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The Economics of Global Saturated Fat Intake and Implications for Public Health

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I am submitting herewith a thesis written by Amelia Grace Ahles entitled "The Economics of Global Saturated Fat Intake and Implications for Public Health." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural and Resource Economics.

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The Economics of Global Saturated Fat Intake and Implications for Public Health

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ABSTRACT

An increasing prevalence of obesity and diet-related diseases has heavily contributed to increased economic challenges including decreased economic productivity and increased healthcare expenditures globally. This has been, in part, attributed to excessive saturate fat intake. Saturated fatty acids (SFAs) are readily found in foods and have been linked to increased risk for diet-related diseases leading to increased mortality and morbidity worldwide. Identifying factors that influence SFA consumption is essential to government intervention strategies to improve dietary choices, decreasing obesity and diet-related diseases. The goal of this study is to estimate the relationship between saturated fat consumption and economic factors such as national income, food prices, and socio-demographics factors globally. SFA intake data from the Global Dietary Database along with gross domestic product, food price, and expenditure data from the World Bank International Comparison Program are used to estimate this relationship across 164 countries. Estimates are used to derive income and price elasticities of saturated fat intake by age, education, urban-rural status, and income. Results are used to assess the potential impacts of polices such as income support, subsidies, and taxes.

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CHAPTER I.

INTRODUCTION AND OVERVIEW

Introduction

Background

When non-communicable disease rates (NCDs) rise, public health worldwide suffers. In recent years, poor eating habits, low nutritional content, and minimal physical activity have contributed to a rise in NCDs globally. This paper addresses some questions surrounding the economic linkage between dietary saturated fat intake and food prices and national income levels in 164 countries. In 2015-2020 Dietary Guidelines for Americans, the U.S Department of Health and Human Services estimates approximately 117 million American adults face health challenges attributed to obesity and preventable NCDs including cardiovascular disease (CVDs) and type 2 diabetes (U.S Department of Health and Human Services, 2015). NCDs heavily contribute to economic challenges including increased health care expenditures and premature death in all countries regardless of economic status. In low-income countries, where undernutrition and malnutrition still remains a prominent issue, increasing rates of obesity and other NCDs can present significant negative impacts on economic development and economic growth (Muhammad et al., 2017a, 2017b). High-income countries are not spared from decreased economic productivity, premature death, and increased healthcare expenses attributed to NCDs such as increased private healthcare premiums and higher government spending by Medicaid and Medicare (Muhammad et al., 2017b; Powell and Chaloupka, 2009). For example, in 2012, estimated costs associated with chronic diabetes in the United States were $245 billion, $69 billion in economic productivity loss and $176 billion in direct medical costs (U.S Department of Health and Human Services, 2015).

Governments are increasingly considering policy instruments such as taxes and subsidies to improve consumer food choices and related health outcomes (Powell and Chaloupka, 2009; Powell et al., 2013; Franck, Grandi, and Eisenberg, 2013). Prior economic studies show that food prices affect consumption, which is an indication that price interventions can improve diets, decrease obesity and NCDs prevalence (Andreyeva, Chaloupka, and Brownell, 2011; Andreyeva, Long, and Brownell, 2010; Powell and Chaloupka, 2009). The successful reduction of tobacco use in the United States is attributable to higher taxes, subsequent increases in tobacco prices, and public education campaigns. The case of tobacco demonstrates that effective public intervention policy can alter consumer consumption. Nutrition policy decisions could lead to similar positive results in decreasing NCDs (Powell et al., 2013).

Saturated fatty acids (SFAs), more commonly known as saturated fats, are solid fats readily found in meats, poultry, dairy, vegetables, and some tropical oils (coconut and palm oil). Present dietary guidelines recommend a saturated fat intake of less than 10% of total daily caloric intake (U.S Department of Health and Human Services, 2015; Zong et al., 2016; Lock et al., 2010). However the majority of Americans consume more than 16% of their daily calories from solid fats with cheese, beef, and milk being the top three contributing categories (Huth et al., 2013; U.S Department of Health and Human Services, 2015). Saturated fat consumption is associated with an increased risk of NCDs, especially CVD, which is the leading global cause of mortality and morbidity (Martikainen et al., 2011; U.S Department of Health and Human Services, 2015; World Health Organization, 2018; Zong et al., 2016). Reductions in saturated fat intake can decrease low-density lipoprotein-cholesterol (LDL-cholesterol) and total cholesterol levels. Evidence supports that lowering saturated fat intake can decrease the risks of CVD and related deaths (Briggs, Petersen, and Kris-Etherton, 2017; Huth et al., 2013). Despite overall nutritional guidelines which call for a reduction of SFA intake, the relationship between dietary fat intake and NCDs remains a point of contention within the medical community (Forouhi et al., 2018).

Agricultural subsidies and subsequent production are largely conflicting with the public health sector's nutrition recommendations (Lock et al., 2010; Fields, 2004; Franck et al., 2013). In the United States, wheat, soybeans, and corn are highly subsidized crops with highly efficient production practices. Subsidies in these crops have created a market saturated with high-fructose corn syrup, hydrogenated fats from soybeans, and grain feed for cattle and pork which are used as basic ingredients in low cost, energy dense foods with poor nutritional value to consumers (Fields, 2004; Franck et al., 2013). Similar to the United States, the European Union faces similar subsidy policy decisions related to subsidizing agricultural production, nutritional intake and subsequent health concerns. The European Union's Common Agriculture Policy (CAP) contributes to excessive production of dairy and beef through direct subsidies to farmers. The EU dairy industry receives significant subsidization from CAP upwards of 16 billion euros annually in 2008, which has prompted increasing consumption of full-fat dairy products. Both beef and full-fat dairy products, milk and butter, have been identified as sources of high saturated fat levels (Huth et al., 2013; Lloyd-Williams et al., 2008).

While estimating the monetary and social costs associated with diet-related diseases, including CVD, a study in Finland a research study concludes that a "modest reduction" in salt intake and saturated fat would have a substantial economic impact on the costs associated with prescribed medication, rehabilitation, production losses, and in some cases morbidity (Martikainen et al., 2011).

Objectives

The goal of this study is to examine how economic factors such as income and prices influence saturated fat intake globally. Differences in economic factors can explain differences in saturated fat intake across countries and can inform policy decisions aimed at decreasing intake. Determining how economic factors impact saturated fat intake globally also provides insight into the increasing prevalence of NCDs worldwide. This study estimates the relationship between saturated fat intake and national income, the price of various foods, and other socioeconomic factors across countries. Estimates will be used to derive demand elasticities by national income deciles. Elasticities will provide valuable information to policy makers about the impact of potential invention policy initiatives will have on reducing saturated fat intake in individual countries and also on a global scale.

This study has four specific objectives, which will be the basis of the study; (1) examine the influence of national income on saturated fat intake levels and how the relationship between saturated fat intake and national income varies with a country's affluence; (2) analyze the impact of prices for select contributing products such as: dairy, beef, oils and fats on saturated fat intake; (3) analyze the impact of prices for healthy alternative such as fresh vegetables; (4) derive income and price elasticities of saturated fat intake by urban-rural status, education, age and income deciles using the model estimates; (5) discuss the effectiveness of price interventions such as taxes and subsidies based on the estimated elasticities.

CHAPTER II.

LITERATURE REVIEW

Saturated Fats and Non-communicable Diseases

The link between dietary fat intake and cardiovascular disease (CVDs) was first proposed in 1953 by Ancel Keyes leading to numerous controlled and observational studies on saturated fatty acids effect on health (Billingsley, Carbone, and Lavie, 2018). However, few economic studies have focused on how food prices and income effect saturated fat consumption among consumers. Increased saturated fat intake is associated with increased risk for CVDs, particularly coronary heart disease (CHD), the leading cause of mortality worldwide (Martikainen et al., 2011; World Health Organization, 2018; Zong et al., 2016). Current dietary guidelines aimed at reducing CVD risk recommend increased intake of whole grains and unsaturated fats to replace saturated fats. Intervention and prospective studies have determined that when saturated fats are replaced with low-quality carbohydrates rather than whole grains and unsaturated fats there is little to no nutritional or health benefits attributed to the reduction of SFA intake (U.S Department of Health and Human Services, 2015; Zong et al., 2016). Low-fat diets have similarly demonstrated inadequacies of increased health benefits or decreased CVD risk. While eating patterns high in healthy unsaturated fats such as the Mediterranean diet, rich in fruits, vegetables, whole grains, legumes, and unsaturated fats from olive oil and nuts may aid in reducing NCDs such as type 2 diabetes and reduce the risk of CVD (Billingsley et al., 2018). Saturated fats are required in the human body for normal biological functions, however individuals over the age of two produce adequate levels of saturated fat naturally and thus no dietary consumption of saturated fats is required to maintain regular bodily function (Institute of Medicine, 2005; U.S Department of Health and Human Services, 2015).

When looking at SFA intake in nutritional guidelines it is imperative to look at overall dietary fat intakes. While almost all nutritional guidelines currently call for the reduction of total dietary fat intake, which includes reductions in SFAs intake, the scientific literature is not clear on the causal link between SFAs intake and risk of CVDs (Forouhi et al., 2018; Yu and Hu, 2018). Despite this conflict, health researchers have reached the consensus that the impact of dietary fat intake cannot be taken at face value. Different types of dietary fat exists and each must be considered individually due to the variety of biochemical properties which form individual fat types and produce different metabolic and physiological effects (Forouhi et al., 2018). Low density lipoprotein-cholesterol (LDL-cholesterol), which are found in SFAs, are a cause of coronary heart disease, a leading CVD worldwide, and therefore SFAs effect on LDL-cholesterol had led to the implication that there is a direct relationship between dietary fat intake and CVDs. However, direct evidence of lowering LDL-cholesterol through changes in SFA intake is lacking (Forouhi et al., 2018). However, despite this link between SFAs and increased risk of CVDS, the relationship between dairy products, a food group generally high in SFAs, and NCDs also remains uncertain. Current research indicates little to no inverse association between dairy fat intake and CVD, however odd chain fatty acids (OCFAs) 15:0 and 17:0 found in dairy appear to be inversely linked with CVD risk, however there is little proof of causation. Current research does not conclusively determine a significant association between low-fat and high-fat diary intake and increased risk of CVD (Forouhi et al., 2018; Yu and Hu, 2018).

Economic Factors Impacting Food Consumption

Food prices and income are two economic factors traditionally identified as determinants' which have direct impacts on consumer food choices and nutrition. Blaylock et al. (1999) identified that rising incomes, time constraints, consumer preferences, and food prices outweigh nutrition and health information in influencing American decisions to consume unhealthy foods. Andreyeva et al. (2010) estimated price elasticities for sixteen categories of major food and beverage groups from 160 food demand studies to determine the potential consumption impact of price changes on select food categories. Elasticities can provide meaningful insight to potential changes in consumer demand and dietary quality relative to price and income changes (Nicholson and Snyder, 2008). Own price elasticities measure consumer responsiveness to prices: the percentage change in the quantity demanded for good X based on a 1% change in the price of good X. Income elasticities are similar measures based on income changes. Cross-price elasticities can be used to measure the ratio of change in the quantity demanded for good X when there is a change in the price of good Y. Cross-price elasticities of demand help determine if goods are substitutes or complements by the consumer (Goolsbee, Levitt, and Syverson, 2016). Price elasticities have significant implications for public policy aimed at improving dietary quality and decreasing the rate of NCDs and obesity. Studies have shown that targeting nutrient poor foods and beverages with increased prices, often through taxes, can lead to reduced consumption (Andreyeva et al., 2011, 2010; Cornelsen et al., 2015). Lowering food prices for healthier foods and increasing unhealthy food prices can shift food choice and dietary quality and NCD outcomes.

French et al. (2003) examined a price intervention study where vending machines at 12 secondary school and 12 work sites in Minnesota had a range of price reductions on low fat snacks compared to the other snacks available in machine inventory. Reducing the lower fat snack prices by 10%, 25%, and 50% comparatively to the alternative, higher fat, snacks resulted in a significant increase of lower fat snack sales of 9%, 39%, and 93%, respectively. Price reduction of nutritionally superior snacks can be an effective means to encourage healthier food choices by consumers purchasing food away from home. There are linkages between a greater demand for convenience foods and food away from home and higher incomes due to increased time constraints such as increased working hours and decreased meal preparation time available (Blaylock et al., 1999). For example, following economic growth in Brazil there is an increase in demand for ultra-processed, ready-to-eat, nutrient poor foods and a decrease in demand for minimally processed foods. Meals in the ultra-processed category overall had negative nutritional profiles leading to concern on future health and nutrition concerns (Monteiro et al., 2011).

In a global analysis of low-, middle-, and high-income countries, own- and cross-price elasticities were reviewed across seven major food groups to determine where price changes would alter consumption. Low-income countries were determined to be the most responsive to own-price changes while cross-price effects were more varied and had a greater dependence on a country's level of income (Cornelsen et al., 2015). In China, Chen et al. (2016) found declining income elasticities for certain foods when per capita income increases. In contrast, own-price elasticities for some food products are more negative when per capita income increases indicating increasing substitution possibilities as economic development brings more secure food supply chains and greater food choices. Muhammad et al. (2017b) found that income elasticities based on food category, region, age, and gender varied widely in a 164 country analysis. Globally, older women had income elasticities which indicated a higher likelihood of fruit intake when compared to young men, however red meats and fruit juices had relatively consistent positive income elasticities globally across all categories.

Nutrient Elasticities

Traditional demand elasticities measure food choice responsiveness to changes in price and income for a particular good, however they do not necessarily measure nutrient intake changes with respect to price and income (Pitt, 1983; Sahn, 1988). Nutrient elasticities are an empirical tool of analysis that derive the relationship between nutrient consumption, price and income by using price and income elasticities of demand (Huang, 1996; Pitt, 1983; Sahn, 1988). Based on the demand structure of food consumption, nutrient bundles are attributable for certain food categories and the relationship between nutrient intake, price and income can thus be examined (Huang, 1996; Lancaster, 1966).

Shan (1988) estimated the responsiveness of calorie intake of households with respect to changes in price for 13 food commodities and changes in household income in Sri Lanka by aggregating demand functions and taking the weighted average. The nutrient price elasticities of demand for calorie intake presented were mostly negative and were lower than own-price elasticities of demand indicating that households mitigate rising food prices by adjusting consumption bundles. While most nutrient elasticities for calorie intake were negative, exceptions do occur. For example, the own-price elasticity of demand for meat in Sri Lanka was greater than unity for all income classifications, however the nutrient elasticity of calories with respect to meat price was positive for all income classifications except the richest. This indicates that rising meat prices discourages meat consumption in almost all households and more inexpensive, calorie-dense foods cause an increase in household calorie intake (Sahn, 1988).

Behrman, Deolalikar, and Wolfe (1988) hypothesized nutrient elasticities as an inverse function of per capita income after results from estimating direct nutrient elasticities with respect to income for Nicaragua's capital of Managua found very small, but significant, effects. The small nutrient elasticity estimates for the relatively high per-capita income of Managua could have been consistent with higher nutrient elasticities in poorer areas of Nicaragua, however further estimated nutrient elasticities remained low despite increasing the sample size to all of Nicaragua instead of only Managua as originally estimated. Nevertheless, the estimated nutrient elasticities with respect to income and per capita income were found to have a statistically significant inverse relationship (Behrman et al., 1988). Reasoning for nutrient elasticities remaining small is that as income increases, food expenditures increases with the purchasing of more expensive foods, however there is little consideration for increased nutritional content. Other food characteristics such as taste, associated status, degree of processing or preparation time. This results in low nutrient elasticities even when high food expenditure elasticities exist (Behrman et al., 1988; Behrman and Wolfe, 1984).

Huang (1996) examines the linkage of nutritional intake and price and income changes in the United States for 35 food categories by deriving nutrient elasticities for 15 nutrients from an interdependent demand relationships. By incorporating a complete demand system including own- and cross-price and income elasticities Huang was able to derive nutrient elasticities from an interdependent demand relationships thereby allowing analysis of how a 1% change in the price of a food commodity will affect the entirety of food consumption for all commodities within the model. For example, a 1% increase in the price of beef will result in a 0.027% decrease in per capita food energy, 0.025% decrease in fat, and a 0.064% increase in vitamin A. The increase in vitamin A can be directly attributed to the interdependent demand relationship due to cross-commodity effects. Vitamin A is not found in beef, rather vitamin A is prevalent in carrots and chicken two commodities which presented with positive nutrient elasticities with respect to an increase in beef prices (Huang, 1996).

Pitt (1983) examines uncompensated and compensated nutrient elasticities of demand pertaining to calorie intake with respect to price and income in rural Bangladesh. For income, two representative household percentiles were chosen. The '25th percentile' household represents a high expenditure income household where per capita food expenditure is higher than 75% of households sampled, and the '90th percentile' household represents a low expenditure household with per capita food expenditures represent the lowest 20% of households sampled. Households within the 90th percentile are more likely to suffer from seriously nutritional deficiencies than other households sampled. The uncompensated nutrient demand elasticities are expected to have negative signs. For the 90 percentile household, rice had the greatest absolute value for uncompensated nutrient price elasticity for calorie intake. While unsurprising given rice is the leading caloric source within this study, positive nutrient elasticities for onions present intriguing results as elasticities implicate an increase in onion price would result in an increased consumption of all nutrients. Pitt (1983) notes that the two household percentiles have several important differences in nutrient price elasticities, including the magnitude of nutrient intake with respect to the price of rice.

Gould, Cox, Perali (1991) identify and examine demographic, social, and economic demand factors which impact the consumption of fats and oils in the United States. Nutrient elasticities were estimated as the change in dietary fat intake in response to a change in a selected aforementioned socio-demographic variable. Age was found to have a negative and statistically significant nutrient elasticity for total fat, implying that a reduction in total fat intake is associated, ceteris paribus, with an aging population. Total fat intake from fat and oil consumption was also positively impacted by increased education levels, implying that a population with higher education levels will likely consume less total fats from fat and oil commodities. Gould et al., (1991) hypothesizes that this correlation implies that higher levels of education allow for the population to obtain more information about nutrient consumption, particularly dietary fats, and the impact of nutrition on health.

Various methods can be used to estimate nutrient price elasticities. Pitt (1983), Sahn (1988), and Gould, Cox, and Perali (1991) estimate nutrient elasticities by the weighted average of own- and cross-price and income elasticities of demand. Huang (1996) notes that the previously mentioned method is accurate for the purpose of deriving nutrient elasticities but does not provide an underlying demand model that can be empirically analyzed. An alternate approach uses interdependent demand relationships, including own- and cross-price and income elasticities, to estimate nutrient elasticities based on a complete food demand system (Huang, 1996). Substitution may have an effect on nutrient elasticities for various food categories therefore Pitt (1983) examines compensated nutrient elasticities as a method to analyze the net effects of pure substitution on nutrient intake which may result in insights for price invention programs.

Taxes and Subsidies as Intervention Strategies

Sugar-sweetened beverages (SSBs) have recently come under scrutiny as governments worldwide consider implementing taxes on SSBs to reduce intake, improving dietary quality, decreasing NCDs and healthcare expenditure rates, and potentially generating government revenue to fund related health programs (Brownell, Popkin, and Ludwig, 2009; Cawley et al., 2019; Malik, Schulze, and Hu, 2006). SSBs are defined as any beverage which contains naturally derived or added sugars including sucrose (table sugar), high-fructose corn syrup, or fruit-juice concentrates (Brownell et al., 2009). Formed from refined carbohydrates, SSBs metabolize quickly which leads to low satiety and thus contribute to higher overall calorie intake. SSBs are a leading source of added sugar consumption in American diets and research indicates the high glycemic load of SSBs increase the risk of diabetes due to the direct physiological effects on pancreatic islet cells and insulin resistance (Brownell et al., 2009; Cawley et al., 2019; Malik et al., 2006). Numerous studies indicate there is an association between increased consumption of SSBs and increased risk of obesity, diabetes and CVDs (Andreyeva et al., 2011; Brownell et al., 2009; Malik et al., 2006).

