoire            | 0.192        | 0.211       | 0.093       | 0.064        | 0.030       | 0.239                   | 0.102             | 0.069            |
| Mauritania               | 0.195        | 0.230       | 0.111       | 0.080        | 0.035       | 0.202                   | 0.090             | 0.057            |
| Cambodia                 | 0.189        | 0.176       | 0.112       | 0.084        | 0.023       | 0.222                   | 0.119             | 0.075            |
| Kenya                    | 0.155        | 0.249       | 0.030       | 0.107        | 0.014       | 0.257                   | 0.097             | 0.091            |
| Sudan                    | 0.141        | 0.256       | 0.061       | 0.115        | 0.010       | 0.183                   | 0.120             | 0.115            |
| Bangladesh               | 0.156        | 0.184       | 0.080       | 0.092        | 0.023       | 0.329                   | 0.070             | 0.065            |
| Myanmar                  | 0.161        | 0.203       | 0.112       | 0.085        | 0.023       | 0.230                   | 0.105             | 0.080            |
| Nigeria                  | 0.054        | 0.317       | 0.087       | 0.127        | 0.021       | 0.230                   | 0.046             | 0.118            |
| Pakistan                 | 0.180        | 0.221       | 0.087       | 0.076        | 0.023       | 0.265                   | 0.085             | 0.063            |
| Ghana                    | 0.190        | 0.244       | 0.097       | 0.052        | 0.036       | 0.203                   | 0.097             | 0.083            |
| Congo, Rep.              | 0.195        | 0.202       | 0.091       | 0.085        | 0.038       | 0.239                   | 0.090             | 0.059            |
| Djibouti                 | 0.154        | 0.215       | 0.083       | 0.072        | 0.027       | 0.269                   | 0.091             | 0.088            |
| Kyrgyzstan               | 0.162        | 0.250       | 0.058       | 0.115        | 0.032       | 0.221                   | 0.081             | 0.082            |