Pricing strategies, such as taxation and subsidies, are proposed methods to influence food consumption and reduce obesity and NCD rates (Brownell et al., 2009;

Cawley et al., 2019; Eyles et al., 2012). The World Health Organization (WHO) recommends that policy makers and governments utilize pricing policies as market normalizing instruments to offset negative externalities and support policy objectives. The WHO recommends taxation, particularly on SSBs, to support public health policy objectives including increasing overall health and decreasing health care expenditures and other societal costs associated with NCDs (World Health Organization and Regional Office for Europe, 2015). Government intervention is acceptable when sub-optimal production and consumption levels result from market failures. In the case of SSBs, Brownell et al., (2009) identifies three market failures to correct when placing a tax on SSBs : (1) consumers have incomplete information about the links between SSBs and health consequences, (2) time-inconsistent preferences of consumers for immediate satisfaction over potential long-term harm, and (3) the financial externality to the market as consumers do not bear the full financials of their consumption decisions generated as excess healthcare expenditures, which are placed on governments.

Proposed taxation measures for SSBs recommend policies levy specific excise taxes based on per ounce or per gram added sugar content to encourage the reduction of SSBs consumption by consumers. A specific excise tax is preferable to an ad valorem or sales tax, where a percentage tax on the sale price is levied, due to the high number of SSBs substitutes. A percentage tax could encourage consumers to purchase generic or lower-cost SSBs brands or larger containers of SSBs with lower per-ounce costs which would result in no-calorie intake changes rather than the intended reduction in SSBs consumption. Evidence from enacted tobacco and alcohol taxation policies indicate that specific excise taxes have a greater impact than ad valorem and sales taxes (Andreyeva et al., 2011; Brownell et al., 2009).

Some objections to SSBs taxation revolve around the regressive nature the tax would embody. Similar to the case of tobacco taxation, proponents of SSBs taxation argue the poor face a disproportionate burden of diet-related diseases and unhealthy diet behavior is most often determined in teenage years (Brownell et al., 2009). Colchero et al., (2016) notes 33% of people between 2-18 years of age are overweight or obese in Mexico, a country with one the highest global prevalence of NCDs. Younger age groups, such as teenagers, and low-income individuals are generally more sensitive to price changes, indicating a tax would likely be an efficient means to shift consumption away from SSBs to more healthy alternatives (Andreyeva et al., 2011; Brownell et al., 2009).

In a country with one of the highest prevalence rates of obesity and diabetes, Colchero et al., (2016) examined the impact of an SSBs excise tax one year after implementation in Mexico. In January 2014, Mexico implemented a 1 peso/Liter, excise tax on SSBs which were non-dairy and non-alcoholic. This tax represented an approximate 10% increase in SSBs pricing from the previous year. The excise tax on SSBs was collected from manufacturers however research indicates the tax was passed on to consumers at the point-of-sale in its entirety. A difference-in-difference fixed effect model was used to analyze if the excise tax of 1 peso/Liter had a statistically significant effect on pre- and post- tax SSBs purchasing trends. Researchers categorized beverage purchases into five total categories, two taxed and three untaxed. The taxed beverage categories were: carbonated sodas and non-carbonated SSBs; un-taxed beverage categories were: carbonated beverages (including diet sodas); still, sparking, or plain water; and other drinks including fruit juices and unsweetened dairy beverages. Within the first year of taxation, SSBs purchased in Mexico decreased by a 6% average and purchases decreased at an increasing rate resulting in a 12% decline by the end of one year. Analysis shows a decline in purchasing of taxed SSBs across high, middle, and low income household groups with low-income households having the greatest reduction. In addition to declines in taxed beverage purchases, a 4% incline in un-taxed beverages occurred, this is mainly attributed to an increase of bottled plain water purchases (Colchero et al., 2016).

Cawley et al., (2019) conducted two surveys of SSB consumption for adults and children in Philadelphia, Pennsylvania and nearby communities outside the SSB tax area but still within Philadelphia's Metropolitan Statistical Area (MSA) to determine the impact of Philadelphia's 1.5 cent per ounce SSB tax pre- and post- implementation. The tax rate fell into the range of similar SSBs taxes implemented in other U.S cities, however Philadelphia differed due to the taxation of non-caloric sweetened beverages (diet soda) in addition to traditional SBBs (regular soda). The burden of Philadelphia's tax was pass through to consumers and varied based on store location and neighborhood characteristics. Therefore, stores close to the city center, and thus far away from alternative stores located outside Philadelphia's city limits who sell untaxed SSBs had higher rates of SSBs tax pass through to consumers than stores near alternative un-taxes stores. Results indicated that shopper who shopped outside of Philadelphia city limits prior to SSB tax implementation, continued to do so at an increasing frequency post implementation, thus shoppers continued to purchase SSBs and increased purchase expenditures outside the city. Overall SSB tax did have a negative impact on sugar consumption, these findings were both modest and insignificant indicating little to no overall health improvements for adults and children. The overall findings for children was that children who had high baselines of added sugar consumption (consumption greater than 67 grams per day) had statistically significant alterations in consumption following the SSBs tax implementation which occurred in the form of a 22% decrease in added sugar consumption. This decrease in consumption was largely attributed to a decrease in frequency of SSBs consumption. It can then be concluded that the implementation of SSBs tax in Philadelphia had a fairly substantial impact on the children who likely face high risk factors for contracting NCDs prior to the tax.

CHAPTER III.

DATA AND METHODS

Data

Global Dietary Database

For this analysis, 2010 saturated fatty acid (SFA) daily intake measured in percent of total energy per day was obtained from the Global Dietary Database (GDD). The database contains representative individual intake values by age (5 to 100 in 5-year intervals), sex, education level (high, medium, and low), and urban-rural status for over 180 countries. The GDD is a comprehensive database aimed at providing global estimates of individual food and nutrient intake levels. The GDD is part of a global initiative of public health and nutrition experts and maintained by the Global Nutrition and Policy Consortium based at Tufts Friedman School of Nutrition Science and Policy. This globally representative database was developed by systematic searches of available survey data of individual-based dietary intakes, both national and subnational, for key food and nutrient categories, extensive communication with researchers and government authorities, and, when other options are unavailable, large subnational surveys (Khatibzadeh et al., 2016). This study is limited to the 164 countries with the corresponding income and price data necessary for analysis.

Food Prices

Price-level indexes at the country level for select food categories were used as proxies for select food prices and were obtained from the 2011 International Comparison Program (ICP) of the World Bank. The ICP is a global statistical initiative which estimates purchasing power parities (PPPs) as currency conversion factors to compare economies globally. The 2011 ICP covers 199 countries for 8 regions, 7 geographical: Africa, Asia and the Pacific, Commonwealth of Independent States, Latin America, the Caribbean, Western Asia, and the Pacific Islands, and the 8th region is compiled of economies participating in the regular PPP program that is maintained by the Office of the European Communities (Eurostat) and Organization for Economic Co-operation and Development (OECD). The ICP distributes worldwide surveys intermittently, currently every six years, to gather price and expenditure data for a variety of final goods and services in GDP expenditure to calculate PPPs. Surveys are organized by region due to the increased homogeneity of price trends for goods and expenditures and other regional related factors (World Bank, 2015).

PPPs are spatial price deflators that make it possible to compare GDP and expenditures across economies. For example, if the price of a hamburger is €4.80 in France and $4.00 in the United States, the PPP for hamburgers between the two economies is $0.83 to the euro from the French perspective (4.00/4.80) and €1.20 to the dollar from the U.S. perspective (4.80/4.00) (World Bank, 2015, p. 13). Strictly speaking, for every euro spent in France, $0.83 will be spent in the United States and for every dollar spent in the United States, €1.20 will be spent in France for the same volume of hamburgers. Price level indexes are PPPs standardized to a common currency unit, generally the U.S Dollar (World Bank, 2015).

To examine the prices associated with saturated fat intake, we selected prices for food categories associated with high saturated fat content (e.g., beef, cheese, milk, and fats and oils). The price of lower-fat, healthier alternatives was also considered: fish, fruits, and vegetables. The selection of food categories are based on the top contributing sources of saturated fat intake in American diets (Huth et al., 2013).

Income

For income, we used the 2010 PPP-adjusted gross domestic product per capita from the World Bank, World Development Indicators (WDI) database. WDI is a comprehensive database of economic factors complied and maintained by the World Bank and global partners in six main categories: world view, people, environment, economy, states and markets, and global links. The goal of WDI is to provide an extensive knowledge of current circumstances in countries worldwide, particularly issues in developing countries. Because differences in currency values and exchange rates do not always consistently reflect price level differences across countries, PPP-adjusted GDP allows for direct cross-country comparisons by accounting for overall price level disparities across countries (World Bank, 2010).

Methodology

Conceptual Framework

As this study focuses on intake, rather than expenditures, traditional demand estimation frameworks do not apply. Previous studies of food, nutrient, or caloric intake use basic econometric models, including linear and log-linear functions. At the core, nutrients are simply a characteristic of goods that are consumed as a part of an individual's preferences and utility maximization (Behrman and Wolfe, 1984; Huang, 1996; Lancaster, 1966). Just as income and prices are primary determinants in food demand functions, any functional form used to examine nutrient intake could also include explanatory variables such prices and income.

It is expected that SFA intake responsiveness to prices and income will diminish with increased income, meaning that, at higher income levels individuals are less responsive to changes in prices and income. This is because higher-income consumers generally spend a significantly smaller share of total income on food and have increased demand for food attributes (taste, convenience, perceived status) beyond basic nutrient intake (Behrman et al., 1988; Behrman and Wolfe, 1984; Muhammad et al., 2017b; Sahn, 1988). While previous studies of food demand have utilized double-log quadratic forms including Shan (1988), a semi-log functional form will be used in this study (LaFrance, 1990). The reasoning for using the semi-log model is to avoid losing significant differences in SFA intake across countries and subgroups when intake values are converted to logs. (LaFrance, 1990; Muhammad et al., 2017b).

Empirical Model

Let q represent mean saturated fat intake (% energy per day) for a representative individual and the subscripts g denote the subgroup (e.g., urban, male, age 30, of education level 1) and C the country. Let Y_C represent real per capita income in country C, PB_C represent the price index for "selected SFA contributing factors" in country C, $PVeg_C$ represent the fresh vegetable price index in country C, and let u denote the random error. Given these terms, the following semi-log demand function is use to estimate the how saturated fat intake is influence by prices, and income.

(1) $q_{gC} = a_0 + a_1 \log(Y_C) + a_2 \log(Y_C)^2 + a_3 \log\left(\frac{PB_C}{P_c}\right) + a_4 \log\left(\frac{PVeg_C}{P_c}\right) +$

$a_5 \left[\log(Y_C) \times \log\left(\frac{PB_C}{P_c}\right)\right] + a_6 \left[\log(Y_C) \times \log\left(\frac{PVeg_C}{P_c}\right)\right] + u_{gC}$

Each parameter (a) can be expanded to account for interactions with age, sex, urban, and region:

(2) $a_n = \beta_n + \beta_{n1} Age + \beta_{n2} Age^2 + \beta_{n3} Sex + \beta_{n4} Edu\ 2 + \beta_{n4} Edu\ 3 +$

$\beta_{n4} Urban + \beta_{n7k} \sum_k Region_k$

$n = \{0,1, \ldots ,6\}$

The quadratic income term, $\log(Y_C)^2$ and price-income interaction terms, $\left[\log(Y_C) \times \log\left(\frac{PB_C}{P_c}\right)\right]$ and $\left[\log(Y_C) \times \log\left(\frac{PVeg_C}{P_c}\right)\right]$ allow for price and income effects to differ by income level. Age, sex, urban, education level, and region were all included as explanatory variables to estimate their effects on SFA intake. As noted, Age is a variable ranging from 5 to 100 in 5-year increments. Age^2 is added to allow for non-linear age effects. Sex is a binary variable where 0 represents male and 1 represents female. Urban is a binary variable where 0 indicates that the representative individual is in a rural area and 1 represents an urban area. Education level was converted from a ranking system from 1 to 3 where 1 represented low education, 2 represents medium education, and 3 represents a high education level to binary variables denoted Edu 1, Edu 2, and Edu 3 respectively with Edu 1 being used as the reference variable. Intake preferences due to factors other than price or income, such as cultural and religious traditions may affect dietary intake. These factors were accounted for with binary regional variables. Regions are defined as followed: East and Southeast Asia (Asia), Central and Eastern Europe (CEE), Latin America and Caribbean (LAC), Middle East and North Africa (MENA), South Asia (SAARC), and Sub-Saharan Africa (SSA). The remaining countries are High-Income OECD Countries (HIC) which is used as the base region (Table III-1).

Price elasticities of demand are unitless measures representing how a change in price affects total spending on a good, ceteris paribus (Nicholson and Snyder, 2008). SFA price (η) and income (ε) elasticity equations are derived from equation (1) with respect to the price of SFA contributing foods (PB), fresh vegetable price $(PVeg)$, and real per capita income (Y_C).

(3) $$\eta_{BC} = \frac{\%\Delta q_{gC}}{\%\Delta PB_C} = \frac{1}{q_{gC}}[a_3 + a_5 \log{(Y_c)}]$$

(4) $$\eta_{VegC} = \frac{\%\Delta q_{gC}}{\%\Delta PVeg_C} = \frac{1}{q_{gC}}[a_4 + a_6 \log{(Y_c)}]$$

(5) $$\varepsilon_C = \frac{\%\Delta q_{gC}}{\%\Delta Y_C} = \frac{1}{q_{gc}}[a_1 + 2a_2 \log{(Y_c)}]$$

Equation (3) represents the percentage change in SFA intake due to a percent change in the price of a SFA contributing food. If $|\eta_{BC}| > 1$ then SFA intake demand is elastic (very responsive to the price change) while if $|\eta_{BC}| < 1$ then SFA intake demand is inelastic. Equation (4) represents the percentage change in SFA intake due to a percentage change in the price of fresh vegetables. If $|\eta_{VegC}| > 0$ then fresh vegetables are a substitute for food high in SFA. Equation (5) represents the percentage change in SFA intake due to a percentage change in real per capita income. If $|\varepsilon_C| > 0$ then SFA can be considered a normal good while if $|\varepsilon_C| < 0$ then SFA can be considered an inferior good.

Table III-1: Countries Included in this Study, by Region

East & Southeast Asia (ASIA)	Central and Eastern Europe (CEE)	High-Income Countries (HIC)	Latin America & Caribbean (LAC)	Middle East & North Africa (MENA)	South Asia (SAARC)	Sub-Saharan Africa (SSA)
Brunei Darussalam	Albania	Australia	Antigua and Barbuda	Algeria	Bangladesh	Angola
Cambodia	Armenia	Austria	Bahamas	Bahrain	Bhutan	Benin
China	Azerbaijan	Belgium	Barbados	Egypt	India	Botswana
Fiji	Belarus	Canada	Belize	Iran	Maldives	Burkina Faso
Indonesia	Bosnia Herzegovina	Cyprus	Brazil	Iraq	Nepal	Burundi
Japan	Bulgaria	Denmark	Chile	Israel	Pakistan	Cabo Verde
Laos	Croatia	Finland	Colombia	Jordan	Sri Lanka	Cameroon
Malaysia	Czechia	France, Monaco	Costa Rica	Kuwait		Central African Republic
Myanmar	Estonia	Germany	Dominica	Morocco		Chad
Philippines	Georgia	Greece	Dominican Republic	Oman		Comoros
South Korea	Hungary	Iceland	Ecuador	Qatar		Congo
Singapore	Kazakhstan	Ireland	El Salvador	Saudi Arabia		Cote d'Ivoire
Thailand	Kyrgyzstan	Italy	Grenada	State of Palestine		Democratic Republic of the Congo
Viet Nam	Latvia	Luxembourg	Guatemala	Tunisia		Djibouti
	Lithuania	Malta	Haiti	Turkey		Equatorial Guinea
	Mongolia	Netherlands	Honduras	United Arab Emirates		Ethiopia
	Montenegro	New Zealand	Jamaica	Yemen		Gabon
	Poland	Norway	Mexico			Gambia
	Republic of Moldova	Portugal	Nicaragua			Ghana
	Romania	Spain	Panama			Guinea
	Russian Federation	Sweden	Paraguay			Guinea-Bissau
	Serbia	Switzerland	Peru			Kenya
	Slovakia	United States	Bolivia			Lesotho
	Slovenia	United Kingdom	Saint Lucia			Liberia
	Tajikistan		Saint Vincent and the Grenadines			Madagascar
	North Macedonia		Suriname			Malawi
	Ukraine		Trinidad and Tobago			Mali
			Uruguay			Mauritania
			Venezuela			Mauritius
						Mozambique
						Namibia
						Niger
						Nigeria
						Rwanda
						Sao Tome and Principe
						Senegal
						Seychelles
						Sierra Leone
						South Africa
						Sudan
						Swaziland
						Togo
						Uganda
						Tanzania
						Zambia
						Zimbabwe

STATA Procedure

STATA 16 was used for data analysis and modeling. Price and national income data previously described was collected and imported to STATA and combined using the "MERGE" command utilizing universal 3-digit ISO codes to match price and national income data to individual countries. Representative SFA intake data for by sex, age, urban, and education obtained from the GDD were collected in an excel file and merged with the price and national income merged data set from STATA. The merger of these two datasets resulted in the final data set named "SFA_A" which was used for analysis. Observations within "SFA_A" which contained missing values for "SFA" or "WDI", our national income variable, were removed using the command "DROP if missing()" in STATA. Countries without price information for any category were removed using "DROP". For estimation, all food prices were expressed in real terms. That is, the food price indexes for individual food categories were divided by a price index for food and beverages in total (All-food). For example, "real_freshveg" is the price of fresh vegetables used in our analysis, it was calculated by dividing the fresh vegetable price index by the All-food price index. Binary variables for education, urban, and regions were created in STATA using "GEN" and "REPLACE, IF" commands.

In our dataset, 164 countries with unique ISO codes are included, however each ISO country code has 240 observations. Therefore, "EGEN" was used to create country groupings named "ISO_id" therefore observations within a specific country with the same ISO code were linked. "EGEN" was then used to create another variable "WDI_ranks" which ranked countries by national income level. "WDI_ranks" listed countries from least to greatest national income level to allow income deciles to be formed. Income deciles, denoted D1-D10, were created as binary variables using "GEN" and "REPLACE, if" with D1-D4 each containing 17 countries and D5-D10 each contained 16 countries. Analysis was performed using "REGRESS" in STATA which fits dependent and independent variables in a linear regression, including ordinary least squares and weighted least squares. When using the "REGRESS" procedure, the "ROBUST CLUSTER" option was selected to obtain robust cluster standard errors that accounted for within country error correlations. The "MARGINS" command was used to calculate elasticities. Within the "MARGINS" command, price elasticities for individual income deciles were calculated for multiple scenarios based on the variables of age, urban, education using, "MARGINS, EYDX, SUBPOP *(income decile)*, AT*(variable specifications)*". For example, an income elasticity for D6 for ages 5 to 100 in five year increments in a urban area and education 2 was derived using the following command: "margins, eydx(log(WDI)) subpop(D6) at(urban=1 edu_2=1 age=5(5)100)."

A full model with all possible interaction terms was estimated first. F-test were then used to determine the significance of the interaction terms. Interaction terms that were determined to be jointly insignificant were removed from the model (Wooldridge, 2013).

CHAPTER IV.

RESULTS AND DISCUSSION

Summary Statistics

The food price, income, and SFA intake data previously described was collected and merged based on universal 3-digit ISO country codes. As these 3-digit codes are used worldwide, utilizing ISO codes helps limit some concerns over data merger errors. Countries which did not have data from all three sources were removed from our dataset. In the final dataset used for analysis, 164 countries were identified and reported by 7 defined regions (Table III-1). These 164 countries were ranked from lowest to highest base on income levels and distributed into decile groups for later analysis at multiple income levels. Decile 1 represents the lowest 10% of countries globally and Decile 10 represents the wealthiest 10% of countries. Deciles 1-4 each contain 17 countries and the remaining 6 deciles each contain 16 countries (Table IV-2). Regional composition of each decile was reported (Table IV-3) and used to identify potential regional impacts on analysis which may occur when one region represents the majority of an income decile. For example, the lowest two income deciles "D1" and "D2" are comprised by SSA countries at 94.12% and 76.47% respectively. In higher income deciles, 56.25% of "D8" is from CCE countries and HIC countries comprise 75% of "D9" and 56.25% of "D10". MENA and ASIA comprise the other regional share of "D10" with 31.25% and 12.5% respectively. Table IV-4 reports selected summary statistics of variables included in the model. 2010 SFA intake range is reported in % energy per day with a minimum value of 2.15 and maximum value of 24.31, a mean of 9.67 and standard deviation of 2.94.

Table IV-2: Decile Breakdown, by Country

D1	D2	D3	D4	D5
Burkina Faso	Bangladesh	Cameroon	Angola	Albania
Burundi	Benin	Ghana	Armenia	Bosnia Herzegovina
Central African Republic	Cambodia	Honduras	Belize	China
Congo, Dem. Rep.	Chad	India	Bhutan	Colombia
Ethiopia	Comoros	Kyrgyzstan	Cabo Verde	Dominica
Gambia	Cote d'Ivoire	Laos	Congo	Ecuador
Guinea-Bissau	Djibouti	Mauritania	El Salvador	Egypt
Haiti	Guinea	Myanmar	Fiji	Grenada
Liberia	Kenya	Nicaragua	Georgia	Indonesia
Madagascar	Lesotho	Nigeria	Guatemala	Jordan
Malawi	Mali	Pakistan	Jamaica	Namibia
Mozambique	Nepal	Rep. of Moldova	Mongolia	Paraguay
Niger	Sao Tome and Principe	State of Palestine	Morocco	Peru
Rwanda	Senegal	Sudan	Philippines	St. Vincent and the Grenadines
Sierra Leone	Tajikistan	Viet Nam	Bolivia	Sri Lanka
Togo	Tanzania	Yemen	Swaziland	Tunisia
Uganda	Zimbabwe	Zambia	Ukraine	
D6	**D7**	**D8**	**D9**	**D10**
Algeria	Antigua and Barbuda	Bahamas	Australia	Austria
Botswana	Azerbaijan	Croatia	Bahrain	Brunei Darussalam
Brazil	Barbados	Czechia	Belgium	Denmark
Bulgaria	Belarus	Estonia	Canada	Ireland
Costa Rica	Chile	Greece	Cyprus	Kuwait
Dominican Republic	Iran	Hungary	Equatorial Guinea	Luxembourg
Gabon	Kazakhstan	Israel	Finland	Netherlands
Iraq	Latvia	Lithuania	France, Monaco	Norway
Maldives	Mauritius	Malaysia	Germany	Oman
Montenegro	Mexico	Malta	Iceland	Qatar
Saint Lucia	Panama	Poland	Italy	Saudi Arabia
Serbia	Romania	Portugal	Japan	Singapore
South Africa	Seychelles	Rep. of Korea	New Zealand	Sweden
Suriname	Turkey	Russia	Spain	Switzerland
Thailand	Uruguay	Slovakia	Trinidad and Tobago	United States
North Macedonia	Venezuela	Slovenia	United Kingdom	United Arab Emirates

Table IV-3: Decile Breakdown by Regional Share

	East & Southeast Asia (ASIA)	Central and Eastern Europe (CEE)	High-Income Countries (HIC)	Latin America & Caribbean (LAC)	Middle East & North Africa (MENA)	South Asia (SAARC)	Sub-Saharan Africa (SSA)
D1				5.88%			94.12%
D2	5.88%	5.88%				11.76%	76.47%
D3	17.65%	11.76%		11.76%	11.76%	11.76%	35.29%
D4	11.76%	23.53%		29.41%	5.88%	5.88%	23.53%
D5	12.50%	12.50%		43.75%	18.75%	6.25%	6.25%
D6	6.25%	25.00%		31.25%	12.50%	6.25%	18.75%
D7	0.00%	31.25%		43.75%	12.50%		12.50%
D8	12.50%	56.25%	18.75%	6.25%	6.25%		
D9	6.25%		75.00%	6.25%	6.25%		6.25%
D10	12.50%		56.25%		31.25%		

Table IV-4: Selected Summary Statistics

Variable	Measure	Mean	Std. Dev.	Min	Max
Sex	binary	0.5	0.50	0	1
Age	5-year Intervals	52.5	28.83	5	100
ASIA	binary	0.09	0.28	0	1
CEE	binary	0.16	0.37	0	1
HIC	binary	0.15	0.35	0	1
LAC	binary	0.18	0.38	0	1
MENA	binary	0.10	0.30	0	1
SAARC	binary	0.04	0.20	0	1
SSA	binary	0.28	0.45	0	1
SFA	% energy per day	9.67	2.94	2.15	24.31
Income per capita	$/person (2010)	$ 17,483.86	$ 19,117.13	$ 659.80	$ 119,973.60
Fresh Vegetable Price	index (U.S. = 1)	0.76	0.23	0.34	1.41
Contributing SFA Factors Index	index (U.S. = 1)	1.15	0.19	0.67	1.89

The means for the regional binary variables identifies the region's share of the total number of countries in the data. SSA has the largest share at 0.28, LAC has the second highest share at 0.18 and is followed closely by CEE at 0.16 and HIC at 0.15. MENA, ASIA, and SAARC have the smallest regional shares at 0.10, 0.09, and 0.04 respectively. Income is measured on a per capita basis, with a mean value of $17,483.86, a standard deviation of $19,117.13, and minimum and maximum values at $659.80 and $119,973.60, respectively. Based on preliminary analysis, a "bad" price index was created by calculating an expenditure weighted average of beef and veal, pork, lamb, preserved milk, cheese, butter, and other oils and fats. Preliminary analysis also indicated that fresh vegetables was the only "good" price needed for the analysis. Both the fresh vegetable and bad price index prices are reported in Table IV-4 (the price indexes for the U.S. =1). Fresh vegetables price has a mean of 0.76 with a minimum of 0.34, maximum of 1.41 and standard deviation of 0.23. The selected contributing factors price index has a mean value of 1.15, with a 0.67 minimum value, 2.89 maximum value and standard deviation of 0.19.

To visually identify regions and countries with higher SFA intake, Figure IV-2 maps median SFA intake across the 164 countries included in this study. Countries are shaded from light orange to red and represent the lowest to highest SFA intake, gray areas indicate countries that are not included in our study. A higher SFA intake is found within the "ASIA" region, particularly the southwestern portion of the region with countries such as Indonesia, Malaysia, and the Philippines, in comparison to other regions and countries worldwide.

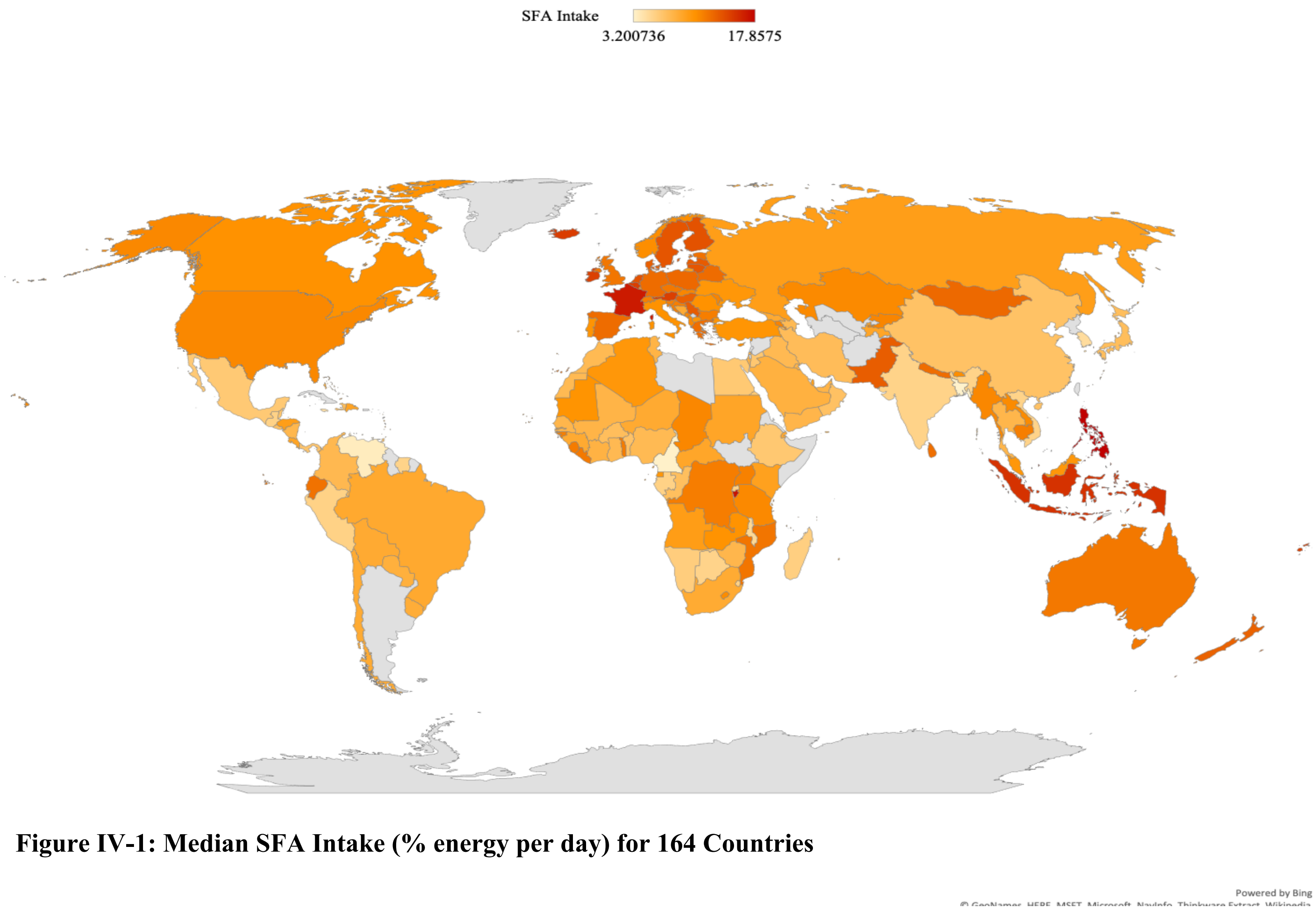

Figure IV-1: Median SFA Intake (% energy per day) for 164 Countries

Nordic countries and parts of central and eastern European countries such as Iceland, Finland, Austria, Belgium, Sweden, and the Neatherlands all have higher than average inidviual SFA intake compared to other parts of the world.

Figure IV-2 shows the differences between individuals median SFA intake in rural and urban areas by region. Overall, individuals in urban areas have higher SFA intake than their rural counterparts. High income countries (HIC) are the exception where individual in rural areas have a slightly higher median SFA intake at 12.57 compared to 12.54 in HIC urban areas. Individuals in LAC have the greatest difference between urban and rural areas, where rural areas median SFA intake is 6.63 to urabn areas 9.14.

Figure IV-3 shows regional median SFA intake across the three education levels. Individuals in HIC have the highest SFA intake at all education levels while individuals in LAC have the lowest SFA intake. In CEE, MENA, and SSA regions, individuals with the middle education level (edu 2) have the highest SFA intake. However, in CEE and MENA the lowest SFA intake were individuals at the highest education level (edu 3), while SSA has an opposing pattern with individuals were the lowest education level (edu 1) have the highest SFA intake value at 8.86 and individuals at the highest education level (edu 3) have the lowest SFA intake at 8.81. All other regions have ascending patterns of SFA intake where individuals at the highest education level (edu 3) also have the highest SFA intake and individuals at lowest education level (edu 1) have the lowest SFA intake. Regardless of region, there were no large differences between individuals SFA intake between education levels within a region, the largest difference between individuals at the highest education level and lowest education level were located in LAC

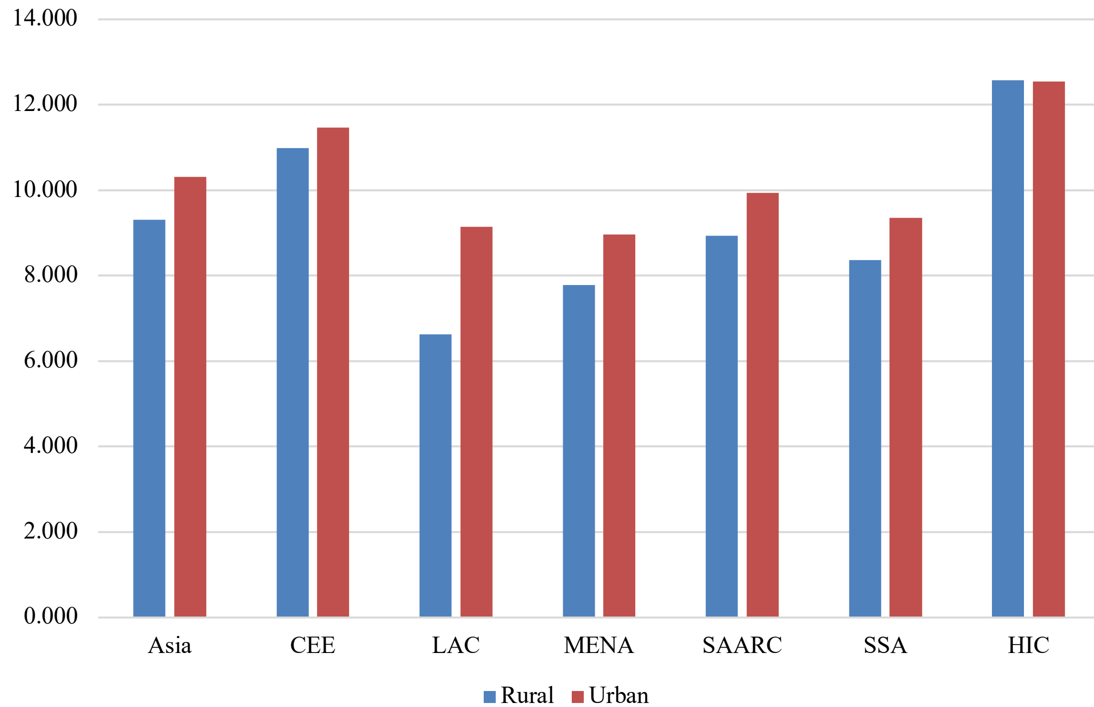

Figure IV-2: Regional Median SFA Intake by Rural vs Urban Areas

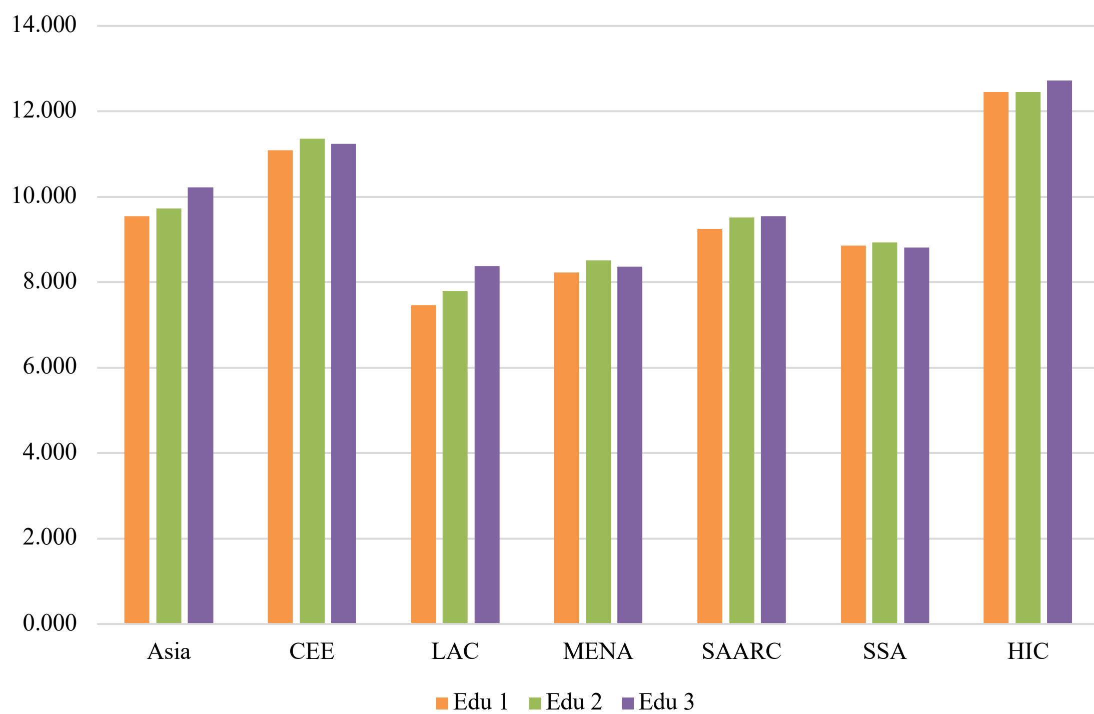

Figure IV-3: Regional Median SFA Intake by Education

with a difference of 0.911 and the smallest difference, in absolute value, was SSA with a difference of 0.049.

In Figure IV-5, median SFA intake by indivduals of all education levels in rural and urban communities were compared. At all education levels (edu 1, edu 2, and edu 3) individuals living in urban areas had higher median SFA intake than rural counterparts. From lowest education level to highest education levels individuals SFA intake have a difference of 0.973, 0.992, and 1.007 repectively from urban areas to rural. Among individuals in both urban and rural areas, the highest median SFA intake was found in indivuals at the highest education level (edu 3) and SFA intake decended as an individuals education level decreased.

In Figure IV-4, rural and urban median SFA intakes were compared across age groups. Across ages, individual SFA intake peaks at the tail ends, with a high intake at age 5 and 100. Individuals in urban areas had a higher median SFA intake than individuals in rural areas across all age groups. The difference in SFA intake when comparing individuals from urban areas to rural ranged from 0.972 to 1.065 % energy per day intake from SFA.