Table 15. Continued

| Country                           | Bread | Meat  | Fish  | Dairy | Oils  | Fruits & Veg | Other Food | Beverages |
|-----------------------------------|-------|-------|-------|-------|-------|--------------|------------|-----------|
| Honduras                          | 0.134 | 0.247 | 0.060 | 0.114 | 0.019 | 0.212        | 0.111      | 0.103     |
| Nicaragua                         | 0.114 | 0.270 | 0.060 | 0.121 | 0.027 | 0.211        | 0.089      | 0.108     |
| India                             | 0.196 | 0.190 | 0.078 | 0.096 | 0.032 | 0.306        | 0.060      | 0.042     |
| Cabo Verde                        | 0.179 | 0.251 | 0.085 | 0.127 | 0.035 | 0.126        | 0.115      | 0.083     |
| Vietnam                           | 0.167 | 0.226 | 0.092 | 0.088 | 0.020 | 0.220        | 0.104      | 0.084     |
| Belize                            | 0.167 | 0.238 | 0.078 | 0.112 | 0.026 | 0.200        | 0.099      | 0.079     |
| Lao PDR                           | 0.177 | 0.212 | 0.099 | 0.086 | 0.026 | 0.232        | 0.097      | 0.071     |
| Angola                            | 0.160 | 0.255 | 0.064 | 0.099 | 0.032 | 0.189        | 0.103      | 0.098     |
| Morocco                           | 0.158 | 0.172 | 0.086 | 0.118 | 0.034 | 0.273        | 0.086      | 0.073     |
| Philippines                       | 0.099 | 0.285 | 0.132 | 0.098 | 0.011 | 0.139        | 0.109      | 0.128     |
| Bolivia                           | 0.072 | 0.321 | 0.051 | 0.140 | 0.015 | 0.192        | 0.092      | 0.118     |
| El Salvador                       | 0.097 | 0.242 | 0.087 | 0.114 | 0.019 | 0.207        | 0.125      | 0.108     |
| Eswatini                          | 0.160 | 0.272 | 0.072 | 0.115 | 0.024 | 0.210        | 0.073      | 0.075     |
| Moldova                           | 0.179 | 0.238 | 0.067 | 0.114 | 0.034 | 0.245        | 0.064      | 0.059     |
| Jordan                            | 0.194 | 0.170 | 0.080 | 0.099 | 0.029 | 0.272        | 0.084      | 0.071     |
| Jamaica                           | 0.215 | 0.263 | 0.129 | 0.074 | 0.027 | 0.141        | 0.106      | 0.045     |
| Iraq                              | 0.144 | 0.189 | 0.128 | 0.105 | 0.027 | 0.247        | 0.072      | 0.087     |
| Namibia                           | 0.168 | 0.220 | 0.183 | 0.080 | 0.024 | 0.146        | 0.100      | 0.080     |
| Tunisia                           | 0.174 | 0.173 | 0.040 | 0.142 | 0.026 | 0.259        | 0.100      | 0.086     |
| Indonesia                         | 0.142 | 0.248 | 0.122 | 0.098 | 0.018 | 0.163        | 0.108      | 0.100     |
| Mongolia                          | 0.133 | 0.388 | 0.031 | 0.126 | 0.021 | 0.107        | 0.087      | 0.106     |
| Dominica                          | 0.153 | 0.269 | 0.140 | 0.104 | 0.026 | 0.115        | 0.103      | 0.089     |
| Algeria                           | 0.169 | 0.155 | 0.001 | 0.152 | 0.028 | 0.233        | 0.147      | 0.115     |
| Ecuador                           | 0.149 | 0.220 | 0.038 | 0.108 | 0.026 | 0.328        | 0.070      | 0.062     |
| Bhutan                            | 0.149 | 0.253 | 0.104 | 0.104 | 0.029 | 0.209        | 0.079      | 0.074     |
| Armenia                           | 0.157 | 0.235 | 0.082 | 0.117 | 0.031 | 0.237        | 0.069      | 0.073     |
| Peru                              | 0.138 | 0.268 | 0.053 | 0.110 | 0.024 | 0.253        | 0.075      | 0.080     |
| Sri Lanka                         | 0.179 | 0.177 | 0.141 | 0.099 | 0.013 | 0.216        | 0.101      | 0.075     |
| Paraguay                          | 0.070 | 0.356 | 0.039 | 0.144 | 0.013 | 0.158        | 0.090      | 0.130     |
| Gabon                             | 0.172 | 0.207 | 0.112 | 0.102 | 0.028 | 0.207        | 0.101      | 0.070     |
| St. Lucia                         | 0.199 | 0.154 | 0.193 | 0.055 | 0.022 | 0.192        | 0.113      | 0.072     |
| South Africa                      | 0.182 | 0.225 | 0.089 | 0.101 | 0.033 | 0.227        | 0.077      | 0.067     |
| St. Vincent and the<br>Grenadines | 0.153 | 0.307 | 0.154 | 0.095 | 0.023 | 0.132        | 0.065      | 0.072     |
| Albania                           | 0.139 | 0.261 | 0.028 | 0.133 | 0.029 | 0.284        | 0.057      | 0.070     |
| Egypt, Arab Rep.                  | 0.088 | 0.188 | 0.076 | 0.120 | 0.019 | 0.359        | 0.064      | 0.086     |
| Fiji                              | 0.172 | 0.215 | 0.107 | 0.076 | 0.033 | 0.251        | 0.085      | 0.062     |
| Bosnia and Herzegovina            | 0.134 | 0.265 | 0.043 | 0.144 | 0.031 | 0.211        | 0.080      | 0.091     |
| China                             | 0.176 | 0.230 | 0.081 | 0.078 | 0.032 | 0.269        | 0.064      | 0.070     |
| Colombia                          | 0.106 | 0.256 | 0.005 | 0.127 | 0.019 | 0.311        | 0.077      | 0.099     |
| Azerbaijan                        | 0.130 | 0.268 | 0.051 | 0.121 | 0.026 | 0.271        | 0.057      | 0.077     |
| Brazil                            | 0.098 | 0.314 | 0.070 | 0.114 | 0.026 | 0.216        | 0.065      | 0.097     |
| Barbados                          | 0.195 | 0.243 | 0.118 | 0.127 | 0.034 | 0.118        | 0.104      | 0.060     |
| North Macedonia                   | 0.125 | 0.252 | 0.036 | 0.143 | 0.031 | 0.242        | 0.080      | 0.092     |
| Iran, Islamic Rep.                | 0.163 | 0.188 | 0.077 | 0.132 | 0.026 | 0.246        | 0.088      | 0.081     |