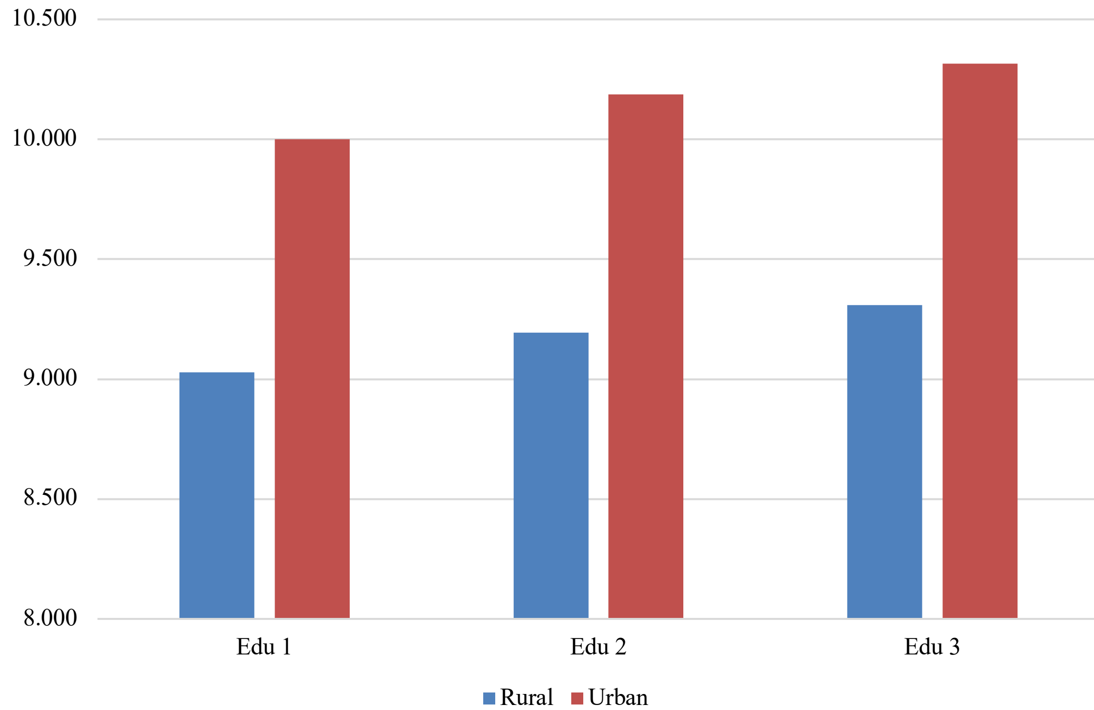

Figure IV-5: Median SFA Intake in Rural vs Urban Areas by Education

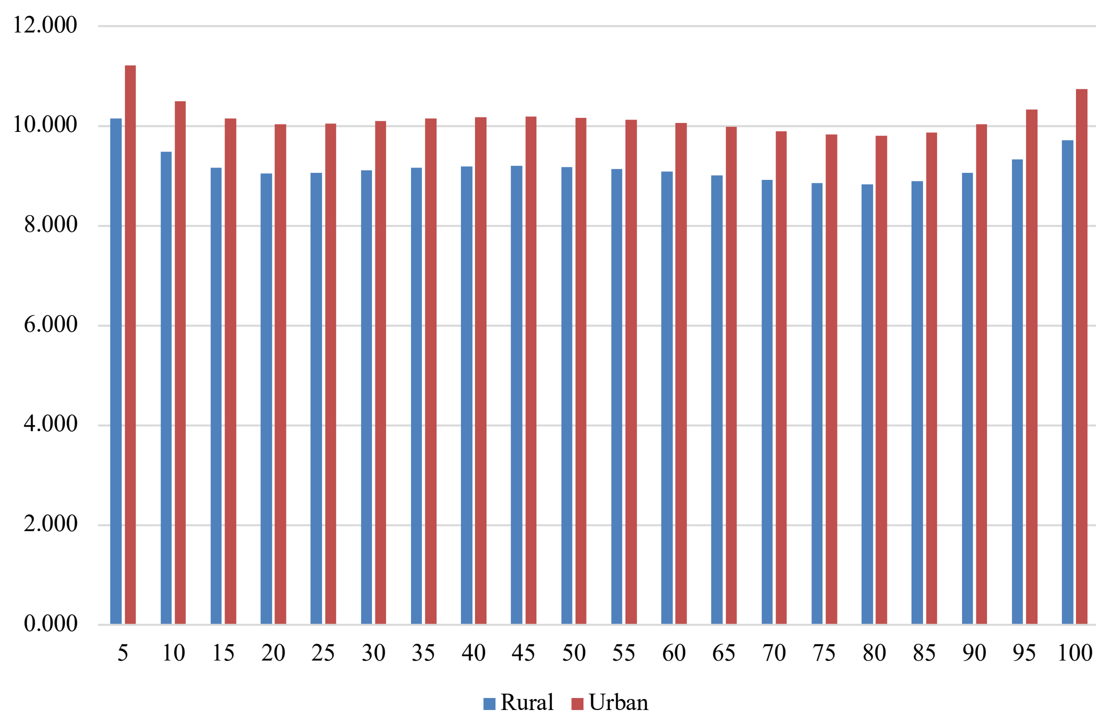

Figure IV-4: Median SFA Intake in Rural vs Urban Areas by Age

Demand Model Results

The price indexes for selected foods that contribute to SFA intake: beef and veal, pork, lamb, other dairy, butter, cheese, and other edible oils and fats; and selected healthy alternatives: fresh fruits and fresh vegetables; were individually analyzed for their effect on SFA intake. Based on preliminary findings no individual SFA contributing foods was attributed to SFA intake more than the other. Due to these results, a weighted average "selected contributing factors price index" was created from the selected SFA contributing foods and used for further analysis. The fresh vegetable price index was found to have a significant, positive relationship with SFA intake. After selecting fresh vegetables and selected contributing SFA factors index as our price variables, various models and F tests were used to compare various restricted models to an unrestricted model with all possible price and income interaction terms to arrive at the final model (Table IV-5, Model 3).

Demand model estimates for three estimations runs (model 3 is the final model used for analysis) are reported in Table IV-5. Model 1 is the relationship between SFA intake and the binary and age variables only. The purpose of each additional model after Model 1 is to demonstrate how the income and price variables further explained SFA intake. Model 2 includes all the variables in Model 1, but also includes the income and price terms without any interactions. From Model 2 we see that the effects of income on SFA intake is negative (-0.943), suggesting an inferior "good." The impact of the SFA "own-price" index is also (-2.77) indicating that higher "SFA prices" result in lower intake. The estimate for fresh vegetable prices is positive indicating a substitute relationship.

Table IV-5: Demand Model Estimates for SFA Intake

Variables	Model 1	Model 2	Model 3
Constant	12.473*** (0.367)	22.949*** (2.726)	53.794*** (11.437)
ASIA	-2.717** (1.091)	-3.283*** (0.945)	-3.238*** (0.941)
CEE	-1.318*** (0.458)	-1.967*** (0.513)	-1.915*** (0.571)
LAC	-4.659*** (0.494)	-5.834*** (0.627)	-5.706*** (0.682)
MENA	-4.173*** (0.508)	-3.926*** (0.645)	-4.396*** (0.727)
SAARC	-3.103** (1.390)	-3.835** (1.497)	-3.674** (1.489)
SSA	-3.681*** (0.509)	-5.773*** (0.708)	-5.859*** (0.733)
Sex	0.269*** (0.018)	0.269*** (0.018)	0.269*** (0.018)
Urban	0.991*** (0.066)	0.991*** (0.066)	-8.917*** (3.192)
Edu 2	0.176*** (0.010)	0.176*** (0.010)	-2.872*** (0.541)
Edu 3	0.298*** (0.028)	0.298*** (0.028)	-6.682*** (1.112)
Age	-0.033*** (0.002)	-0.033*** (0.002)	-0.334*** (0.087)
Age^2	0.000*** (0.000)	0.000*** (0.000)	0.004*** (0.001)
log (Y_c)		-0.943*** (0.247)	-7.590*** (2.478)
log (PB)		-2.770** (1.198)	-11.391 (8.681)
log (PVeg)		1.698* (0.878)	14.001** (6.458)
log $(Y_c)^2$			0.351** (0.135)
log (Y_c) × Urban			2.432*** (0.738)
log (Y_c) × Edu 2			0.685*** (0.126)
log (Y_c) × Edu 3			1.491*** (0.253)
log (Y_c) × Age			0.071*** (0.020)
log (Y_c) × Age^2			-0.001*** (0.000)
log (Y_c) × log(PVeg)			-1.355* (0.699)
log (Y_c) × log(PB)			1.236 (0.994)
log $(Y_c)^2$ × Urban			-0.145*** (0.042)
log $(Y_c)^2$ × Edu 2			-0.038*** (0.007)
log $(Y_c)^2$ × Edu 3			-0.078*** (0.014)
log $(Y_c)^2$ × Age			-0.004*** (0.001)
log $(Y_c)^2$ × Age^2			0.000*** (0.000)
log (PB) × Age			0.195*** (0.059)
log (PB) × Age^2			-0.001 (0.001)
log (PB) × log (Y_c) x Age			-0.025*** (0.007)
log (PB) × log (Y_c) x Age^2			0.000 (0.000)
Adj. R-squared	0.332	0.397	0.424

Note: Standard errors are in parentheses. ***, **, and * denote the 0.01, 0.05, and 0.10 significance level respectively.

Model 3 is the final model. Based on the F-tests results, sex interaction terms with both income and prices were removed, as well as price interactions with age, education and urban variables. Although F-test indicated that the regional interaction terms were significant, they were removed from the model to avoid over-parameterization and nonsensical elasticity estimates. F-Test results are reported in Table A-10.

Elasticities

Elasticities were derived using the final model estimates. Price and income elasticities were derived at each income decile. Based on variables in the final model, income elasticities were derived by age and income decile and differentiated by urban-rural status and education level. Own-price elasticities (price index for contributing foods) were derived by age and income decile only. Note that the price index for contributing factors had no interactions with the urban or education variables. Based on the final model, fresh vegetable price elasticities are reported across income deciles only.

Income elasticities by age and income decile for individuals living in rural areas and with education level 1 are reported in Figure IV-6 (also available in Table A-2 in the appendix). The overall responsiveness of intake to income is negative, indicating that the inferior nature of SFA. Across all income deciles individual's faced increased sensitivity to changes in income with age, becoming more sensitive at older ages relative to younger age groups. For example, in Decile 4, a 1% change in income for an individual age 5

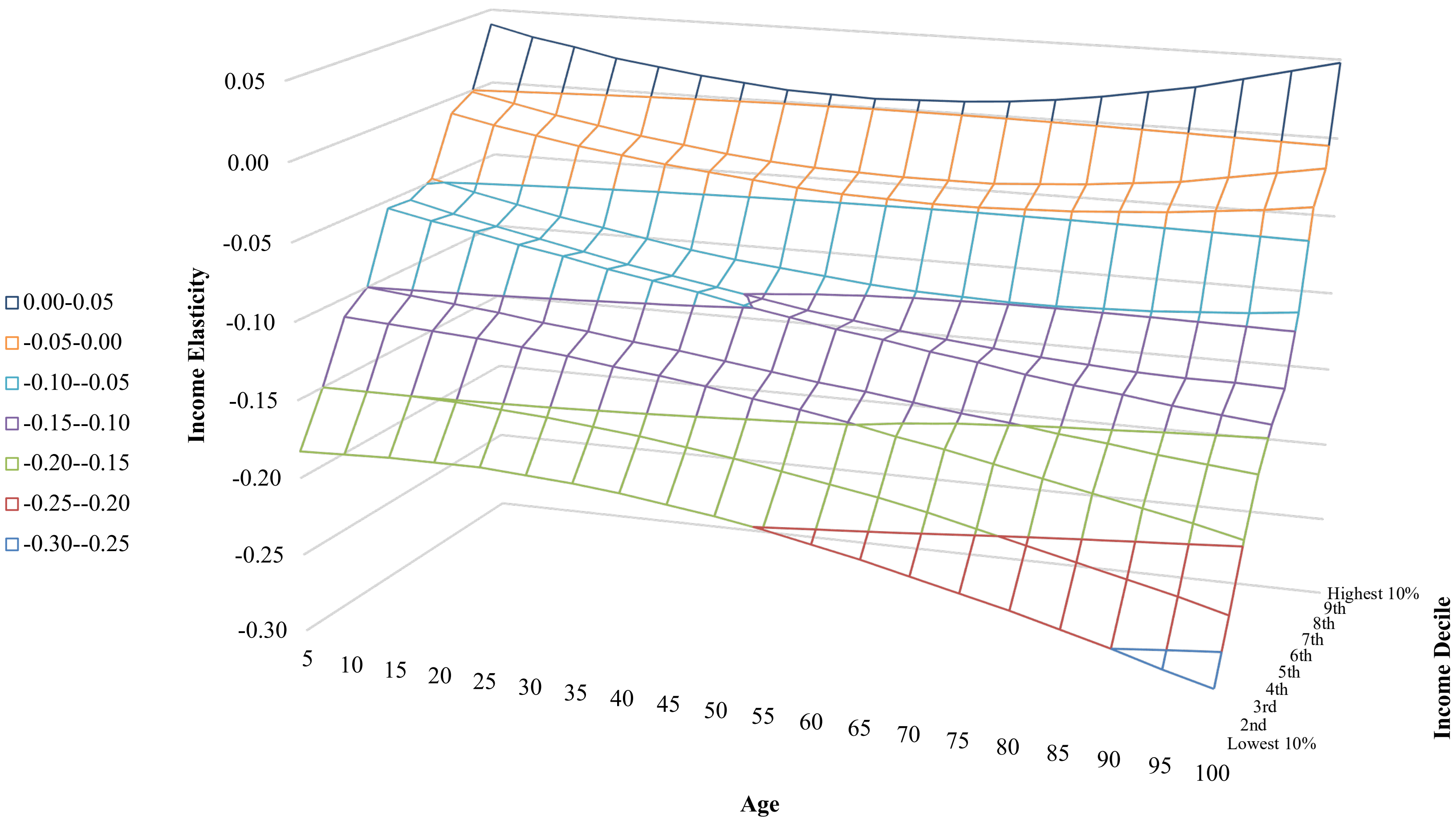

Figure IV-6: Income Elasticities by Age and Decile at Education 1, Rural

results in a decrease of 0.1% in SFA intake, age 25 a decrease of 0.113%, age 40 a 0.123% decrease, age 65 a decrease of 0.145%, and at age 80 a 0.153% decrease. In general, income elasticities faced an overall pattern of decreased sensitivity as income rises. At lower income deciles, individuals are more responsive to changes in income than at higher income deciles where responsiveness is mostly insignificant. For instance, income Deciles 8 to 10 have no significant income elasticities for rural individuals at education level l, suggesting that income is not a factor in the decision to consume SFAs.

Income elasticities for urban individuals at education level 1 are reported in Figure IV-7 (also available in Table A-3 in the appendix); rural individuals at education level 2 are reported in Figure IV-8 (Table A-4 in the appendix); urban individuals at education level 2 are reported in Figure IV-9 (Table A-5 in the appendix); rural individuals at education level 3 are reported in Figure IV-10 (Table A-6 in the appendix); and urban individuals at education level 3 are reported in Figure IV-11 (Table A-7 in the appendix). Overall, the intake-income relationship is relatively the same across education levels. However, there are clear differences in the intake-income relationship between rural and urban individuals. Notable differences between rural and urban individuals are that urban young adults living in middle income countries are more responsive to changes in income at a given education level than rural individuals. Secondly, urban individuals have a greater steepness in the magnitude of their income elasticities changes when compared to rural individuals.

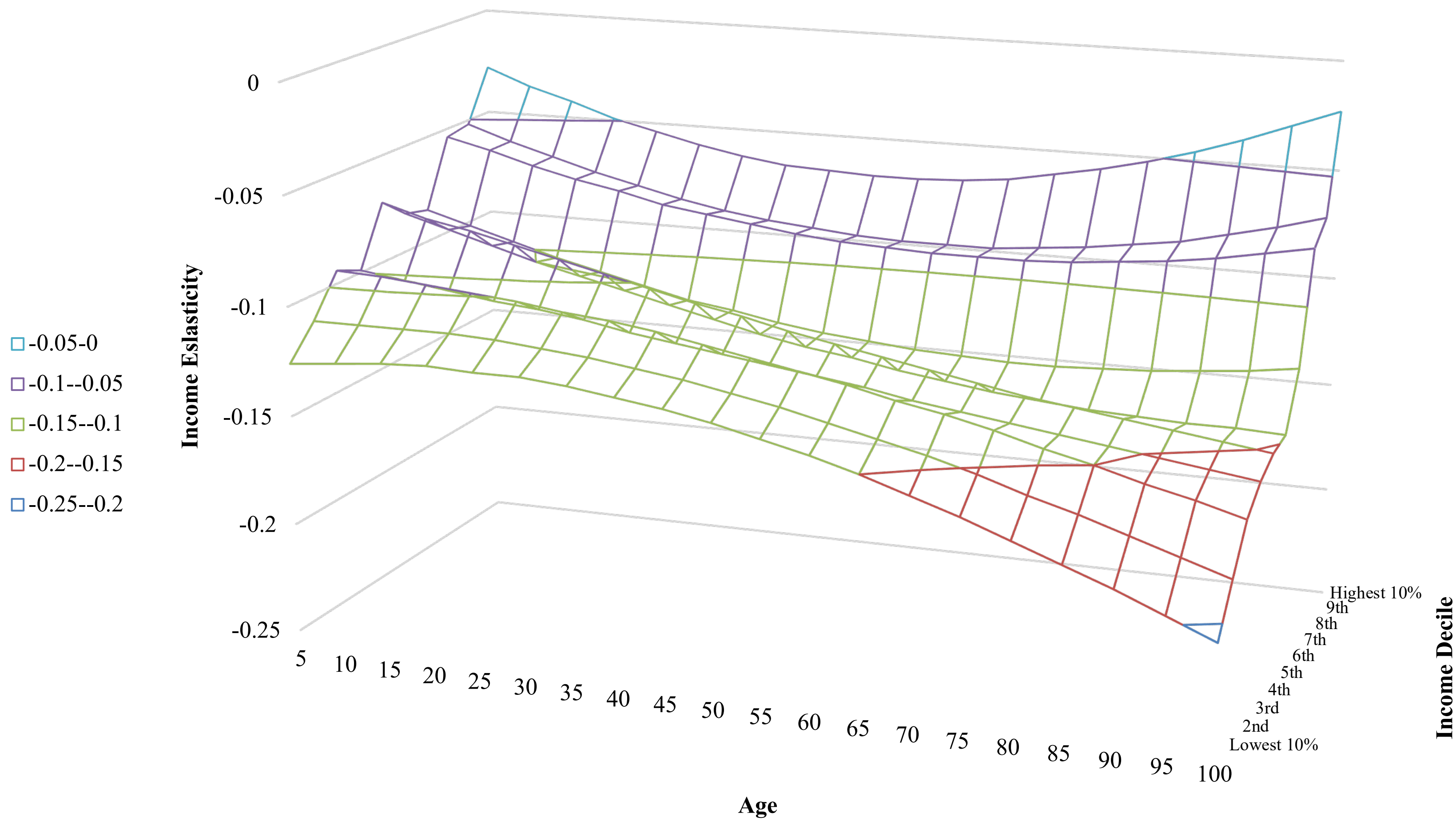

Figure IV-7: Income Elasticities by Age and Decile at Education 1, Urban

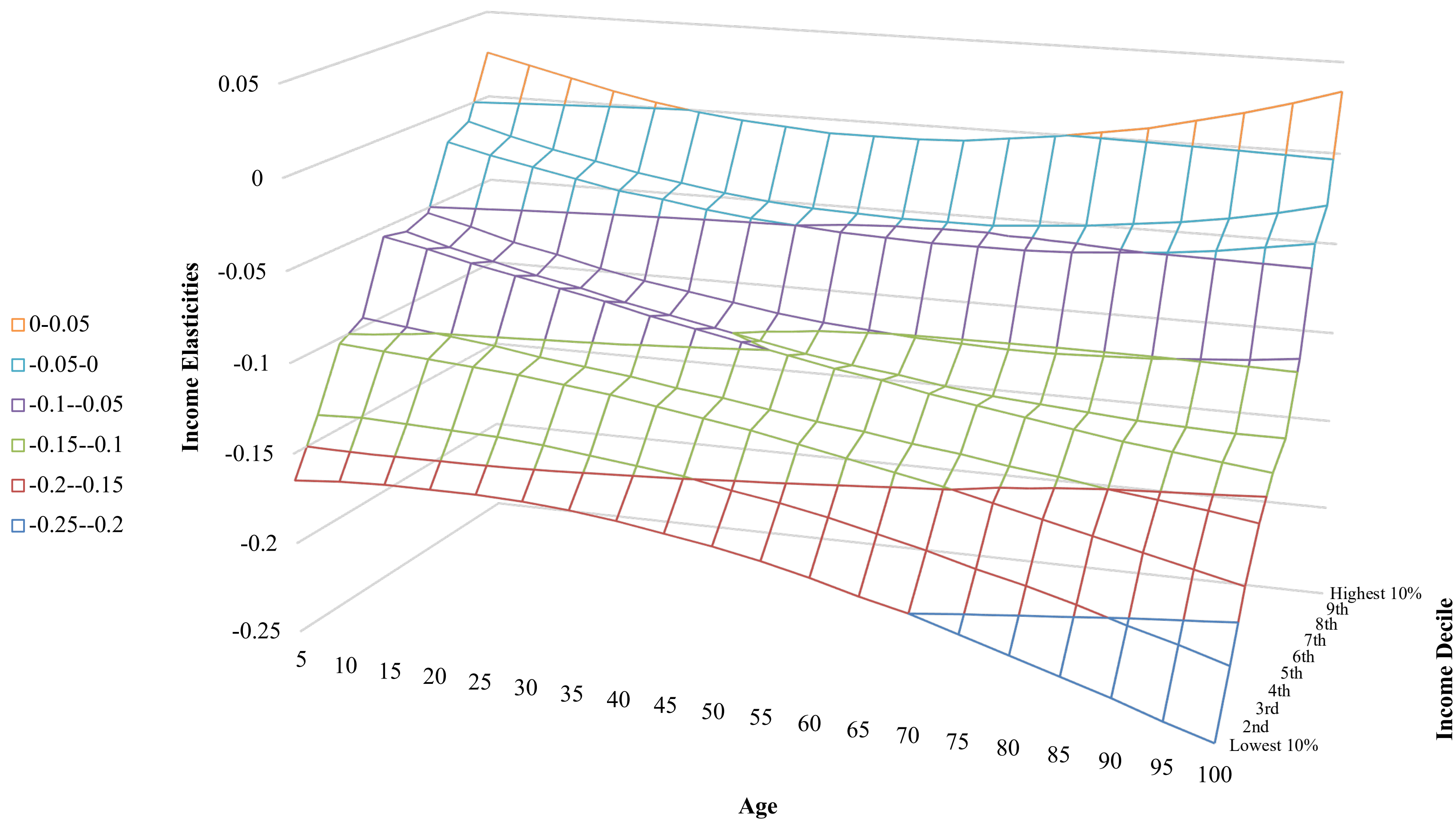

Figure IV-8: Income Elasticities by Age and Decile at Education 2, Rural

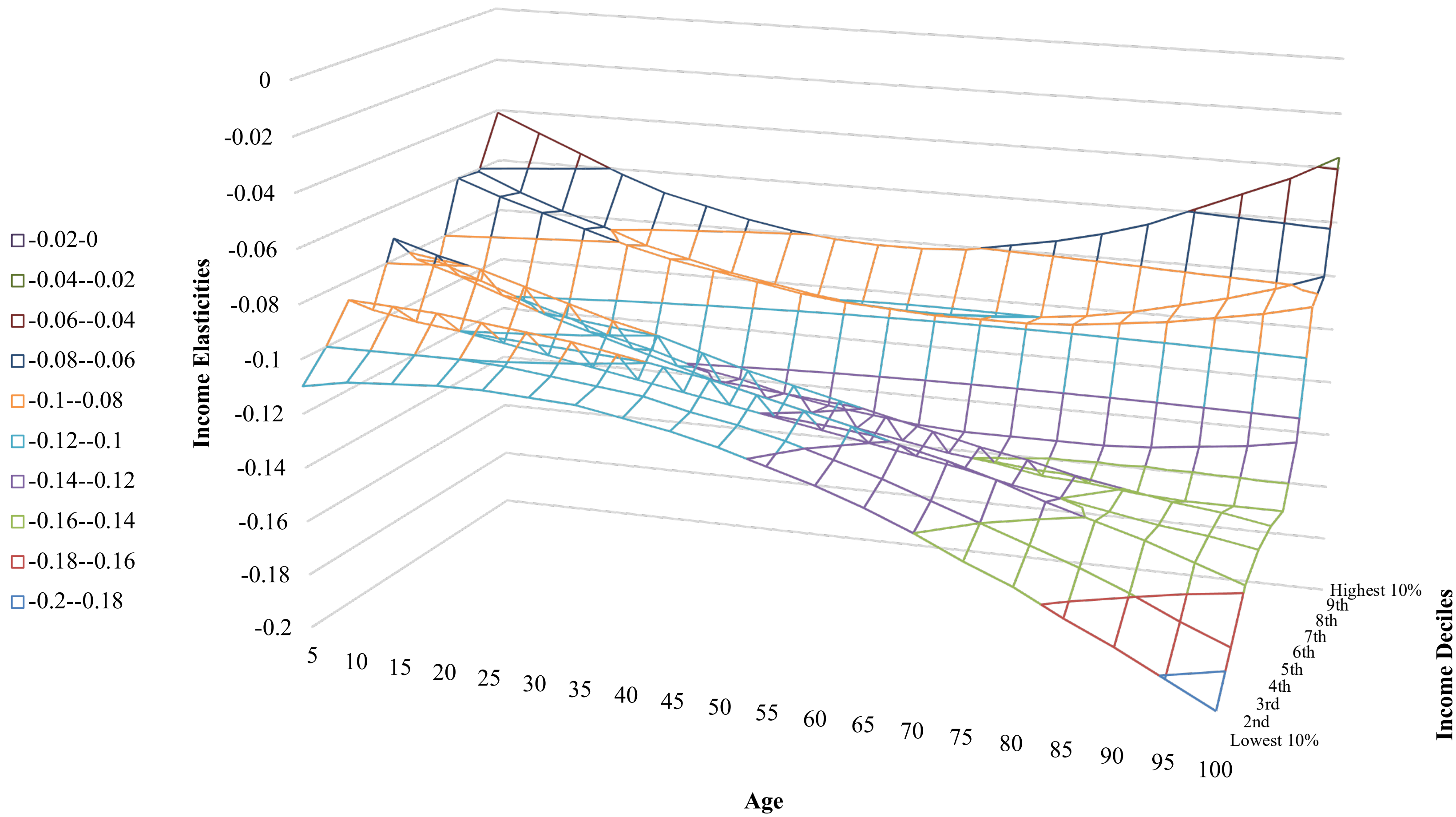

Figure IV-9: Income Elasticities by Age and Decile at Education 2, Urban

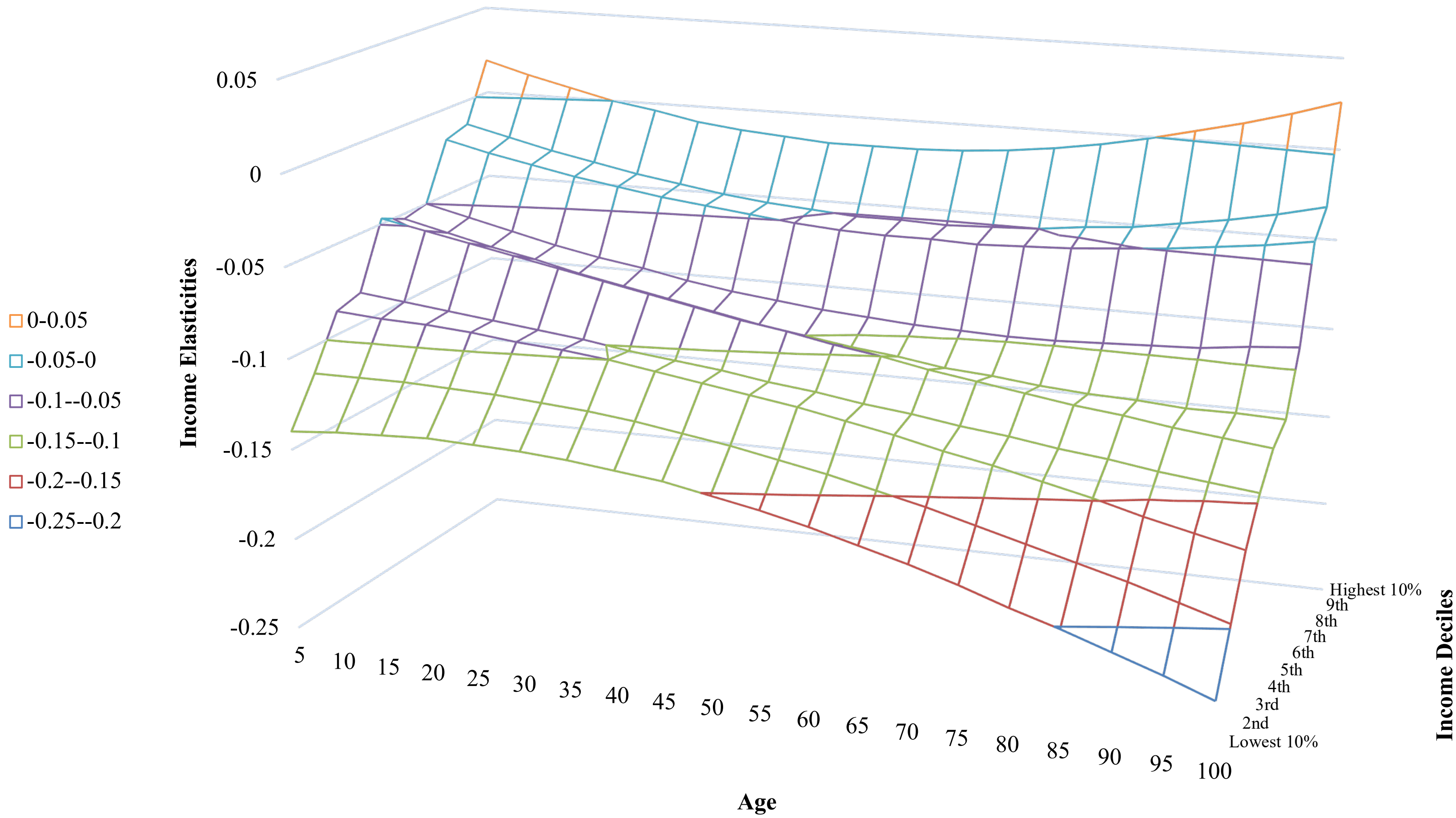

Figure IV-10: Income Elasticities by Age and Decile at Education 3, Rural

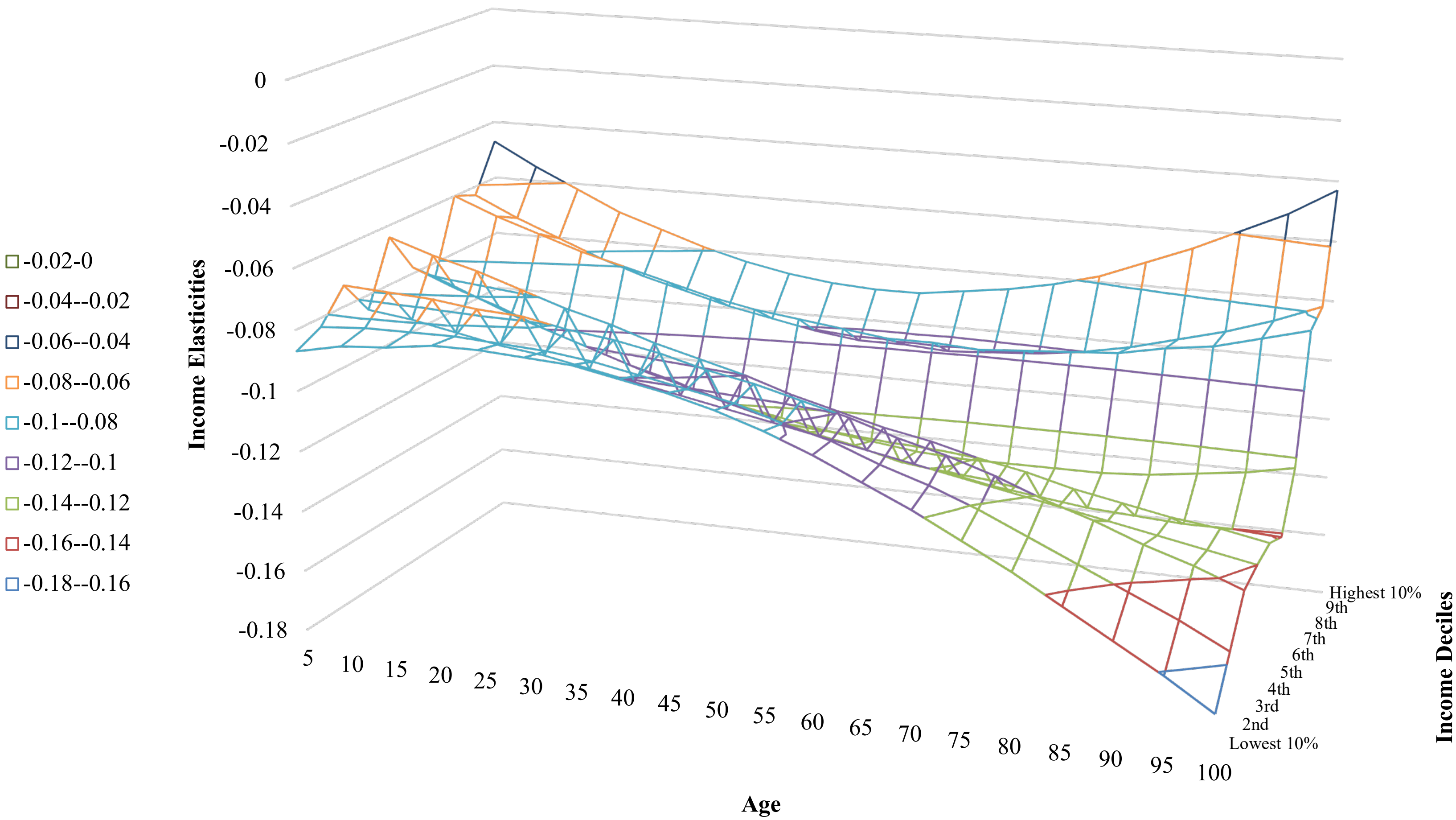

Figure IV-11: Income Elasticities by Age and Decile at Education 3, Urban

The "own-price" (price of selected contributing factors) elasticities are reported in Figure IV-12 (estimates are also reported in Table A-8 in the Appendix). Note that these elasticities should be negative given the inverse relationship between intake and price. Overall, individuals in lower income deciles are more sensitive to own-price changes relative to individuals in higher income countries, such as those countries in Deciles 6 – 10 where elasticities are not significantly different from zero at younger ages. The own-price elasticities are also insignificant at lower income deciles (Deciles 1-6) until age 50 and older. Figure IV-12 shows that intake responsiveness to the price of contributing factors increases as populations get older and that individuals in younger age groups are far less sensitive to contributing factor prices.

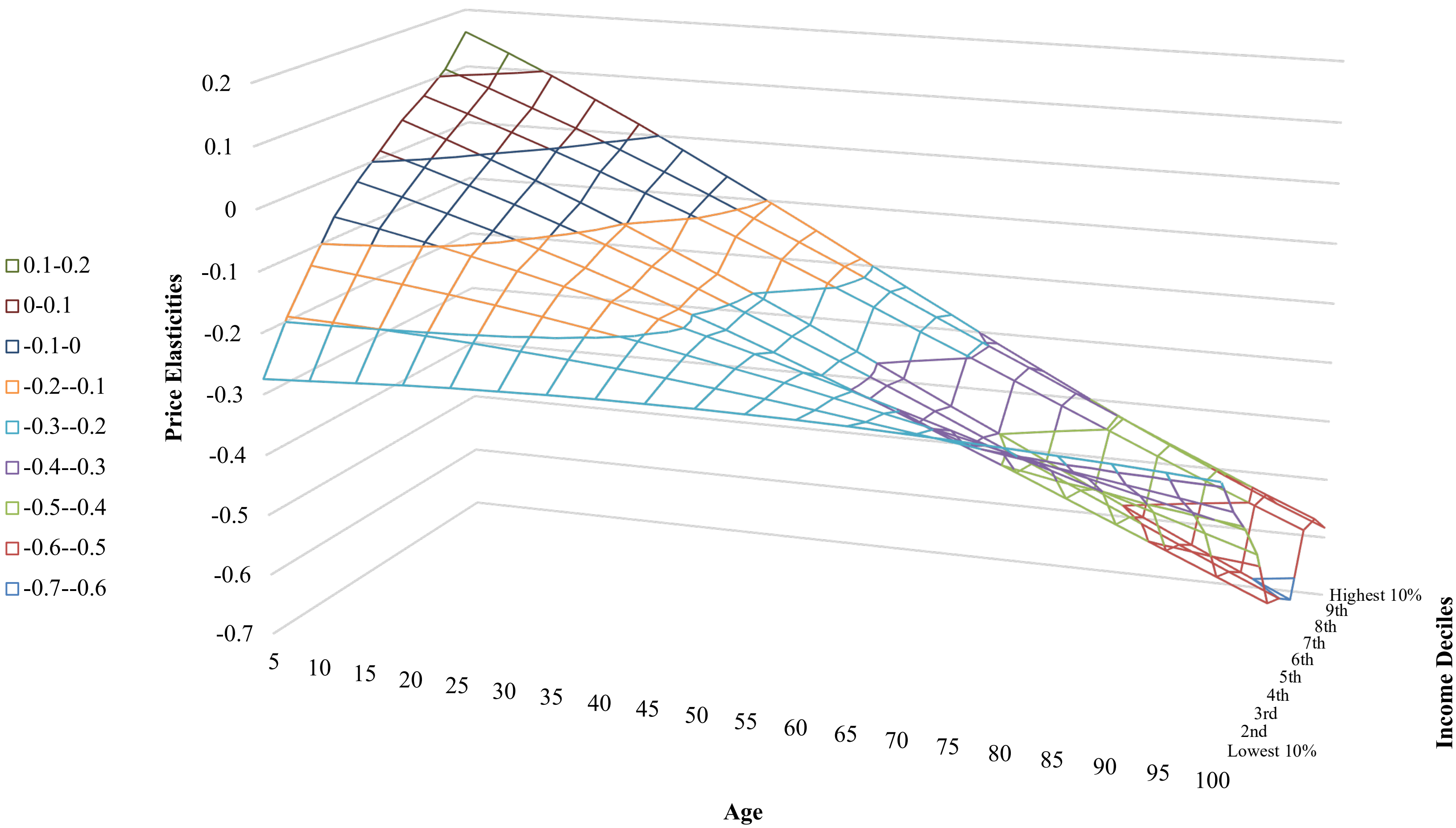

Figure IV-12: Price Elasticities of Selected Contributing Factors Index by Age and Decile

The vegetable price elasticities (Table IV-6) were calculated globally and at each income decile and indicate an overall pattern that as income rises across deciles, individual sensitivity to changes in vegetable prices decreases and becomes less significant. Deciles 6 – 10 are no longer significant compared to lower income deciles. At lower income deciles, individuals have a relatively high sensitivity to changes in vegetable prices. For example, in Decile 1 a 1% increase in vegetable price results in a 0.482% increase in an individual's daily SFA intake. This indicates that the price of a health alternative like fresh vegetables is a significant determinant of SFA intake in the lower income countries.

Table IV-6: Fresh Vegetable Price Elasticity by Decile

Lowest 10%	2nd	3rd	4th	5th	6th	7th	8th	9th	Highest 10%
0.482**	0.384**	0.302***	0.225**	0.186*	0.136	0.091	0.024	-0.022	-0.086
(0.202)	(0.148)	(0.114)	(0.095)	(0.101)	(0.102)	(0.112)	(0.105)	(0.117)	(0.148)

Note: Standard errors are in parentheses. ***, **, and * denote the 0.01, 0.05, and 0.10 significance level respectively.

Potential Policy Implications

Policy intervention strategies aimed at decreasing saturated fat consumption could take the form of subsidies, income support, or taxation. Due to the overall insignificance of the income and price elasticities at higher income deciles, there is little evidence to support subsidies, income growth, or taxation as a strategy in higher income countries, the exception would be older adults and the taxation of "bad" foods. The greatest potential for reductions in saturated fat consumption through policy interventions is in the lower income countries (Deciles 1-5).

Subsidizing fresh vegetable prices would predominantly affect these poorest countries. The countries on the bottom half of the income spectrum had fresh vegetable price elasticities significance at the 5% and 10% levels. Since vegetable prices and saturated fat intake were positively related, an decrease in vegetable prices would likely result in a decrease in saturated fat intake, with the greatest impact occurring in Decile 1, which is comprised almost entirely of SSA countries, where a 10% price subsidy (subsidy that lowers prices by 10%) in Decile 1 would likely result in a SFA intake decrease of 4.82% . Among countries in Deciles 2-5, the same 10% price decrease would result in a decrease of saturated fat intake by 3.84% for individuals in Decile 2, 3.02% for individuals in Decile 3, 2.25% in Decile 4, and 1.86% for individuals in Decile 5. The price elasticities for selected contributing factors were overwhelmingly insignificant in all income deciles for younger age groups, only becoming significant to varying degrees in the poorest countries after age 50. Because of this, it is difficult to determine the effectiveness of implementing potential policy impacts on selected contributing, particularly in higher income countries. For instance, a 10% tax on foods within the group of selected contributing factors would result in an intake reduction ranging from 2.32% for a 50 year old individual in Decile 4 to 5.83% for a 100 year old individual in Decile 10.

The income elasticities indicate that lower income deciles are more responsive to changes in income than wealthier countries. Given a policy that increases income by 10%, for instance, we can expect to see a decrease in saturated fat intake in middle age adults in a middle income decile, 35 years of age living in Decile 4, we can expect a reduction of saturated fat intake of 1.20% in rural individuals at education 1 and a reduced saturated fat intake of 1.17% for an urban individual. Similar middle age and middle-income individuals would have a slightly lower reduction of saturated fat intake at higher education levels.

CHAPTER V.