**Table 15. Continued**

| <b>Country</b>      | <b>Bread</b> | <b>Meat</b> | <b>Fish</b> | <b>Dairy</b> | <b>Oils</b> | <b>Fruits &amp; Veg</b> | <b>Other Food</b> | <b>Beverages</b> |
|---------------------|--------------|-------------|-------------|--------------|-------------|-------------------------|-------------------|------------------|
| Grenada             | 0.158        | 0.293       | 0.123       | 0.103        | 0.028       | 0.139                   | 0.080             | 0.076            |
| Suriname            | 0.129        | 0.242       | 0.152       | 0.120        | 0.023       | 0.108                   | 0.114             | 0.112            |
| Serbia              | 0.140        | 0.269       | 0.025       | 0.140        | 0.027       | 0.221                   | 0.084             | 0.094            |
| Dominican Republic  | 0.081        | 0.323       | 0.065       | 0.124        | 0.015       | 0.185                   | 0.083             | 0.124            |
| Botswana            | 0.131        | 0.351       | 0.018       | 0.135        | 0.025       | 0.203                   | 0.055             | 0.081            |
| Thailand            | 0.135        | 0.271       | 0.106       | 0.101        | 0.018       | 0.176                   | 0.096             | 0.097            |
| Belarus             | 0.136        | 0.263       | 0.061       | 0.136        | 0.028       | 0.242                   | 0.060             | 0.075            |
| Maldives            | 0.164        | 0.277       | 0.221       | 0.074        | 0.026       | 0.041                   | 0.104             | 0.094            |
| Montenegro          | 0.113        | 0.309       | 0.029       | 0.154        | 0.030       | 0.198                   | 0.071             | 0.097            |
| Costa Rica          | 0.145        | 0.272       | 0.046       | 0.123        | 0.036       | 0.186                   | 0.097             | 0.094            |
| Mexico              | 0.083        | 0.289       | 0.036       | 0.156        | 0.023       | 0.212                   | 0.087             | 0.114            |
| Antigua and Barbuda | 0.151        | 0.316       | 0.120       | 0.107        | 0.021       | 0.022                   | 0.135             | 0.128            |
| Uruguay             | 0.088        | 0.323       | 0.131       | 0.106        | 0.035       | 0.190                   | 0.041             | 0.086            |
| Bulgaria            | 0.173        | 0.259       | 0.046       | 0.117        | 0.028       | 0.232                   | 0.077             | 0.068            |
| Equatorial Guinea   | 0.094        | 0.309       | 0.133       | 0.118        | 0.020       | 0.121                   | 0.094             | 0.112            |
| Chile               | 0.155        | 0.235       | 0.084       | 0.103        | 0.034       | 0.259                   | 0.064             | 0.065            |
| St. Kitts and Nevis | 0.084        | 0.315       | 0.119       | 0.117        | 0.018       | 0.086                   | 0.121             | 0.139            |
| Kazakhstan          | 0.139        | 0.286       | 0.077       | 0.130        | 0.027       | 0.190                   | 0.066             | 0.086            |
| Mauritius           | 0.149        | 0.223       | 0.102       | 0.139        | 0.031       | 0.133                   | 0.117             | 0.106            |
| Malaysia            | 0.121        | 0.283       | 0.088       | 0.118        | 0.020       | 0.165                   | 0.099             | 0.106            |
| Russian Federation  | 0.159        | 0.224       | 0.069       | 0.117        | 0.028       | 0.248                   | 0.083             | 0.072            |
| Croatia             | 0.118        | 0.264       | 0.039       | 0.151        | 0.029       | 0.212                   | 0.087             | 0.099            |
| Trinidad and Tobago | 0.131        | 0.257       | 0.136       | 0.101        | 0.018       | 0.132                   | 0.114             | 0.111            |
| Romania             | 0.133        | 0.268       | 0.029       | 0.128        | 0.024       | 0.264                   | 0.072             | 0.082            |
| Seychelles          | 0.177        | 0.226       | 0.117       | 0.104        | 0.033       | 0.162                   | 0.113             | 0.067            |
| Turkey              | 0.155        | 0.223       | 0.017       | 0.124        | 0.031       | 0.278                   | 0.088             | 0.084            |
| Latvia              | 0.143        | 0.282       | 0.048       | 0.135        | 0.028       | 0.209                   | 0.073             | 0.081            |
| Greece              | 0.118        | 0.264       | 0.029       | 0.127        | 0.032       | 0.286                   | 0.059             | 0.084            |
| Hungary             | 0.142        | 0.263       | 0.021       | 0.144        | 0.026       | 0.217                   | 0.091             | 0.095            |
| Oman                | 0.112        | 0.218       | 0.134       | 0.126        | 0.021       | 0.178                   | 0.099             | 0.112            |
| Poland              | 0.114        | 0.274       | 0.035       | 0.158        | 0.023       | 0.202                   | 0.095             | 0.099            |
| Panama              | 0.120        | 0.297       | 0.083       | 0.115        | 0.023       | 0.153                   | 0.103             | 0.106            |
| Slovakia            | 0.137        | 0.280       | 0.016       | 0.149        | 0.026       | 0.207                   | 0.092             | 0.094            |
| Sint Maarten        | 0.139        | 0.301       | 0.069       | 0.114        | 0.019       | 0.109                   | 0.125             | 0.125            |
| Portugal            | 0.125        | 0.281       | 0.042       | 0.142        | 0.033       | 0.235                   | 0.060             | 0.083            |
| Lithuania           | 0.110        | 0.284       | 0.045       | 0.148        | 0.025       | 0.235                   | 0.069             | 0.085            |
| Estonia             | 0.116        | 0.272       | 0.033       | 0.150        | 0.024       | 0.200                   | 0.098             | 0.106            |
| The Bahamas         | 0.093        | 0.345       | 0.151       | 0.092        | 0.030       | 0.127                   | 0.055             | 0.107            |
| Slovenia            | 0.103        | 0.246       | 0.046       | 0.147        | 0.025       | 0.220                   | 0.099             | 0.115            |
| Cyprus              | 0.102        | 0.268       | 0.044       | 0.126        | 0.029       | 0.242                   | 0.083             | 0.107            |
| Czech Republic      | 0.123        | 0.273       | 0.020       | 0.153        | 0.025       | 0.212                   | 0.093             | 0.102            |
| Israel              | 0.130        | 0.212       | 0.064       | 0.109        | 0.038       | 0.318                   | 0.055             | 0.075            |
| Spain               | 0.088        | 0.266       | 0.053       | 0.158        | 0.029       | 0.178                   | 0.102             | 0.125            |
| New Zealand         | 0.159        | 0.229       | 0.099       | 0.118        | 0.040       | 0.207                   | 0.072             | 0.076            |