CONCLUSIONS AND RECOMMENDATIONS

Discussion and Conclusion

While researchers and public health officials continue to seek answers to dietary guidelines aimed at improving overall public health and decreasing NCDs and obesity worldwide our research offers insight into some potential policy decisions aimed at these goals. It is important to consider the continuous changes in nutritional guidelines as new information is uncovered. As previously mentioned, new nutritional studies have placed dietary fat intake under scrutiny, debating previous dietary guidelines which limit SFA intake, particularly when considering diary fats. Interpretations of health and nutritional data for the use as public health policies. While the exact nature, and subsequent aid or harm, dietary fats, especially SFAs, have on human metabolisms and physiology continues to be at the epicenter of new nutritional research, our research indicates several potential policy decisions which may impact SFA intake globally.

Major takeaways from our analysis of SFA intake identified significant responsiveness to income and price. In lower-middle income and poor countries, fresh vegetable prices were a significant determinant of SFA intake, with a positive price elasticity. This indicates that increasing and maintaining the affordability and availability of fresh vegetables is important for decreasing SFA intake, particularly in developing countries. For higher income countries, this is not the case.

Strengths, Limitations, and Next Steps

A strength of this study is the extensive global population which is represented within the analysis. SFA intake data included in this study can help identify regional and global SFA intake patterns and consumer behavior. Representative coverage of global population allows for analysis of SFA intake within countries at various subgroupings (age, education, urban) in additional to cross-country comparisons. This degree of comprehension makes this study one of the few which studies the relationship between intake, food prices, and national income on a global scale. This study also differs from a majority of previous nutrient studies that focused on food expenditures and not intake.

Limitations of this study are also important to consider. SFAs exists within a variety of food categories, some often marketed as “healthy alternatives” to traditional foods high in SFA (e.g. coconut oil as a substitute for butter) which makes SFAs difficult to identify and tax. By creating a selected contributing SFA factors index which contained food categories such as beef and veal, lamb, pork, cheese, butter, other dairy and other fats and oils, both high SFA foods and also lower fat alternatives which may be substituted are accounted for together. This limits our predictive ability of how policy intervention may shift consumers from higher SFA meats to a lean alternative while remaining within the same food category. Furthermore, some foods high in SFAs also may contain import nutrients such as vitamin B12, vitamin D, iron, and calcium, among potentially others. A reduction in the consumption of these foods may decrease SFA intake but could lead to other nutrient deficiencies. Another limitation which needs consideration is the invariability of price and income data within countries and subgroups. Individuals with differing education levels and urban/rural living environments would likely have different incomes and face different food prices, however, this cannot be accounted for within our analysis.

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APPENDIX

Table A-1: Common Abbreviations

Abbreviation	Description
CAP	Common Agricultural Policy
CHD	Coronary Heart Disease
CVDs	Cardiovascular Disease
EU	European Union
FAO	United Nations Food and Agricultural Organization
GDD	Global Dietary Dataset
GDP	Gross Domestic Product
ICP	International Comparison Program
NCDs	Non-communicable Disease
PLIs	Price Level Indices
PPPs	Purchasing Power Parities
SFAs	Saturated Fatty Acids
WDI	World Development Indicators

Table A-2: Income Elasticities, Education 1, Rural

Deciles Age	Global	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
5	-0.069**	-0.183***	-0.150***	-0.112***	-0.100***	-0.055*	-0.056	-0.048	-0.010	-0.001	0.040
	(0.027)	(0.059)	(0.049)	(0.036)	(0.028)	(0.033)	(0.037)	(0.041)	(0.038)	(0.044)	(0.050)
10	-0.073***	-0.182***	-0.150***	-0.114***	-0.103***	-0.061*	-0.063*	-0.055	-0.016	-0.007	0.033
	(0.027)	(0.060)	(0.049)	(0.037)	(0.029)	(0.033)	(0.038)	(0.042)	(0.038)	(0.044)	(0.051)
15	-0.077***	-0.181***	-0.150***	-0.116***	-0.106***	-0.066*	-0.069*	-0.061	-0.021	-0.013	0.028
	(0.027)	(0.060)	(0.050)	(0.037)	(0.029)	(0.034)	(0.038)	(0.042)	(0.038)	(0.045)	(0.051)
20	-0.081***	-0.181***	-0.151***	-0.118***	-0.109***	-0.072**	-0.075*	-0.067	-0.026	-0.018	0.022
	(0.028)	(0.061)	(0.050)	(0.037)	(0.029)	(0.034)	(0.038)	(0.042)	(0.038)	(0.045)	(0.051)
25	-0.085***	-0.181***	-0.153***	-0.121***	-0.113***	-0.077**	-0.081**	-0.072*	-0.030	-0.023	0.018
	(0.028)	(0.061)	(0.050)	(0.038)	(0.029)	(0.034)	(0.039)	(0.043)	(0.038)	(0.045)	(0.052)
30	-0.089***	-0.183***	-0.155***	-0.124***	-0.116***	-0.083**	-0.087**	-0.077*	-0.034	-0.027	0.014
	(0.028)	(0.062)	(0.051)	(0.038)	(0.030)	(0.035)	(0.039)	(0.043)	(0.038)	(0.046)	(0.052)
35	-0.092***	-0.185***	-0.158***	-0.128***	-0.120***	-0.088**	-0.092**	-0.082*	-0.037	-0.031	0.011
	(0.028)	(0.062)	(0.051)	(0.038)	(0.030)	(0.035)	(0.039)	(0.043)	(0.039)	(0.046)	(0.053)
40	-0.096***	-0.188***	-0.161***	-0.131***	-0.123***	-0.093***	-0.097**	-0.086*	-0.040	-0.034	0.008
	(0.028)	(0.062)	(0.051)	(0.038)	(0.030)	(0.035)	(0.040)	(0.044)	(0.039)	(0.046)	(0.053)
45	-0.099***	-0.192***	-0.165***	-0.135***	-0.127***	-0.099***	-0.102**	-0.089**	-0.043	-0.036	0.007
	(0.029)	(0.062)	(0.051)	(0.038)	(0.030)	(0.036)	(0.040)	(0.044)	(0.039)	(0.047)	(0.053)
50	-0.103***	-0.196***	-0.169***	-0.140***	-0.131***	-0.104***	-0.107***	-0.092**	-0.045	-0.037	0.006
	(0.029)	(0.062)	(0.051)	(0.039)	(0.030)	(0.036)	(0.041)	(0.044)	(0.039)	(0.047)	(0.054)

Note: Standard errors are in parentheses. ***, **, and * denote the 0.01, 0.05, and 0.10 significance level respectively.

Table A-2 Continued: Income Elasticities, Education 1, Rural

Deciles Age	Global	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
55	-0.106***	-0.201***	-0.174***	-0.144***	-0.135***	-0.109***	-0.111***	-0.095**	-0.046	-0.038	0.007
	(0.029)	(0.061)	(0.051)	(0.039)	(0.031)	(0.036)	(0.041)	(0.045)	(0.040)	(0.047)	(0.054)
60	-0.109***	-0.207***	-0.179***	-0.149***	-0.138***	-0.113***	-0.115***	-0.097**	-0.047	-0.038	0.008
	(0.029)	(0.061)	(0.051)	(0.039)	(0.031)	(0.037)	(0.041)	(0.045)	(0.040)	(0.048)	(0.054)
65	-0.112***	-0.213***	-0.184***	-0.155***	-0.142***	-0.118***	-0.118***	-0.098**	-0.047	-0.038	0.010
	(0.029)	(0.060)	(0.051)	(0.039)	(0.031)	(0.037)	(0.042)	(0.045)	(0.040)	(0.048)	(0.054)
70	-0.114***	-0.220***	-0.190***	-0.160***	-0.146***	-0.122***	-0.121***	-0.099**	-0.046	-0.036	0.013
	(0.029)	(0.059)	(0.051)	(0.039)	(0.031)	(0.038)	(0.042)	(0.045)	(0.041)	(0.049)	(0.054)
75	-0.117***	-0.227***	-0.197***	-0.166***	-0.149***	-0.127***	-0.124***	-0.099**	-0.045	-0.034	0.017
	(0.029)	(0.058)	(0.050)	(0.039)	(0.031)	(0.038)	(0.043)	(0.046)	(0.041)	(0.049)	(0.055)
80	-0.119***	-0.234***	-0.204***	-0.172***	-0.153***	-0.131***	-0.126***	-0.098**	-0.043	-0.031	0.022
	(0.029)	(0.057)	(0.050)	(0.038)	(0.031)	(0.039)	(0.043)	(0.046)	(0.041)	(0.050)	(0.055)
85	-0.121***	-0.242***	-0.211***	-0.178***	-0.156***	-0.134***	-0.128***	-0.097**	-0.041	-0.028	0.027
	(0.030)	(0.057)	(0.050)	(0.038)	(0.031)	(0.039)	(0.044)	(0.047)	(0.042)	(0.050)	(0.055)
90	-0.122***	-0.250***	-0.218***	-0.184***	-0.160***	-0.138***	-0.129***	-0.095**	-0.038	-0.023	0.034
	(0.030)	(0.056)	(0.049)	(0.038)	(0.031)	(0.040)	(0.045)	(0.047)	(0.043)	(0.051)	(0.056)
95	-0.123***	-0.259***	-0.225***	-0.190***	-0.163***	-0.141***	-0.129***	-0.093*	-0.035	-0.018	0.041
	(0.030)	(0.055)	(0.049)	(0.038)	(0.031)	(0.041)	(0.046)	(0.048)	(0.044)	(0.052)	(0.056)
100	-0.124***	-0.267***	-0.233***	-0.197***	-0.166***	-0.144***	-0.130***	-0.090*	-0.031	-0.013	0.048
	(0.030)	(0.054)	(0.048)	(0.038)	(0.031)	(0.042)	(0.046)	(0.048)	(0.045)	(0.053)	(0.057)

Note: Standard errors are in parentheses. ***, **, and * denote the 0.01, 0.05, and 0.10 significance level respectively.

Table A-3: Income Elasticities, Education 1, Urban

Deciles	Global	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Age											
5	-0.081***	-0.126**	-0.112**	-0.094***	-0.099***	-0.072**	-0.082**	-0.085**	-0.054	-0.052	-0.028
	(0.024)	(0.059)	(0.045)	(0.033)	(0.025)	(0.029)	(0.033)	(0.037)	(0.035)	(0.042)	(0.052)
10	-0.085***	-0.124**	-0.112**	-0.095***	-0.102***	-0.078***	-0.088***	-0.091**	-0.059*	-0.059	-0.036
	(0.025)	(0.059)	(0.046)	(0.034)	(0.026)	(0.029)	(0.033)	(0.037)	(0.035)	(0.043)	(0.052)
15	-0.089***	-0.122**	-0.112**	-0.097***	-0.105***	-0.082***	-0.094***	-0.097**	-0.065*	-0.065	-0.042
	(0.025)	(0.060)	(0.046)	(0.034)	(0.026)	(0.030)	(0.033)	(0.038)	(0.036)	(0.043)	(0.053)
20	-0.092***	-0.121**	-0.112**	-0.099***	-0.108***	-0.087***	-0.100***	-0.103***	-0.070*	-0.071	-0.049
	(0.025)	(0.060)	(0.047)	(0.034)	(0.026)	(0.030)	(0.034)	(0.038)	(0.036)	(0.044)	(0.054)
25	-0.096***	-0.122**	-0.113**	-0.101***	-0.110***	-0.092***	-0.105***	-0.108***	-0.074**	-0.076*	-0.054
	(0.025)	(0.061)	(0.047)	(0.034)	(0.026)	(0.030)	(0.034)	(0.038)	(0.036)	(0.044)	(0.055)
30	-0.100***	-0.122**	-0.115**	-0.104***	-0.113***	-0.097***	-0.110***	-0.113***	-0.079**	-0.081*	-0.059
	(0.026)	(0.061)	(0.047)	(0.035)	(0.026)	(0.030)	(0.034)	(0.039)	(0.037)	(0.045)	(0.055)
35	-0.103***	-0.124**	-0.117**	-0.106***	-0.117***	-0.102***	-0.115***	-0.118***	-0.082**	-0.085*	-0.063
	(0.026)	(0.061)	(0.047)	(0.035)	(0.027)	(0.030)	(0.035)	(0.039)	(0.037)	(0.045)	(0.056)
40	-0.107***	-0.127**	-0.120**	-0.109***	-0.120***	-0.107***	-0.120***	-0.121***	-0.085**	-0.088*	-0.066
	(0.026)	(0.061)	(0.047)	(0.035)	(0.027)	(0.031)	(0.035)	(0.039)	(0.037)	(0.045)	(0.056)
45	-0.110***	-0.130**	-0.123**	-0.113***	-0.123***	-0.111***	-0.125***	-0.125***	-0.088**	-0.090*	-0.067
	(0.026)	(0.061)	(0.047)	(0.035)	(0.027)	(0.031)	(0.035)	(0.040)	(0.037)	(0.046)	(0.057)
50	-0.113***	-0.134**	-0.127***	-0.117***	-0.126***	-0.116***	-0.129***	-0.128***	-0.090**	-0.092**	-0.068
	(0.026)	(0.061)	(0.047)	(0.035)	(0.027)	(0.031)	(0.036)	(0.040)	(0.037)	(0.046)	(0.057)

Note: Standard errors are in parentheses. ***, **, and * denote the 0.01, 0.05, and 0.10 significance level respectively.

Table A-3 Continued: Income Elasticities, Education 1, Urban

Deciles	Global	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Age											
55	-0.116***	-0.139**	-0.131***	-0.121***	-0.129***	-0.120***	-0.132***	-0.130***	-0.091**	-0.093**	-0.068
	(0.026)	(0.060)	(0.047)	(0.035)	(0.027)	(0.032)	(0.036)	(0.040)	(0.038)	(0.046)	(0.057)
60	-0.118***	-0.144**	-0.136***	-0.125***	-0.132***	-0.124***	-0.136***	-0.132***	-0.092**	-0.093**	-0.067
	(0.027)	(0.060)	(0.047)	(0.035)	(0.027)	(0.032)	(0.036)	(0.040)	(0.038)	(0.047)	(0.057)
65	-0.121***	-0.150**	-0.141***	-0.130***	-0.136***	-0.128***	-0.139***	-0.133***	-0.092**	-0.093**	-0.065
	(0.027)	(0.059)	(0.047)	(0.035)	(0.027)	(0.032)	(0.037)	(0.040)	(0.038)	(0.047)	(0.057)
70	-0.123***	-0.157***	-0.146***	-0.134***	-0.139***	-0.132***	-0.142***	-0.134***	-0.092**	-0.091*	-0.061
	(0.027)	(0.058)	(0.047)	(0.035)	(0.027)	(0.033)	(0.037)	(0.041)	(0.038)	(0.047)	(0.057)
75	-0.125***	-0.164***	-0.152***	-0.139***	-0.142***	-0.136***	-0.144***	-0.134***	-0.091**	-0.089*	-0.057
	(0.027)	(0.058)	(0.046)	(0.035)	(0.027)	(0.033)	(0.037)	(0.041)	(0.038)	(0.047)	(0.057)
80	-0.127***	-0.172***	-0.159***	-0.145***	-0.145***	-0.139***	-0.146***	-0.133***	-0.089**	-0.086*	-0.052
	(0.027)	(0.057)	(0.046)	(0.035)	(0.027)	(0.033)	(0.038)	(0.041)	(0.039)	(0.048)	(0.057)
85	-0.129***	-0.180***	-0.165***	-0.150***	-0.148***	-0.142***	-0.147***	-0.132***	-0.087**	-0.083*	-0.046
	(0.027)	(0.056)	(0.046)	(0.035)	(0.027)	(0.034)	(0.038)	(0.041)	(0.039)	(0.048)	(0.057)
90	-0.130***	-0.188***	-0.172***	-0.156***	-0.151***	-0.145***	-0.148***	-0.130***	-0.084**	-0.078	-0.039
	(0.027)	(0.055)	(0.045)	(0.035)	(0.027)	(0.034)	(0.039)	(0.041)	(0.040)	(0.049)	(0.057)
95	-0.131***	-0.197***	-0.179***	-0.161***	-0.154***	-0.148***	-0.148***	-0.128***	-0.080**	-0.073	-0.031
	(0.027)	(0.054)	(0.045)	(0.035)	(0.027)	(0.035)	(0.039)	(0.042)	(0.040)	(0.049)	(0.057)
100	-0.132***	-0.206***	-0.186***	-0.167***	-0.157***	-0.151***	-0.149***	-0.125***	-0.076*	-0.067	-0.023
	(0.027)	(0.053)	(0.045)	(0.035)	(0.027)	(0.036)	(0.040)	(0.042)	(0.041)	(0.050)	(0.057)

Note: Standard errors are in parentheses. ***, **, and * denote the 0.01, 0.05, and 0.10 significance level respectively.

Table A-4: Income Elasticities, Education 2, Rural

Deciles Age	Global	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
5	-0.068**	-0.165***	-0.136***	-0.103***	-0.095***	-0.055*	-0.058	-0.053	-0.017	-0.010	0.026
	(0.026)	(0.060)	(0.048)	(0.036)	(0.028)	(0.032)	(0.036)	(0.040)	(0.037)	(0.043)	(0.050)
10	-0.072***	-0.163***	-0.135***	-0.105***	-0.098***	-0.060*	-0.065*	-0.059	-0.023	-0.017	0.020
	(0.026)	(0.060)	(0.049)	(0.036)	(0.028)	(0.032)	(0.037)	(0.040)	(0.037)	(0.044)	(0.050)
15	-0.076***	-0.162***	-0.136***	-0.107***	-0.101***	-0.066**	-0.071*	-0.066	-0.028	-0.023	0.014
	(0.027)	(0.061)	(0.049)	(0.036)	(0.028)	(0.033)	(0.037)	(0.041)	(0.037)	(0.044)	(0.051)
20	-0.080***	-0.162***	-0.137***	-0.109***	-0.104***	-0.071**	-0.077**	-0.071*	-0.033	-0.028	0.008
	(0.027)	(0.062)	(0.050)	(0.037)	(0.029)	(0.033)	(0.037)	(0.041)	(0.037)	(0.044)	(0.051)
25	-0.083***	-0.162**	-0.138***	-0.111***	-0.108***	-0.076**	-0.082**	-0.077*	-0.038	-0.033	0.003
	(0.027)	(0.062)	(0.050)	(0.037)	(0.029)	(0.033)	(0.038)	(0.041)	(0.037)	(0.045)	(0.052)
30	-0.087***	-0.163***	-0.140***	-0.114***	-0.111***	-0.081**	-0.088**	-0.082*	-0.041	-0.037	-0.001
	(0.027)	(0.063)	(0.050)	(0.037)	(0.029)	(0.033)	(0.038)	(0.042)	(0.038)	(0.045)	(0.052)
35	-0.091***	-0.165***	-0.143***	-0.117***	-0.114***	-0.087**	-0.093**	-0.086**	-0.045	-0.041	-0.004
	(0.028)	(0.063)	(0.051)	(0.037)	(0.029)	(0.034)	(0.038)	(0.042)	(0.038)	(0.045)	(0.053)
40	-0.094***	-0.168***	-0.146***	-0.121***	-0.118***	-0.092***	-0.098**	-0.090**	-0.048	-0.044	-0.006
	(0.028)	(0.063)	(0.051)	(0.038)	(0.029)	(0.034)	(0.039)	(0.042)	(0.038)	(0.046)	(0.053)
45	-0.098***	-0.172***	-0.149***	-0.125***	-0.121***	-0.097***	-0.103***	-0.094**	-0.050	-0.046	-0.008
	(0.028)	(0.063)	(0.051)	(0.038)	(0.030)	(0.034)	(0.039)	(0.043)	(0.038)	(0.046)	(0.053)
50	-0.101***	-0.176***	-0.154***	-0.129***	-0.125***	-0.102***	-0.108***	-0.097**	-0.052	-0.047	-0.008
	(0.028)	(0.063)	(0.051)	(0.038)	(0.030)	(0.035)	(0.039)	(0.043)	(0.039)	(0.046)	(0.054)

Note: Standard errors are in parentheses. ***, **, and * denote the 0.01, 0.05, and 0.10 significance level respectively.