**Table 15. Continued**

| <b>Country</b>       | <b>Bread</b> | <b>Meat</b> | <b>Fish</b> | <b>Dairy</b> | <b>Oils</b> | <b>Fruits &amp; Veg</b> | <b>Other Food</b> | <b>Beverages</b> |
|----------------------|--------------|-------------|-------------|--------------|-------------|-------------------------|-------------------|------------------|
| Japan                | 0.116        | 0.225       | 0.130       | 0.131        | 0.024       | 0.103                   | 0.131             | 0.139            |
| Korea, Rep.          | 0.210        | 0.077       | 0.169       | 0.080        | 0.033       | 0.190                   | 0.154             | 0.087            |
| Malta                | 0.142        | 0.251       | 0.043       | 0.139        | 0.030       | 0.215                   | 0.089             | 0.092            |
| Italy                | 0.099        | 0.230       | 0.049       | 0.154        | 0.030       | 0.201                   | 0.110             | 0.127            |
| France               | 0.115        | 0.214       | 0.040       | 0.171        | 0.027       | 0.181                   | 0.126             | 0.125            |
| United Kingdom       | 0.136        | 0.231       | 0.065       | 0.149        | 0.033       | 0.192                   | 0.099             | 0.095            |
| Taiwan, China        | 0.122        | 0.256       | 0.082       | 0.122        | 0.022       | 0.168                   | 0.114             | 0.114            |
| Bahrain              | 0.113        | 0.240       | 0.140       | 0.123        | 0.019       | 0.168                   | 0.084             | 0.114            |
| Finland              | 0.115        | 0.233       | 0.050       | 0.156        | 0.033       | 0.189                   | 0.112             | 0.111            |
| Saudi Arabia         | 0.135        | 0.245       | 0.101       | 0.129        | 0.028       | 0.203                   | 0.069             | 0.091            |
| Canada               | 0.155        | 0.234       | 0.080       | 0.113        | 0.035       | 0.191                   | 0.100             | 0.092            |
| Kuwait               | 0.148        | 0.231       | 0.119       | 0.124        | 0.023       | 0.136                   | 0.109             | 0.110            |
| Australia            | 0.112        | 0.263       | 0.066       | 0.136        | 0.031       | 0.190                   | 0.094             | 0.109            |
| Belgium              | 0.119        | 0.210       | 0.041       | 0.157        | 0.028       | 0.223                   | 0.114             | 0.109            |
| Sweden               | 0.108        | 0.237       | 0.048       | 0.160        | 0.027       | 0.180                   | 0.117             | 0.123            |
| Germany              | 0.111        | 0.246       | 0.003       | 0.175        | 0.026       | 0.198                   | 0.119             | 0.120            |
| Austria              | 0.113        | 0.197       | 0.028       | 0.171        | 0.025       | 0.205                   | 0.135             | 0.127            |
| Denmark              | 0.103        | 0.255       | 0.032       | 0.163        | 0.035       | 0.236                   | 0.073             | 0.104            |
| Netherlands          | 0.137        | 0.197       | 0.045       | 0.157        | 0.031       | 0.202                   | 0.124             | 0.107            |
| Iceland              | 0.120        | 0.199       | 0.083       | 0.135        | 0.038       | 0.221                   | 0.097             | 0.107            |
| Hong Kong SAR, China | 0.144        | 0.268       | 0.068       | 0.109        | 0.026       | 0.201                   | 0.086             | 0.097            |
| United States        | 0.119        | 0.257       | 0.053       | 0.151        | 0.028       | 0.176                   | 0.107             | 0.110            |
| Brunei Darussalam    | 0.176        | 0.235       | 0.136       | 0.098        | 0.029       | 0.127                   | 0.111             | 0.088            |
| Norway               | 0.145        | 0.207       | 0.101       | 0.121        | 0.038       | 0.226                   | 0.081             | 0.082            |
| United Arab Emirates | 0.094        | 0.236       | 0.101       | 0.129        | 0.016       | 0.175                   | 0.114             | 0.136            |
| Switzerland          | 0.129        | 0.138       | 0.052       | 0.164        | 0.028       | 0.219                   | 0.145             | 0.126            |
| Ireland              | 0.146        | 0.245       | 0.057       | 0.139        | 0.037       | 0.198                   | 0.087             | 0.090            |
| Singapore            | 0.137        | 0.218       | 0.066       | 0.120        | 0.022       | 0.191                   | 0.128             | 0.118            |
| Qatar                | 0.119        | 0.225       | 0.091       | 0.132        | 0.026       | 0.197                   | 0.095             | 0.115            |
| Luxembourg           | 0.114        | 0.208       | 0.054       | 0.148        | 0.028       | 0.214                   | 0.117             | 0.116            |