Table A-4 Continued: Income Elasticities, Education 2, Rural

Deciles	Global	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Age											
55	-0.104***	-0.181***	-0.158***	-0.134***	-0.129***	-0.107***	-0.112***	-0.099**	-0.053	-0.048	-0.008
	(0.028)	(0.062)	(0.051)	(0.038)	(0.030)	(0.035)	(0.040)	(0.043)	(0.039)	(0.047)	(0.054)
60	-0.107***	-0.187***	-0.163***	-0.139***	-0.132***	-0.111***	-0.115***	-0.101**	-0.054	-0.048	-0.007
	(0.028)	(0.061)	(0.051)	(0.038)	(0.030)	(0.035)	(0.040)	(0.043)	(0.039)	(0.047)	(0.054)
65	-0.110***	-0.194***	-0.169***	-0.144***	-0.136***	-0.116***	-0.119***	-0.102**	-0.054	-0.048	-0.004
	(0.029)	(0.061)	(0.050)	(0.038)	(0.030)	(0.036)	(0.040)	(0.044)	(0.039)	(0.047)	(0.054)
70	-0.112***	-0.200***	-0.175***	-0.149***	-0.139***	-0.120***	-0.122***	-0.103**	-0.054	-0.046	-0.001
	(0.029)	(0.060)	(0.050)	(0.038)	(0.030)	(0.036)	(0.041)	(0.044)	(0.040)	(0.048)	(0.054)
75	-0.115***	-0.208***	-0.182***	-0.155***	-0.143***	-0.124***	-0.124***	-0.103**	-0.053	-0.044	0.003
	(0.029)	(0.059)	(0.050)	(0.038)	(0.030)	(0.037)	(0.041)	(0.044)	(0.040)	(0.048)	(0.054)
80	-0.117***	-0.216***	-0.188***	-0.161***	-0.146***	-0.128***	-0.126***	-0.102**	-0.051	-0.041	0.007
	(0.029)	(0.058)	(0.049)	(0.038)	(0.030)	(0.037)	(0.042)	(0.045)	(0.040)	(0.049)	(0.055)
85	-0.119***	-0.224***	-0.195***	-0.167***	-0.150***	-0.132***	-0.128***	-0.101**	-0.049	-0.038	0.013
	(0.029)	(0.057)	(0.049)	(0.038)	(0.030)	(0.038)	(0.042)	(0.045)	(0.041)	(0.049)	(0.055)
90	-0.120***	-0.232***	-0.203***	-0.173***	-0.153***	-0.135***	-0.129***	-0.099**	-0.046	-0.034	0.019
	(0.029)	(0.056)	(0.049)	(0.037)	(0.030)	(0.039)	(0.043)	(0.045)	(0.042)	(0.050)	(0.055)
95	-0.121***	-0.241***	-0.210***	-0.179***	-0.156***	-0.138***	-0.130***	-0.097**	-0.042	-0.029	0.026
	(0.029)	(0.055)	(0.048)	(0.037)	(0.030)	(0.039)	(0.044)	(0.046)	(0.042)	(0.051)	(0.055)
100	-0.122***	-0.249***	-0.218***	-0.185***	-0.160***	-0.141***	-0.130***	-0.094**	-0.038	-0.023	0.034
	(0.029)	(0.054)	(0.048)	(0.037)	(0.030)	(0.040)	(0.045)	(0.047)	(0.043)	(0.052)	(0.056)

Note: Standard errors are in parentheses. ***, **, and * denote the 0.01, 0.05, and 0.10 significance level respectively.

Table A-5: Income Elasticities, Education 2, Urban

Deciles	Global	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Age											
5	-0.080***	-0.110*	-0.100**	-0.087***	-0.095***	-0.072**	-0.084**	-0.089**	-0.060*	-0.061	-0.041
	(0.024)	(0.060)	(0.045)	(0.033)	(0.025)	(0.028)	(0.032)	(0.036)	(0.035)	(0.042)	(0.052)
10	-0.084***	-0.107*	-0.100**	-0.088***	-0.098***	-0.077***	-0.089***	-0.095**	-0.066*	-0.068	-0.048
	(0.024)	(0.060)	(0.046)	(0.033)	(0.025)	(0.029)	(0.032)	(0.037)	(0.035)	(0.043)	(0.053)
15	-0.088***	-0.106*	-0.100**	-0.089***	-0.100***	-0.081***	-0.095***	-0.101***	-0.071**	-0.074*	-0.055
	(0.025)	(0.061)	(0.046)	(0.034)	(0.025)	(0.029)	(0.033)	(0.037)	(0.035)	(0.043)	(0.054)
20	-0.091***	-0.105*	-0.100**	-0.091***	-0.103***	-0.086***	-0.101***	-0.106***	-0.076**	-0.079*	-0.062
	(0.025)	(0.062)	(0.047)	(0.034)	(0.026)	(0.029)	(0.033)	(0.037)	(0.036)	(0.044)	(0.055)
25	-0.095***	-0.105*	-0.101**	-0.093***	-0.106***	-0.091***	-0.106***	-0.112***	-0.081**	-0.085*	-0.068
	(0.025)	(0.062)	(0.047)	(0.034)	(0.026)	(0.029)	(0.033)	(0.038)	(0.036)	(0.044)	(0.056)
30	-0.098***	-0.106*	-0.103**	-0.095***	-0.109***	-0.096***	-0.111***	-0.116***	-0.085**	-0.089**	-0.072
	(0.025)	(0.063)	(0.047)	(0.034)	(0.026)	(0.030)	(0.034)	(0.038)	(0.036)	(0.045)	(0.056)
35	-0.102***	-0.107*	-0.105**	-0.098***	-0.112***	-0.100***	-0.116***	-0.121***	-0.088**	-0.093**	-0.076
	(0.026)	(0.063)	(0.047)	(0.034)	(0.026)	(0.030)	(0.034)	(0.038)	(0.037)	(0.045)	(0.057)
40	-0.105***	-0.110*	-0.107**	-0.101***	-0.115***	-0.105***	-0.121***	-0.124***	-0.091**	-0.096**	-0.079
	(0.026)	(0.063)	(0.047)	(0.035)	(0.026)	(0.030)	(0.034)	(0.039)	(0.037)	(0.046)	(0.057)
45	-0.108***	-0.113*	-0.111**	-0.104***	-0.118***	-0.110***	-0.125***	-0.128***	-0.094**	-0.099**	-0.081
	(0.026)	(0.063)	(0.047)	(0.035)	(0.026)	(0.030)	(0.035)	(0.039)	(0.037)	(0.046)	(0.058)
50	-0.111***	-0.117*	-0.114**	-0.108***	-0.121***	-0.114***	-0.129***	-0.131***	-0.096**	-0.101**	-0.082
	(0.026)	(0.062)	(0.047)	(0.035)	(0.027)	(0.031)	(0.035)	(0.039)	(0.037)	(0.046)	(0.058)

Note: Standard errors are in parentheses. ***, **, and * denote the 0.01, 0.05, and 0.10 significance level respectively.

Table A-5 Continued: Income Elasticities, Education 2, Urban

Deciles	Global	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Age											
55	-0.114***	-0.122*	-0.118**	-0.112***	-0.124***	-0.118***	-0.133***	-0.133***	-0.097**	-0.102**	-0.082
	(0.026)	(0.062)	(0.047)	(0.035)	(0.027)	(0.031)	(0.035)	(0.039)	(0.038)	(0.046)	(0.058)
60	-0.117***	-0.127**	-0.123***	-0.116***	-0.127***	-0.122***	-0.136***	-0.135***	-0.098**	-0.102**	-0.081
	(0.026)	(0.061)	(0.047)	(0.035)	(0.027)	(0.031)	(0.035)	(0.040)	(0.038)	(0.047)	(0.058)
65	-0.119***	-0.133**	-0.128***	-0.121***	-0.130***	-0.126***	-0.139***	-0.136***	-0.098**	-0.101**	-0.078
	(0.026)	(0.060)	(0.047)	(0.035)	(0.027)	(0.031)	(0.036)	(0.040)	(0.038)	(0.047)	(0.058)
70	-0.122***	-0.140**	-0.134***	-0.125***	-0.133***	-0.130***	-0.141***	-0.136***	-0.098**	-0.100**	-0.075
	(0.026)	(0.060)	(0.047)	(0.035)	(0.027)	(0.032)	(0.036)	(0.040)	(0.038)	(0.047)	(0.058)
75	-0.124***	-0.148**	-0.140***	-0.130***	-0.137***	-0.133***	-0.144***	-0.136***	-0.097**	-0.098**	-0.071
	(0.026)	(0.059)	(0.046)	(0.035)	(0.027)	(0.032)	(0.036)	(0.040)	(0.038)	(0.047)	(0.058)
80	-0.125***	-0.155***	-0.146***	-0.136***	-0.140***	-0.137***	-0.145***	-0.136***	-0.095**	-0.095**	-0.066
	(0.026)	(0.058)	(0.046)	(0.035)	(0.027)	(0.033)	(0.037)	(0.040)	(0.038)	(0.047)	(0.058)
85	-0.127***	-0.164***	-0.152***	-0.141***	-0.143***	-0.140***	-0.147***	-0.135***	-0.093**	-0.091*	-0.059
	(0.026)	(0.057)	(0.046)	(0.035)	(0.027)	(0.033)	(0.037)	(0.040)	(0.039)	(0.048)	(0.057)
90	-0.128***	-0.172***	-0.159***	-0.146***	-0.146***	-0.143***	-0.148***	-0.133***	-0.090**	-0.087*	-0.052
	(0.026)	(0.056)	(0.045)	(0.034)	(0.027)	(0.033)	(0.038)	(0.040)	(0.039)	(0.048)	(0.057)
95	-0.129***	-0.181***	-0.167***	-0.152***	-0.148***	-0.145***	-0.148***	-0.131***	-0.087**	-0.082*	-0.045
	(0.027)	(0.055)	(0.045)	(0.034)	(0.027)	(0.034)	(0.038)	(0.041)	(0.040)	(0.049)	(0.057)
100	-0.130***	-0.190***	-0.174***	-0.158***	-0.151***	-0.148***	-0.148***	-0.128***	-0.083**	-0.076	-0.036
	(0.027)	(0.054)	(0.045)	(0.034)	(0.027)	(0.035)	(0.039)	(0.041)	(0.040)	(0.049)	(0.057)

Note: Standard errors are in parentheses. ***, **, and * denote the 0.01, 0.05, and 0.10 significance level respectively.

Table A-6: Income Elasticities, Education 3, Rural

Deciles Age	Global	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
5	-0.060**	-0.140**	-0.115**	-0.087**	-0.083***	-0.047	-0.053	-0.050	-0.018	-0.014	0.019
	(0.026)	(0.063)	(0.049)	(0.036)	(0.027)	(0.031)	(0.035)	(0.039)	(0.036)	(0.043)	(0.050)
10	-0.064**	-0.138**	-0.115**	-0.089**	-0.086***	-0.052	-0.059	-0.056	-0.024	-0.020	0.012
	(0.026)	(0.063)	(0.049)	(0.036)	(0.028)	(0.032)	(0.036)	(0.039)	(0.036)	(0.043)	(0.050)
15	-0.067**	-0.137**	-0.115**	-0.090**	-0.089***	-0.057*	-0.065*	-0.062	-0.029	-0.026	0.006
	(0.026)	(0.064)	(0.050)	(0.036)	(0.028)	(0.032)	(0.036)	(0.040)	(0.036)	(0.044)	(0.051)
20	-0.071***	-0.136**	-0.116**	-0.092**	-0.092***	-0.062*	-0.070*	-0.068*	-0.034	-0.031	0.000
	(0.027)	(0.065)	(0.050)	(0.037)	(0.028)	(0.032)	(0.036)	(0.040)	(0.037)	(0.044)	(0.051)
25	-0.075***	-0.137**	-0.117**	-0.095**	-0.095***	-0.067**	-0.076**	-0.073*	-0.038	-0.036	-0.004
	(0.027)	(0.065)	(0.050)	(0.037)	(0.028)	(0.032)	(0.037)	(0.040)	(0.037)	(0.044)	(0.052)
30	-0.078***	-0.138**	-0.119**	-0.097***	-0.098***	-0.072**	-0.081**	-0.077*	-0.042	-0.040	-0.009
	(0.027)	(0.065)	(0.051)	(0.037)	(0.028)	(0.033)	(0.037)	(0.041)	(0.037)	(0.044)	(0.052)
35	-0.082***	-0.140**	-0.121**	-0.100***	-0.102***	-0.077**	-0.086**	-0.082**	-0.045	-0.044	-0.012
	(0.027)	(0.065)	(0.051)	(0.037)	(0.029)	(0.033)	(0.037)	(0.041)	(0.037)	(0.045)	(0.052)
40	-0.085***	-0.143**	-0.124**	-0.104***	-0.105***	-0.082**	-0.091**	-0.086**	-0.048	-0.047	-0.014
	(0.027)	(0.065)	(0.051)	(0.037)	(0.029)	(0.033)	(0.037)	(0.041)	(0.037)	(0.045)	(0.052)
45	-0.089***	-0.146**	-0.128**	-0.108***	-0.108***	-0.087**	-0.096**	-0.089**	-0.051	-0.049	-0.016
	(0.028)	(0.065)	(0.051)	(0.038)	(0.029)	(0.033)	(0.038)	(0.041)	(0.037)	(0.045)	(0.053)
50	-0.092***	-0.151**	-0.132**	-0.112***	-0.112***	-0.091***	-0.100***	-0.092**	-0.053	-0.051	-0.016
	(0.028)	(0.065)	(0.051)	(0.038)	(0.029)	(0.034)	(0.038)	(0.041)	(0.037)	(0.045)	(0.053)

Note: Standard errors are in parentheses. ***, **, and * denote the 0.01, 0.05, and 0.10 significance level respectively.

Table A-6 Continued: Income Elasticities, Education 3, Rural

Deciles	Global	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Age											
55	-0.095***	-0.156**	-0.137***	-0.116***	-0.115***	-0.096***	-0.104***	-0.094**	-0.054	-0.051	-0.016
	(0.028)	(0.064)	(0.051)	(0.038)	(0.029)	(0.034)	(0.038)	(0.042)	(0.038)	(0.046)	(0.053)
60	-0.098***	-0.162**	-0.142***	-0.121***	-0.119***	-0.100***	-0.107***	-0.096**	-0.054	-0.052	-0.015
	(0.028)	(0.064)	(0.051)	(0.038)	(0.029)	(0.034)	(0.039)	(0.042)	(0.038)	(0.046)	(0.053)
65	-0.101***	-0.169***	-0.148***	-0.126***	-0.122***	-0.105***	-0.111***	-0.097**	-0.055	-0.051	-0.013
	(0.028)	(0.063)	(0.050)	(0.038)	(0.029)	(0.035)	(0.039)	(0.042)	(0.038)	(0.046)	(0.053)
70	-0.103***	-0.176***	-0.154***	-0.132***	-0.126***	-0.109***	-0.113***	-0.098**	-0.054	-0.050	-0.010
	(0.028)	(0.062)	(0.050)	(0.038)	(0.029)	(0.035)	(0.039)	(0.042)	(0.038)	(0.046)	(0.053)
75	-0.106***	-0.184***	-0.161***	-0.137***	-0.129***	-0.113***	-0.116***	-0.098**	-0.053	-0.047	-0.006
	(0.028)	(0.061)	(0.050)	(0.037)	(0.029)	(0.036)	(0.040)	(0.043)	(0.039)	(0.047)	(0.053)
80	-0.108***	-0.193***	-0.168***	-0.143***	-0.133***	-0.117***	-0.118***	-0.097**	-0.051	-0.045	-0.001
	(0.028)	(0.060)	(0.049)	(0.037)	(0.029)	(0.036)	(0.040)	(0.043)	(0.039)	(0.047)	(0.053)
85	-0.110***	-0.201***	-0.175***	-0.149***	-0.136***	-0.120***	-0.119***	-0.096**	-0.049	-0.041	0.005
	(0.028)	(0.059)	(0.049)	(0.037)	(0.029)	(0.037)	(0.041)	(0.043)	(0.040)	(0.048)	(0.054)
90	-0.111***	-0.210***	-0.182***	-0.156***	-0.140***	-0.124***	-0.121***	-0.095**	-0.046	-0.037	0.011
	(0.028)	(0.058)	(0.049)	(0.037)	(0.029)	(0.037)	(0.042)	(0.044)	(0.040)	(0.049)	(0.054)
95	-0.113***	-0.219***	-0.190***	-0.162***	-0.143***	-0.127***	-0.121***	-0.092**	-0.043	-0.032	0.018
	(0.028)	(0.057)	(0.048)	(0.037)	(0.029)	(0.038)	(0.042)	(0.044)	(0.041)	(0.049)	(0.054)
100	-0.114***	-0.229***	-0.198***	-0.168***	-0.146***	-0.130***	-0.122***	-0.090**	-0.039	-0.026	0.026
	(0.029)	(0.056)	(0.048)	(0.037)	(0.029)	(0.039)	(0.043)	(0.045)	(0.042)	(0.050)	(0.055)

Note: Standard errors are in parentheses. ***, **, and * denote the 0.01, 0.05, and 0.10 significance level respectively.

Table A-7: Income Elasticities, Education 3, Urban

Deciles	Global	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Age											
5	-0.073***	-0.087	-0.083*	-0.073**	-0.085***	-0.064**	-0.078**	-0.085**	-0.060*	-0.063	-0.047
	(0.024)	(0.063)	(0.046)	(0.033)	(0.025)	(0.028)	(0.031)	(0.035)	(0.034)	(0.042)	(0.052)
10	-0.076***	-0.084	-0.082*	-0.074**	-0.087***	-0.069**	-0.084***	-0.091**	-0.066*	-0.070*	-0.055
	(0.024)	(0.063)	(0.047)	(0.034)	(0.025)	(0.028)	(0.032)	(0.036)	(0.035)	(0.042)	(0.053)
15	-0.080***	-0.083	-0.082*	-0.075**	-0.090***	-0.073**	-0.089***	-0.097***	-0.071**	-0.076*	-0.062
	(0.024)	(0.064)	(0.047)	(0.034)	(0.025)	(0.028)	(0.032)	(0.036)	(0.035)	(0.043)	(0.054)
20	-0.083***	-0.081	-0.082*	-0.077**	-0.093***	-0.078***	-0.095***	-0.102***	-0.076**	-0.082*	-0.069
	(0.025)	(0.065)	(0.047)	(0.034)	(0.025)	(0.028)	(0.032)	(0.036)	(0.035)	(0.043)	(0.054)
25	-0.087***	-0.081	-0.083*	-0.078**	-0.095***	-0.083***	-0.100***	-0.107***	-0.080**	-0.087**	-0.074
	(0.025)	(0.065)	(0.048)	(0.034)	(0.025)	(0.029)	(0.032)	(0.037)	(0.035)	(0.043)	(0.055)
30	-0.090***	-0.082	-0.084*	-0.081**	-0.098***	-0.087***	-0.105***	-0.112***	-0.084**	-0.091**	-0.079
	(0.025)	(0.065)	(0.048)	(0.034)	(0.026)	(0.029)	(0.033)	(0.037)	(0.035)	(0.044)	(0.055)
35	-0.094***	-0.083	-0.086*	-0.083**	-0.101***	-0.092***	-0.109***	-0.116***	-0.088**	-0.095**	-0.083
	(0.025)	(0.065)	(0.048)	(0.034)	(0.026)	(0.029)	(0.033)	(0.037)	(0.036)	(0.044)	(0.056)
40	-0.097***	-0.086	-0.089*	-0.086**	-0.104***	-0.096***	-0.114***	-0.120***	-0.091**	-0.098**	-0.086
	(0.025)	(0.065)	(0.048)	(0.035)	(0.026)	(0.029)	(0.033)	(0.037)	(0.036)	(0.044)	(0.056)
45	-0.100***	-0.089	-0.092*	-0.090**	-0.107***	-0.100***	-0.118***	-0.123***	-0.093**	-0.101**	-0.088
	(0.025)	(0.065)	(0.048)	(0.035)	(0.026)	(0.030)	(0.033)	(0.038)	(0.036)	(0.045)	(0.057)
50	-0.103***	-0.093	-0.095**	-0.093***	-0.110***	-0.105***	-0.122***	-0.126***	-0.095***	-0.103**	-0.089
	(0.025)	(0.065)	(0.048)	(0.035)	(0.026)	(0.030)	(0.034)	(0.038)	(0.036)	(0.045)	(0.057)

Note: Standard errors are in parentheses. ***, **, and * denote the 0.01, 0.05, and 0.10 significance level respectively.