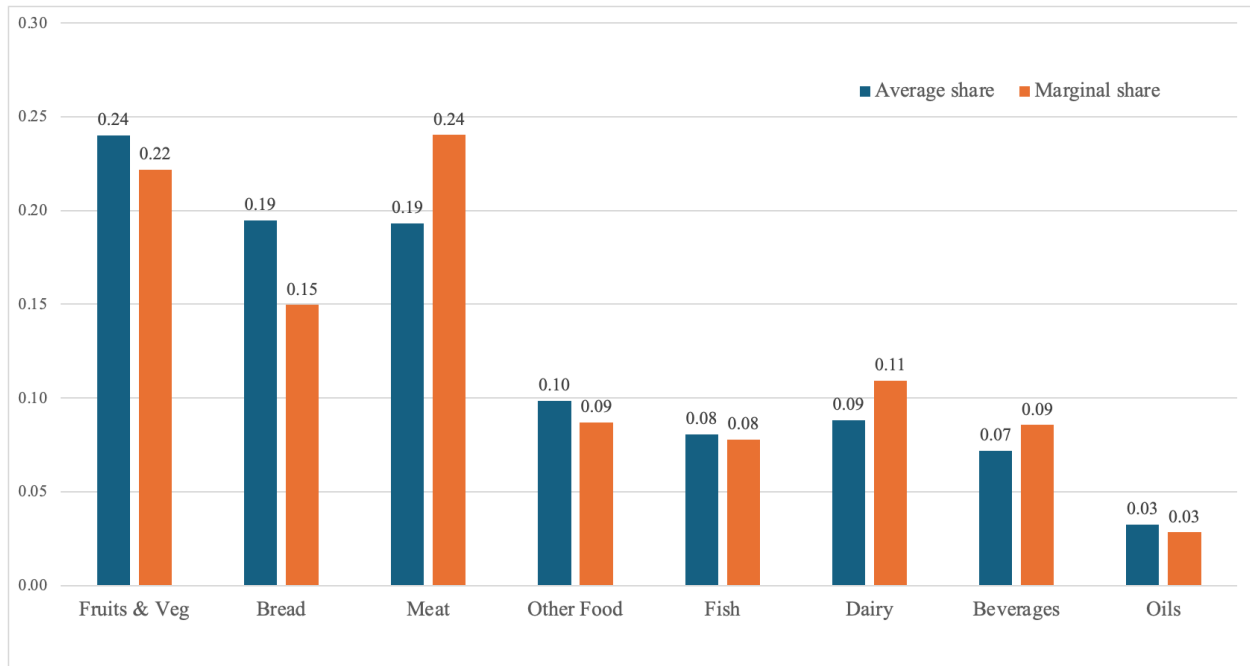


**Figure 5. Global average share vs marginal share per food category.**

Source: Author's calculations using 2017 International Comparison Program (ICP) data, World Bank.

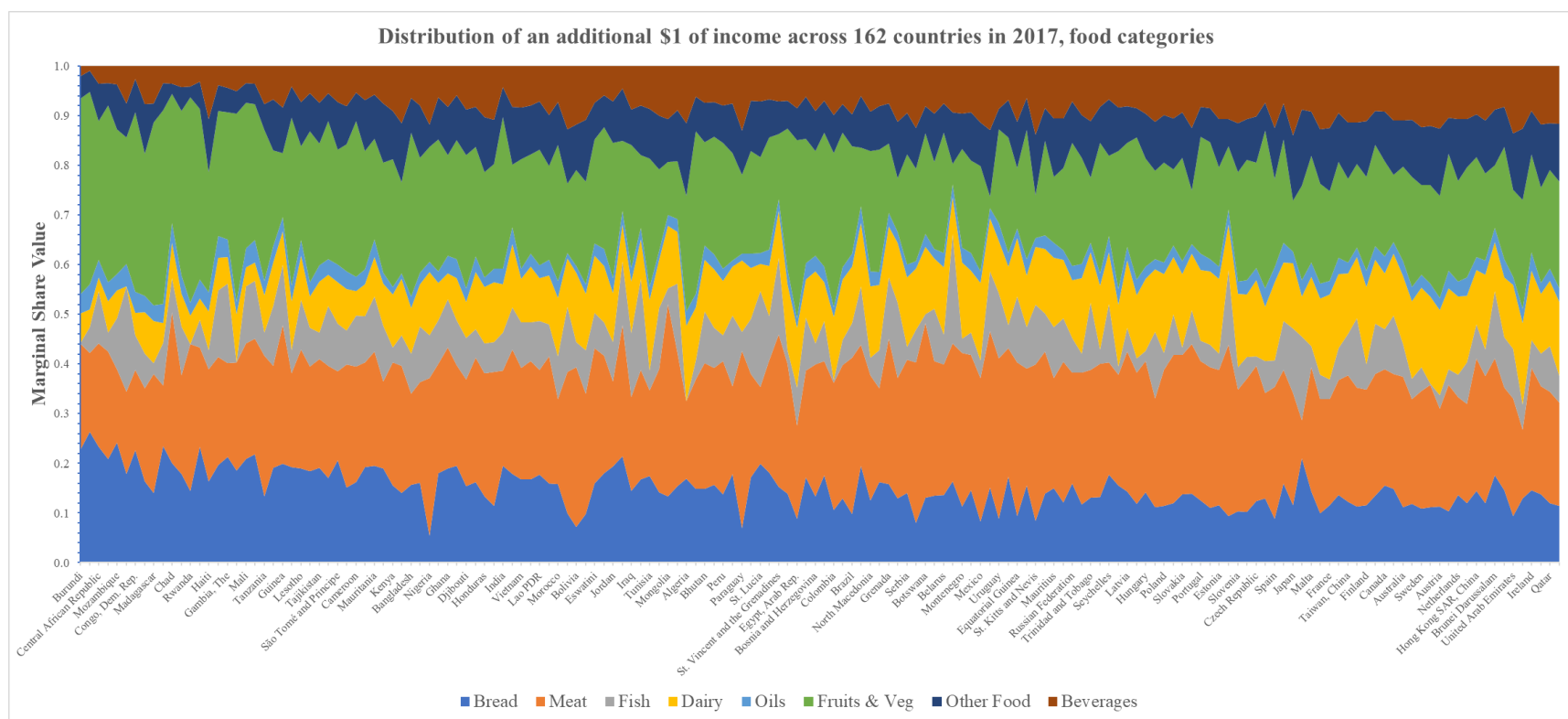


**Figure 6. Distribution of an additional \$1 of food budget across countries, food categories.**

Note: Countries are arranged from low to high GDP Per Capita.

Source: Author's calculations using 2017 International Comparison Program (ICP) data, World Bank.