Table A-7 Continued: Income Elasticities, Education 3, Urban

Deciles Age	Global	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
55	-0.106***	-0.098	-0.100**	-0.097***	-0.113***	-0.109***	-0.125***	-0.128***	-0.097***	-0.103**	-0.089
	(0.026)	(0.064)	(0.048)	(0.035)	(0.026)	(0.030)	(0.034)	(0.038)	(0.036)	(0.045)	(0.057)
60	-0.108***	-0.104	-0.104**	-0.101***	-0.116***	-0.113***	-0.129***	-0.130***	-0.097***	-0.104**	-0.087
	(0.026)	(0.064)	(0.048)	(0.035)	(0.026)	(0.030)	(0.034)	(0.038)	(0.036)	(0.045)	(0.057)
65	-0.111***	-0.111*	-0.110**	-0.106***	-0.119***	-0.116***	-0.131***	-0.131***	-0.098***	-0.103**	-0.085
	(0.026)	(0.063)	(0.047)	(0.035)	(0.026)	(0.031)	(0.034)	(0.038)	(0.037)	(0.045)	(0.057)
70	-0.113***	-0.118*	-0.115**	-0.110***	-0.122***	-0.120***	-0.134***	-0.131***	-0.097***	-0.102**	-0.082
	(0.026)	(0.062)	(0.047)	(0.035)	(0.026)	(0.031)	(0.035)	(0.038)	(0.037)	(0.045)	(0.056)
75	-0.115***	-0.126**	-0.121**	-0.115***	-0.125***	-0.123***	-0.136***	-0.131***	-0.096***	-0.100**	-0.078
	(0.026)	(0.061)	(0.047)	(0.035)	(0.026)	(0.031)	(0.035)	(0.038)	(0.037)	(0.046)	(0.056)
80	-0.117***	-0.134**	-0.128***	-0.121***	-0.128***	-0.127***	-0.138***	-0.131***	-0.095**	-0.097**	-0.072
	(0.026)	(0.060)	(0.046)	(0.035)	(0.026)	(0.032)	(0.035)	(0.038)	(0.037)	(0.046)	(0.056)
85	-0.119***	-0.143**	-0.135***	-0.126***	-0.131***	-0.130***	-0.139***	-0.130***	-0.092**	-0.093**	-0.066
	(0.026)	(0.059)	(0.046)	(0.034)	(0.026)	(0.032)	(0.036)	(0.039)	(0.037)	(0.046)	(0.056)
90	-0.120***	-0.152***	-0.142***	-0.132***	-0.134***	-0.133***	-0.140***	-0.128***	-0.090**	-0.089*	-0.059
	(0.026)	(0.057)	(0.046)	(0.034)	(0.026)	(0.032)	(0.036)	(0.039)	(0.038)	(0.047)	(0.056)
95	-0.121***	-0.161***	-0.149***	-0.137***	-0.137***	-0.135***	-0.140***	-0.126***	-0.086**	-0.084*	-0.052
	(0.026)	(0.056)	(0.045)	(0.034)	(0.026)	(0.033)	(0.037)	(0.039)	(0.038)	(0.047)	(0.056)
100	-0.122***	-0.171***	-0.157***	-0.143***	-0.140***	-0.138***	-0.141***	-0.123***	-0.082**	-0.078	-0.043
	(0.026)	(0.055)	(0.045)	(0.034)	(0.026)	(0.034)	(0.037)	(0.039)	(0.039)	(0.048)	(0.056)

Note: Standard errors are in parentheses. ***, **, and * denote the 0.01, 0.05, and 0.10 significance level respectively.

Table A-8: Price Elasticities for Selected Contributing Factors Index

Deciles Age	Global	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
5	-0.031	-0.275	-0.193	-0.128	-0.065	-0.023	0.013	0.050	0.077	0.109	0.161
	(0.139)	(0.213)	(0.167)	(0.140)	(0.135)	(0.154)	(0.165)	(0.189)	(0.175)	(0.192)	(0.237)
10	-0.049	-0.271	-0.196	-0.137	-0.079	-0.043	-0.010	0.022	0.051	0.081	0.128
	(0.138)	(0.215)	(0.168)	(0.140)	(0.134)	(0.153)	(0.165)	(0.188)	(0.175)	(0.192)	(0.237)
15	-0.067	-0.267	-0.200	-0.146	-0.095	-0.065	-0.035	-0.007	0.024	0.051	0.093
	(0.137)	(0.216)	(0.168)	(0.140)	(0.134)	(0.152)	(0.164)	(0.187)	(0.174)	(0.192)	(0.238)
20	-0.087	-0.263	-0.204	-0.156	-0.112	-0.088	-0.061	-0.037	-0.004	0.021	0.056
	(0.137)	(0.217)	(0.169)	(0.140)	(0.133)	(0.152)	(0.164)	(0.186)	(0.174)	(0.192)	(0.238)
25	-0.108	-0.260	-0.209	-0.167	-0.130	-0.112	-0.089	-0.069	-0.033	-0.011	0.018
	(0.136)	(0.218)	(0.169)	(0.139)	(0.132)	(0.151)	(0.163)	(0.186)	(0.173)	(0.192)	(0.239)
30	-0.130	-0.258	-0.215	-0.179	-0.149	-0.137	-0.117	-0.102	-0.064	-0.044	-0.022
	(0.135)	(0.219)	(0.169)	(0.139)	(0.131)	(0.151)	(0.163)	(0.185)	(0.173)	(0.192)	(0.240)
35	-0.154	-0.256	-0.221	-0.192	-0.168	-0.164	-0.147	-0.137	-0.095	-0.078	-0.063
	(0.135)	(0.219)	(0.169)	(0.139)	(0.130)	(0.151)	(0.163)	(0.185)	(0.173)	(0.192)	(0.240)
40	-0.177	-0.255	-0.228	-0.205	-0.189	-0.192	-0.178	-0.172	-0.127	-0.113	-0.104
	(0.134)	(0.219)	(0.168)	(0.138)	(0.130)	(0.151)	(0.163)	(0.185)	(0.173)	(0.193)	(0.241)
45	-0.202	-0.255	-0.236	-0.220	-0.210	-0.220	-0.211	-0.208	-0.160	-0.148	-0.146
	(0.133)	(0.218)	(0.168)	(0.138)	(0.129)	(0.150)	(0.163)	(0.184)	(0.173)	(0.193)	(0.241)
50	-0.228*	-0.255	-0.245	-0.235*	-0.232*	-0.250*	-0.244	-0.245	-0.194	-0.184	-0.189
	(0.133)	(0.217)	(0.167)	(0.137)	(0.128)	(0.150)	(0.163)	(0.184)	(0.173)	(0.194)	(0.242)

Note: Standard errors are in parentheses. ***, **, and * denote the 0.01, 0.05, and 0.10 significance level respectively.

Table A-8 Continued: Price Elasticities for Selected Contributing Factors Index

Deciles	Global	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Age											
55	-0.254*	-0.256	-0.254	-0.250*	-0.255**	-0.281*	-0.278*	-0.283	-0.228	-0.221	-0.232
	(0.132)	(0.216)	(0.167)	(0.137)	(0.127)	(0.150)	(0.164)	(0.184)	(0.174)	(0.194)	(0.243)
60	-0.280**	-0.257	-0.264	-0.267*	-0.278**	-0.312**	-0.312*	-0.322*	-0.263	-0.258	-0.274
	(0.132)	(0.215)	(0.166)	(0.136)	(0.127)	(0.151)	(0.164)	(0.185)	(0.175)	(0.195)	(0.243)
65	-0.307**	-0.259	-0.275*	-0.284**	-0.302**	-0.344**	-0.347**	-0.361*	-0.297*	-0.295	-0.317
	(0.132)	(0.213)	(0.165)	(0.136)	(0.126)	(0.151)	(0.165)	(0.185)	(0.176)	(0.197)	(0.244)
70	-0.335**	-0.262	-0.286*	-0.301**	-0.326**	-0.377**	-0.383**	-0.399**	-0.332*	-0.331*	-0.358
	(0.132)	(0.212)	(0.164)	(0.135)	(0.126)	(0.152)	(0.166)	(0.186)	(0.177)	(0.198)	(0.246)
75	-0.362***	-0.265	-0.297*	-0.319**	-0.351***	-0.410***	-0.419**	-0.438**	-0.367**	-0.368*	-0.399
	(0.132)	(0.210)	(0.163)	(0.135)	(0.126)	(0.154)	(0.168)	(0.188)	(0.179)	(0.201)	(0.248)
80	-0.389***	-0.269	-0.309*	-0.337**	-0.375***	-0.444***	-0.455***	-0.477**	-0.402**	-0.404**	-0.439*
	(0.133)	(0.207)	(0.162)	(0.135)	(0.126)	(0.156)	(0.170)	(0.190)	(0.182)	(0.204)	(0.250)
85	-0.417***	-0.273	-0.321**	-0.355***	-0.400***	-0.478***	-0.491***	-0.516***	-0.437**	-0.440**	-0.477*
	(0.135)	(0.205)	(0.161)	(0.135)	(0.127)	(0.158)	(0.173)	(0.193)	(0.185)	(0.207)	(0.253)
90	-0.444***	-0.277	-0.333**	-0.374***	-0.425***	-0.512***	-0.528***	-0.554***	-0.471**	-0.475**	-0.514**
	(0.136)	(0.203)	(0.160)	(0.135)	(0.128)	(0.161)	(0.177)	(0.196)	(0.189)	(0.211)	(0.256)
95	-0.471***	-0.282	-0.345**	-0.392***	-0.450***	-0.546***	-0.564***	-0.591***	-0.504**	-0.510**	-0.550**
	(0.139)	(0.201)	(0.160)	(0.135)	(0.129)	(0.165)	(0.181)	(0.201)	(0.194)	(0.216)	(0.261)
100	-0.497***	-0.288	-0.358**	-0.411***	-0.475***	-0.580***	-0.599***	-0.628***	-0.537***	-0.543**	-0.583**
	(0.142)	(0.199)	(0.159)	(0.135)	(0.131)	(0.169)	(0.186)	(0.206)	(0.199)	(0.222)	(0.266)

Note: Standard errors are in parentheses. ***, **, and * denote the 0.01, 0.05, and 0.10 significance level respectively.

Table A-9: Maximum Model Output

Variables	Estimates
Constant	-705.166*** (200.252)
ASIA	821.999*** (212.123)
CEE	681.290*** (221.189)
LAC	702.704*** (216.026)
MENA	753.661*** (203.087)
SAARC	7,379.504*** (200.394)
SSA	760.677*** (202.621)
Sex	1.125 (0.791)
Age	-0.371*** (0.093)
Age^2	0.004*** (0.001)
$\log(Y_c)$	135.405*** (36.422)
$\log(Y_c)^2$	-6.379*** (1.659)
Urban	-2.915 (3.992)
Edu 2	-2.328*** (0.659)
Edu 3	-4.764*** (1.317)
$\log(P_{veg})$	121.117 (114.225)
$\log(P_{bp})$	35.372 (219.487)
$\log(Y_c) \times \log(P_{veg})$	-11.425 (10.912)
$\log(Y_c) \times \log(P_{bp})$	-3.094 (20.280)
$\log(Y_c) \times Age$	0.076*** (0.020)
$\log(Y_c) \times Age^2$	-0.001*** (0.000)
$\log(Y_c)^2 \times Age$	-0.004*** (0.001)
$\log(Y_c)^2 \times Age^2$	0.000*** (0.000)
$\log(Y_c) \times Sex$	-0.180 (0.160)
$\log(Y_c)^2 \times Sex$	0.009 (0.008)
$\log(Y_c) \times Urban$	1.356 (0.857)
$\log(Y_c)^2 \times Urban$	-0.097** (0.046)
$\log(P_{veg}) \times Age$	0.030 (0.044)
$\log(P_{veg}) \times Age^2$	-0.000 (0.000)
$\log(P_{veg}) \times Sex$	0.641 (0.642)
$\log(P_{veg}) \times Urban$	4.270** (1.992)
$\log(P_{bp}) \times Age$	0.121** (0.058)
$\log(P_{bp}) \times Age^2$	0.000 (0.001)
$\log(P_{bp}) \times Sex$	-0.557 (0.558)
$\log(P_{bp}) \times Urban$	0.792 (2.011)
$\log(Y_c) \times \log(P_{veg}) \times Age$	-0.008 (0.005)
$\log(Y_c) \times \log(P_{veg}) \times Age^2$	0.000 (0.000)
$\log(Y_c) \times \log(P_{veg}) \times Sex$	-0.070 (0.074)
$\log(Y_c) \times \log(P_{bp}) \times Age$	-0.017** (0.008)
$\log(Y_c) \times \log(P_{bp}) \times Age^2$	-0.000 (0.000)
$\log(Y_c) \times \log(P_{bp}) \times Sex$	0.085 (0.072)
$\log(Y_c) \times$ Edu 2	0.580*** (0.142)
$\log(Y_c) \times$ Edu 3	1.112*** (0.280)
$\log(Y_c)^2 \times$ Edu 2	-0.033*** (0.008)
$\log(Y_c)^2 \times$ Edu 3	-0.059*** (0.015)
$\log(P_{veg}) \times$ Edu 2	0.545* (0.315)
$\log(P_{veg}) \times$ Edu 3	0.143 (0.655)

Note: Standard errors are in parentheses. ***, **, and * denote the 0.01, 0.05, and 0.10 significance level respectively.

Table A-9 Continued: Maximum Model Output

Variables	Estimates
$\log(P_{bp}) \times$ Edu 2	0.172 (0.326)
$\log(P_{bp}) \times$ Edu 3	-0.932 (0.703)
$\log(Y_c) \times \log(P_{veg}) \times$ Edu 2	-0.063* (0.035)
$\log(Y_c) \times \log(P_{veg}) \times$ Edu 3	0.031 (0.070)
$\log(Y_c) \times \log(P_{bp}) \times$ Edu 2	-0.013 (0.039)
$\log(Y_c) \times \log(P_{bp}) \times$ Edu 3	0.170** (0.085)
$\log(Y_c) \times \log(P_{veg}) \times$ Urban	-0.388* (0.220)
$\log(Y_c) \times \log(P_{bp}) \times$ Urban	-0.058 (0.246)
$\log(Y_c) \times$ ASIA	-152.776*** (38.693)
$\log(Y_c) \times$ CEE	-129.290*** (41.093)
$\log(Y_c) \times$ LAC	-133.774*** (40.047)
$\log(Y_c) \times$ MENA	-144.294*** (37.042)
$\log(Y_c) \times$ SAARC	-1,839.735*** (36.456)
$\log(Y_c) \times$ SSA	-145.273*** (37.111)
$\log(Y_c)^2 \times$ ASIA	7.053*** (1.766)
$\log(Y_c)^2 \times$ CEE	6.133*** (1.914)
$\log(Y_c)^2 \times$ LAC	6.318*** (1.867)
$\log(Y_c)^2 \times$ MENA	6.916*** (1.696)
$\log(Y_c)^2 \times$ SAARC	113.540*** (1.661)
$\log(Y_c)^2 \times$ SSA	6.893*** (1.708)
$\log(P_{veg}) \times$ ASIA	-5.556 (125.075)
$\log(P_{veg}) \times$ CEE	-137.158 (121.236)
$\log(P_{veg}) \times$ LAC	-122.337 (121.102)
$\log(P_{veg}) \times$ MENA	-136.629 (117.124)
$\log(P_{veg}) \times$ SAARC	451.133*** (114.407)
$\log(P_{veg}) \times$ SSA	-127.597 (115.620)
$\log(P_{bp}) \times$ ASIA	-16.626 (231.196)
$\log(P_{bp}) \times$ CEE	-19.523 (222.313)
$\log(P_{bp}) \times$ LAC	-29.586 (222.319)
$\log(P_{bp}) \times$ MENA	13.839 (221.779)
$\log(P_{bp}) \times$ SAARC	3,426.407*** (219.628)
$\log(P_{bp}) \times$ SSA	-50.575 (220.451)
$\log(Y_c) \times \log(P_{veg}) \times$ ASIA	0.077 (12.281)
$\log(Y_c) \times \log(P_{veg}) \times$ CEE	13.345 (11.797)
$\log(Y_c) \times \log(P_{veg}) \times$ LAC	11.498 (11.704)
$\log(Y_c) \times \log(P_{veg}) \times$ MENA	14.088 (11.236)
$\log(Y_c) \times \log(P_{veg}) \times$ SAARC	-60.736*** (10.934)
$\log(Y_c) \times \log(P_{veg}) \times$ SSA	12.724 (11.131)
$\log(Y_c) \times \log(P_{bp}) \times$ ASIA	1.389 (21.970)
$\log(Y_c) \times \log(P_{bp}) \times$ CEE	1.024 (20.629)
$\log(Y_c) \times \log(P_{bp}) \times$ LAC	2.820 (20.622)
$\log(Y_c) \times \log(P_{bp}) \times$ MENA	-0.981 (20.532)
$\log(Y_c) \times \log(P_{bp}) \times$ SAARC	-388.022*** (20.297)
$\log(Y_c) \times \log(P_{bp}) \times$ SSA	4.713 (20.440)
Adj. R-squared	0.619

Note: Standard errors are in parentheses. ***, **, and * denote the 0.01, 0.05, and 0.10 significance level respectively.

Table A-10: Selected F Test Results

	Hypothesis	F Statistic	Prob > F	Reject/Fail to Reject
Test 1	Quadratic income significantly impact the model	2.5E09 (13,163)	0.000	Fail to Reject
Test 2	Selected contributing factor prices and income significantly impact the model	7277.93 (12, 163)	0.000	Fail to Reject
Test 3	Fresh vegetable and income interaction terms significantly impact the model	340.49 (12, 163)	0.000	Fail to Reject
Test 4	Income and regional interaction terms significantly impact the model	27425.06 (6, 163)	0.000	Fail to Reject
Test 5	Quadratic income and regional interaction terms significantly impact the model	39212.85 (6, 163)	0.000	Fail to Reject
Test 6	Vegetable price, income, and regional interaction terms significantly impact the model	468.56 (6, 163)	0.000	Fail to Reject
Test 7	Selected contributing factor prices, income, and regional interaction terms significantly impact the model	11190.01 (6, 163)	0.000	Fail to Reject
Test 8	Vegetable price and regional interaction terms significantly impact the model	378.37 (6, 163)	0.000	Fail to Reject
Test 9	Selected contributing factor prices and regional interaction terms significantly impact the model	11368.97 (6, 163)	0.000	Fail to Reject
Test 10	Income, age and quadratic age significantly impact the model	8.32 (2, 163)	0.0004	Fail to Reject
Test 11	Quadratic income, age, and quadratic age significantly impact the model	8.7 (2, 163)	0.0003	Fail to Reject
Test 12	Vegetable price, age, and quadratic age significantly impact the model	8.32 (2, 163)	0.0004	Fail to Reject
Test 13	Selected contributing factor prices, age, and quadratic age significantly impact the model	8.53 (2, 163)	0.0003	Fail to Reject
Test 14	Vegetable price, income, age, and quadratic age significantly impact the model	1.28 (2, 163)	0.2804	Reject
Test 15	Selected contributing factor prices, income, age, and quadratic age significantly impact the model	11.95 (2, 163)	0.0000	Fail to Reject
Test 16	Vegetable price, selected contributing factor prices, income, age, and quadratic age significantly impact the model	8.02 (4, 163)	0.0000	Fail to Reject
Test 17	Sex significantly impacts the model	2.13 (6, 163)	0.0529	Reject

VITA

Amelia Ahles was born on January 6, 1997 in San Diego, California where she and her two siblings, Miles and Ellie, were raised by Steve and Mari Ahles. She graduated from Torrey Pines High School in 2015 and received a Bachelors' in Science in Agribusiness from Clemson University in 2018. Amelia and her family are avid purveyors of athletics and the outdoors including equestrian, running, backpacking, and football as well as overall health and wellbeing. As a May 2020 graduate of the University of Tennessee, Knoxville, Amelia aims to continue to learn while pursuing a doctorate degree in Agriculture Economics at Texas A&M University, likely related to health and nutrition economics, food policy, and international development. After receiving her doctorate Amelia hopes to split her time between academia and a joint venture with her siblings to combined their skills in biotechnology, agricultural economics, and clinical nutrition to combat non-communicable diseases, especially those which may be linked to genetics and diet.