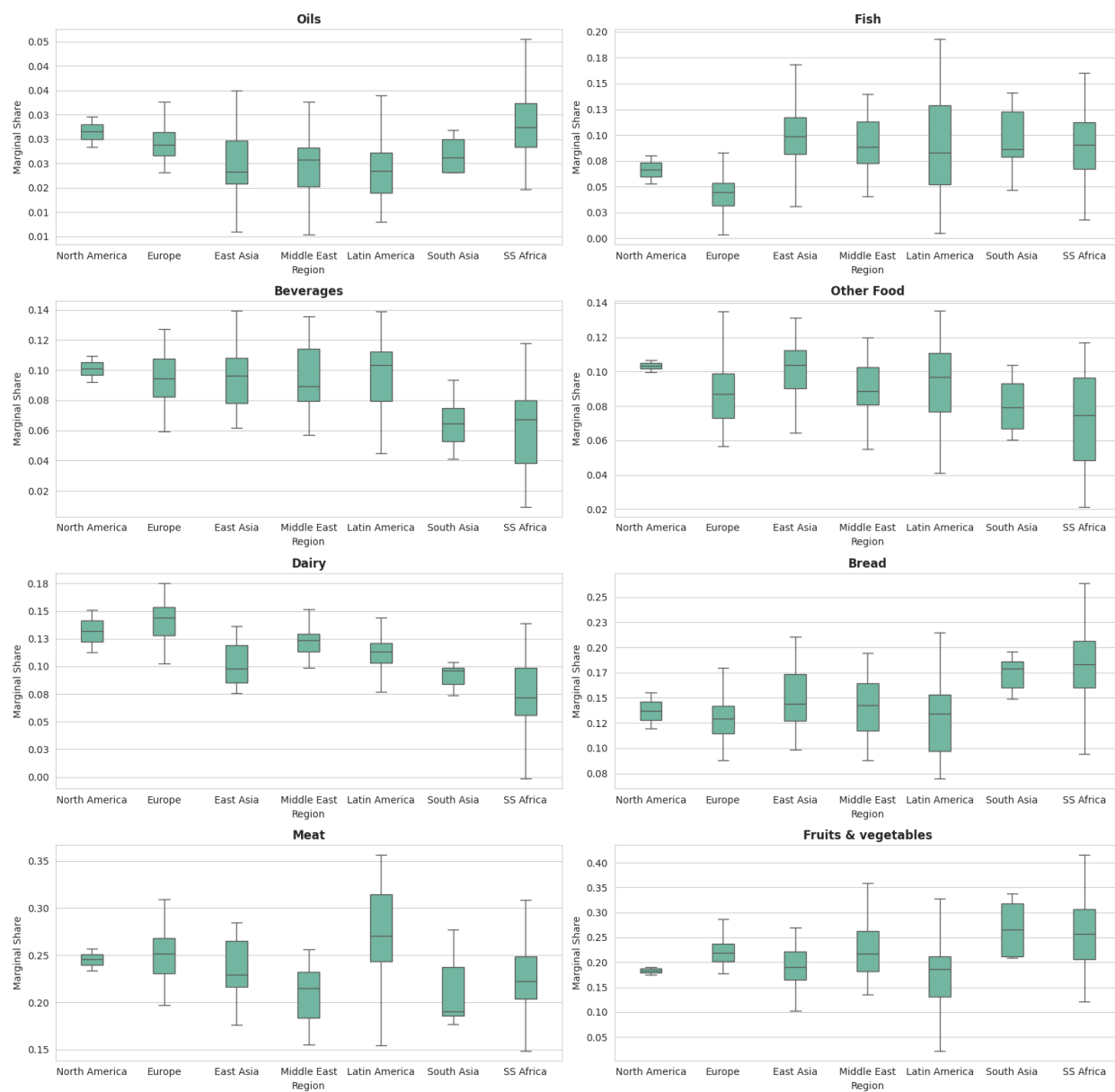


**Figure 7. Comparison of regional marginal shares for food categories.**

Source: Author's calculations using 2017 International Comparison Program (ICP) data, World Bank.

## **VITA**

Savant Nzayiramyia grew up in Nyamata, Rwanda, and completed his high school education at College Saint Andre in Kigali, Rwanda, in December 2016. He earned an Associate of Arts degree in General Studies (Management) from Southern New Hampshire University in 2018. In August 2018, he relocated to Lincoln, NE, where he graduated with a Bachelor of Science in Integrated Science with Highest Distinction in May 2022. Afterwards, he moved to Knoxville, TN, to pursue his graduate studies and received a Master of Science degree in Agricultural and Resource Economics from the University of Tennessee, Knoxville, in May 2024.